# TUNNEL SPECIFICATION AND PRELIMINARY REPORTS

## SPECIAL CONDITIONS / SPECIFICATION FOR NS ITEMS TUNNEL WORK

**1. Underground excavation for tunneling:**

1.1. SCOPE OF WORK

1.1.1. The specifications described herein under relate to the excavation work for the underground structures and shall include all labour, materials, equipment all drilling and blasting, loading, transporting and disposal of materials in spoil or stockpile areas as well as the removal of all loose material and cleaning of excavated surfaces, to be carried out by the Contractor under this contract. In general, the excavation work shall be done by mechanical equipments or drill and blast (DBM) and in exceptional cases, by manual means

1.1.2. All excavation is covered under Sch G including any type of overbreak, no additional amount for excavation is payable on account of any types of overbreak including geological overbreak

1.1.3. Excavation shall be made to the lines, grades and dimensions shown on the drawings or as otherwise directed by the Engineer, which shall be required to be backfilled with acceptable material and compacted by contractor in a manner acceptable to the engineer.

1.1.4. Structural supports, structural steel support, rock bolts, shotcrete, grouting, concrete lining and dewatering works are covered in other chapters of technical specifications.

1.1.5. The contractor shall be required to perform surface exploratory drilling during excavation of the tunnel whenever required.

1.1.6. Advance probing and maintaining specified water tightness (as detailed in the respective sub-chapters) is mandatory and can't be relaxed without approval of Authority engineer.

1.1.7. Fore probing shall be done through MWD capable drill jumbos and data so acquired will be used for decision making regarding the probable nature of the ground ahead and its water- bearing capacity.

1.1.8. The approval given by the Authority Engineer to the Contractor's methods and equipment shall not relieve the Contractor of his full responsibility for proper and safe execution of underground excavations, or liability of injuries to or death of person or any obligations under this contract.

1.1.9. The Contractor shall comply with all safety procedures and requirements as stipulated elsewhere in the tender documents, and as per all prevailing railway instructions with respect to Safety during Tunneling operations.

1.1.10. All excavations done inside ground with overlying material left in place shall be treated as underground excavation.

**1.1.11. STANDARDS:**

The specifications, production, working etc. shall conform to the following latest Indian

Standards or where not covered by these Standards, to the equivalent International Standards. The list is for guidance purposes only. The contractor shall abide by all codes/regulations/ specifications as are deemed necessary for the satisfactory completion of work.

i. IS: 4756: - 1978 – Safety Code for Tunnelling work

ii. IS: 3764 –1966 – Safety Code for Excavation work

iii. IS: 4081-1967 – Safety Code for Blasting and Related drilling operations

iv. IS: 4138-1977 – Safety Code for Working on Compressed Air

v. IS: 7293-1974 – Safety Code for Working with Construction Machinery

vi. IS: 5878 (Various parts) – Codes of practices relating to tunnelling and underground excavations

vii. Indian Explosive Act -1988

viii. Indian Explosive Rules -1983

ix. IS: 823 -1964 – Code of procedure for manual metal Arc welding of mild steel

x. IS: 816-1969 – Code of practice for use of Metal Arc welding for General Construction in Mild steel.

## 1.2. SUBMITTALS

1.2.1. At least 28 days prior to the commencement of underground excavation, the contractor shall submit details of his excavating methods and sequences for all underground works and portal excavation, including equipment, ventilation air cooling equipment, rock support, details of methods for drilling probe holes, grouting and safety measures. The contractor shall get approval for excavation and sequences from the Engineer.

1.2.2. The description of drilling and blasting procedures shall include the following:

i. Diameter, spacing, depth, pattern and orientation of blast holes.

ii. Pattern of delays to be used per blast.

iii. The sequence of various activities of the excavation works differently. Heading faces with indication of corresponding time requirements.

iv. Excavation methodology shall include proposed exaction cycle time for each class of rock mass along with advance rock stabilization measures.

v. The details to be backed up by supporting calculations & details of trials.

1.2.3. At least 28 days prior to dumping or stockpiling of any material, the contractor shall submit the methodology of the same.Excavated material is the property of the contractor. Contractor can utilise excavated material free of cost for Railway work subjected to its fitness for intended use. The authority has taken certain dumping areas as indicated in kml. These dumping areas can be used for dumping excavated muck subject to

compliance of all forest conditions imposed in Stage I II and working permission. To prevent erosion and washing away of muck, protection work may be required to be constructed as per instruction of Authority Engineer in consultation with the Forest Department, the same shall be payable under relevant item of Sch G-1. There will be no payment of leading muck to dumping areas. The contractor has to quote his rates accordingly. Remaining all excess unused material which can not be dumped in dumping areas to be disposed of outside by contractor at its own cost.

1.2.4. To enable the Engineer to verify all necessary setting out and elevations carried out by the Contractor, the latter shall notify the Engineer in writing, giving at least 1 (One) week notice, of his intention to start excavation.

1.2.5. During the advance of underground excavations, the Contractor shall record and submit weekly to the Engineer, 2 copies of the following:

i. Advance of each heading face and chainage of heading face before the blasting of each round.

ii. Amount, location, spacing, and type of steel support/Lagging installation in various zones, as defined hereafter.

iii. Surface area of shotcrete installed in various zones.

iv. Number, length, and type of rock bolts installed in various zones.

v. Occurrence of gas, if any.

vi. Water inflows at the heading face including its temperature.

vii. Personnel employed during various stages of the operation and their qualification.

viii. Unusual occurrences, all delays and the reason for delays.

ix. Type and number of drill holes, and length of each round.

x. Pattern of drill holes their diameter and length.

1.2.6. A.E. (Authority Engineer) reserves the right to require any additional information deemed necessary to be included in the submitted documents.

1.2.7. For geological overbreak and adverse geological occurrence Contractor shall be responsible for preparing geological plans and survey plot cross section at required intervals by tunnel profiler to allow for reasonably accurate assessment of the volumes and taking video / still photographs of overbreak in the presence of the representative of A.E. and providing copies of the same to A.E.. The exact locations and or chainage shall also be included therein. Such incidences shall be reported immediately to the Authority ENGINEER. Detailed reports on adverse geological occurrences shall also be prepared along with probable reasons and submitted to Authority engineers as soon as possible. All cavities and voids formed due to geological overbreak shall be measured in situ, quantified and proposed by contractor for immediate approval of Engineer, If possible, before the excavation of the subsequent blast.

1.2.8. The drilling parameters retrieved from the Jumbo machine will be submitted to the Engineer before every blast.

## 1.3. DEFINITIONS

### 1.3.1. Conventional Excavation

i. Excavation performed underground by conventional methods using mechanical means (except TBM) or drilling and blasting and in exceptional cases, by manual means.

### 1.3.2. Tunneling Face

i. The advance end of a tunnel at which the work is progressing.

### 1.3.3. Heading Zone

**i.** Heading zone refers to tunnels (upstream and downstream headings) excavated by conventional method and is defined as a zone between the newly established face and 7m or equal to the excavated diameter of the tunnel behind the face, measured along the tunnel centerline.

### 1.3.4. Rear Zone

**i.** Rear Zone is the whole length of tunnel between the heading zone and the portal.

### 1.3.5. Excavation Rate per working day

**i.** The daily excavation rate is the average of daily rates calculated over a period of 1 month.

### 1.3.6. Working Days (WD)

**i.** Working days are calendar days on which work is performed. When working days are mentioned in writing, they must be indicated with additional indices such as WD1, WD2 or WD3 in order to show whether on the day in question 1, 2 or 3 shifts will be working.

### 1.3.7. Crown

**i.** Crown is the top arch of the tunnel above the spring line.

### 1.3.8. Spring Line

**i.** The level at which the overt and vertical I wall of the tunnel meet is called Spring level and the horizontal line passing through the junction points of the tunnel is called Springing Line.

**1.3.9. Round length (Pull):** Maximum distance (along tunnel axis) between any two points on two successive tunnelling faces by which the excavation is advanced from previous face to next face by conventional drill and blast or any other method in one go.

## 1.4. General

1.4.1. The Contractor shall always be responsible for the safety and security of excavations during the execution of the Contract.

1.4.2. **Mechanized techniques for excavation shall be used.**

1.4.3. **Advance probing and attaining specified water tightness in underground excavation is mandatory and can't be relaxed without approval of the Engineer.**

1.4.4. **Excavation shall generally be full face, heading and benching or multi-drift (weak strata or larger tunnels in yard areas) as defined in the construction drawings.**

1.4.5. The Contractor shall provide details of his proposed methods for excavation support and spoil removal to the Engineer for agreement. No excavation shall take place until the Engineer's agreement has been obtained. Such agreement shall not relieve the Contractor of any of his obligations under the Contract.

1.4.6. Excavation shall be carried out in a uniform and controlled manner and over-cutting shall be kept to a minimum consistent with the need to maintain the necessary clearance for construction of the Works.

1.4.7. The invert of the tunnel shall be protected against damage and deterioration which may be caused by construction traffic. Any other surfaces which deteriorate or are damaged shall be made good to a standard agreed with the Engineer. After invert casting, tunneling muck will be filled, levelled and compacted over concrete inverters.

1.4.8. Excavation shall be carried out in sections limited to such lengths, depths and widths as may be safely executed having regard to all the circumstances and as appropriate to the ground conditions and the equipment and method of construction being used.

1.4.9. In water-bearing strata the Contractor shall use such methods and take such steps as are necessary to control flows and maintain the stability of the excavation.

1.4.10. Where necessary to ensure the safety and security of the Works, excavation shall be continuous by day and night.

1.4.11. Weekends, general holidays and enforced stoppages will require the Works to be made safe and inspected by the Contractor at intervals agreed with the Engineer.

1.4.12. Any voids formed during the excavation process by machine overcut slips, falls of material, overbreak and temporary works shall be filled either completely or partially in agreement with the engineer, with grout, concrete, sprayed concrete or other approved durable material.

1.4.13. Where the Contract specifies limits to surface settlement and/or protection in respect of existing services or structures, the Contractor shall provide calculations demonstrating that the method of excavation will result in compliance with those requirements. Details of the monitoring arrangements which are proposed for the recording of movements and the verification of the degree of any settlement or damage to services or structures shall be in accordance with the specified limits.

1.4.14. Where agreed or required by the Authority Engineer, temporary support shall be left in the Works. Generally, timber shall not be left permanently in the Works.

1.4.15. The volume of excavated material shall be measured and recorded as the Works proceed. The Contractor shall present to the Engineer after every 50m of advance, a Chainage wise reconciliation of volumetric advance of tunnel against volume of materials excavated and quantum of support installed (Bolts/Shotcrete), concrete placed, length of drilling of holes

and grout injected.

1.4.16. All excavation shall be carried out to a profile as close as possible to the specified minimum excavation line.

1.4.17. The Contractor shall be constantly aware of the possibility of slips and ground movement which may be caused by his method or order of excavation. He shall maintain on-site material, and equipment, for use in ensuring the stability of the face.

1.4.18. The proximity of other tunnels and excavations shall be considered when determining the method of excavation.

1.4.19. Enlargement of tunnel cross section or excavation of bypass tunnel shall also be done as wherever required as per instruction of Engineer.

## 1.5. EXCAVATION LINES AND TOLERANCES

### 1.5.1. Definitions:

i. Theoretical excavation line: The excavation profiles as shown on the cross-section drawings refer to the theoretical excavation lines.

ii. "A" Line" – Depending on the quality of the rock, an appropriate enlargement of the theoretical excavation profile shall be made in order to provide enough space for the anticipated radial deformations along with construction tolerane. The "A" Line takes into consideration the anticipated radial deformations above the theoretical excavation line along with construction tolerance. This is minimum excavation line.

iii. "B" Line – Line within which neither rock bolts nor sprayed concrete or any part of the primary support shall intersect except for bolt end hardware.

iv. "C" Line – A Line within which the final lining shall not protrude and be constructed within -0/+50mm radially (Negative value radially inward). The Contractor shall accommodate all his construction tolerances for excavation and support installation within this given allowance.

v. "Z" Line – The "Z" Line is a line which is beyond and parallel to the "Pay" Line. The distance between Pay Line and "Z" Line is 300mm.

vi. "Pay" Line – "Pay" Line is a line which is 150 mm beyond and parallel to the "A" Line. Payment for filling the portion between A line and Pay line will be made if actual excavation is between pay line and minimum excavation line. **"Pay" Line will be the same as "A" Line for all excavation profiles at invert.**

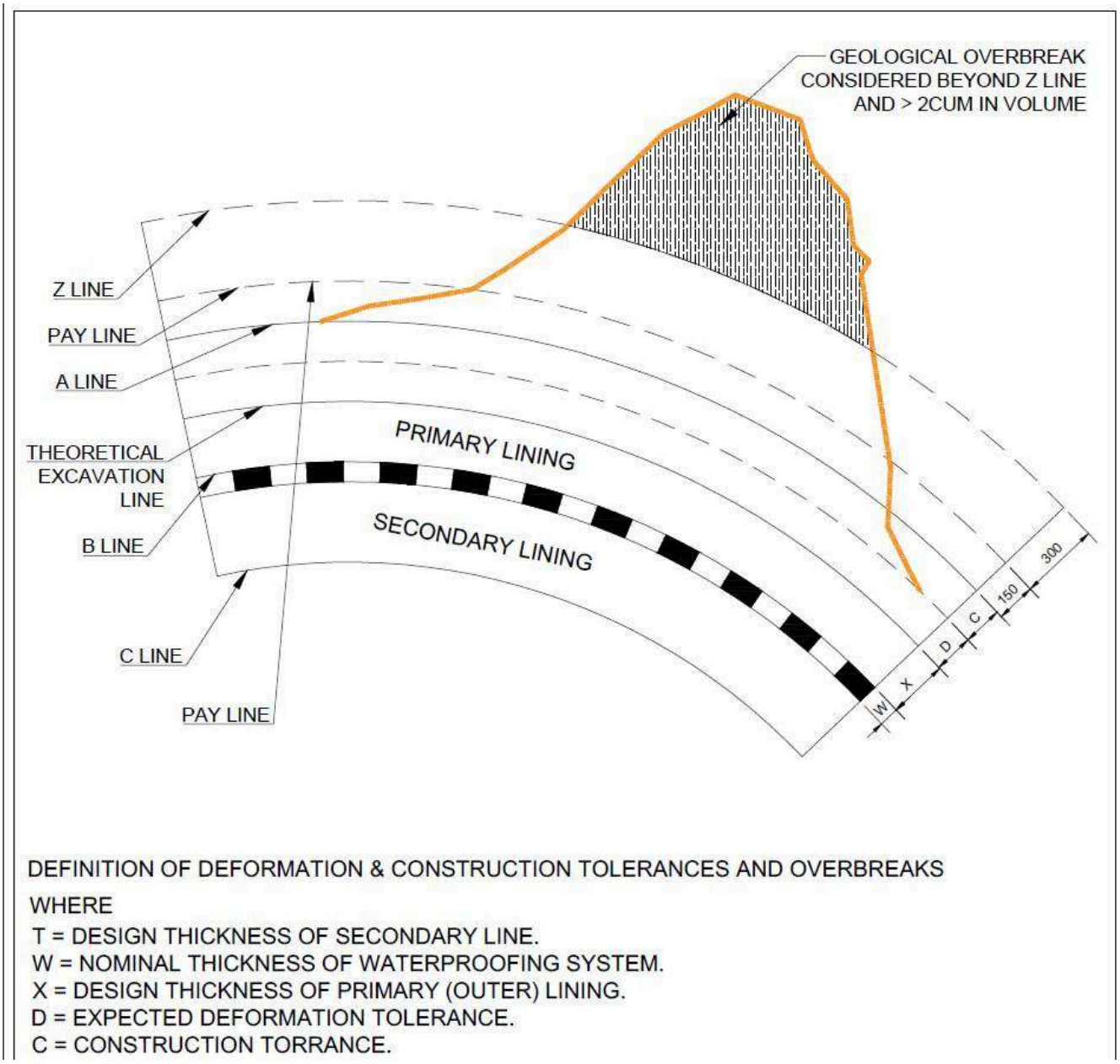
vii. Deformation+construction tolerance will be 80 mm total (c=30 mm, d=50 mm)

viii. "No Pay Zone" – Region between "Z" Line and "Pay" Line is defined as "No Pay Zone". No payment will be admissible for filling the No Pay Zone.

ix. "Overbreak" – "Overbreak" consists of the volume of rock removed during excavation operation outside the "Pay" Line irrespective of its extent. The Contractor shall make all reasonable effort to maintain the excavated profile within "Pay" Line, by exercising careful control of drilling and by varying the various elements of smooth blasting suiting various categories of excavation classes, so as not to create any overbreak. Occurring

"Overbreak" may be caused by improper workmanship and careless working techniques (avoidable Overbreak) and/or by reasons which cannot be influenced by the Contractor (unavoidable Overbreak). Unavoidable Overbreak is "Overbreak" caused by unfavourable geological conditions.

**Figure:1.5.1: Definition**




ix "Geological Overbreak" (GOB)– "Geological Overbreak" consist of that portion of over break, the occurrence of which is an unavoidable result of adverse geological conditions due to concealed joints, faults and other structural defect in rock and not due to

negligence or lack of reasonable care and skill in excavation operations.

"Overbreak" shall be termed as "Geological Overbreak" if all the following conditions are met: -

A. Part of any "overbreak" which is beyond "Z" Line and exceeds 2 (two) Cum in volume. Volume of GOB for that part will be calculated by multiplying its area measured beyond "Z" line at such cross section recorded as per clause 1.6.4 below.

B. The "overbreak" occurs above the Invert level of the tunnel.

C. The excavation profile is free from drilling impressions.

D. "Over break" is not caused by spalling of the well-known foliation or combination of regular family joints.

E. "Over break" caused due to contractor's not probing ground ahead at locations either mentioned in Geotechnical baseline reports or instructed by Authority engineer otherwise shall not be considered as Geological Overbreak.

F. Approved round length and method of excavation i.e. Drill & Blast or mechanical excavation have been applied and executed drilling pattern of blast holes and relief hole against approved pattern is shared with the Engineer before taking blast.

G. The Engineer is immediately informed in writing and given an opportunity for inspection while both the cause and the extent of the "overbreak" are clearly visible.

H. When it is decided by the Authority Engineer that "over break" occurred due to unforeseeable geological conditions beyond the control of the Contractor and not due to Contractor's using improper or improperly applied working methods / bad blasting or negligence and could not have been prevented by prompt and appropriate installation of supports.

I. In case of any dispute regarding the "geological overbreak". The decision of the Authority Engineer shall be final and binding.

For the approval of a "geological overbreak", according to the above described criteria, the Contractor should submit following elements:

1. Detailed geological report including photographic record of the encountered geological conditions.
2. Tunnel excavation profile.
3. Interpretation of Measure While Drilling (MWD) data from Jumbo if any.
4. Daily record of the blast design with information regarding explosives used (quantity, powder factor, etc.)

Typical cross section, minimum excavation lines and dimensions of excavations will vary for different Support Section Types required to be installed. The "A" Line shall accordingly be modified, and the contractor shall be bound by all such adjustments.

**Construction +deformation tolerance is fixed and kept at 80 mm.**
**Since all excavation is covered under Sch-G, here overbreak and geological overbreaks are defined whether filling those overbreaks will be payable or contractor has to fill those on its own cost. Any overbreak beyond the pay line, contractor has to fill those at its own cost. If geological overbreak occurs, then filling those Geological overbreaks will be payable under Schedule G-1**

1.5.2. Regulation for installation of Primary and Secondary Lining Support

i. **Primary Lining Support**: After scaling, the entire excavated profile will be measured in situ with tunnel Profiler. The excavated profile shall be placed with Shotcrete up to **a line** 30 mm inside and parallel to A line i.e covering the construction tolerance. Design thickness of shotcrete and other supports shall be applied below this line, as indicated in the approved drawing. The finished profile of shotcrete shall be checked with tunnel Profiler and shall meet the tolerance for surface finish requirements for installation of water proofing membrane. A smoothening layer of shotcrete shall be applied as per drawings or as instructed by Authority engineer.

ii. **Secondary Lining Support**: Before application of water proofing membrane, Profile of existing shotcrete surface shall be recorded with tunnel Profiler to establish actual deformation occurred. Any eventual space between the shotcrete surface and "C" Line shall be filled with the inner lining concrete. This eventual space comprises concrete volumes required on account of the portion of radial deformation (δ) which did not occur added to the volume of theoretical lining thickness.

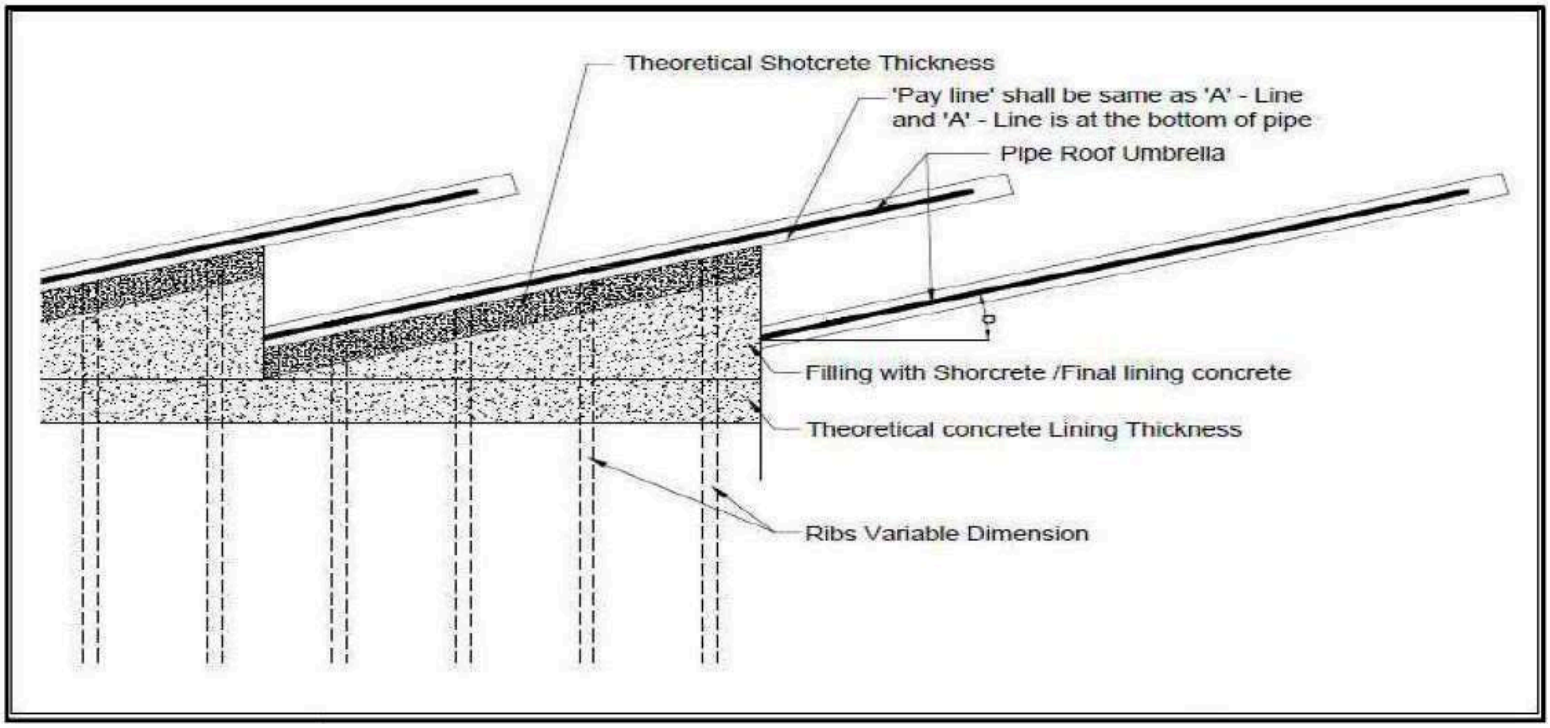
1.5.3. The drilling jumbo should be positioned as per precise survey reference points/lines and shall preferably be laser/total station navigated before its usage in drilling etc.

1.5.4. The Contractor shall measure the excavated profile by means of a 3- laser tunnel profiler after each round or as per direction of Engineer.

1.5.5. Excavation not shown on drawings, but which the Contractor considers necessary for his own purposes such as excavation from mucking pits, pump sumps, niche for vehicle parking/turning, drain ditches other than those shown on the drawings and specifications etc. for supply facilities shall only be carried out with the approval of the Authority Engineer.

1.5.6. Excavation of adits other than those shown on the drawings, by the contractor for his convenience, shall be subject to the prior approval of Authority Engineer. Such adit, when no longer required, shall be plugged, as directed by Authority Engineer.

1.5.7. In case of pipe roof umbrellas, the excess excavation below the steel pipes will be filled with Shotcrete/ final lining concrete as instructed by the Authority Engineer.




1.5.8. **Tolerances for Lining:**

i. **Secondary Lining:** Finished surface of Secondary Lining shall not protrude “C” Line and be constructed within tolerance of -0/+50mm radially (Negative value radially inward).

ii. No reduction of the theoretical thickness of the inner lining is permitted unless approved by the Authority Engineer. To achieve this requirement, no support elements such as primary shotcrete, rock bolts and steel ribs etc. shall penetrate the theoretical outer boundary of the inner lining.

iii. In the area of the invert and the foundation beams, no rock parts or rock peaks shall protrude into the theoretical excavation line.

1.5.9. Tolerance for Excavation level on invert:

i. For tunnel sections with no concreted invert arch the Contractor shall excavate the bottom level of the invert with an accuracy of +0 to -100 mm related to the theoretical excavation line of the invert.

ii. If the bottom excavation level, after cleaning loose materials etc. is more than 100 mm below the designed theoretical excavation line, t**he Contractor shall backfill such areas at his own cost up to the designed, theoretical level by means of sub-base material or as directed and approved by the Engineer.**

iii. For tunnel sections with a concrete invert arch no reduction of the designed, theoretical thickness of the concrete structure is permitted. **Over excavation must be compensated with structural concrete/ shotcrete for the invert arch as specified. The inside face of a concrete invert arch may deviate not more than +/-50 mm in elevation from the theoretical cross section**

## 1.6. PROFILE CONTROL

### 1.6.1. Scope

i. The Contractor is required to perform a careful and systematic checking of the final clearance of the primary tunnel lining in order to accommodate the designed nominal thickness of the secondary (inner) lining without interfering with the clearance requirements of the underground structure.

### 1.6.2. Method of Profile Control

i. For profile control for the shotcrete lining see relevant Clause.

ii. It is the Contractor's responsibility to ensure that the minimum clearance for the final (inner) lining as shown on the drawings is provided. On approval, the Authority Engineer will issue instructions regarding the systematic checking of the geometry of the template during profiling operations.

iii. The Contractor may prefer to use advanced surveying techniques and data processing to establish the final clearance profile. In which case he shall define a method of marking out areas of deviation from the theoretical profile to be approved by the Engineer.

### 1.6.3. Execution

i. The checking of the final clearance shall not proceed before the geotechnical measurements show that the radial displacements at any position of the tunnel have, in the opinion of the Authority Engineer, largely stopped.

ii. The final clearance profile after the completion of support works of the tunnel and after deformation as per this Clause shall conform to the minimum clearance profile as indicated on the drawings. Final control is required before a water proofing system is applied.

iii. In case of an existing under profile, the Contractor shall submit a proposal for the remedial works to the Authority Engineer for approval.

iv. No reshaping (re-profiling) of the tunnel support shall be carried out without the approval of the Authority Engineer.

v. Geotechnical measurements before, during and after the respective reshaping measures shall be carried out in compliance with the relevant design. The measurement points such as convergence bolts and/or extensometers shall be retained or substituted well in advance in order to establish "transfer - zero - readings".

vi. Geotechnical measurement stations shall not be removed and abandoned without the

approval of the Engineer.

**1.6.4. Records**

i. Records shall be kept for each stage of the remedial measures executed.

ii. The clearance profile i.e cross-sections of excavated profile shall be recorded at every meter of tunnel Chainage in longitudinal direction and at multiple points, 0.5 mtr apart along the periphery of the tunnel or as instructed by the Authority Engineer. The clearance profile shall be recorded by non-contact method (by manually or automatically) i.e by means of a "Tunnel profiler". The checking of the clearance profile shall be done in presence of the Engineer.

iii. For the shotcrete lining, the final checking of the clearance profile after completion of re-profiling and surface preparation in compliance with this Specification shall be done in presence of the Authority Engineer or its representative

## 1.7. EXCAVATION UNDER GEO-THERMAL CONDITION

1.7.1. When temperatures above 50°c are encountered it shall be considered as Geo-thermal condition. Temperature of seepage water shall be the criteria for considering the Geothermal condition in various reaches. Where there is no seepage of hot water, temperature of rock mass at the face, inside the tunnel shall be measured.

1.7.2. In case of such occurrence the contractor shall provide additional adequate ventilating /cooling measures so that ambient air temperature below 35° C is maintained inside the tunnel.

1.7.3. In addition to above, provision of ice jackets to workers, ice blocks near working areas and other measures may also be required for a congenial working atmosphere.

## 1.8. ADVERSE GEOLOGICAL OCCURRENCE (A.G.O)

1.8.1. Geological occurrence is called adverse if its occurrence is unexpected and there is no possibility of further advance by conventional excavation, including fore poling or pre excavation grouting provided for and priced quoted by the Contractor in his bid, even by using the best qualified tunneling crew.

1.8.2. In the case of such occurrence, the contractor may adopt an alternate method with the approval of the Authority Engineer for which he will be compensated as per relevant item of BOQ. (This completion period is subject to time extension given on account of A.G.O.)

1.8.3. In absence of any mutually signed records of Advance probing for the stretch where AGO has occurred, the contractor will rectify the situation on its own without any additional cost to the Authority. Time loss on this account shall be attributable to the contractor and no claim shall be entertained.

## 1.9. ADDITIONAL EXCAVATION

1.9.1. The Contractor may be directed by the Authority Engineer to enlarge or change the section or carry out excavation beyond the minimum excavation line in parts of the underground works where excavation has already been completed or carry out excavation for making niches. Additional excavation may be carried out for, but not be limited to the

following purposes. **Cost of all such additional excavation is deemed to be included in Sch-G**

i. To enable efficient machinery movement.

ii. To enable the Authority Engineer to carry out rock mechanics tests if any.

iii. To accommodate the increased thickness of the tunnel lining for structural reasons.

iv. Authorized excavation for electrical facilities, dewatering, crossovers etc.

v. Authorized excavation on account of unexpected squeezing ground conditions.

1.10. DELETED

1.11. SUPPORT FOR UNDERGROUND EXCAVATION

1.11.1. The provisional and permanent supports for the underground excavation shall principally consist of spot or pattern rock bolts and / or shotcrete and/or Structural steel and final concrete lining supports as approved by the Authority Engineer.

1.11.2. The Contractor shall install the support system as shown on the drawings or as directed by the Authority Engineer in any part of the underground excavation based on rock conditions encountered during the work.

1.11.3. The contractor shall employ a team of qualified geologists, who have adequate working experience in rock supporting work to act as support supervisor(s). The support supervisor(s) shall examine the rock conditions after each excavation advance and shall verify that the rock support system is installed as directed. The support supervisor(s) shall take necessary steps in consultation with Authority Engineer in order to install additional supports or to stop further advance if, in his opinion, the conditions are unsafe. However, he shall have no right to cancel the type or amount of rock supports previously directed by the Authority Engineer. The support supervisor(s) shall be present at each heading face throughout the duration of underground excavation work.

1.11.4. The required supports shall be installed concurrently without delay during the process of excavation within the heading zones. In the rear zones additional supports shall be installed immediately after it is observed by monitoring that the supporting system previously installed is not enough to prevent further loosening of the material surrounding the excavation.

1.11.5. Shotcrete shall be applied, in accordance with the provision as per the support class encountered (Refer Excavation/Support class Drawings). The Contractor shall consider in his construction planning, that placing of shotcrete protection will be required immediately after blasting a round in conventional method of drill and blast.

1.11.6. The use of timber will not be permitted for tunnel supports in any form. However, the Authority Engineer, in exceptional circumstances may permit use of timber for providing temporary supports, which shall be removed as early as practicable.

1.11.7. The Contractor shall keep on the site all necessary construction plant and equipment for

installing rock bolts and shotcrete, ready for operation in the excavation heading zones during the entire excavation period.

1.11.8. The contractor shall bear the whole responsibility for the proper and safe excavation. With the prior approval of Authority Engineer, extra support and special protection for the personnel when the conditions so require can be provided.

## 1.12. CLASSIFICATION OF UNDERGROUND EXCAVATION

### 1.12.1. Excavation

i. This section covers the description of rock mass types and rock classes relevant to the underground excavation with respect to the geotechnical properties of rock encountered and its behavior under the influence of tunnel construction. The terminology "rock" in this context shall also include soil conditions. The rock (ground) classes are derived not only from the rock parameters, but also from considerations of a number of external factors such as overburden, size of excavated section and length of round, driving sequence, ground water, water infiltration, results from geotechnical measurements, etc. which can essentially influence the classification.

Based on the observed layered combinations of the basic rock types and associated structural defects (joints, folding and Shears/ Faults), a range of Ground/ Rock Mass Types (GTs) has been established. The mechanical attributes of each ground type is expected to vary based on the range of intact properties, joint condition/ characteristics. Based on this bandwidth the ground type can be further divided into high (H), Low (L) and Shallow (S) of mechanical properties to decide the behavior and support type. The anticipated Behavior type is defined in tunnel design reports.

However, irrespective of any ground type and behavior type, Tunnel Portals (50 m) have been envisaged to be made in Support Class V and above because tunnel portals are the more vulnerable locations since it is the primary location to enter the tunnel. Therefore, tunnel portals need to be stabilized with higher supports to continue tunnel construction safely.

ii. The type of support section required shall be based on behavior of rock masses under load and monitoring the performance of underground excavations during construction. Rock (ground) classes are determined on the grounds of the appearance of the rock at the excavation face of the tunnel before the commencement of the respective excavation sequence. The results of geotechnical measurements under similar rock conditions shall be considered for prediction of deformations and for the

determination of rock classes. The aforesaid classifications may not be applicable for a situation requiring multi drift excavation or locations encountering unexpected geological conditions requiring extra measures, for which the support system would be decided by the engineer depending upon the judgement of the rock type being encountered. In case of a drive subdivided into top heading - bench - invert excavation, the rock conditions of

the top heading drive shall govern the classification.

**iii. SUPPORT SECTION TYPE**

**A. The Support classes for the rock mass type is given in the Primary Design report and Excavation/Support Drawings**

B. The selection of Support Section Type and its adjustment shall be according to NATM or any other Controlled Convergence Method with observational feedback through 3D instrumentation and monitoring.

C. The defined Support Section Type classes reflect the excavation system, the round lengths of each advance and the support requirements under consideration of the behaviour of the rock mass.

D. The defined Support Section Type classes are derived not only from the rock parameters, but also from considerations of a number of external factors such as overburden, size of excavated section and length of round, driving sequence, ground water, results from geotechnical measurements, etc. which can essentially influence the classification.

E. The Support Section Type to be applied must be determined on site through Tunnel Face Mapping, 3-D Geo-logging at the excavation face of the tunnel before/prior the commencement of the excavation sequence.

F. The Support Section Type at the face for each round shall be jointly agreed between the Contractor and the Engineer. In case of disagreement, the decision of the Engineer is binding.

G. The results of geotechnical measurements and monitoring during tunnel construction shall be considered for prediction of deformations and for the determination of Support Section Type to be applied for future excavations.

H. The behaviour of the rock in a newly exposed round is time dependent, i.e. rock mass quality will decrease with the free span if no support is installed within a reasonable time. Accordingly, the maximum length of a round which can be excavated and supported in time is a criterion for the rock classification.

I. Advance probing shall be carried out during tunnel excavation as and when required, as per instruction of Engineer. During advance probing, joint measurements & collection of data with contractor and Engineer shall be carried out.

J. The selection of the Support Section Type shall be done jointly by Contractor and the Engineer in writing on agreed form-sheets. The classification record is a collection of all classification sheets, which shall be kept accessible for consultation and modification whenever excavation works are under progress/post construction phase. In case of disagreement, the decision of the Engineer shall be binding.

K. Notwithstanding the duties of the Authority Engineer, the Contractor is solely responsible for the safety of the works under construction.

iv. The contractor will adopt the round length for each blast as instructed by the Authority engineer. The Authority engineer's decision to adopt a round length will depend on the behaviour of rock mass in previous few rounds and the Support Section Type required to be installed in the round under consideration. Range of non-overlapping round lengths for

various Support Section Types are mentioned in tender drawings.

v. **Variability for Each Support Section Type:** The defined Support Section Type includes some parameters variability (Round length, Support installations and locations) that should be managed during excavation using the parameters like Q Value, RMR Value and Behaviour in the last few rounds. During execution, the Round length, Support installations and locations may vary on upside or downside from the given values, however only the net effect of all such variations shall be considered.

vi. **After each blast, the support section required shall be decided by the** Authority **Engineer and Contractor on the basis of recorded observations. Geological face mapping sheet and Geo-mechanical classification of the excavation whose face shall be elaborated by** the Contractor and validated by the Authority Engineer. Required Excavation and Support Sheet (RESS) shall be used.

vii. Pull for the next round will not be taken unless the already excavated tunnel section in the previous round has been supported to the satisfaction of the Authority Engineer.

viii. After each blast, fumes shall be ventilated immediately within 15 minutes and scaling shall be done subsequently to remove loose or hanging rock pieces. The contractor's geologist at the time of scaling shall prepare a tunnel geological map registering joint sets, foliation, joint, infill materials, weak zones etc.

ix. After completion of mucking, a period of 30 minutes and a man lift platform (Employer's half hour) shall be kept ready by the contractor at the excavated face for engineer to check for any loose scaling, visually inspection and checking of rock classification carried out by Contractor and to come to a mutual agreement of the support section to be adopted. In case of any dispute, the decision of the Authority Engineer shall be final.

x. Immediately after the decision on the support section, supports shall be installed. The behavior of the rock in a newly exposed round will be time dependent, i.e. rock mass quality will decrease with the free span if no support is installed within a reasonable time. Therefore, the contractor is required to respect the cycle time for timely support installation.

xi. The contractor shall document time taken for various activities, blast pattern adopted, charging of holes, blast sequence, geological mapping, scanning of tunnel profile before and after installation of support, actual support installed etc. in any excavation cycle on a shift basis and the record shall be approved by the engineer.

xii. Additional excavation tolerance has already been inbuilt which shall be further established through a system of well documented monitoring observations, during excavation.

xiii. The assignment of an individual support class shall always apply to the whole of the round length.

xiv. For mixed face conditions, the applicable support system shall be guided by the conditions representative of more than 50% of the mixed face. Engineers may direct to adopt a different support class also in such conditions. In case of any dispute, the decision of the Authority Engineer shall be final.

### 1.12.1. Support System for Tunnels

**i.** The contractor shall understand and recognize the technical and design concepts of the NATM for the mined tunnels and shall appreciate the function and merits of each component of the tunnel support.

**ii.** The type and amount of tunnel support to be installed immediately after excavation is directly related to the rock classification as established. The initial support system associated with the established Rock mass types and relevant rock mass behaviors

classification is shown on the Bid Drawings for reference. However, as a consequence of variations from the anticipated rock conditions the initial support system as shown on the drawing for each rock mass type may require modifications and adjustment during construction as per agreement between the representative of the Authority Engineer and Contractor. The decision of the Authority Engineer shall be final.

**iii.** The contractor shall ensure that support elements will be installed or applied in such a manner and sequence as to prevent disintegration and loosening of the rock mass in front and around of the excavated tunnel.

**iv.** Advance probing and Pre-injection grouting will be mandatory to control water ingress to limits and to strengthen the ground by filling dry joints and cavities and can't be relaxed without approval of Authority engineer.

**v.** In the event of more than expected squeezing of the ground the excavated section shall be restored to its theoretical dimensions and the special supporting measures shall be resorted to with the approval of Authority engineer.

**vi.** Additional support types like pipe roof, face bolting etc. will be provided at the discretion of Authority engineers.

1.13. PROBE HOLES IN TUNNELS

1.13.1. Probing is to be carried out simultaneously with any other activity (For E.g. Installation of support or drilling holes for subsequent charging) except that no probing will be undertaken during charging of drill holes for blasting. Probing shall be carried out ahead of face in such a way that at all times during further excavation, probed ground ahead of the face is maintained to allow modification of the method of working ahead of any change in ground conditions and shall be governed by the ground conditions and the degree of uncertainty with distance.

1.13.2. Probe positions in the face and angles with respect to the tunnel drive shall be governed by the actual ground conditions encountered and the machinery in use. Preferably 4 probe lengths will be drilled from each position whenever carrying out probing and each shall have diameter of holes not less than 51 mm.

1.13.3. A trial shall be carried out in advance of tunnelling activities in order to identify the optimum drill bit, drill diameter, flush and percussion rate. These parameters shall be kept constant during drilling to allow direct comparison between probe holes.

1.13.4. An accurate and systematic record of probe hole positions (positions in the face and angles with respect to tunnel drives), drill penetration rate, drill parameters (percussion,

torque, thrust), flush (color, percentage return), drilling sounds (loud, quiet, intermittent), water strikes and interpretation of the nature of the ground ahead shall be noted at the time the holes are bored and a copy provided to the Authority Engineer.

1.13.5. Based on the probe hole information, the Contractor shall, without delay, provide in writing, a proposal for modification of method of working if any required, for agreement of Authority Engineer.

1.13.6. Should the probe hole indicate the presence of excessive water, high pressure water or geothermal conditions ahead of the excavation face, the Contractor shall take appropriate precautions such as necessary to facilitate excavation. Similarly, the contractor shall adopt suitable measures to deal with *any* gases or zones or weakened rock, which may be encountered. All measures deemed necessary by the contractor shall be subject to approval by the Engineer.

1.13.7. Full facilities shall be provided for the Authority Engineer to inspect probing work in progress.

1.14. EXECUTION

1.14.1. General

i. Prior to commencement of excavation, Tunnel portal, Tunnels, junction of tunnels with adits, caverns and chambers shall be strengthened as per construction drawings or as directed by Authority Engineer.

ii. All rock material projecting inside the minimum excavation line shall be removed.

iii. All loose rock shall be removed from the underground construction sites and disposed off in the approved dump areas.

iv. The contractor shall constantly check the progress of excavation by means of Laser survey in order to avoid any substantial rectification of the already opened profile and eventual rearranging of the installed rock supports.

v. Where excessive inflows of water occur at the heading face, the contractor shall take all appropriate measures to execute the excavation work safely and properly including provision of extra supports and protection of workmen and any special equipment necessary for working in waterlogged conditions.

vi. When deemed necessary and ordered by the Authority Engineer, the Contractor shall carry

out long exploratory drilling (other than probe holes) with core recovery. Payment will be made under the relevant item of the schedule.

vii. The Geological Report, as a part of these documents, contains the results of Geological studies carried out on this component of the Project.

viii. The orientation of the tunnel as indicated on the drawings is subject to modification. It may be necessary to introduce slight shifting of the axes of the tunnel after additional information is available. The drawing showing the final orientation will be prepared by the Contractor prior to start of work and he shall be required to execute the Work as per drawings or as directed by the Engineer.

ix. Sheared or shattered rock zones, foliation shears, thick joints with gouge or other thick discontinuities may be encountered during excavation. Whenever shear zones and poor rock bands are encountered along the tunnel, Additional provisions of fore poling, pipe roof, face bolting, etc. will be undertaken at once by the Contractor to avoid any cavity formation as shown on the drawings or as directed by the Authority Engineer.

1.14.2. **Method of Excavation**

i. The Contractor shall establish by trial blast and use drilling and blasting techniques, which will produce a smooth final profile, a minimum of Overbreak and a minimum of fracturing of the rock beyond the minimum excavation lines. The techniques used shall always be subject to the Authority Engineer's approval, who may direct several blasting tests to be undertaken by the Contractor to substantiate his proposed blast design.

ii. Only controlled blasting techniques shall be used. It shall be performed as described below:

A. Presplitting: Consists of drilling a single row of closely spaced holes along the final excavation perimeter. These holes are Lightly charged and simultaneously detonated before the main blast to produce a presplit crack, which limits the propagation of crack from the subsequent main blast, and in such a way, reduces damage in the rock beyond it. The blasting of the main excavation zone requires a reduced explosive charge in the line of hole nearest to the presplit line and a limit on the distance between the presplit line and the nearest line of main blast holes. The presplit holes shall be drilled deeper than the depth of the pull.

B. Smooth Blasting: Consist of drilling several closely spaced holes along the final excavation perimeter, placing light charges in the holes and detonating the charges simultaneously after the main blast. The outer line of drill holes for the main blast is set at an approved distance inside the final perimeter leaving an annulus of rock to be peeled off the damaged final excavation perimeter by the smooth blast The smooth blast holes are drilled, charged and blasted in the same tunneling cycle as the main blast.

C. Cushion Blasting: As special case blasting in which considerable air space of stemming surrounds charges in the holes and serves to reduce undesired blast effect on the final excavation perimeter.

iii. During the progress of excavation the drilling and blasting pattern specifically the number and depth of holes, quantity, quality and distribution of explosives, shall be varied as necessary to suit the rock conditions encountered taking into consideration the information obtained from the probe/exploratory holes, the actual drilling work (velocity, color of rinsing water, etc.,) as well as the previous blasting results.

iv. Only wet drilling will be permitted in order to reduce dust in the underground excavations.

v. Perimeter drill holes shall be placed such that the over excavation beyond the minimum excavation line is minimized. The Contractor shall pay utmost attention to obtain a smooth and uniform excavated surface.

vi. Should the entire length of most of the perimeter drill holes not be visible after each round of blasting, the contractor shall make an adequate adoption in the blasting pattern used and submit it to the Engineer for approval.

vii. The depth of a new round shall never exceed that which was determined and approved prior to commencement of basting. The Engineer may order reduction of the adopted round depth if the actual rock condition requires it.

viii. Blasting of new rounds will not be permitted if no, or insufficient, personnel are available to perform the mucking and subsequent support work afterwards. This applies to Work before holidays, non-working weekends etc.

ix. Blasting that may damage the rock beyond the required excavation lines or the tunnel installations will not be permitted. Any damage to, or displacement of the supports and

any damage to, any part of the Works caused by blasting or any other of the Contractor's operations shall be repaired by the Contractor in a manner satisfactorily to the Engineer.

x. No new round shall be blasted until the supports required within the heading zone have been installed.

xi. All loosened material that is likely to fall shall be removed immediately following blasting, at frequent intervals during the progress of the Wonk, and finally during the clean-up prior to placing the final tunnel lining.

xii. After excavating, the Contractor shall adequately protect the tunnel invert, surface from damage caused by the construction traffic, should small grain or broken excavation material be used for such protection, it shall be removed prior to placing the final tunnel lining. No vehicular traffic will be permitted over tunnel invert after removal of the protective material.

**1.14.3. Cleaning of Excavation Surfaces**

i. Even prior to the removal of the bulk of the material loosened by blasting, the contractor shall undertake scaling activities to clean the newly exposed rock surface from loose rock fragments, dust and debris to permit, if required, the application of the first lay of shotcrete.

ii. Cleaning shall be done by directing a jet of water or air at the rock face. Compact washable rock shall be cleaned with compressed air water jets. Rock, which is prone to quick disintegration, swelling, heaving or is interspersed with clay filled fissures, shall be cleaned with compressed air only. The cleaning shall be done to the satisfaction of the Engineer.

iii. The cleaning is separate from the cleanup of excavated surface required immediately prior to placing of the final lining tunnel Maintenance The Contractor shall be responsible for maintaining the completed underground works throughout the construction and contract period. As part of this maintenance, remedial work shall be carried out when repairs are required to the structural or other systems or when grouting is required to stop water inflow.

a. The Contractor shall monitor the tunnel support systems and record any damage to the support systems. If necessary, remedial action shall be taken with temporary propping, including evacuating the area and posting warning signs accordingly.

b. The Contractor shall, in addition to monitoring the support system, carry out regular maintenance of the underground works, including but not limited to bench marks, 3D monitoring, drainage and pumping systems, light bulb replacement, cleaning, water removal, water pipe maintenance, ventilation system, communication system, and emergency equipment, and all cabling, transformers and pipes for different purposes and its maintenance. Maintenance shall include all repair work required to maintain all equipment in working order.

c. All these maintenance activities are deemed to be included in the rates quoted for the items of the BOQ and nothing extra shall be payable.

1.14.4. **Site Traffic on Final excavation levels**

i. (Formation level) for pavement construction shall be protected against any wear or

deterioration of rock properties following site traffic by backfilling with rock material excavated in the tunnel or similar, to a minimum thickness of 0.5 meters. The access to the main drainage control shafts shall be possible at any time. These must be protected and marked on the side wall for later recovery.

ii. Pounding water and traffic through pounding water for vehicles or pedestrians shall not be allowed.

iii. Any deteriorated material shall be removed and replaced prior to pavement works as directed by the Engineer.

iv. The backfill material used for protection purposes shall be removed in the main tunnel only until immediately prior to pavement construction works

1.14.5. **Site Traffic on Invert Support**

i. To avoid damage to the Invert structures, these should be duly protected by giving a course constituted of excavated material and having an approximate average thickness of 0.5m. No site traffic shall be allowed to run on unprotected invert structures. Boulders larger than 100mm dia should not normally be used for this purpose.

## 1.15. DISPOSAL OF EXCAVATED MATERIALS

1.15.1. The disposal of all excavated material must be as specified in Schedule-B, clause 5 of Tunnels

## 1.16. EVACUATION OF WATER

1.16.1. The Contractor shall carry out all Works required to capture and drain service and infiltrate groundwater during the construction as stipulated in Section of “Dewatering Drainage and Pumping”

## 1.17. ILLUMINATION

1.17.1. The Contractor shall install an adequate illumination system in the Underground works as stipulated in Section of “Site Installations and Services."

## 1.18. VENTILATION & AIR COOLING

The Contractor shall install and operate equipment and carry out all works required for the ventilation and air-cooling for construction of the tunnel as stipulated in Section of “Site Installation and Services". Wherever due to dimensions of tunneling machinery, available space is less for installation of non-rigid ventilation ducts; contractors will be required to install wire reinforced/Solid/other types of ventilation ducts, for which nothing extra shall be paid.

## 1.19. CONTROL OF DUST, SILICA AND NOXIOUS GASES IN UNDER-GROUNDWORK.

1.19.1. The Contractor shall install and operate equipment for the control and monitoring of dust, silica and noxious gases in Underground Works as stipulated in Section of "Site Installations and Services".

## 1.20. COMMUNICATION SYSTEM

1.20.1. The contractor shall install and operate the communication system between each heading face and entrance to the tunnel, shaft or cavern/chamber as stipulated in Section of “Site Installations and Services".

## 1.21. GEOLOGICAL MAPPING

1.21.1. The purpose of engineering geological mapping and follow-up is the documentation of rock and rock mass conditions as encountered during excavation. The documentation shall enable the verification of the suitability of the designed support and excavation

measures, the prediction of rock mass conditions ahead as well as the interpretation of results of the geotechnical monitoring concerning ground deformations. After each blast, Mucking and scaling shall be done. After completion of scaling, a period of 30 minutes (Authority’s half hour) shall be kept by the contractor for Authority engineer to visually inspect and check the rock classification carried out by Contractor and to come to a mutual agreement. In case of any dispute, the decision of the Authority Engineer shall be final.

1.21.2. If stand up time of unsupported tunnel is very less, then the mutual agreement on rock classification may be required to be arrived at during mucking and scaling activities for early installation of the required support.

1.21.3. Contractor shall use mapping and related information along with the rock mechanics test and instrumentation monitoring results shall be used to optimize design of the final lining and rock reinforcement for the tunnel (s), shaft, cavern and chambers.

1.21.4. The Contractor always shall provide adequate lighting, proper ventilation, reasonable access, cleaning and washing of the walls and crowns for checking correctness of mapping by “Authority ENGINEER” representative.

**1.21.5. Documentation:**

i. The mapping and documentation of encountered geological conditions during the excavation shall be based on uniform legend and terminology for Rock Types / Rock Mass Types, Discontinuities, Jointing, Water seepage, Weathering, Rock Strength, Behavior of Rock Mass and other features which are needed to be described for complete record.

ii. The documentation of the tunnels shall be based on the mapping of the face and the full periphery mapping method. The full periphery mapping method shall be applied for the permanent walls only. The frequency shall be adjusted to the variability of the encountered ground conditions. In case ground conditions are frequently changing within one round length each round shall be mapped. Each drive which is under construction shall be checked at least once a day. Support types will also be checked during periphery mapping studies.

iii. Face mapping sheets: In general, the mapping shall be performed in a scale 1:100 and shall have a grid of 1 x 1 m for easier drafting, marked with "+". If necessary, details shall be mapped at other suitable scales. Using the uniform terminology, remarks can b stated directly on the mapping sheet or can be referred to the data sheet.

iv. Data Sheets: The data sheet format shall be got pre-approved and shall consist of details

like Tunnel, Location, Chainage, Excavation method, Name of mapping geologist, Date and Time, Rock Mass/Types, Discontinuities, Jointing, water, weathering, Behavior, General remarks etc.

v. Vertical and Horizontal Sections: Based on the follow-up of mapping and data sheets, a vertical as well as a horizontal cross section shall be drawn, where the actual mapping results are incorporated continuously daily. The vertical section shall be located along the axis of the tunnel. The horizontal section must be fixed according to the chosen excavation cross section (full face, top heading – bench etc.). In case the tunnel is excavated by top heading - bench excavation the horizontal cross section shall be drawn on the level of the invert of the top heading. Horizontal and vertical scale shall be the same.

vi. The position of the laser beams on the face as well as the steel rib connections may be marked as drafting guides.

vii. Remarks can be stated directly on the mapping sheet or can be referred to the Face Mapping Sheet.

## 1.22. MEASUREMENT AND PAYMENT

### 1.22.1. General

i. Measurement of tunnels, shafts, caverns and chambers excavation are included in Sch-G. **Excavation including those of Geological over break are deemed to be included in Sch-G.** No extra payment for excavation will be provided.

ii. Unit Rates, if not specifically stipulated otherwise, shall be deemed to include the entire cost of, but not be limited to the following:

A. The installation of pumps and pipes as well as their maintenance along the excavation for water inflows is included in Sch-G. No separate item for dewatering/separate payment for dewatering will be given

B. Provision of all labour equipment and materials required for the Underground excavation including drilling holes for blasting;

C. Developing and improving controlled blasting methods, blasting tests and performance of blasting.

D. Cleaning, washing, protection and maintaining excavated surfaces in satisfactory conditions and protection of tunnel invert until concrete lining is placed,

E. All enlargements and additional excavations or any temporary supports required by the Contractor for his construction methods,

F. Loading, hauling and dumping the excavated material on stockpiles, dumping area or points of incorporation into Permanent Works as mentioned below, shaping and trimming of the excavated materials in the dumping areas as specified, clearing of the stockpile areas, formation and maintenance of stockpiles, rehandling of suitable materials including segregating, grading, draining and drying of materials suitable for use in embankment construction or as backfill.

G. All delays during excavation work resulting from installation of rock supports and

instrumentation measures as advised by Authority engineers required by the Geo-technical conditions of the material encountered, irrespective of the distance from the heading face.

H. Complying with all requirements of statutory laws and regulations relating to underground works and any restrictions resulting therefore obtaining all necessary permits and licenses for the purchase use storage and transport of explosives and other materials.

I. Surveying, setting out, checking of excavated profile, alignment and any subsequent rectification works resulting from undue or incorrect surveys, provision of suitable equipment for and delays due to carrying out his work.

J. Furnishing, installation, operation, maintenance and removal of communication, illumination and ventilation system, observing safety precautions and measurement / monitoring of dust silica and noxious and Inflammable gases.

K. Recording and preparation of reports related to excavation progress and procedures. No separate remuneration shall be paid for geological mapping during tunnel excavation.

L. All works involved with and any partial or short interruptions or inconvenience caused by the check surveys, performance of the rock mechanic test, installation and monitoring of instruments and geological mapping, for which no separate payment is provided elsewhere in these specifications.

M. Seepage/ingress of water suitably collected and drained away either by gravity or against gravity

N. For Support Section Type where Forepoling is required, pay line will remain fixed at the minimum Cross-Section throughout the length of the Forepoles. No separate remuneration for excavation and Backfill of the over breaks will be made and shall be included in the rates of Items for excavation and Support installation.

**O.** For Support Section Type where Pipe roof is required, the pay line will be the same as “A” line and situated at the Bottom of Pipe roof as shown in Figure under Para 1.5.7. Remuneration for backfill will be made below “A” Line shall be made as per Relevant Item of BOQ. **Remuneration of Over Break and it’s backfilled between the Pipe roof shall be included in the rates of Items for excavation and Support installation.**

**P.** The payment towards the preparation of Muck disposal plan shall be deemed to be included in the quoted rates of excavation.

**Q.** No separate compensation for the provisions for the start of tunnel excavation from the pre-cut is envisaged. The quoted rate for underground excavation shall include all costs required for the construction of the canopy structure (false portal), if required.

**R. No extra Payment will be made for hauling the excavated material for a lead upto muck disposal area or disposal outside forest area. The quoted rates must include hauling and disposing muck outside.**

**S.** No separate payment shall be made for multiple drifting. No separate remuneration shall be paid for the removal of temporary support installed at the tunnel face or at the top heading invert.

**T.** All delays during excavation work resulting from fore probing and grouting activities required to achieve the specified water tightness on the project.

**U.** In case adverse geological occurrence could not be predicted through advance probing or exploratory holes, the Authority engineer shall determine the rates involved in tackling such occurrence as per relevant clause of conditions of contract.

1.22.2. Overbreak

i. All excavation including all types of overbreak and geological overbreak are included in Sch-G

1.22.3. Excavation under Geo-thermal conditions.

i. For Excavation under Geo-thermal conditions for the stretches where the geothermal condition prevails, no extra payment shall be made on account of providing and running ventilation / cooling measures and the cost of the same shall be deemed to be included in the rates of the underground excavation under Sch-G

ii. However, separate measurement and payment shall be made for providing and running ventilation / cooling measures under geothermal conditions beyond temperature of 70°c and a flow rate of 20 lit / sec as per the rates quoted for this item in the schedule of item rates. Measurement for this item shall be made in units of r.m (tunnel length) x °c (increase in temperature beyond 70°c). The tunnel length shall be that length where geothermal conditions beyond temperature of 70°c have prevailed during excavation.

1.22.4. Other Conditions

i. All costs for supply and installation of rock support for tunnels and shaft will be covered by the applicable Unit Rates as specified in the BOQ.

ii. Rock supports required due to the Contractor not observing approved drilling and blasting techniques will not be included for payment.

iii. No extra measurement for payment or payment will be made for

a. Geological mapping as described in this chapter or performed at site.

b. Any rectification Works resulting from incorrect surveys and / or blasting.

c. Over excavation including the works mentioned in section “Excavation Lines and Tolerances” above, required for Contractor's convenience. The concrete and grout required to fill such excavation shall also be at the Contractors expense.

d. Extra work or material required for repairing any damage to the tunnel invert caused by construction equipment.

## 2. SN Bolts: Supply drilling installation and grouting.

### 2.1. DRILLING HOLES & PREPARATION FOR INSTALLATION

2.1.1. Holes for rockbolts shall be drilled as specified herein and in accordance with the provisions set out in Section of “Drilling and Grouting”

2.1.2. The minimum diameter of each hole shall be as specified below or as directed by the Engineer.

**2.1.2.1.** Rock Bolt of 25mm dia: Hole dia 45mm with coupler and 38mm without coupler

**2.1.2.2.** Rock Bolt of 32mm dia: Hole dia 64mm with coupler and 50mm without coupler

2.1.3. The length of drill hole shall be such as to receive the specified rockbolt and to provide for its satisfactory anchorage.

2.1.4. After drilling, each hole in compact, washable rock shall be washed out with clean water and cleaned by blowing out all drill cuttings and debris with compressed air. The holes in rock, which tend to swell or are interspersed with clay filled fissure shall be cleaned with compressed air only. The compressed air shall not contain any oil or other material preventing the bond.

2.1.5. Prior to installing the rock bolts, which will be stressed, the rock surface adjacent to the hole shall be prepared for the bearing plate. Only bevel washers shall be used which shall be placed between the bearing plate and the nut, or dished bearing plate and hemispherical washer used to ensure uniform bearing.

2.1.6. If a rock bolt is not installed immediately after drilling the hole, the hole shall be washed and cleaned as stipulated above, immediately prior to installing the rockbolt.

2.1.7. Fresh holes, as directed by the Engineer, shall be drilled by the contractor at his expense to substitute such holes as have been drilled out of place or alignment.

2.1.8. The rock surface around the drilled holes to receive the bearing plate shall be chipped smooth or be covered with a smooth quickset cement pad.

2.1.9. All bolts within 10 m of a blasting operation shall be retightened to the specified torque within 4 hours after each blast. If it is found that any bolt does not take the required torque without anchorage slip, a new bolt shall be installed in the immediate vicinity of the unsatisfactory bolt.

2.2. **Installation Records**

Comprehensive records about details of the installation of rock bolts during drivage, such as grout consistency, drilling depth, length and type of rock bolts, deviations from the theoretical position, type and time of grouting, time of tightening, special observations, etc. shall be kept for each round by the Contractor and countersigned by the Authority Engineer's supervisory personnel. Copies of these records shall be submitted to the Authority Engineer.

2.3. **ROCK BOLT RESIN-GROUTED (SN Bolt)**

2.3.1. Rockbolts shall consist of deformed steel bar of 25 mm or 32 mm Ø (Grade Fe-500D conforming to IS 1786). Each bolt shall have one end chamfered and the other end threaded with a coarse thread over a length of 200 mm.

2.3.2. After the hole is drilled and cleaned, fast setting resin cartridges shall be placed in the fixed length of the drill hole at bottom as determined by the pull-out tests and slow setting

resin cartridge in remaining length of drill hole. These cartridges shall be tamped with the bolt for proper packing. The rock bolt shall then be advanced and rotated steadily through the capsules at the rate recommended by the manufacturer by means of a pneumatic tool and a coupling attached to the threaded end of the bolt. The rotation shall be continued after the bolt has been fully inserted for a further 30 seconds. Bolt shall be stressed by torqueing/jacking, by means of an approved and regularly calibrated stressing device to the level as directed by Authority Engineer. The bolt shall be stressed before setting time of slow setting resin cartridges as suggested by the manufacturer. The Contractor shall demonstrate the resin cartridges used satisfy the specified strength requirements of the bolts to the satisfaction of Authority Engineer, before use.

2.3.3. Bolts shall be thoroughly cleaned before being placed in the drill hole.

2.3.4. The minimum capsule diameter should be proposed for each drill bit dimension, considering that the hole must be fully filled with resin. The drill bit diameter should be defined by the manufacturer, however, as guidance, for a 32 mm resin capsule diameter, the drilling should not be more than 38 mm.

### 2.4. ROCK BOLT CEMENT-GROUTED (SN Bolt)

2.4.1. Rockbolt shall consist of deformed steel bar of 25 mm or 32 mm Ø (Grade Fe-500D conforming to IS 1786). Each bolt shall have one end threaded with a coarse thread over a length of 200 mm.

2.4.2. Anchor bars/anchor bolts shall be thoroughly cleaned before being placed in the drill hole. The hole shall be filled with grout constituting 1:1 cement/sand mix with low water cement ratio, by inserting the grout hose to the full depth of the hole and withdrawing as the grout is pumped in. The nozzle shall be kept buried in the grout as the pipe is withdrawn so that air is displaced as the hole is filled. The bolt is then pushed into the hole. Admixtures for fast setting and low shrinkage may also be required.

2.4.3. In case of coupled rock bolts, partly collapsed boreholes, or major water- flow from the borehole, grouting may be done after installation of the bolt (post-grouting). The hole is then grouted by a special attachment which allows the mouth of the borehole to be sealed whilst the grout is pumped in. Air is displaced from the hole via a tube which is attached to the full length of the rock bolt as it is installed. Grout is then pumped in and the hole can be seen to be full, when grout escapes from the end of the tube.

2.4.4. The nut of the grouted rock bolts shall be tightened not later than 12 hours after installation to achieve a force at the anchor plate of approx. 20 KN. This force shall be applied by a calibrated torque wrench.

### 2.5. Rockbolts: Testing and Monitoring

2.5.1. Payment shall be made for the supply and installation of all rockbolts used in pullout test provided that the rockbolt tested comply with these specifications. Measurement for payment will be as for rockbolts used for the permanent works. Rockbolts failed before reaching yield point due to improper workmanship or defect in material shall be rejected. No measurement for payment & payment for such bolts shall be made. The rate of rock

bolts includes drilling of holes.

2.5.2. No extra measurement for payment or payment will be made for the testing equipment and carrying out test and the cost thereof shall be included in the Unit Rates Provided in Schedule of Item Rate. **Minimum two testing equipment per tunnel shall be maintained by contractor, out of which one shall be kept for stand- by.**

2.6. **Cement/Resin Grouted Rockbolts (SN Bolt)**

2.6.1. Measurement for payment for cement/resin grouted type bolts (SN Bolt) installed shall be of the total length of bolts (including threaded portion) of the same bar diameter installed and approved by the Authority Engineer.

2.6.2. Payment will be made separately for each bolt dia at the Unit Rate per linear meter entered in the Schedule of Item Rate, which shall include the entire cost of:

a. Furnishing and installation of quickset resin cartridges.

b. Furnishing and filling the hole with slow set resin.

c. Furnishing and installation of reinforcing steel bars and bearing plates and all other accessories.

d. Centralizers, couplers and all accessories.

e. Stressing the bolt.

f. Load/pull out testing.

2.6.3. The drilling of holes shall not be paid for separately.

2.6.4. Payment for drilling holes and installation and grouting of fore poles will be made at unit rates quoted for self-drilling bolts or end anchored bolts whichever is used.

## 3. Self-Drilling Rock Bolts (SDA): Supply drilling installation and grouting.

3.1. This is a high-grade (Yield load more than equal to 230KN) hollow core steel bar with continuous threaded surface for mechanical coupling. In addition to hollow core steel bars, other parts of the assembly consist of a hexagonal nut, bearing plate, extension couplings and sacrificial drill bit. Before and during installation, thread ends will be kept cleaned to allow hex nut and coupler threadability. Construction and drilling shall be as per manufacturers guidelines.

3.2. SDA Bolts shall have outer dia of minimum 32mm and inner diameter less than equal to 18mm. Length of rod to be procured shall be decided in agreement with the engineer.

3.3. Bearing plates shall allow articulation of 5 to 7 degrees in all directions.

3.4. The drill bit to be used shall be selected according to installed length of bolt, geology and size of bolt.

3.5. Couplers and Nuts shall exceed the tensile strength of bars by minimum 20%.

3.6. The bolt shall be grouted according to manufacturer's guideline (to a minimum pressure of 6 bars) with manufacturer's grout material supplied along with the bolt. Alternatively, grout

mix (M-35 grade) may be prepared using OPC 53 cement and sand having maximum particle size of less than 0.3mm. Grout mix shall have a water cement ratio less than 0.4 and shall contain PC based super plasticizer (Minimum 2%) and expanding plasticizer (allowing up to 3.5% expansion in neat cement) from reputed manufacturers. Admixtures containing chlorides and alkali shall not be used. Face of the Bolts shall be sealed off with GP2 or Similar rapid setting grout to prevent grout leakage during buildup of pressure.

3.7. All accessories of self-drilling rock bolts shall be suited to the main anchor rod type and shall be procured from the original manufacturer of the bolt.

3.8. Measurement for payment for self-drilling bolts installed shall be of the total length of the Bolts (including threaded portion) of the same diameter installed and approved by the Authority Engineer.

3.9. Payment will be made at the unit rate per meter entered in the Schedule of Item Rate, which shall include the entire cost of:

a. Drilling of the holes.

b. Supply and installing self-drilling rock bolts with all accessories including bearing plates, nuts, bolts, Couplers etc.as recommended by the manufacturer.

c. Grouting of rock bolts.

d. Load / pull out testing.

3.10. Nothing extra shall be paid to complete the item according to specification mentioned in this sub-chapter or to specification of the manufacturer.

4. **GFRP Rock bolting GFRP (Glass Fiber Reinforced Polymer) rock bolts are a type of** reinforcement used in geotechnical engineering and construction projects. GFRP rock bolts are made of high-strength glass fibers embedded in a polymer resin matrix. The glass fibers provide the primary load-carrying capacity, while the polymer resin binds the fibers together and protects them from environmental conditions. This combination results in a lightweight and corrosion-resistant rock bolt system. The installation process of GFRP rock bolts typically involves drilling holes into the rock or soil, inserting the rock bolt, and grouting the surrounding area with cement or resin. The grout provides a transfer of load from the rock bolt to the surrounding ground, increasing stability and reinforcing the structure. Compared to traditional steel rock bolts, GFRP rock bolts offer several advantages:

1. Corrosion resistance: GFRP rock bolts are not susceptible to corrosion, making them suitable for environments with high moisture or chemical exposure.

2. Lightweight: GFRP rock bolts are significantly lighter than steel rock bolts, which simplifies transportation, handling, and installation.

3. High tensile strength: GFRP rock bolts exhibit high tensile strength, allowing them to withstand heavy loads and provide reliable reinforcement.

4. Non-conductive: GFRP rock bolts do not conduct electricity, making them suitable for use in areas with electrical hazards.

5. Longevity: GFRP rock bolts have a long service life and can maintain their structural integrity over extended periods.

   GFRP rock bolts are commonly used in applications such as Tunnelling, mining, slope stabilization, and ground support in civil engineering projects. They offer an alternative to traditional steel rock bolts, providing improved durability and performance in challenging environments. It is recommended to use GFRP rock bolts in conjugation with approval from Engineer-In charge. Following technical specifications shall be adhered in conjugation with engineer in charge as per requirement at field. Please note any change in technical specifications may kindly be brought to notice to Authority Engg and final decision lies with Railways only.

1. GFRP Rock Bolt Material

a. The fiber type shall be ECR-Glass with fiber content ≥ 80%

b. The resin used in formation must be Vinyl ester

c. The min shear strength shall be 300 MPa.

d. The strain at failure shall be ≥ 2.5%

2. Creep Rupture Strength

a. Test shall be conducted as per ACI 440.3R-04 B.8 – Test method for creep rupture of FRP bars.

b. Creep Rupture Strength shall be ≥ 54% of UTS for a linear correlation of 1 million hours. The linear correlation coefficient should be ≥ 0.95.

3. Alkali Resistance

a. Test shall be conducted as per ASTM D7705/D7705M – 12 Standard Test Method for Alkali Resistance of Fiber Reinforced Polymer (FRP) Matrix Composite Bars

b. Alkali resistance shall be ≥ 83% of UTS after a conditioning of 5,000 hours in a solution with temperature of 60℃ and pH between 12.6-13.0

4. In-Situ Pull-Out Test

a. Reference - As per ISRM - Suggested Methods – Rock bolt Testing

b. The system shall develop for 5 minutes a maximum pull-out strength equivalent to 2/3 of the bolt UTS.

c. Displacement at maximum pull-out force shall be less than 5mm.

5. ISO Certification (QMS / EHS)The manufacturing facility for the GFRP bar should be holding valid ISO 9001 (QMS) and ISO 14001 (EHS) certificates.

6. Accreditation of Testing Center For each delivery of GFRP bolt, a routine tensile test report shall be issued by a laboratory accredited in accordance with ISO/IEC17025:2017 or similar relevant.

**Note: GFRP rock bolting can be used in place of steel bolts with approval from Authority Engineer**

## 5. PIPE ROOF UMBRELLA

When ground conditions are such that the face cannot be supported by fore poling, then pipe roofing shall be required to be implemented. Pipe roofing consists of high tensile seamless steel pipes (Having a minimum outer diameter of 76mm and a minimum yield load of 1200 KN) conforming to IS: 1611 (Maximum 24 m long) placed along periphery of the tunnel in one or two layers, each layer inclined at angle and pipe spacing (mentioned in drawings) at the heading face or as directed by the Engineer. Engineers may require use of Self drilling 76mm dia pipes. Other pipes of larger dia shall be connected to each other by nipple coupling or squeezed connection or seamless butt-welded producing a leak proof connection. Standard threaded connection shall not be permitted. The cement (OPC 53 or other) grouting of pipes shall be done. In case of perforated pipes grouting shall take place in stages using packers in each stage and starting at the deepest location first. Sacrificial ring bits should be used. AT-casing system (or similar) shall be used and orientation of drilling shall be guided by means of equipment installed on the jumbo boom.

5.1. Pipe roofs

5.1.1. Measurement and payment for pipe roofing will be made for supply and installation at rates quoted in the schedule.

5.1.2. Measurement for payment includes supply and installation (Excluding length projected outside the rock mass). The rates are deemed to include the entire cost of handling, storage cutting, drilling, grouting of pipe, coupler and other accessories, installation of pipes including its supply.

5.1.3. Nothing extra shall be paid to complete the item according to specification mentioned in this sub-chapter or to specification of the manufacturer.

5.1.4. Item shall be executed with Seamless pipe, OD Φ114.3mm, 6.3mm thick, Yield load ≥ 1200KN

## 6. Fore Poling of Schedule

Fore poles shall be 25/32 mm diameter self-drilling anchor bars or SN bolts or pipes having outer dia less than 48mm of this sub chapter having length of 6 meters or more. The fore poles shall be placed along the periphery of the tunnel inclined at angle and pipe spacing (mentioned in drawings), at the heading face and cement grouted in place as directed by the Engineer.

6.1. MEASUREMENT AND PAYMENTS

6.1.1. General

i. The unit Rates entered in the Schedule of Item Rate shall be applied regardless of the work being performed on the surface or underground. The unit rate shall be deemed to include

supply of material, labour, equipment and placing of anchors / bolts / wire mesh in position etc. Payment for rock bolt, Self-drilling anchors, forepoles, pipe roofs, fibre glass bolts and wire mesh in all works shall be made on the basis of item rate quoted in schedule of items. The rate shall include the cost of nuts, bearing plates, bearing heads, couplers, centralizers, color coded end caps including required excavation and concrete works (in case of cable anchors) and other accessories. The rates shall also include all other costs associated with carrying the job in full as described in this sub-chapter including all possible delays in the excavation of the tunnel because of installation of rock bolts, whether delays are because of geological conditions, water inflow or other conditions in the tunnel.

ii. Rock bolts required according to design spacing and length or as instructed by engineer only shall be installed and paid. Nothing extra shall be paid in case of over excavation or over break which was unnecessary/due to contractor's fault or need.

iii. In case of geologically accepted overbreak, the payment for rock bolts shall be made as per actuals according to support measures as instructed by engineer.

iv. The cost of testing of materials specified in this chapter shall be deemed to be included in the quoted rate for the relevant item of work.

6.1.2. Measurement for payment of installation of forepoles will be of the total length of forepoles installed (Excluding length projected outside the rock mass).

## 7. Lattice girders

The lattice girders shall be installed in a similar manner as steel ribs. Lattice girder segments shall have butt plates and the method of installation shall ensure tight connection of all elements. The accessories of lattice girders like plates, bolts, nuts and washers etc. shall be like steel rib accessories. Lattice girders shall be fully encased in shotcrete. Under no circumstance shall lattice girders be installed under unsupported ground.

7.1. Lattice Girders

7.1.1. Measurement for payment for supply, handling, fabrication and installation of the Lattice Girders will be of the weight of Lattice Girders (in MT) actually installed and approved by the Authority Engineer. Payment for the same shall be made in tunnels, shafts, chambers etc., on the basis of schedule of item rates. The rate for Lattice Girders as above shall include the entire cost of:

a. Supply, handling, fabrication, transportation to the place of installation and installation of Lattice Girders, Connection plates, all foot plates, foot blocks, tie rods, bolts nuts cross bracing and all other accessories

b. Surveying and marking the position of Lattice Girders on the finished concrete surfaces.

7.1.2. For the measurement and payment purposes, the weight of the Lattice Girders will be

based on the unit weight of the steel profile per linear meter (without any accessories) as per relevant IS Code required to be installed according to drawing.

## 8. WELDED WIRE MESH

8.1. Welded wire mesh shall be installed in surface and underground excavation as reinforcement for shotcrete, usually in combination with rockbolts. It may also be used with steel ribs, when it shall be laid over the outer flange of the rib and pinned or fixed to the excavated surface between the ribs where necessary.

8.2. Welded wire mesh shall conform to the requirements of IS: 1566. The fabric shall have a minimum square mesh of 150x150x6 or 150x150x8, made of wires or as directed by Authority engineer.

8.3. Where possible, the welded wire mesh shall be placed at the same time as rockbolts are installed. It shall not be placed between the rock surfaces and bearing plates of rockbolts but shall be placed over the heads of rockbolts and fastened to them by separate plates and nuts. Sufficient intermediate mesh anchors, or if directed by the Engineer, additional rockbolts, shall be placed to ensure that the mesh is drawn close to the excavated surface so that when shotcrete is applied subsequently, the mesh neither sags nor vibrates excessively and impairs the effectiveness of the shotcrete.

8.4. In case the welded wire mesh is placed at such locations where rockbolts have not been provided, wire mesh anchors of a type acceptable to the Engineer shall be\ used to secure the edges of wire mesh tight to the rock surface to provide anchorage at overlaps and to provide intermediate support. The wire mesh anchors shall have a minimum length of 450 mm.

8.5. The use of wooden pegs and pins for fastening the wire mesh to the rock surface will not be permitted.

8.6. Welded wire mesh shall be firmly stretched between the rockbolts. Care shall be taken to ensure that air pockets are not formed behind the wire mesh, when used as reinforcement for shotcrete. Overlaps in the wire mesh shall not be less than 300mm.

8.7. Measurement

8.7.1. Measurement for payment for welded wire mesh provided shall be for the net area **(without overlaps)** actually installed. The weight will be computed using unit weight per square meter as specified in the relevant IS code.

8.7.2. Payment will be made at the Unit Rate per metric tonne entered in the Schedule of Item Rate, which shall include the entire cost of supply and installation of welded wire mesh, including overlaps, and the provision of all necessary accessories for fixing, such as steel pins / mesh anchors and extra plates and nuts for fastening to rock bolts.

8.7.3.

## 9. Shotcreting with design cement concrete mix:

Work consists of the production and application of shotcrete to the specified thickness at the locations required using wet shotcrete machine with required materials, equipment, tools and labour necessary to perform the preparation, application and the clean-up

pertaining thereto.

**Definition:** Shotcrete for this work, shall be defined as spraying premixed Portland cement concrete as per approved design with admixtures including silica fumes if required and additives (i.e. water reducing agents, thixotropic agent, accelerators etc.)

from a spray nozzle by means of compressed air using wet/shotcrete machine. When steel fibers and micro silica are added to shot Crete, it shall form SFRS, Shot Crete/SFRS shall be applied in accordance with relevant ACI/ASTM/EFNARC specifications/guidelines.

Rebound is defined as the constituent of Shotcrete SFRS that rebound from surface during the application of Shotcrete /SFRS.

9.1. **MATERIALS**

9.1.1. Ingredients of Shotcrete / SFRS include (i) Cement (ii) Aggregate, (iii) Admixtures, (iv) Silica Fume and (v) Steel Fibres, Specifications of ingredients are given below: Cement: Cement (OPC Gr. 53) or as directed by Authority Engineer shall be used.

9.1.2. Aggregate: Aggregate shall conform to the requirements of relevant IS code or as directed by Authority Engineer. The aggregate size shall not exceed 10mm. The grain size distribution of aggregate shall be as under:

| Sieve Size (mm) | Parentage(%) passing through sieve | |
|---|---|---|
| | Minimum% | Maximum% |
| 10 | 100 | 100 |
| 8 | 90 | 100 |
| 4 | 73 | 100 |
| 2 | 55 | 90 |
| 1 | 37 | 72 |
| 0.5 | 22 | 50 |
| 0.25 | 11 | 26 |
| 0.125 | 4 | 12 |

The aggregate shall be well graded and no fraction shall constitute more than 30% of the total mass.

9.1.3. Admixtures: Only approved admixtures which meet the requirement of the specification on field trial and satisfactory performance on other projects already constructed in India and elsewhere shall be used to ensure a homogeneous mix and better dispersions of various constituents of shotcrete/SFRS. A two component system to control the consistency shall be used to ensure good workability and low rebound. The admixture system shall produce slump killing effect and thixotropic consistency thus adhering in

thick layers without trickling and subsequently reducing the low rebound. The contractor shall submit along with the design a certificate for satisfactory performance of admixtures and chemical compatibility between two components from user treatment and manufacturer.

9.1.4. Admixture shall consist of following: -

Water reduction/ thixotropic agents. This shall be added at the batching plant/concrete mixture to keep the shotcrete / SFRS mix workable during transportation and to ensure pump-ability at an acceptable low W/C ratio. The chloride contents shall not exceed 0.1% by weight.

Accelerators: Accelerator shall meet the following requirements:

(a) Only liquid accelerators shall be used.

(b) Water glass (sodium silicate) shall not be used unless in a modified polymer based form approved by the Engineer-in-charge

(c) Only the minimum quantity of the accelerator necessary shall be permitted in normal shotcreting operations subject to maximum-dosage of 5% by weight of cementitious material. The accelerator should have a pH value less than 12.

(d) Accelerators shall be selected such that at the chosen dosage for use in the works, the decrease in strength at 28 days compared with the base concrete without any accelerators shall not exceed 20%. There shall be no further reduction in strength of the shotcrete mix between 28 and 90 days.

(e) Accelerator shall have the property to provoke sharp slump loss and shotcrete should have thixotropic consistency as it hits the substrate to reduce the fibre rebound.

9.1.5. Micro Silica (Silica Fumes): Micro silica produced/manufactured by only approved suppliers as approved byAuthority Engineer shall be used for the work. It should be as per specifications of the supplied conforming to relevant ASTM/Canadian Standards. The doze of silica fumes shall be 5 to 7% of cement weight subject to site conditions. Silica fumes shall have bulk density between 500 to 700Kg per cum. Few important requirements of Canadian code are reproduced below for guidance.

| A-CHEMICAL REQUIREMENT | | |
|---|---|---|
| Description/Property | Specification | Frequency of test |
| Content of SIO2 | More than 85% | Lot or 100MT (or as directed by Authority Engineer ) |
| Content of SIO3 | Less than 1% | Lot or 100 MT (or as directed by Authority Engineer) |
| Less on Ignition | Less than 6% | Lot or 100MT (or as directed by Authority Engineer ) |
| B-PHYSICAL REQUIREMENT | | |
| Description/Property | Specification | Frequency of test |

| | | |
|---|---|---|
| Accelerated Pozzolonic Activity index with Portland Cement at 7 days (Min %age of control) | More than 85% | Lot or 100MT (or as directed by Engineer in |
| Increase in drying shrinkage of mortar Bars | 5% | Lot or 100 MT (or as directed by Authority Engineer |

| | | |
|---|---|---|
| at 28days (Max% Age joints) | | |
| Reactivity with cement portion Of mortar expansion at 14 days (Min %age) | Less than 6% | Lot or 100MT (or as directed by Authority Engineer |

| C-METHOD OF TESTS | |
|---|---|
| Chemical Tests | Reference Standards |
| 1. Silica (SIO2) | ASTMC114 |
| 2. trioxide | CSCANBAS |
| 3. Moisture content | ASTMC311 |
| 4. Loss in ignition | ASTMC311 |
| 5.PozzolonicActivity Index 7 days | ASTMC311(Section 29-32) |
| 6.PozzolonicActivity Index 28 days | ASTMC 311(Section 29-32) |
| 7.StagActivity Index | ASTMC311 Clause 6 |
| 8 Soundness | ASTMC311 (Section 25) |
| 9. Drying shrinkage | ASTMC311 (Section 22-24) except that for testing silica fume use 500g of Portland cement 50gm of silica fume and 1325gm of sand in test mixture) |
| 10.Reactivitywith cement alkatis | ASTMC441 |
| 11. Fineness | CSN CAN 3-A5 |
| 12. Relative density | ASTMC311 (Section 20) |
| 13.Uniformity of air content | ASTMC311 (Section 27 & 28) |

The contractor shall submit a test certificate from a reputed laboratory/supplied certificate for all ingredients brought and intended to be used in Shot Crete/SFRS by him. The Authority Engineer will get the samples of these materials tested independently at the contractor's own cost. The cost of such a test shall be deemed to be included in the quoted rates and shall be as per approved QAP.

## 9.2. STEEL FIBERS

The steel fibers to be used in SFRS shall be of high tensile steel, either cold rolled or cold drawn wires. Fibers shall be dry and free from oil, grease and chlorides. The fiber shall be in accordance with ASTM A 820-85. However, some of the control parameters are given below for guidance.

a) Length of steel fibers: 25-40 mm

b) Geometric shape: - The steel fibers shall have suitably deformed profile to ensure proper matrix of end to develop better and anchorage with no fibre balling.

c) Aspect ratio: 45-75

d) Length/diameter: As per standard norms

e) Fiber tensile strength: Not less than 1100 Mpa.

(f) Quantity of steel fibres: As per design

g) In situ fibre contents concrete (subject to design requirement)

h) The mixing procedure adopted by the contractor should be such that there is no fibre balling.

## 9.3. STRENGTH CRITERIA

The final product shall meet the strength criteria as per relevant EFNARC/ACT standard. cement concrete mix for shortcrete shall have compressive strength as specified in approved drawings/ M-30. The frequency of testing shall be as specified in the codes or as directed by Engineer-in-charge.

The strength requirements for SFRS/Plain Shot Crete are given below:

(A) Steel Fibre Reinforced Shotcrete:

The SFRS shall meet the following strength requirement:

| Sr. No. | Description | Days after which testing done | Required strength(MPA) |
|---|---|---|---|
| 1. | Compressive Strength on Cylindrical Cores | 3 | 10 |
| 2. | Compressive Strength on Cylindrical Cores | 28 | 20 |
| 3. | Flexural Strength | 28 | 38 |

| | | | |
|---|---|---|---|
| 4. | Toughness | 28 | 24 |

(B) Plain wet concrete

The mix shall be designed to give the following strength requirements

| Sr. No. | Description | Days after which testing done | Required strength(MPA) |
|---|---|---|---|
| 1. | Compressive Strength on Cylindrical Cores | 3 | 10 |
| 2. | Compressive Strength on Cylindrical Cores | 28 | 20 |
| 3. | Flexural Strength | 28 | 38 |

9.4. **STRENGTH CRITERIA**

The contractor shall submit a mix design to meet the strength as specified for. prior approval of Authority Engineer prior to commencement of Shot Crete /SFRS. Mix design should be following details.

| | | |
|---|---|---|
| (i) | Ordinary Portland cement | Kg. |
| (ii) | Micro Silica. | Kg |
| (iii) | Natural fine aggregate | Kg. |
| (iv) | Crushed coarse aggregate | Kg. |
| (v) | Crushed fine aggregate | Kg. |
| (vi) | Steel fibres | Kg. |
| (vii) | Water reduce/ thixotropic agent | Kg. |
| (viii) | Accelerator | As per standard norms. |
| (ix) | W/C ratio | As per standard norms. |
| (x) | Slump | As per standard norms. |
| (xi) | Density (wet) | As per standard norms. |
| (xii) | Compressive Strength on | 3Dalys/7 Days/ 28 Days |
| (xiii) | On cylindrical cores | As per standard norms. |
| (xiv) | Equivalent cubes strength | 28 Days |
| (xv) | Flexural Strength | 28 Days |
| (xvi) | Toughness | 28 Days |

9.5. **TEST PROCEDURE**

Tests of SFRS/Shotcrete shall be done as per relevant ASTM/ JSCE/ EFNARC standard or as directed byAuthority Engineer , Alf equipment for testing shall be arranged by the contractor at his own cost. Some of the tests of the Shotcrete/SFRS are given below for guidance:

9.6. **COMPRESSIVE STRENGTH**

The specimen cylindrical cores measuring minimum 75mm dia or as directed by Authority Engineer or concrete cubes 100mm size, shall be drilled/sawn/extracted out of prepared test panels. Panels for testing shall be at least 600x 600mm in size and shall be of thickness as per design. The panel shall be prepared by Shotcreting into vertical moulds, which shall be constructed of steel or other non-water absorbent material and shall have side splayed out moulds at 15 degree to prevent the entrapment of rebound.

9.7. **FLEXIBLE STRENGTH AND TOUGHNESS PROPERTIES**

Flexural strengths and toughness properties shall be measured in accordance with Japanese standard JSCE/ASTM standards. The beam shall be cut out from splayed panels. The beam shall be stored in water for a minimum of 3 days after saving and immediately before testing and kept moist during testing.

9.8. **PLACING EQUIPMENT**

The contractor should have a wet shotcrete machine with a Robot arm, which can do shotcreting efficiently without any wastage of working hours. The machine should be able to place the shot Crete & SFRS as per design mix.

The air supply system shall be capable of supplying air at the pressure and volumes needed for the efficient operation of the machine. No air supply system shall be used that delivers air contaminated by oil or that is incapable of maintaining constant pressure.

In addition, a separate air hose and blowpipe shall be available to remove dust & rebound during shotcrete application.

9.9. **METHOD OF APPLICATION**

Only wet mix method shall be used for the purpose of spraying Shotcrete/SFRS. Water cement ratio shall be 0.45 (maximum) by weight of cementitious material.

The workability shall be measured by slump test and should be within prescribed limits. The Shotcrete older than 2 hours and having slump not within prescribed limits shall not be used unless treated with hydration control additives.

The required workability shall be ensured before transporting the mix for execution at batching plants/transit mixer itself.

The surface shall be suitably prepared by scaling followed by cleaning with compressed air and water under pressure through nozzle. All surfaces shall be wet and clean at the time of applying SFRS/ Shotcrete. Before filling the mix in the hopper of the Shotcrete machine, slurry shall be mixed and put into the concrete hose.

The application procedure of SFRS/Shotcrete shall be developed in the field to give minimum rebound, minimum shrinkage to the satisfaction of Engineer-in-charge.

The nozzle shall be held at a predetermined distance approximately one metre but in no case greater than 1.5 metre from the surface to the covered and positioned so that the stream of flowing material shall be applied as early as possible at right angles to the surface to be covered. Nozzle shall be held in steady motion so that the Shot Crete is applied uniformly to build up the required thickness of layer. Acceptable. Shot Crete shall consist of dense and uniform concrete without rebound inclusions segregation or discernible weakness of bond between layers. The nozzlemen shall apply shotcrete with a uniform consistency in order to minimize binding cohesion and density, minimize

rebound and segregation and present sagging of applied Shotcrete.

Shot Crete shall always be started from the bottom to avoid rebound material getting locked in.

The first 50mm thick layer of SFRS shall be applied uniformly and before applying SFRS, local depressions shall be filled with plain Shotcrete or as directed by Engineer-in-charge. Before laying the second layer of SFRS, the first layer shall be allowed to take its initial set and have loose materials removed. Care shall be taken to ensure that no air pockets formed behind the SFRS during application of SFRS.

All applied SFRS/Shotcrete shall be kept wet for at least 7 days to ensure proper curing of the Shotcrete. Sufficient air shall be added to the nozzle to get good compaction and higher compressive strength.

All necessary precautions shall be taken to ensure that there is no damage to the instrument installed in rock and the drainage holes do not get plugged.

9.10. **PROFICIENCY OF WORKMEN**

Nozzleman shall have previous experience in the application of shotcrete on at least two projects of comparable nature and shall work under immediate supervision of a foreman or instructor with at least Five years of experience. Proficiency of workmen will be checked by the Authority engineer or its representative before allowing them to work.

9.11. **CONTROL OF WATER**

Water flow and seepage shall be controlled in such a manner that detrimental effects are completely and permanently eliminated. The contractor may drain such water by pipes chases or other appropriate methods approved by the Authority Engineer

9.12. **SAFETY MEASURES**

Alkali hydroxides and other chemicals contained in Shotcrete admixture are moderately toxic and can cause skin and respiratory Imitation unfess, adequate safety measures are undertaken. In applying Shot Crete containing toxic admixtures the nozzlemen should have air to breathe, which shall be free of toxic or objectionable material, Gloves and necessary protective clothing shall be worn to protect against dermatitis AILWA

9.13. **SUPPORTING BOLTS**

Where, in the opinion of the Authority Engineer, blocks of rock are likely to get loose and fall down, the contractor shall arrange, and install supporting bolts. Such supporting bolts are expected to be needed mostly in the roofs only, it shall however be the sole responsibility of the contractor to bring in writing to the notice of the Authority Engineer , the location where the contractor may consider it necessary to provide supporting bolts. The final decision about installation of supporting bolts at any location and the total quantity thereof shall however, vest with the Authority Engineer.

**9.14. MEASUREMENT AND PAYMENT**

(a) Measurement for payment of Shotcrete/SFRS shall be made of volume in cubic meters

of Shot Crete/SFRS placed computed by multiplying the payment area by the specified (i.e. design) thickness. The payment area shall be defined as under: -

(b) When the excavated profile does not extend to a portion of 'GEOLOGICAL OVERBREAK, payment area shall be projection of irregular area onto the payment line i.e. payment-line perimeter multiplied by length along the tunnel.

(c) When the excavated profile extends to a portion of GEOLOGICAL OVERBREAK, an imaginary line parallel to 'Payment Line' shall be drawn in such a way that it depicts the average line of the actual excavation. In case perimeter of such an imaginary line is less than or equal to the perimeter of a line parallel and 300mm beyond 'payment line or Pay line' the payment area shall be calculated by considering perimeter of Payment Line only as described in para (ii) above, However, in case perimeter of such an imaginary line is more than the perimeter of a line parallel to and 300mm beyond 'Payment Line' the Payment area shall be calculated by multiplying the perimeter of such an imaginary line with length along the tunnel.

(d) Where Shotcrete is used only for filling of local depressions before applying SFRS, measurement and payment of Shot Crete shall be made on the basis of concrete deposited to obtain the required thickness of Shotcrete.

(e) Shot Crete placed by the contractor in excess of thickness shown on the Drawings or as specified byAuthority Engineer shall not be measured for payment.

(f) Rate being quoted for Shotcrete / SFRS should include cost of all materials, providing and incorporating admixtures or other additives in Shot Crete/SFRS but excluding cost of cement.

(g) Wire mesh as per specifications shall be paid in relevant items .

(h) No separate payment shall be made for Shot Crete/SFRS consumed in rebound and/or wasted shotcrete/SFRS. The cost of various ingredients of rebound/wastage is deemed to be included in the unit price of Shotcrete/SFRS

## 10. Cement concrete in M-15 & RCC M-30 Concrete Work

10.1 **Scope:** The work covered by this section consists furnishing all materials equipment and of labour for the manufacture, transport, placing, finishing and curing of concrete in the portal structures, lagging and back fill concrete behind RCC lagging and for construction of mass CC/RCC work in CUT AND COVER construction tunnels and shafts, inner main RCC lining. The item of concrete is split up into several items according to the class of concrete to be used and its location and will be measured and paid for accordingly.

(a) All concrete works whether Plain or RCC should conform to IS 456-2000 and the relevant India Standards Specifications as directed by the Engineer, Payment of CEMENT CONCRETE and RCC will be made under relevant schedule of items, rates and quantities.

(b) All concrete shall be mixed in an approved concrete mixing machine and such cement concrete should be vibrated by use of mechanical vibrator and nothing extra over and above the quoted rates for mass concrete will be payable for this operation unless mentioned specifically.

(c) The contractor will have to arrange the material required for providing weep holes or other drainage holes at his cost. The cost should include supplying and fixing 75mm GI/AC pipes in cut and cover tunnels as per approved drawings. No deduction of volume of weep holes/drainage holes for the purpose of calculations of volume of concrete payable shall be cloned.

(d) Butt joints are to be provided at places at the direction of the Engineer. 12mm thick mud plaster will be done on one of the surfaces of the concrete. No extra payment for this plaster or any deduction in the quantities of concrete will be made and the rates for mass cement concrete will be inclusive of this plaster.

(e) The exposed surface of mass cement concrete and RCC work shall be rendered smooth and even. Nothing extra will be payable for rendering the exposed surface smooth, the cost of which will be considered as having been included in the rates quoted for mass CC/RCC items.

**10.2 ERECTION AND REMOVAL**

Shortly before placing concrete the surface of all forms shall be oiled with suitable non-staining oil, not harmful to concrete, so as to prevent sticking of concrete and facilitate removal of forms. Forms for unexposed surfaces may be thoroughly wetted in lieu of oiling, immediately before placing the concrete.

For use of wood forms, the oil should be capable of penetrating the wood and remaining sufficiently oily to eliminate sticking and of preventing absorption of water and consequent warping. Almost any of the light colored and light oiled straight petroleum oils are acceptable for use on wood.

Compounded oils composed essentially of petroleum oils and other oils and animal or vegetable origin and gums or resin which is heavier in body and frequently darker than straight petroleum oils will be used in the case of steel lining forms. The oils should be applied by brush, spray or swab and the forms should be covered fully and evenly without excess of drip. Care should be taken to prevent oil from getting in the surface of construction joints or on therein forcing bars. Special care should be taken to thoroughly form strips for narrow groove seats, window doors and elsewhere so as to prevent swelling of the forms and consequent damage to concrete prior to removal of forms.

Immediately before concrete is placed, precaution shall be taken to see that all forms are in proper alignment and that forms anchor and ties are thoroughly secure and light. Where forms of continuous surfaces are placed in successive units, the form shall sit tightly over the surface so as to prevent leakage from the concrete and to maintain accurate alignment of the surface.

The contractor shall strengthen or modify the formwork, when the Authority Engineer considers it necessary and as directed by him. Forms should be left in place until their removal is authorized and shall be removed with care so as to avoid any injury to the concrete. All forms shall be entirely removed from a pour to permit inspection before being reset for their next lift. Unless authorized, suitable mouldings shall be placed to level all exposed edges, at construction joints, and any other edges shown on the drawings or as required by the Authority Engineer. The final detailed drawings will show any formed recesses, slots, block outs and similar construction details, which have to be taken into account in fixing the form work cost of forming the recess shall be deemed to

have been included in the overall rate of the item.
The contractor shall take into account all the cost of formwork while quoting for the rates of the concrete work items, and no separate payment shall be due to the contractor for the erection etc. of the formwork to the specification herein detailed.

**Shuttering for final inner lining to be compulsorily Movable Shutter with hydraulic moving and adjustment facilities**

## 10.3 WATER DISPOSAL

The method used for disposing of the water from washing the surfaces shall be such as would not stain discolor or otherwise affect exposed surface.

## 10.4 DAMAGED OR DEFECTIVE CONCRETE

Concrete damaged from any cause and any concrete which shall be found defective by reason of the contractor's operations at any time before the completion and final acceptance of the work shall be removed and replaced by the contractor with acceptable concrete as such removed concrete shall be borne by the contractor.

## 10.5 MEASUREMENTS AND PAYMENT

Measurements and payment shall be made on the basis of the actual volume of the concrete placed but limited to the quantity upto the payment line indicated in drawings. No deduction shall be made for the space occupied by reinforcement and other metalwork, electric conduit lines etc. The quantities of all holes and passages and embedded parts greater than 0.05 Sqm in cross-section shall however be deducted from the total quantity to arrive at the concrete work for payment. The over Break/Cavity due to contractor fault formed beyond the Pay line shall be filled up by the contractor with back fill concrete and no payment for such extra concrete will be made. In case of Geological Over break" the concreting will be paid at the tendered rate. No payment will, however, be made for embedding fixtures or providing other installations, electric surface and construction joints shall be deemed to be included in the unit rate to be paid for concrete.

## 10.6 TESTS

The contractor shall set up at his cost a folic-equipped concrete testing laboratory, where facilities and equipment for concrete mix-design, Cube testing, setting time of cement etc. are available. All tests to be done as per QAP approved by Authority Engg
Concrete samples and cement samples shall be tested in this laboratory as and when required at no extra cost in the presence of Authority Engineer or his authorized representative at such frequent intervals and as such specimens of work as stipulated by the Authority Engineer The results of such tests should be made available to the Authority Engineer as and when done. However, if the contractor fails to get the above tests done at his cost, the Authority Engineer may order to get these tests done at Railway laboratory or any other approved laboratory at contractor's cost and recover the cost including supervision and incidental charges from contractor's on account bills.
Test cubes required as per the code shall be manufactured and supplied free of cost by

the contractor and shall submit a mix design for verification and approval before the work is taken up.

The contractor shall provide all necessary facilities materials and labour for these tests as the Authority Engineer may consider necessary for which no separate payment shall be made.

### 10.7 RECORD OF CONCRETING OPERATIONS

A systematic joint record in the form as approved by the Authority Engineer shall be maintained to record the details regarding use of cement, number of units and location in which concrete or mortar is used etc. This record shall be signed by the Authority Engineer or his authorized representative at the site in token of having scrutinized and verified the correctness of the entries made in the joint record. If the contractor fails to scrutinize and verify the entries and sign, the joint record as scrutinized, the entries verified and signed by the Authority Engineer or his representative shall be taken as final and binding on the contractor.

## 11. STEEL RIBS

### 11.1 STEEL RIBS

(a) The steel ribs shall comprise of I-beam or built up sections as shown on the drawings.

(b) Rib splices shall be welded or made of bolted plates in such a manner as not to reduce the section moment of resistance.

(c) Preferably one section size of steel rib profile shall be used for each portion of the Underground Works and the structural requirements due to rock conditions encountered shall be met by varying the spacing of the ribs as directed by the Engineer.

### 11.2 STEEL RIB ACCESSORIES

Steel support accessories shall include, but not be limited to, collar braces, tie rods, spreaders, liner plates, cribbing, blocking wedges, foot blocks, sills and invert struts which are fabricated from steel plates or sections or other steel products. Steel support accessories shall be used exclusively in conjunction with the steel ribs in the underground excavations and shall be used elsewhere when required by the Engineer.

### 11.3 STEEL RIBS

(a) Measurement for payment for supply, handling, fabrication and installation of the steel ribs will be of the weight of steel ribs (in MT) installed as per approved drawings. Payment for the same shall be made in tunnels, shafts, and chambers etc., based on schedule of item rates. The rate for steel ribs as above shall include the entire cost of:

- Supply, handling, fabrication, transportation to the place of installation and installation of steel ribs, Connection plates, all foot plates, foot blocks, tie rods, bolts nuts cross bracing and all other accessories.
- Surveying and marking the position of ribs on the finished concrete surfaces.

(b) For the measurement and payment purposes, the weight of the steel ribs will be the theoretical weight as per approved drawings of fabrication & erection structure taking the unit weight of the steel profile per linear meter as per relevant IS Code required to be installed according to drawing.

(c) Payment of supply of Structural Steel will be made in relevant item

## 12. Dewatering Drainage and pumping:

Underground Construction: No separate payment will be given for dewatering during entire tunnel execution. All the cost is deemed to be included in Sch-G

## 13. Drilling holes, Grouting - As per Item description.

## 14. Percussion Drilling of Holes

14.1 DRILLING OF HOLES

(a) The number of holes to be drilled, their location, sequence, orientation, inclination and the depth shall be as per approved methodology.

(b) All holes shall be established within 0.10 m of the specified location. Maximum deviation for holes shall be 20 (degree) from the proposed values.

(c) If for any reason, the drill hole deviates in inclination or orientation in such a way that it does not satisfy the purpose for which it was intended, the contractor shall correct the deviation or shall drill another hole to the satisfaction of the Engineer.

(d) Hole size for probing and consolidation grouting holes (Drilled in the face) shall be kept the same.

(e) Drilling of Holes for Probing/Grouting

(f) The Contractor shall drill holes around the periphery of the excavation for draining the surrounding rock. The minimum diameter of holes shall be 57 mm or as directed by the Engineer. The contractor shall also submit interpretation of MWD data.

(g) When so required according to approved methodology or as directed by the Engineer, these holes (along with additional holes if required) shall be used for consolidation grouting of the surrounding rock.

14.2 Drilling of Holes for Rock bolts, Exploration and Instrumentation and other than Grouting, etc.

(a) The minimum diameter of holes shall be 38 mm or as directed by the Engineer.

(b) Holes shall be drilled either directly into the rock or through the concrete lining and then into rock as directed by the Engineer.

(c) The holes shall be drilled in a direction normal/inclined to the surface of the underground excavation / concrete lining as the case may be or as directed by the Engineer.

(d) While drilling the holes, utmost care shall be taken to ensure that the reinforcement or structural ribs, if any, in the concrete lining, shall not be cut through. The position of steel

ribs shall be recorded and marked on the finished concrete lining. If the reinforcement or steel ribs are encountered during drilling of any holes in concrete, drilling shall be discontinued immediately, and a new hole shall be drilled nearby. The holes so abandoned shall be backfilled with concrete as directed by the Engineer and the surface of concrete shall be repaired.

(e) Each hole shall be protected from becoming clogged or obstructed by a grout connection pipe fixed suitable into the holes and the holes shall be suitably capped or otherwise protected until these are grouted. Any hole that becomes obstructed before being grouted shall be cleaned out in a satisfactory manner.

(f) The use of rod dope, grease or other lubricants on drill rods shall not be permitted and no drilling water additives of any kind shall be used without the approval of the Engineer.

(g) Whenever the drilled water is lost or artesian flow is encountered, drilling operations shall be stopped, and the hole shall be grouted before drilling operations are resumed. The Contractor shall record the location, flow and the pressure of any artesian conditions encountered in any drill hole.

(h) Drilling of holes for having diameter between 50 – 65 mm

- Measurement and payment will be made at the unit rates per linear length (meter) entered in the Schedule of Item Rates.

## 15. Drainage Pipe: As per Item Description.

## 16. Geotextile

### 16.1 Protective Felt

(i) The protective felt shall be a continuous filament non-woven poly-propylene geotextile of uniform thickness and surface texture meeting the requirements listed below.

| Property | Specified Value | Standard |
|---|---|---|
| Unit Weight | 700g/m2 min | DIN 53854 |
| Thickness at 0.02 bar | 4.0 mm min | DIN 53855/3 |
| Thickness at 2.0 bar | 1.9 mm min | DIN 53855/3 |
| Tensile strength | 1000 N/cm2 min | DIN 53857/2 |
| Extension at break | 70 % min | DIN 53857/2 |
| Extension at 30% of Tensile Strength | 20 % min | DIN 53857/2 |
| Permeability in plane at 0.02 bar | 5x10-1 cm/s min | * |
| Permeability in plane at 2.00 bar | 5x10-2 cm/s min | * |
| Resistance against acid and Alkaline solutions (pH 2-13) | Loss of strength 10% max | DIN 53857/2 |
| Resistance to Punching | 2000 N | DIN 54307 |

## 17. Membrane

## 17.1 Specifications

(a) The waterproofing membrane shall be Polyvinyl Chloride (PVC).

(b) The membrane shall be supplied with a signal layer, i.e. a thin sheeting of different color, bonded to one side, which is intended to facilitate the detection of damages.

(c) PVC Waterproofing Membrane (poly-vinyl-chloride) will satisfy following specifications:

(d) Accessories: Fixing material, flashing, reinforcement for expansion joints, sealing flanges and preparation of corners and intersections shall be made as recommended by the manufacturer of the membrane.

| Property | Specified Value | Standard |
|---|---|---|
| Thickness (mm) | ≥ 2.0 | EN 1894-2 |
| Tensile strength at break (N/mm2) Elongation at break (%) | ≥ 17<br>≥ 300% | EN 12311-2 |
| Resistance to tearing (N/mm) | ≥ 100 | EN 12310-2 |
| Puncture static test (kN) | ≥ 2.5 | EN ISO 12236 |
| Water tightness (B method – 24 hours at 0.5N/ mm2) | Watertight | EN 1982 |
| Change of dimensioning after heating at +70°C for 2 hours | Stable | EN 1110 |
| Cold bending (°C) | ≥ -35 | EN 495/5 |
| Resistance to acidic and alkaline at 28 days | 20% maximum elongation. | DIN 16726 |
| Resistance of joints (N/mm2) | ≥ 10.5 | EN 12317-2 |
| Fire reaction classification | Class E | EN 13501-1 |

**Note: Or as per Indian Standards.**

## 17.2 Waterproofing Membrane (Installation)

### (A) Surface Preparation

**(a)** All surfaces to which waterproofing is to be applied shall be sufficiently clean, smooth and free from deleterious materials and projections.

**(b)** The following treatment of surfaces shall be performed prior to the installation of waterproofing:

(i) For the fixing of the protective felt and the waterproofing membrane, a minimum shotcrete cover of 50 mm to rock is required.

(ii) Irregularities of the shotcrete lining surface shall be eliminated by means of additional shotcrete. The ratio of the diameter to depth of irregularities shall be not less than 5:1. Rounding at rock bolts (where applicable), etc. shall have a min. radius “ra” of 0.3 m.

Details are given in Figure below

(iii) Transitions and intersections of tunnel profiles shall be rounded off with a minimum radius of 500 mm.

(iv) Protruding steel bars, wires, spacers, pipes etc. shall be cut off unless treated with additional shotcrete cover.

(v) Exposed steel parts such as rock bolts, if not intended to remain accessible, shall be covered with shotcrete.

(vi) All shotcrete surfaces shall finally be smoothened with fine-graded shotcrete (rounded aggregates, grain size 0 - 4 mm), applied in a layer of 50 mm minimum thickness.

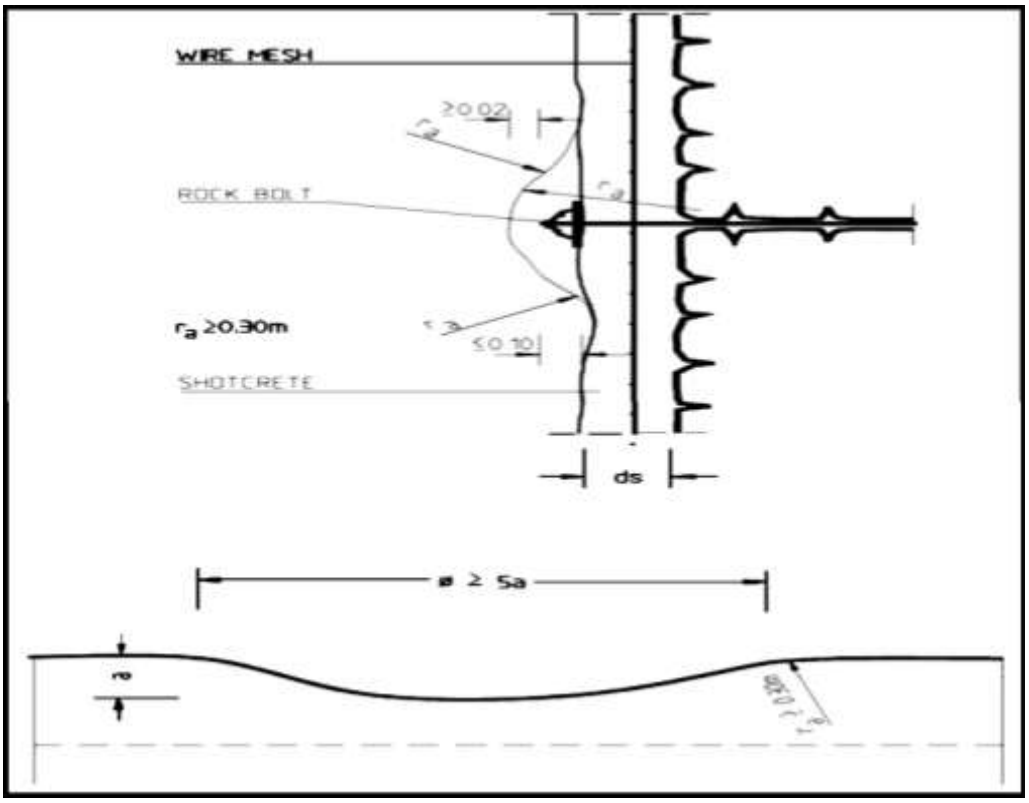



**Figure 1: Requirements on surface irregularities of shotcrete**

**(B) Application**

**(a)** General: Prior to the application of the waterproofing, all surfaces to which it shall be applied, shall be inspected and approved by the ENGINEER. The application shall follow the written instructions of the manufacturer. Special preparations will be required for waterproofing at tunnel intersections and for projections passing through the membrane. They shall be carried out according to the manufacturer's recommendation.

**(b)** Fixing of Felt: The protective felt shall be attached to the shotcrete surface using suitable fixings specified by the manufacturer. Depending on the location 2 to 4 nos. fixing elements shall be used per square meter. The felt shall be laid with enough slack to avoid overstress during concreting. Adjacent sections of felt shall be overlapped by 100 mm and joined by point welding or similar suitable method. Along the bottom of the tunnel side walls the felt shall extend sufficiently to cover the lateral drainages as shown on the drawings.

**(c)** Fixing of Waterproofing Membrane: The waterproofing membrane shall be installed to cover the felt and shall be attached to the felt fixings and to each other and to the washers by means of thermal welding. No perforation of the membrane shall be allowed for installation purposes. The waterproofing membrane shall be laid with the signal layer towards the inside and with enough slack to prevent overstressing during concreting. Adjacent sheets of waterproofing shall be joined by a double weld. Along the bottom of the tunnel side walls the membrane shall extend sufficiently to cover the lateral drainages as shown on the drawings. Connections to water stops and to the waterproofing of structures in open cuts shall be carried out according to drawings to be furnished by the supplier.

## 18. STEEL REINFORCEMENT FOR LATTICE GIRDERS

### 18.1 General

i. High strength deformed steel bars and wires for reinforcing bars used in the works shall be deformed TMT Fe-500D conforming to IS:1786 manufactured by primary steel producers such as SAIL/TISCO/JINDAL/RINL/IISCO.

ii. Manufactured test certificates shall be supplied for each lot.

iii. Steel shall be free from loose mill scale, rust, oil, grease, dirt, paint or other deleterious matter, when examined immediately before concrete is being placed.

iv. Upto 10mm dia, one sample per 25MT and beyond 10mm dia one sample per 40 MT or part thereof shall be tested for various physical tests as per IS:226, IS:1608, IS:1559 and IS:1387.

v. Wire for tying reinforcement steel shall be black annealed iron wire or acceptable equivalent, with a suitable diameter and shall have an ultimate strength of 5.68 tonne/cm2 and yield strength of not less than 8.8 tonne/cm2.

vi. After material passing done by engineer, the reinforcement rods shall then be treated in accordance with IS: 9077.

vii. No extra payment for re-bar treatment shall be made and is deemed to be included in the quoted rates.

### 18.2 Transportation and Storage

i. Transportation shall be undertaken in such a manner that no damage is done to the steel.

ii. Reinforcement steel shall be stored off the ground in separate groups according to size and length. Reinforcement steel, which has been cut and bent according to the schedules provided by the contractor, shall be marked with bar number, as shown in the schedule, by using weather proof tag or by placing in marked bins and shall be stored in such a manner as to be readily accessible when required and to facilitate inspection.

## 19. STRUCTURAL STEEL

### 19.1 General

i. Structural steel used in the works shall conform to IS:2062 manufactured by primary steel producers such as SAIL/TISCO/JINDAL/RINL/IISCO.

ii. All structural steel shall be of new/unused stock, clean and straight, free from excessive rust or scale and without any sharp kinks, bends or other objectionable defects.

iii. All structural steel including steel plates and steel to be used for Supports for tunnel and cavities as also for bolts, nuts and washers etc. for steel support shall conform to relevant Standards. Manufactured test certificates shall be supplied for each lot.

iv. The material used in splices shall conform to the Specifications of the material being spliced.

**19.2 Transportation and Storage**

i. Structural steel shall be transported, handled and stored in such a manner that no damage is done to the materials or the structure.

ii. All timber to be used for support accessories.

**19.3 MEASUREMENT AND PAYMENT**

No separate Measurement & Payment shall be made for supplying, including transportation and storage of material until and unless specifically included in the technical specification/BOQ. The cost of the materials and testing (including the royalties, if any) used in works shall be deemed to be included in the quoted rate for the relevant items of works.

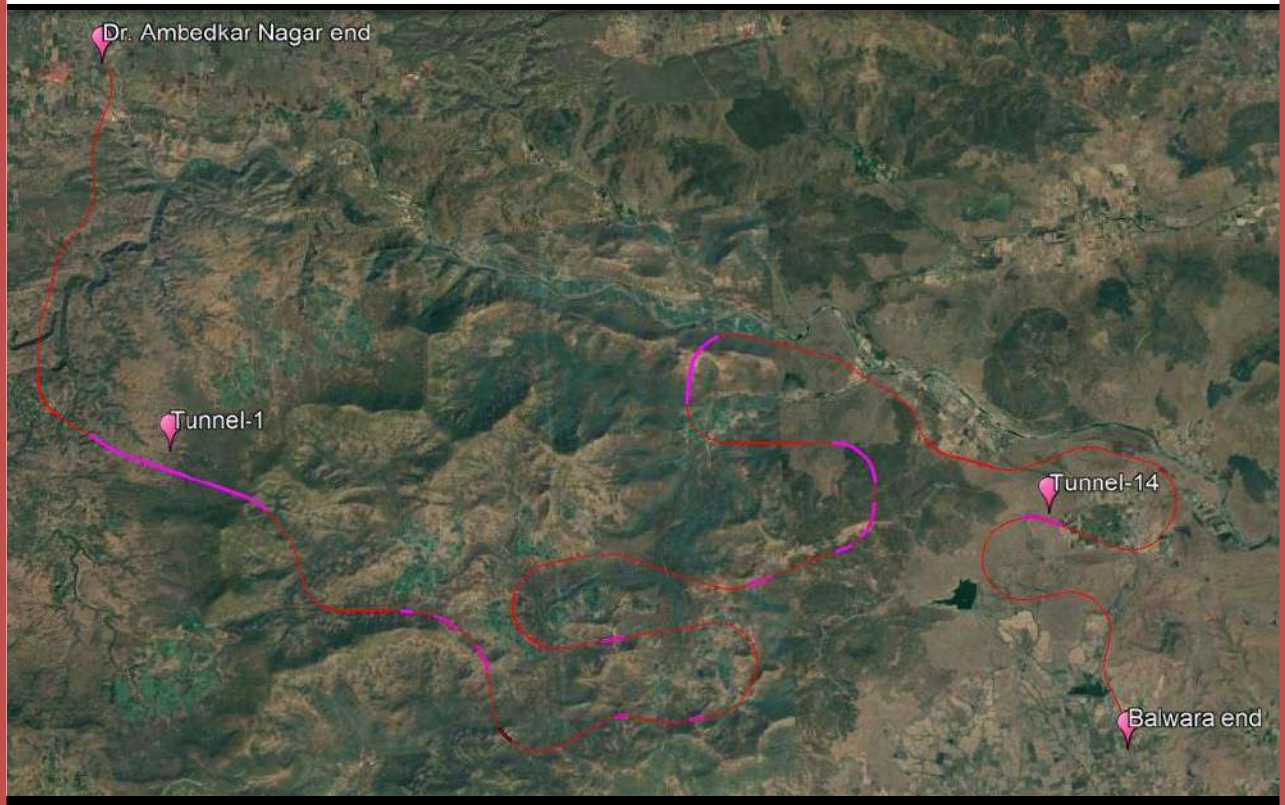
Payment of structure steel shall be made on theoretical weight as per approved drawing of fabricated & erected structure- (Excluding all wastages). No payment will be made for wastages.

**Condition of contract for instrumentation**

1. Authority Engineer will engage consultant/DDC for instrumentation, necessary support needs to be provided to the consultant to enable them to install and monitor tunnel behaviour via those instruments without any hurdle.

# पश्चिम रेलवे
# WESTERN RAILWAY

**Final Location Survey using modern survey equipments LIDAR etc., Geological mapping and Geo Physical Survey, Soil exploration, hydraulic data collection and GAD of minor and major bridges, preparation of L-sections, preparation of land schedules for land acquisitions and digitalization of land records from Dr. Ambedkar Nagar (Excluding yard) to Muktiyara Balwara (Excluding yard) for Existing/new detour BG line in connection with gauge conversion of existing Ratlam-Khandwa MG section of Western Railway**




**Report No. RITES/UI/CEDS/GT/WR/R-K/TUNNELS/R2/2025**

**Final Report on**
**Geotechnical Investigation of Tunnels locations for Final Location Survey of Ratlam-Khandwa section of Western Railway**

**JANUARY 2025**

MARKING THE GOLD 50 RITES

RITES
THE INFRASTRUCTURE PEOPLE
(A Government of India Enterprise)

# Contents

## ABSTRACT

As a part of the Geotechnical studies, Geological Mapping, Seismic Refraction Survey and Exploratory drilling have been carried out at Major Bridges, Minor Bridges, ROB's, RUB's and Tunnels from Tunnel -1 to Tunnel – 14 from Dr. Ambedkar Nagar (Excluding Yard) to Muktiyara - Balwara (Excluding Yard) for Existing / New detour BG line in connection with gauge conversion of existing Ratlam – Khandwa MG section of Western Railway

The aim of the investigations was to understand the surface and subsurface geology along the alignment, with a view to assess the feasibility of the proposed alignment and to highlight various geotechnical problems likely to be encountered. Adequate surface & subsurface data was collected which helped in detailing of the overburden material and rock conditions at the proposed tunnels & bridge sites.

The present report summarizes the results of Exploratory Drilling executed at selected locations of tunnels along with lab test results. A total 60 no's of boreholes drilled at tunnel portals along with few boreholes in mid part of the long tunnels as per site conditions.

## 1.0 INTRODUCTION

Western Railway has awarded the work of Geotechnical Investigation for Seventeen (17) tunnels along with major bridges, Minor Bridges, ROB's & RUB's from Dr. Ambedkar Nagar (Excluding Yard) to Muktiyara Balwara (Excluding Yard) for Existing / New detour BG line in connection with gauge conversion of existing Ratlam – Khandwa MG section of Western Railway between km 00.000 to km 64.960 was entrusted to RITES Ltd. Tunnel no. T1 to Tunnel no. 14 are located approximately 50 to 60 km away from the Indore Town.

Geotechnical Investigation includes Geological Mapping, Geophysical survey (Seismic refraction, ERT & MASW), Exploratory Drilling of boreholes along with lab testing of rocks core sample along the alignment of Twenty (20) tunnels & major/Minor bridges, RO's & RUB's. **Present report summarizes results of exploratory drilling carried out along proposed Tunnels T1 to T14.**

## 2.0 SCOPE OF WORK

The work of Detailed Geological Mapping, Seismic Refraction survey, ERT, MASW & Exploratory Drilling work of boreholes at selected locations along with lab testing of soil / Rock samples for Tunnels T1 toT14 between km 00.000 to km 64.960 have been carried out to understand the surface & sub-surface geology along the alignment with a view to assess the feasibility of the proposed alignment and to highlight various geotechnical problems likely to be encountered. The drilling of total sixty boreholes was carried out for all Twenty (20) tunnels to know the sub-surface strata at selected locations and boreholes varying in depth from 25m to 84m. The various lithological units such as different rock formations exposed in the area, slope wash/slide debris material etc. were demarcated during geological mapping. Besides, other tectonic & structural features such as folds, faults, joints, shear zones, slides etc. if any, were also recorded during mapping to know the structural & geological conditions of the rock mass exposed in the area to assess the suitability of the alignment from construction point of view and remedial measures to be adopted in such type of geological set up and these features were further explored in detail with Seismic Refraction survey, ERT & exploratory drilling. The reports of surface geological mapping & seismic refraction survey have already been submitted separately.

## 3.0 SITE CONDITIONS AND ACCESSIBILITY

The Tunnel No. T1 to Tunnel No. T14 having gentle to steep hilly terrain with thick vegetation cover/dense forest, with rock outcrops exposures at places. The area along the tunnel alignment is accessible through foot tracks only at most of the places except for only a few locations.

## 4.0 REGIONAL GEOLOGY

Indore district is situated in the southwestern part of Madhya Pradesh and covers an area of 3898 sq. km. It falls in Survey of India's degree sheet Nos. 46M, N and 55B between latitudes 22°20’ - 23°05' 17" N and longitudes 75°25'28" - 76°l 4'38"E. The district is bounded by Ujjain district on the north and northwest, Dewas district on the East, Nimar district on the south and Dhar district on the west.

The area consists of horizontally disposed basalt flows and forms a part of Malwa plateau. These lava flows ware termed as 'Malwa Traps' and correlated with the Deccan Trap formation of Upper Cretaceous to upper Eocene age. The important characteristics of 'aa' type flows is the presence of a thick, highly vesicular and fragmentary top zone. The vesicles of this zone are irregular in shape and are filled with zeolites, calcite and silica and in some flows the geodes are also common. The 'pahoehoe' type flows are characterized by presence of toes, ropes, pipe amygdule’s, glassy crust, hummocky surface and rounded vesicles. Some flows exhibit the characters of both 'aa' and 'pahoehoe' type of flows.

The entire project area is covered with Deccan Trap basaltic rocks of Malwa Group of Cretaceous to Palaeogene age. It consists of a sequence of 42 horizontally disposed tholeitic lava flows, of which two-thirds exhibits 'Aa' characters and remaining flows are compound ‘Pahoehoe’ and mega -porphyritic natures. These basaltic lava flows represent a sequence of cyclic eruptions with very fine to fine grained, non-porphyritic to moderately porphyritic and mega porphyritic at the end of each cycle.

Malwa Group is classified. under Kalisindh, Kankariya-Pirukheri, Indore, Bargonda, Singarchori and Mandaleshwar Formations corresponding to five episodic eruptions. Kalisindh Formation is the oldest Formation of Malwa Group in the district and exposed in the southeastern and southwestern part, comprises ten 'Aa' basaltic lava flows with

a mega-porphyritic basaltic lava flow at the top. Kankariya-Pirukberi Formation is exposed in the southern and in the upper reaches of Chambal, Gambhir, Khan and Kshipra rivers, comprises five 'Aa' basaltic lava flows and a mega porphyritic basaltic lava flow at the top. Some of the flows of this Formation show lateral variations in the physical character from 'Aa' in the west to compound 'Pahoehoe' in the east. Indore Formation occupies the wide area of the district and comprises seven 'Aa' and compound 'Pahoehoe' basaltic lava flows with a mega-porphyritic basaltic lava flow at the top and inconsistent intertrappean bed in the eastern part. Bargonda Formation occupies the southwestern part and isolated residual plateaus in the southeastern part. It comprises nine 'Aa' and a compound ‘Pahoehoe' basaltic lava flow with a mega porphyritic basaltic lava flow at the top and inconsistent intertrappean bed in the eastern part. Singarchori Formation forms isolated residual plateaus in the southwestern part and comprises five compound 'Pahoehoe' basaltic lava flows with a mega -porphyritic basaltic lava flow at the top. Mandaleshwar Formation occupies the southeastern part.

Thin Quaternary alluvium consisting of clay, silt, fine to coarse sand, kankar and gravel is restricted to narrow patches along the course of rivers. The alluvial deposits of recent to sub-recent age are mainly confined to the banks of Khan River. They comprise mostly sand, gravel, clay and silt. While the sand and gravel are restricted to the riverbed, clay and silt are confined to the banks. These deposits attain a maximum thickness of about 10 to 12 m. The major Narmada fault is located more than 60 kilometer south of this area. A small fault with about 3-4m displacement has been reported near Simrol.

The massive unit of Deccan basalt is dark grey in colour, fine grained in texture hard and compact in nature. The vesicular trap unit is medium to fine grained in texture and the vesicles are filled with secondary minerals like the colloidal silica, calcite, etc. The massive unit of the trap has undergone weathering to some extent, the maximum depth being 3 to 5 m, followed by brecciated and jointed basalt. Both columnar and irregular jointing is frequently present. Spheroidal as well as layered weathering is common. The tops of the flows and flow units are, in general, highly vesicular and amygdaloidal often with geodes filled with zeolite, silica and calcite. Pahoehoe type is the most common among the flows which, at places, grades to blocky type towards the top.

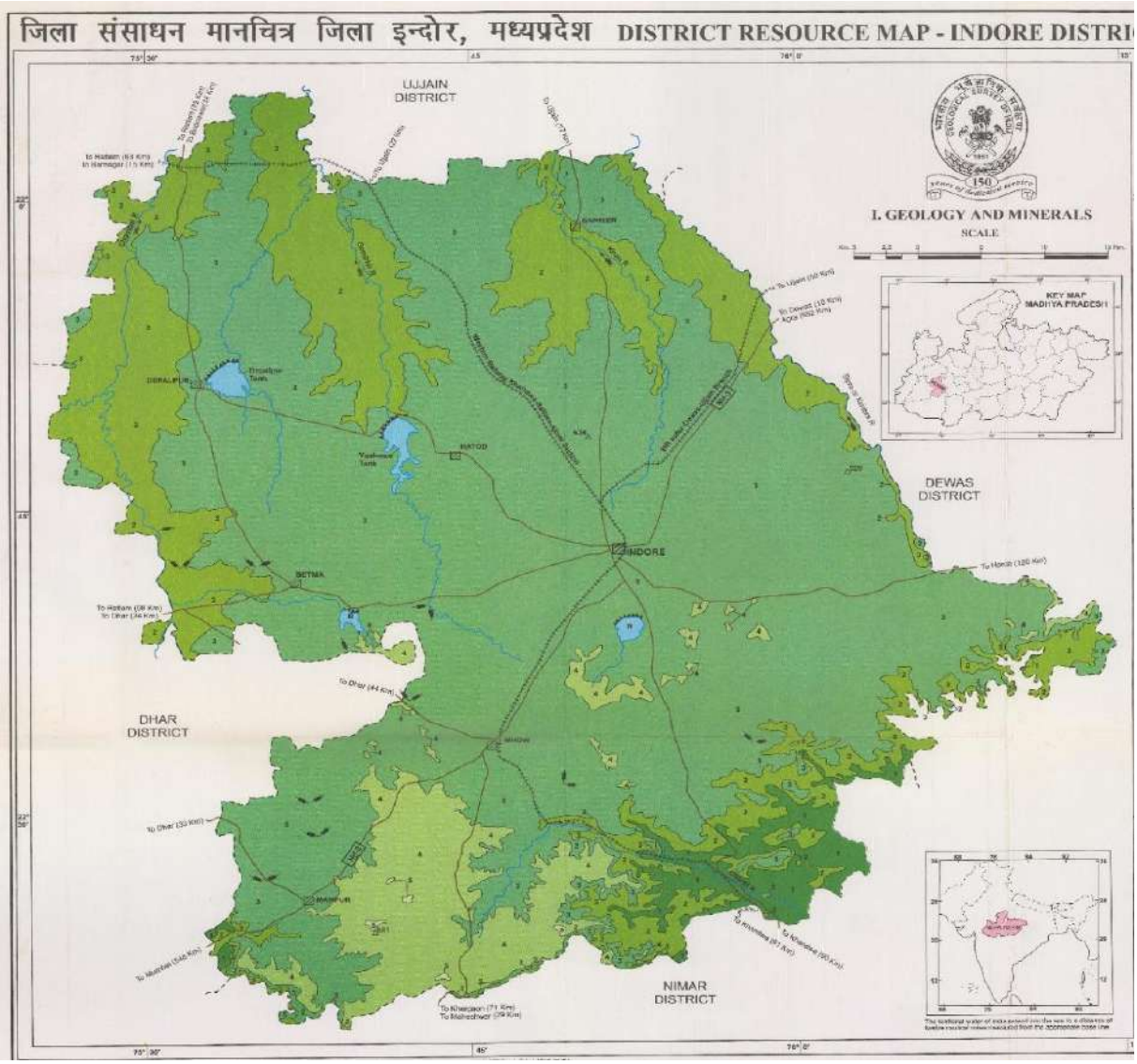



**Fig. No.1: Geological map of study area (GSI)**

## CLIMATE AND RAINFALL:

The Indore city enjoys a composite climate with extended hot humid period from July to September, winter period from November to February, summer from April to June and a temperate climate from October to March. The climate of the city is typically seasonal with three distinct dry, wet and cold seasons. The mean daily temperature is about 25.1°C throughout the year. January is generally the coolest month. Sometimes in December, the minimum temperature drops down to even as low as about 2 to 3°C. During summer, the days are hot (35-40°C) with peak summer (May) day temperature touches up to 45°C. Due to its location on the south edge of Malwa Plateau, however, hot it may be during the day, in the late evening, cool breezes make the evenings quite pleasant. Normal annual rainfall of the district is 960.96 mm. The district receives

maximum rainfall during the southwest monsoon period. Thus about 91.2 % of the total annual rainfall takes place during the southwest monsoon period alone. The maximum monthly rainfall takes place during the month of July.

**GEOMORPHOLOGY & SOIL TYPE:**

Geomorphologically, the district can be divided into three units; Units of extrusive origin, units of denudational origin and units of fluvial origin. The units of extrusive origin comprise of region of middle level plateaus (550- 900m amsl), Region of low-level plateaus (350-550m amsl) and Plain. The Region of middle level plateaus is scattered, while the Regions of low-level plateaus form the main unit in the district. The Plain occupies a very small area around the border of Khandwa district of the units of denudational origin, denudational slope on Deccan Trap occupy a large area in Mhow block and is mostly covered with forests. The undifferentiated colluvial fans occupy a very small area in Mhow block. The Unit of fluvial origin viz; floodplain is confined to the drainage of the main rivers in the district.

The district is covered by medium black soils. These soils are 0.46 to 0.9 meters thick and are rich in lime and lime nodules. The sub-soil and the partially disintegrated rock below allow easy drainage and hence these medium black soils can be freely irrigated.

**HYDROGEOLOGY:**

The Deccan Traps, which are the predominant rocks in the district, have wide variation in the water bearing properties of the different units constituting them. The massive basalts their weathered zones and secondary porosities and the vesicular basalts with their minutely connected and partially filled vesicles play an important role in determining the occurrence, movement and storage of ground water. These invariably form potential aquifers. The red bole is nonproductive. In the alluvial areas, the occurrence of ground water is governed by sand/clay ratio. The sand beds generally form good aquifers.

The main source of recharge to the basaltic aquifer in the district is rainfall. To some extent, recharge also takes place by influent seepage from the streams and their tributaries. Due to low permeabilities of basalts and undulating topography, the runoff is very high. This restricts the recharge to ground water body. This is the reason for large scale seasonal fluctuation in the water level of the wells. Ground Water in the Deccan Traps in Indore district occurs mostly under water table conditions. The nature

of topography, extent and depth of weathering, distribution of secondary porosity in the form of fractures and joints and the occurrence and disposition of vesicular units govern the movement of ground water.

At some places, confined conditions area also observed due to the alternating nature of the impermeable massive and productive vesicular basalts. At places, like Khajarana, Betma and Gautampura, semi-artesian conditions are also observed.

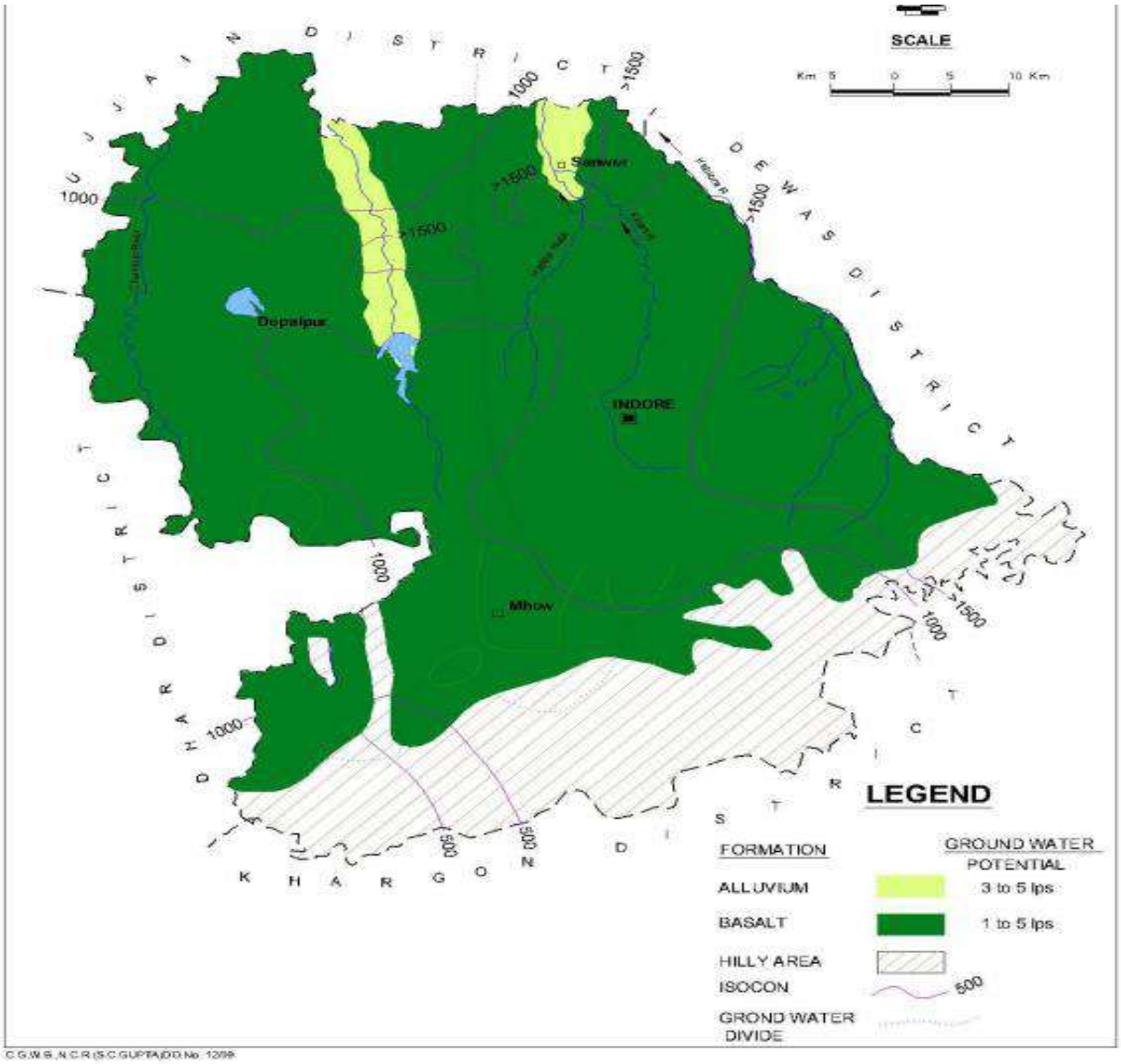



**Fig. No.2: Hydrogeological map of study area (CGWB)**

## LOCAL GEOLOGY OF STUDY AREA:

One main stratigraphic unit has been recognized in this area i.e., Basaltic Lava Flow of Malwa Plateau. Geological Survey of India (GSI) has reported as many as 42 horizontally disposed lava flows in the district. The Stratigraphic Sequence of rocks exposed in the area on regional scale is given below:

**Table 1: Stratigraphic Sequence of Rocks**

| Formation | Group | Super Group | Age |
|---|---|---|---|
| Singarchori | Malwa | Deccan Trap | Upper Cretaceous to Paleocene |
| Bargonda | | | |
| Indore | | | |
| Kankariya- Pirukhedi | | | |
| Kalisindh | | | |
| Mandaleshwar | | | |

## 5.0 SUBSURFACE INVESTIGATION BY EXPLORATORY DRILLING

The proposed tunnels T1 to T14 are explored by drilling boreholes along the alignment of tunnel at portal locations and in between part to know the subsurface conditions of the rock mass. The number of boreholes drilled at various locations is varied from place to place as per design requirement and site conditions, the details & summarized results of exploratory drilling executed at different Tunnels are tabulated below:

### 5.1 TUNNEL –T1

The proposed 4100m long tunnel is explored by drilling Fifteen no's of boreholes along the alignment of tunnel between Chainage 7540m to 11610m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T1 | BH – 1A | 7540 | 0.00 –0.50 | 0.50– 24.65 | 24.65 | 29 - 97<br>At T.G: 79 - 97 | 0 - 94<br>At T.G: 25 - 94 | 6.15 | Basalt |
| 2 | T1 | BH – 1B | 7740 | 0.00 –0.50 | 0.50– 27.00 | 27.00 | 20 - 99<br>At T.G: 86 - 90 | 0-95<br>At T.G: 26 - 83 | 7.70 | Basalt |
| 3 | T1 | BH – 1 | 8150 | 0.00 –1.50 | 1.50– 30.00 | 30.00 | 26 - 98<br>At T.G: 89 - 96 | 0 - 93<br>At T.G: 30 - 85 | 6.50 | Basalt |
| 4 | T1 | BH– 2 | 8350 | 0.00 –1.50 | 1.50 – 37.00 | 37.00 | 15 - 98<br>At T.G: 79 - 96 | 0 - 93<br>At T.G: 26 - 93 | 5.10 | Basalt |
| 5 | T1 | BH– 3 | 8550 | 0.00 –1.50 | 1.50– 47.00 | 47.00 | 24 - 99<br>At T.G: 91 - 95 | 0 - 95<br>At T.G: 48 - 90 | 3.70 | Basalt |
| 6 | T1 | BH– 4 | 8750 | 0.00 –1.50 | 1.50– 46.50 | 46.50 | 27 - 98<br>At T.G: 88 - 96 | 0 - 95<br>At T.G: 28 - 95 | 4.50 | Basalt |

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 7 | T1 | BH– 5 | 8950 | 0.00 –0.50 | 0.50– 47.00 | 47.00 | 41 - 98<br>At T.G: 87 - 98 | 0 - 97<br>At T.G: 0 - 87 | 4.0 | Basalt |
| 8 | T1 | BH– 6 | 9150 | 0.00 –0.50 | 0.50– 53.00 | 53.00 | 38 - 98<br>At T.G: 85 - 98 | 9 - 97<br>At T.G: 11 - 97 | 4.5 | Basalt |
| 9 | T1 | BH– 7 | 9350 | 0.00 | 0.00– 52.00 | 52.00 | 34 - 98<br>At T.G: 69 - 91 | 0 - 98<br>At T.G: 0 - 48 | 3.5 | Basalt |
| 10 | T1 | BH – 10 | 9970 | 0.00 –3.00 | 3.00– 69.00 | 69.00 | 38 - 98<br>At T.G: 88 - 94 | 8 - 97<br>At T.G: 35 - 79 | 17.20 | Basalts |
| 11 | T1 | BH – 11 | 10170 | 0.00 –3.00 | 3.00– 61.50 | 61.50 | 10 - 100<br>At T.G: 62 - 96 | 0 - 100<br>At T.G: 33 - 96 | 15.80 | Basalt |
| 12 | T1 | BH – 12 | 10370 | 0.00 –3.00 | 3.00– 77.00 | 77.00 | 15 - 96<br>At T.G: 80 - 96 | 0 - 96<br>At T.G:55 - 96 | 3.50 | Basalt |
| 13 | T1 | BH – 13 | 10570 | 0.00 –1.50 | 1.50– 81.00 | 81.00 | 23 - 98<br>At T.G: 87 - 91 | 0 - 97<br>At T.G: 52 - 71 | 16.90 | Basalt |
| 14 | T1 | BH – 14 | 10770 | 0.00 –1.50 | 1.50– 84.00 | 84.00 | 61 - 97<br>At T.G: 82 - 93 | 0 - 93<br>At T.G: 82 - 93 | 12.0 | Basalt |
| 15 | T1 | BH – 18 | 11570 | 0.00 –6.00 | 6.00– 36.00 | 36.00 | 19 - 100<br>At T.G: 75 - 100 | 0 - 91<br>At T.G: 29 - 91 | 4.10 | Basalt |

The bedrock in both boreholes of Tunnel-T1 encountered from shallow depth of 0.0 to 3.0m from surface which comprises of slightly weathered to moderately weathered followed by fresh Basalt which is hard & compact intact rock with good to very good core recovery & RQD at tunnel grade.

## 5.2 TUNNEL – T1A

The proposed 130m long tunnel is explored by drilling two no.'s of boreholes along the alignment of tunnel between Chainage 12560m to 12690m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T1A | BH – 1 | 12590 | 0.00 – 1.50 | 1.50– 37.00 | 37.00 | 13 - 92<br>At T.G: 33 - 92 | 0 - 83<br>At T.G: 21 - 87 | 19.50 | Basalt |
| 2 | T1A | BH – 2 | 12650 | 0.00 –3.00 | 3.00– 35.50 | 35.50 | 21 - 98<br>At T.G: 57 - 98 | 0 - 98<br>At T.G: 25 - 98 | 5.0 | Basalt |

The bedrock in both boreholes of Tunnel-T1A encountered from shallow depth of 1.50 to 3.0m from surface which comprises of highly to completely weathered rock mass at top followed by moderately weathered to fresh Basalt which is hard & compact intact rock with good to very good core recovery & fair to good RQD at tunnel grade.

## 5.3 TUNNEL – T1B

The proposed 170m long tunnel is explored by drilling two no.'s of boreholes along the alignment of tunnel between chainage 13960m to 14130m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T1B | BH-1 | 13990 | 0.00 –1.50 | 1.50– 37.00 | 37.00 | 17 - 92<br>At T.G:37 - 92 | 0 - 92<br>At T.G:0 - 92 | 25.50 | Basalt |
| 2 | T1B | BH-2 | 14090 | 0.00 –1.50 | 1.50– 30.00 | 30.00 | 23 - 91 | 0-85.3 | 10.50 | Basalt |

The bedrock in BH-1 boreholes of Tunnel-T1B encountered from near surface at 1.50m depth which comprises of moderately to highly weathered Basalt with poor to very good core recovery & very poor to good RQD at tunnel grade.

## 5.4 TUNNEL – T2

The proposed 190m long tunnel is explored by drilling Two no.'s of boreholes along the alignment of tunnel between Chainage 15380m to 15570m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T2 | BH-1 | 15410 | 0.00 –3.00 | 3.00 – 40.00 | 40.00 | 16 - 95<br>At T.G:85 - 95 | 0 - 88<br>At T.G: 58 - 88 | 19.50 | Basalt |
| 2 | T2 | BH-2 | 15510 | 0.00 –3.00 | 3.00 – 31.50 | 31.50 | 10 - 96<br>At T.G: 86 - 96 | 0 - 94<br>At T.G: 75 - 88 | 13.50 | Basalt |

**** TG = Tunnel Grade**

The bedrock in both boreholes of Tunnel-T2 encountered from 3.0m depth which comprises of moderately to highly weathered Basalt, weak & fractured rock mass at top followed by fresh to slightly weathered strong basalt with very good core recovery & RQD at tunnel grade.

## 5.5 TUNNEL – T3

The proposed 360m long tunnel is explored by drilling Two no.'s of boreholes along the alignment of tunnel between Chainage 16010m to 16370m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T3 | BH-1 | 16090 | 0.00 –1.50 | 1.50– 35.00 | 35.00 | 13 - 98<br>At T.G:79 - 98 | 0 - 95<br>At T.G: 45 - 88 | 15.25 | Basalt |

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 2 | T3 | BH-2 | 16290 | 1.50 | 44.50 | 46.00 | 15 – 97<br>At T.G: 86 - 97 | 0 – 95<br>At T.G: 58 - 95 | 21.10 | Basalt |

**** TG = Tunnel Grade**

The bedrock in borehole of Tunnel-T3 encountered from near surface at 1.5m depth which comprises of moderately to highly weathered basalt followed by slightly weathered to fresh Basalt which is hard & compact intact rock good to very good core recovery & fair to good RQD.

## 5.6 TUNNEL – T4

The proposed 530m long tunnel shall be explored by drilling two no.'s of boreholes along the alignment of tunnel between Chainage 17020m to 17550m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T4 | BH-1 | 17050 | 0.00 –1.50 | 1.50 – 25.00 | 25.00 | 25 – 92<br>At T.G: 76 –92 | 0 – 76<br>At T.G: 0 – 76 | 5.10 | Basalt |
| 2 | T4 | BH-2 | 17550 | 0.00 –3.50 | 3.50 – 40.00 | 40.00 | 40 – 99<br>At T.G: 69 –99 | 0 – 98<br>At T.G: 34 – 98 | 6.00 | Basalt |

## 5.7 TUNNEL – T5

The proposed 430m long tunnel is explored by drilling two no. of boreholes along the alignment of tunnel between Chainage 18660m to 19090m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T5 | BH-1 | 18690 | 0.00 –3.00 | 3.00 – 42.00 | 42.00 | 15 – 100<br>At T.G:90 – 99 | 0 – 97<br>At T.G: 67 – 95 | 20.0 | Basalt |
| 2 | T5 | BH-2 | 19090 | 0.00 –1.50 | 1.50 – 30.00 | 30.00 | 23 – 85<br>At T.G:43 – 85 | 0 – 51<br>At T.G: 0 – 51 | 12.50 | Basalt |

**** TG = Tunnel Grade**

The bedrock in one borehole of Tunnel-T5 encountered at 3.0m depth from surface which comprises of highly weathered to completely weathered Basalt at top followed by fresh to slightly weathered basalt rock with good to very good core recovery & RQD at the tunnel grade.

## 5.8 TUNNEL – T5A

The proposed 160m long tunnel –T5A is explored by drilling two no.'s of boreholes along the alignment of tunnel between Chainage 19880m to 20040m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T5A | BH-1 | 19880 | 0.00 –3.00 | 0.50 – 40.00 | 40.00 | 39 – 99<br>At T.G:57 – 99 | 0 – 83<br>At T.G: 11 – 83 | 11.00 | Basalt |
| 2 | T5A | BH-2 | 20040 | 0.00 –0.50 | 0.50 – 35.00 | 35.00 | 34 – 90<br>At T.G:63 – 90 | 0 – 73<br>At T.G: 0 – 73 | 14.00 | Basalt |

## 5.9 TUNNEL – T6

The proposed 300m long tunnel shall be explored by drilling two no.'s of boreholes along the alignment of tunnel between Chainage 21150m to 21450m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T6 | BH-1 | 21150 | 0.00 –1.50 | 1.50 – 40.00 | 40.00 | 27 – 85<br>At T.G: 74 – 85 | 0 – 76<br>At T.G: 16 – 76 | Not met | Basalt |
| 2 | T6 | BH-2 | 21380 | 0.00 –0.50 | 0.50 – 40.00 | 40.00 | 27 – 84<br>At T.G: 77 – 84 | 0 – 73<br>At T.G: 16 – 73 | Not met | Basalt |

## 5.10 TUNNEL – T7

The proposed 290m long tunnel is explored by drilling Two no.s of boreholes along the alignment of tunnel between Chainage 22600m to 22830m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T7 | BH-1 | 22580 | 0.00 –3.50 | 3.50 – 25.00 | 25.00 | 25 - 95<br>At T.G: 57 - 95 | 0 - 90<br>At T.G: 0 - 90 | 12.0 | Basalt |
| 2 | T7 | BH-2 | 22800 | 0.00 –7.86 | 7.86 – 41.00 | 41.00 | 17 - 100<br>At T.G: 82 - 100 | 0 - 100<br>At T.G: 65 - 100 | 25.0 | Basalt |

**** TG = Tunnel Grade**

The bedrock in borehole of Tunnel-T7 encountered from 3.50m to 7.86m depth which comprises of highly to completely weathered basalt at top followed by slightly weathered to fresh Basalt which is hard & compact intact rock poor to good core recovery & RQD at tunnel grade.

## 5.11 TUNNEL – T8

The proposed 440m long tunnel is explored by drilling two no's of boreholes along the alignment of tunnel between Chainage 27480m to 27920m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T8 | BH-1 | 27530 | 0.00 –0.50 | 0.50 – 34.00 | 34.00 | 12 - 100<br>At T.G: 91 - 100 | 0 - 96<br>At T.G: 30 - 96 | 10.0 | Basalt |
| 2 | T8 | BH-2 | 27790 | 0.00 –4.89 | 4.89 – 30.00 | 30.00 | 18 - 100<br>At T.G: 93 - 100 | 0 - 100<br>At T.G: 38 - 100 | 9.0 | Basalt |

**Note: TG = Tunnel Grade**

The bedrock in all boreholes of Tunnel-T8 encountered from near surface 0.0 - 5.0m depth which comprises of top soil followed by highly to completely weathered basalt further followed by slightly weathered to fresh Basalt which is strong & compact intact rock with good to very good core recovery & RQD at tunnel grade.

## 5.12 TUNNEL – T8A

The proposed 820m long tunnel is explored by drilling two no's of boreholes along the alignment of tunnel between Chainage 31640m to 32460m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T8A | BH-1 | 31640 | 0.00 –0.50 | 0.50 – 30.00 | 30.00 | 39 - 99<br>At T.G: 75 - 99 | 0 - 99<br>At T.G: 74 - 99 | 9.0 | Basalt |
| 2 | T8A | BH-2 | 32460 | 0.00 –1.50 | 1.5 – 25.00 | 25.00 | 39 - 90<br>At T.G: 57 - 90 | 0 - 86<br>At T.G: 0 - 86 | 2.0 | Basalt |

**Note: TG = Tunnel Grade**

The bedrock in all boreholes of Tunnel-T8A encountered from near surface 0.50 - 1.50m depth which comprises of top soil followed by highly to completely weathered basalt further followed by slightly weathered to fresh Basalt which is strong & compact intact rock with good to very good core recovery & RQD at tunnel grade.

## 5.13 TUNNEL – T9

The proposed 1470m long tunnel is explored by drilling Three no's of borehole along the alignment of tunnel between Chainage 34140m to 35610m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Mass at tunnel grade |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T9 | BH-1 | 35090 | 0.00 – 0.50 | 0.50 – 28.00 | 28.00 | 10 – 100<br>At T.G: 87 – 100 | 0 – 100<br>At T.G: 85 – 100 | 12.40 | Fresh to slightly weathered, strong, jointed, Greyish Basalt |
| 2 | T9 | BH-2 | 35325 | 0.00 – 0.50 | 0.50 – 33.50 | 33.50 | 21 – 100<br>At T.G: 84 – 100 | 0 – 87<br>At T.G: 28 – 83 | 12.40 | Fresh to slightly weathered, strong, jointed, Greyish Basalt |

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Mass at tunnel grade |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 3 | T9 | BH-3 | 35550 | 0.00 – 0.50 | 0.50 – 29.00 | 29.00 | 16 – 99<br>At T.G: 87 – 99 | 0 – 69<br>At T.G: 20 – 69 | 15.50 | Fresh to slightly weathered, strong, jointed, Greyish Basalt |

**** TG = Tunnel Grade**

The bedrock in all the drilled three boreholes of Tunnel- T9 encountered from shallow depth of 0.50m from surface which comprises of highly weathered Basalt at top followed by slightly weathered to fresh, strong basalt with good to very good core recovery & and poor to good RQD at tunnel grade except BH-1 with very good RQD.

## 5.14 TUNNEL – T9A

The proposed 250m long tunnel is explored by drilling two no.'s of boreholes along the alignment of tunnel between Chainage 36290m to 36540m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T9A | BH-1 | 36330 | 0.00 –1.50 | 1.50– 31.50 | 31.50 | 5 - 92<br>At T.G: 76 - 92 | 0 - 77<br>At T.G: 31 - 77 | Not met | Basalt |
| 2 | T9A | BH-2 | 36490 | 0.00 – 1.83 | 1.83 – 33.00 | 33.00 | 9 – 100<br>At T.G:45 – 100 | 0 – 100<br>At T.G: 9 – 99 | 27.0 | Basalt |

**** TG = Tunnel Grade**

The bedrock in both boreholes of Tunnel-T9A encountered from near surface 1.5m – 2.0m which comprises of highly weathered to fresh Basalt which is hard & compact intact rock good to very good core recovery & poor to good RQD at tunnel grade.

## 5.15 TUNNEL – T10

The proposed 400m long tunnel is explored by drilling Three no.'s of boreholes along the alignment of tunnel between Chainage 36820m to 37220m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T10 | BH-1 | 36850 | 0.00 – 0.50 | 0.50 – 35.00 | 35.00 | 27 – 100<br>At T.G: 86 – 100 | 0 – 96<br>At T.G: 74 – 96 | 7.0 | Basalt |
| 2 | T10 | BH-2 | 37040 | 0.00 – 1.95 | 1.95 – 30.00 | 35.00 | 11 – 97<br>At T.G: 21 – 97 | 0 – 87<br>At T.G: 0 – 87 | 3.0 | Basalt |
| 3 | T10 | BH-3 | 37170 | 0.00 – 0.50 | 0.50 – 36.00 | 36.00 | 16 – 100<br>At T.G: 93 - 100 | 0 – 95<br>At T.G: 81 - 95 | 10.12 | Basalt |

**** TG = Tunnel Grade**

The bedrock in all the three boreholes of Tunnel-T10 encountered from near surface which comprises of very thin layer of completely to highly weathered Basalt at top followed by slightly weathered to fresh Basalt, which is strong, hard & compact intact rock with good to very good core recovery & RQD at tunnel grade.

## 5.16 TUNNEL – T11

The proposed 810m long tunnel is explored by drilling Five no.'s of boreholes along the alignment of tunnel between Chainage 37380m to 38190m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T11 | BH-1 | 37410 | 0.00 – 1.50 | 1.50 – 33.00 | 33.00 | 11 – 100<br>At T.G: 81 – 100 | 0 – 100<br>At T.G: 81 – 100 | 8.0 | Basalt |
| 2 | T11 | BH-2 | 37600 | 0.00 – 0.50 | 0.50 – 35.00 | 35.00 | 28 – 100<br>At T.G: 65 - 100 | 0 – 100<br>At T.G: 65 - 100 | 2.0 | Basalt |
| 3 | T11 | BH-3 | 37780 | 0.00 – 0.30 | 0.30 – 54.00 | 54.00 | 30 – 100<br>At T.G: 93 - 100 | 0 – 100<br>At T.G: 67 - 100 | 8.0 | Basalt |
| 4 | T11 | BH-4 | 37950 | 0.00 –0.50 | 0.50 – 51.00 | 51.00 | 16 – 100<br>At T.G: 95 - 100 | 0 – 100<br>At T.G: 93 - 100 | 7.50 | Basalt |
| 5 | T11 | BH-5 | 38120 | 0.00 –1.88 | 1.88 – 35.00 | 35.00 | 19 – 100<br>At T.G: 78 - 100 | 0 – 100<br>At T.G: 74 - 100 | 15.0 | Basalt |

**** TG = Tunnel Grade**

The bedrock in both boreholes of Tunnel-T11 encountered from near surface which comprises of moderately to highly weathered Basalt at top followed by slightly weathered to fresh Basalt which is strong & hard & compact rock with good to very good core recovery & RQD at tunnel grade.

## 5.17 TUNNEL – T12

The proposed 1280m long tunnel explored by drilling two no.'s of boreholes along the alignment of tunnel between Chainage 38510m to 39790m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T12 | BH-1 | 38550 | 0.00 –1.90 | 1.90 – 30.00 | 30.00 | 18 - 100<br>At T.G: 46 - 100 | 0 - 97<br>At T.G: 29 - 97 | 14.0 | Basalt |
| 7 | T12 | BH-2 | 39810 | 0.00 –1.90 | 1.50 – 30.00 | 30.00 | 21 - 88<br>At T.G: 47 - 88 | 0 - 84<br>At T.G: 0 - 84 | 7.50 | Basalt |

**Note: TG = Tunnel Grade**

The bedrock in borehole of Tunnel-T12 encountered from surface which comprises of slightly weathered to fresh Basalt which is hard & compact intact rock good to very good core recovery & RQD.

## 5.18 TUNNEL – T12A

The proposed 140m long tunnel is explored by drilling two no.'s of boreholes along the alignment of tunnel between Chainage 40540m to 40680m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T12A | BH-1 | 40605 | 0.00 – 0.50 | 0.50 – 36.00 | 36.00 | 9 – 100<br>At T.G: 36 – 100 | 0 – 100<br>At T.G: 13 – 100 | 10.0 | Fresh to slightly weathered, jointed, strong, greyish basalt |
| 2 | T12A | BH-2 | 40670 | 0.00 – 0.00 | 0.00 – 34.00 | 34.00 | 10 – 100<br>At T.G: 75 – 99 | 0 – 100<br>At T.G: 15 – 99 | 12.0 | Fresh to slightly weathered, jointed, strong, greyish basalt |

**** TG = Tunnel Grade**

The bedrock in borehole of Tunnel-T12A encountered from near surface which comprises of highly weathered to fresh Basalt which is hard & compact intact rock good to very good core recovery & RQD.

## 5.19 TUNNEL – T13

The proposed 1600m long tunnel is explored by drilling Two no.'s of boreholes along the alignment of tunnel between Chainage 42800m to 44400m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T13 | BH-1 | 42910 | 0.00 - 3.45 | 3.45 – 25.00 | 25.00 | 44 - 100<br>At T.G: 87 - 100 | 0 - 100<br>At T.G: 77 - 100 | 10.0 | Basalt |
| 2 | T13 | BH-2 | 44410 | 0.00 – 1.86 | 1.86– 25.00 | 25.00 | 7 - 100<br>At T.G:70 - 100 | 0 - 95<br>At T.G:55 - 85 | 10.0 | Basalt |

**** TG = Tunnel Grades**

The bedrock in borehole of Tunnel- T13 encountered from 3.0 - 4.0m depth from surface which comprises of completely weathered to slightly weathered Basalt at top followed by fresh basalt which is hard & compact intact rock good to very good core recovery & RQD at tunnel grade.

## 5.20 TUNNEL – T14

The proposed 2290m long tunnel is explored by drilling Four no's of boreholes along the alignment of tunnel between Chainage 55700m to 57990m. The details are tabulated below:

| S. No. | Tunnel No. | BH. No. | BH. Chainage (m) | Depth(m) | | Total Depth of BH. | Range of % CR in Bedrock | Range of % RQD | Depth of water level in BH(m) | Rock Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Overburden (m) | Bed Rock (m) | | | | | |
| 1 | T14 | BH-1 | 57470 | 0.00 – 4.70 | 7.70 – 30.00 | 30.00 | 17 – 100<br>At T.G: 93 – 100 | 0 – 96<br>At T.G: 53 – 91 | Not Met with | Fresh to slightly weathered, jointed, strong, greyish basalt |
| 2 | T14 | BH-2 | 57650 | 0.00 – 1.85 | 1.85 – 35.00 | 35.00 | 11 – 100<br>At T.G: 89 – 100 | 8 – 100<br>At T.G: 51 – 100 | Not Met with | Fresh to slightly weathered, jointed, strong, greyish basalt |
| 3 | T14 | BH-3 | 57830 | 0.00 – 1.85 | 1.85 – 42.00 | 42.00 | 26 – 100<br>At T.G: 75 – 97 | 0 – 100<br>At T.G: 75 – 97 | Not Met with | Fresh to slightly weathered, jointed, strong, greyish basalt |
| 4 | T14 | BH-4 | 58010 | 0.00 – 0.50 | 0.50 – 41.50 | 41.50 | 29 – 100<br>At T.G: 60 – 100 | 0 – 100<br>At T.G: 59 – 100<br>(except 40.50 – 41.50) | Not Met with | Fresh to slightly weathered, jointed, strong, greyish basalt except 40.50 – 41.50 with moderately weathered weak to medium strong Basalt |

**Note: TG = Tunnel Grade**

The bedrock in the drilled boreholes of Tunnel-T14 encountered from near surface at 0.50m depth to 7.70m depth which comprises of highly to weathered Basalt at top followed by fresh to slightly weathered Basalt which is jointed and strong & compact intact rock with fair to very good core recovery at tunnel grade & fair to very good RQD.

## 6.0 WEATHERING GRADES OF ROCK MASS

The weathering Grade classification of rock mass by ISRM is given as under for reference and better understanding of the geological borehole logs:

**Weathering Grade of Rock Mass (ISRM 1987)**

| Term | Description | Grade |
|---|---|---|
| Fresh rock | No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces. | I |
| Slightly weathered | Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and the external surface may be somewhat weaker than in its fresh condition. | II |
| Moderately weathered | Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as continuous framework or as corestones. | III |
| Highly weathered | More than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as discontinuous framework or as corestones. | IV |
| Completely weathered | All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact. | V |
| Residual soil | All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported. | VI |

The detailed geological logs depicting the nature & characteristic of subsurface data are attached as **Annexure-I, Core photographs as Annexure-II, Field Photographs as Annexure- IV and Geological Sections as Annexure-V.**

## 7.0 LAB TEST RESULTS

Representative rock samples have been selected in the boreholes and lab testing has been done in RITES Geo-Tech laboratory & outside agency to determine various properties and engineering parameters like density, specific gravity, water absorption, uniaxial compressive strength, deformability of rock materials (Young's modulus, modulus of Deformability, stress strain curve, failure energy) IS 9221,IS 9143 and Tensile strength of rock materials(Indirect tensile strength, Brazilian Test) IS 10082. The UCS value of the rock mass is ranging from 8.92 Mpa to 366.635 Mpa.

**Lab test results of tunnels are attached as Annexure-III.**

## 8.0 GEOTECHNICAL ASSESSMENT OF TUNNELING MEDIA BASED ON SUB-SURFACE EXPLORATION

Based on sub-surface data of exploratory boreholes done at different selected locations of Tunnel-1 to Tunnel-15, geological observations in nearby area of tunnels & slope cuttings, lab test result (UCS value) and other data required to calculate RMR & Q-Value, an attempt has been made to calculate the tentative RMR & Q-values along the tunnel media.

The Q-value calculated for litho-units of study area by using the standard formula given by Dr. Nick Barton. In the similar way to the RMR system of Bieniawaski, the Q-rating is developed by assigning values to six parameters as given below:

Where $$Q = \left(\frac{RQD}{Jn}\right) \times \left(\frac{Jr}{Ja}\right) \times \left(\frac{Jw}{SRF}\right)$$

RQD = Rock Quality Designation : 10 – 100

Jn = Joint set number : 1 – 20

Jr = Joint roughness factor : 1 – 4

Ja = Joint alteration and clay fillings : 1 – 20

Jw = Joint water inflow or pressure : 0.1 – 1

SRF = Stress reduction factor : 1 – 20

**Table-2 Barton's Rock mass classification based on Q- value**

| Q-VALUE | ROCK MASS CATEGORY |
|---|---|
| 0.001 – 0.01 | Exceptionally Poor |
| 0.01 – 0.1 | Extremely poor |
| 0.1 – 1.0 | Very poor |
| 1.0 – 4.0 | Poor |
| 4.0 – 10.0 | Fair |
| 1.0 – 40.0 | Good |
| 40.0 - 100 | Very good |
| 100 - 400 | Extremely good |
| 400 - 1000 | Exceptionally good |

**Table 3 Rock mass classification based on RMR**

| Q-VALUE | ROCK MASS CATEGORY |
|---|---|
| <21 | Very Poor |
| 21-40 | Poor |
| 41-60 | Fair |
| 61-80 | Good |
| 81 -100 | Very Good |

**The inferred rock class based on RMR & Q-Value at different locations / tunnels at tunnel grade is tabulated below: -**

### 8.1 TUNNEL – T1

**Anticipated RMR & Q-value of Basalt at Tunnelling media of T1:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 8.92 – 121.34 MPa | 9 |
| $A_2$ | Rock quality Designation (RQD) | 50 - 90 % | 15 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to Rough, undulating, Fresh to slightly weathered, wall rock separation 1-5mm | 10 |
| $A_5$ | Ground water condition | Dripping to minor inflow | 7 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 46 |
| C | Rock Mass rating | 46 | |
| D | Rock class | III (Fair) | |

| | Chainage (m) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| **Tunnel -T1** | 7540 | 8200 | 1.0 - 10.0 | Poor to Fair |
| | 8200 | 11560 | 10.0 - 40.0 | Good |
| | 11600 | 11640 | 4.0 - 10.0 | Fair |

## 8.2 TUNNEL – T1A

**Anticipated RMR & Q-value of Basalt at Tunnelling media of T1A:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 32.54 – 112 MPa | 8 |
| $A_2$ | Rock quality Designation (RQD) | 35 - 75 % | 12 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough undulating, fresh to slightly weathered, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Dripping to damp | 8 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 45 |
| C | Rock Mass rating | 45 | |
| D | Rock class | III (Fair) | |

| Tunnel - T1A | Chainage (m) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 12560 | 12610 | 1.0 - 10.0 | Poor to Fair |
| | 12610 | 12630 | 10.0 - 40.0 | Good |
| | 12630 | 12680 | 1.0 - 10.0 | Poor to Fair |

## 8.3 TUNNEL – T1B

**Anticipated RMR & Q-value of Basalt at Tunnelling media of T1B:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 83.19 – 88.45 MPa | 7 |
| $A_2$ | Rock quality Designation (RQD) | 34 - 82 % | 13 |
| $A_3$ | Spacing of discontinuities | 60-600mm | 9 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough undulating, fresh to moderately weathered, wall rock separation 1-5mm | 10 |
| $A_5$ | Ground water condition | Dripping to damp | 8 |
| B | Orientation of main discontinuity of structure | Fair to Favourable | -5 |
| | | Total | 42 |

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| C | Rock Mass rating | 42 | |
| D | Rock class | III (Fair) | |

| Tunnel - T1B | Chainage (m) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 13960 | 14010 | 1.0 - 10.0 | Poor to Fair |
| | 14010 | 14070 | 4.0 - 40.0 | Fair to Good |
| | 14070 | 14120 | 1.0 - 10.0 | Poor to Fair |

## 8.4 TUNNEL – T2

**Anticipated RMR & Q-value of Basalt Tunnelling media of T2:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 38.36 – 104.255 MPa | 9 |
| $A_2$ | Rock quality Designation (RQD) | <75 - 53% | 15 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating, moderately to highly weathered, wall rock separation 1-5mm | 8 |
| $A_5$ | Ground water condition | Damp to Dry | 12 |
| B | Orientation of main discontinuity of structure | Fair to Favourable | -5 |
| | | Total | 49 |
| C | Rock Mass rating | 49 | |
| D | Rock class | III (Fair) | |

| Tunnel – T2 | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 15380 | 15430 | 1.0 - 4.0 | Poor |
| | 15430 | 15510 | 10.0 - 40.0 | Fair to Good |
| | 15510 | 15560 | 1.0 - 4.0 | Poor |

## 8.5 TUNNEL – T3

**Anticipated RMR & Q-value of Basalt Tunnelling media of T3:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 35.714 – 95.278 MPa | 7 |
| $A_2$ | Rock quality Designation (RQD) | 45 - 88 % | 13 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Rough to Slightly rough, undulating, fresh to slightly weathered, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Dripping to minor inflow | 4 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 41 |
| C | Rock Mass rating | 41 | |
| D | Rock class | III (Fair) | |

| | Chainage (m) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| **Tunnel – T3** | 16060 | 16110 | 4.0 - 10.0 | Fair |
| | 16110 | 16300 | 10.0 - 40.0 | Good |
| | 16300 | 16350 | 4.0 - 10.0 | Fair |

## 8.6 TUNNEL – T4

**Anticipated RMR & Q-value of Basalt Tunnelling media of T4:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 15.05 – 105.67 MPa | 10 |
| $A_2$ | Rock quality Designation (RQD) | 36 - 98 % | 13 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating stained, fresh to slightly weathered, wall rock separation 1-5mm | 17 |
| $A_5$ | Ground water condition | Damp to Dry | 7 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 52 |
| C | Rock Mass rating | 52 | |
| D | Rock class | III (Fair) | |

| | Chainage (m) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| **Tunnel –T4** | 17020 | 17070 | 1.0 - 10.0 | Poor to Fair |
| | 17070 | 17500 | 10.0 - 40.0 | Fair to Good |
| | 17500 | 17550 | 1.0 - 10.0 | Poor to Fair |

## 8.7 TUNNEL – T5

**Anticipated RMR & Q-value of Basalt Tunnelling media of T5:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 84.4 – 105.19 MPa | 10 |
| $A_2$ | Rock quality Designation (RQD) | 50 - 90 % | 15 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating stained, fresh to highly weathered, wall rock separation 1-5mm | 10 |
| $A_5$ | Ground water condition | Damp to Dry | 7 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 47 |
| C | Rock Mass rating | 47 | |
| D | Rock class | III (Fair) | |

| | Chainage (m) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| **Tunnel –T5** | 18660 | 18710 | 1.0 - 10.0 | Poor to Fair |
| | 18710 | 18990 | 10.0 - 40.0 | Fair to Good |
| | 18990 | 19040 | 1.0 - 10.0 | Poor to Fair |

## 8.8 TUNNEL – T5A

**Anticipated RMR & Q-value of Basalt Tunnelling media of T5A:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 15.20 – 103.5 MPa | 6 |
| $A_2$ | Rock quality Designation (RQD) | 25 - 91% | 12 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating | 13 |

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| | | stained, fresh to highly weathered, wall rock separation 1-5mm | |
| $A_5$ | Ground water condition | Damp to Dripping | 7 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 43 |
| C | Rock Mass rating | 43 | |
| D | Rock class | III (Fair) | |

| | Chainage (m) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| Tunnel – T5A | 19880 | 19930 | 1.0 - 10.0 | Poor to Fair |
| | 19930 | 18990 | 10.0 - 40.0 | Fair to Good |
| | 18990 | 20040 | 1.0 - 10.0 | Poor to Fair |

## 8.9 TUNNEL – T6

**Anticipated RMR & Q-value of Basalt Tunnelling media of T6:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 19.78 – 205.13 MPa | 10 |
| $A_2$ | Rock quality Designation (RQD) | 16 - 98 % | 14 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating stained, fresh to slightly weathered, wall rock separation 1-5mm | 15 |
| $A_5$ | Ground water condition | Damp to Dripping | 7 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 51 |
| C | Rock Mass rating | 51 | |
| D | Rock class | III (Fair) | |

| | Chainage (m) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| Tunnel –T6 | 21150 | 21200 | 1.0 - 10.0 | Poor to Fair |
| | 21200 | 21400 | 10.0 - 40.0 | Fair to Good |

| | | | | |
|---|---|---|---|---|
| | 21400 | 21450 | 1.0 - 10.0 | Poor to Fair |

## 8.10 TUNNEL – T7

**Anticipated RMR & Q-value of Basalt Tunnelling media of T7:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 32 – 68 MPa | 6 |
| $A_2$ | Rock quality Designation (RQD) | 65 - 100 % | 16 |
| $A_3$ | Spacing of discontinuities | 200 - 600mm | 10 |
| $A_4$ | Condition of discontinuities | Rough, undulating, stained, fresh to moderately weathered, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Damp to Dry | 10 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 49 |
| C | Rock Mass rating | 49 | |
| D | Rock class | III (Fair) | |

| | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| Tunnel – T7 | 22580 | 22630 | 4.0 - 10.0 | Fair |
| | 22630 | 22820 | 10.0 - 40.0 | Fair to Good |
| | 22820 | 22870 | 4.0 - 10.0 | Fair |

## 8.11 TUNNEL – T8

**Anticipated RMR & Q-value of Basalt Tunnelling media of T8:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 15 – 69 MPa | 5 |
| $A_2$ | Rock quality Designation (RQD) | 30 - 96% | 15 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating, stained to clean, fresh to highly weathered, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Dripping to Dry | 10 |

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| B | Orientation of main discontinuity of structure | Fair -5 | -5 |
| | | Total | 47 |
| C | Rock Mass rating | 47 | |
| D | Rock class | III (Fair) | |

| | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| Tunnel – T8 | 27480 | 27530 | 1.0 - 4.0 | Poor |
| | 27530 | 27870 | 4.0 - 40.0 | Fair to Good |
| | 27870 | 27920 | 1.0 - 4.0 | Poor |

## 8.12 TUNNEL – T8A

**Anticipated RMR & Q-value of Basalt Tunnelling media of T8A:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 21 – 369 MPa | 11 |
| $A_2$ | Rock quality Designation (RQD) | 75 - 99% | 18 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating, slightly stained to clean, fresh to slightly weathered, wall rock separation 0.1-1.0mm | 20 |
| $A_5$ | Ground water condition | Dripping to Dry | 10 |
| B | Orientation of main discontinuity of structure | Fair -5 | -5 |
| | | Total | 64 |
| C | Rock Mass rating | 64 | |
| D | Rock class | II (Good) | |

| | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| Tunnel – T8A | 31640 | 31700 | 1.0 - 4.0 | Poor to fair |
| | 31700 | 32400 | 4.0 - 40.0 | Fair to Good |
| | 32400 | 32460 | 1.0 - 4.0 | Poor to fair |

## 8.13 TUNNEL – T9

**Anticipated RMR & Q-value of Basalt Tunnelling media of T9:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 21.56 – 107.36 MPa | 9 |
| $A_2$ | Rock quality Designation (RQD) | <25 – 100% | 13 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Rough, undulating, fresh to highly weathered, wall rock separation 1-5mm | 9 |
| $A_5$ | Ground water condition | Dripping to Damp | 8 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 44 |
| C | Rock Mass rating | 44 | |
| D | Rock class | III (Fair) | |

| Tunnel – T9 | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 34140 | 34190 | 1.0-4.0 | Poor |
| | 34190 | 35560 | 4.0 - 40.0 | Fair to Good |
| | 35560 | 35610 | 1.0 - 10.0 | Poor to Fair |

## 8.14 TUNNEL – T9A

**Anticipated RMR & Q-value of Basalt Tunnelling media of T9A:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 46.33 – 105.78 MPa | 7 |
| $A_2$ | Rock quality Designation (RQD) | <25 - 99 % | 15 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Rough, undulating, fresh to highly weathered, wall rock separation 1-5mm | 9 |
| $A_5$ | Ground water condition | Damp to Dry | 12 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 48 |

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| C | Rock Mass rating | 48 | |
| D | Rock class | III (Fair) | |

| Tunnel – T9A | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 36290 | 36340 | 1.0-4.0 | Poor |
| | 36340 | 36490 | 4.0 - 40.0 | Fair to Good |
| | 36490 | 36540 | 1.0 - 10.0 | Poor to Fair |

## 8.15 TUNNEL – T10

**Anticipated RMR & Q-value of Basalt Tunnelling media of T10:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 29.81 – 103.96MPa | 8 |
| $A_2$ | Rock quality Designation (RQD) | <25 - 95 % | 15 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating, fresh to moderately weathered, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Dripping to damp | 8 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 48 |
| C | Rock Mass rating | 48 | |
| D | Rock class | III (Fair) | |

| Tunnel – T10 | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 36820 | 36870 | 1.0-10.0 | Poor to Fair |
| | 36870 | 37170 | 10.0 - 40.0 | Fair to good |
| | 37170 | 37220 | 1.0-10.0 | Poor to Fair |

## 8.16 TUNNEL – T11

**Anticipated RMR & Q-value of Basalt Tunnelling media of T11:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 18.49 – 112.33 MPa | 9 |
| $A_2$ | Rock quality Designation (RQD) | 65 - 100 % | 17 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Rough, undulating, fresh to slightly weathered, wall rock separation 1-5mm | 14 |
| $A_5$ | Ground water condition | Damp to Dry | 12 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 57 |
| C | Rock Mass rating | 57 | |
| D | Rock class | III (Fair) | |

| | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| Tunnel – T11 | 37380 | 37430 | 4.0 - 10.0 | Fair |
| | 37440 | 38140 | 4.0 - 40.0 | Fair to Good |
| | 38140 | 38190 | 4.0 - 10.0 | Fair |

## 8.17 TUNNEL – T12

**Anticipated RMR & Q-value of Basalt Tunnelling media of T12:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 50-100 MPa | 7 |
| $A_2$ | Rock quality Designation (RQD) | 25 - 97 % | 15 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating, slightly weathered, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Damp to Dry | 12 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 51 |
| C | Rock Mass rating | 51 | |

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| D | Rock class | III (Fair) | |

| Tunnel – T12 | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 38530 | 38580 | 1.0 - 10.0 | Poor to Fair |
| | 38580 | 39790 | 4.0 - 10.0 | Fair to Good |
| | 39790 | 39840 | 1.0 - 10.0 | Poor to Fair |

### 8.18 TUNNEL – T12A

**Anticipated RMR & Q-value of Basalt at Tunnel Grade of T12A:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 7.22 – 185.84 MPa | 8 |
| $A_2$ | Rock quality Designation (RQD) | <25 -100 % | 14 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough to rough, undulating, fresh to slightly weathered, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Damp to dry | 12 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 51 |
| C | Rock Mass rating | 51 | |
| D | Rock class | III (Fair) | |

| Tunnel – T12A | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 40590 | 40615 | 1.0-4.0 | Poor |
| | 40615 | 5920 | 4.0 - 40.0 | Fair to Good |
| | 40655 | 40680 | 4.0-10.0 | Fair |

### 8.19 TUNNEL – T13

**Anticipated RMR & Q-value of Basalt Tunnelling media of T13:**

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 50-100 MPa | 7 |
| $A_2$ | Rock quality Designation (RQD) | 50 to 100% | 16 |
| $A_3$ | Spacing of discontinuities | 200-600mm | 10 |
| $A_4$ | Condition of discontinuities | Slightly Rough, undulating, slightly weathered to fresh, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Damp to Dry | 12 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 52 |
| C | Rock Mass rating | 52 | |
| D | Rock class | III (Fair) | |

| Tunnel – T13 | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 42880 | 42930 | 1.0-4.0 | Poor |
| | 42930 | 44390 | 4.0 - 40.0 | Fair to Good |
| | 44390 | 44440 | 4.0-10.0 | Fair |

## 8.20 TUNNEL – T14

### Anticipated RMR & Q-value of Basalt Tunnelling media of T14:

| Item No. | Parameter | Condition | Rating |
|---|---|---|---|
| $A_1$ | Strength (UCS) of intact rock | 19.02 – 61.28 MPa | 6 |
| $A_2$ | Rock quality Designation (RQD) | 40-100 % | 17 |
| $A_3$ | Spacing of discontinuities | 200 - 600mm | 10 |
| $A_4$ | Condition of discontinuities | Fresh to slightly weathered, Rough, undulating, wall rock separation 1-5mm | 12 |
| $A_5$ | Ground water condition | Damp to Dry | 12 |
| B | Orientation of main discontinuity of structure | Fair | -5 |
| | | Total | 52 |
| C | Rock Mass rating | 52 | |
| D | Rock class | III (Fair) | |

| Tunnel – T14 | Chainage (Km) | | Tentative range of Q-value | Rock Class |
|---|---|---|---|---|
| | From | To | | |
| | 57400 | 57450 | 1.0 - 10.0 | Poor to Fair |
| | 57450 | 5700 | 4.0 - 40.0 | Fair to Good |
| | 57990 | 58040 | 4.0 - 10.0 | Fair |

## 3.0 CONCLUSIONS AND CONCLUSIONS

From the results of detailed geotechnical investigation in the form of exploratory drilling executed at different tunnel locations, it is concluded that:

### 3.1 TUNNEL – T1 (CH. 7540M TO 11640M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T1 revealed overburden ranging from 0.50m to 6.0m thickness followed by bedrock. The drilled bore holes have proved fair to very good core recovery in general and very poor to very good RQD but in general the rock is falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50 to 6.0m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T1 from limited sub-surface findings is 46 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 8.92 MPa to 121.34 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 3.50m to 17.20m which may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.

- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T1 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.2 TUNNEL – T1A (CH. 12560M TO 12690M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T1A revealed overburden ranging from 0.50m to 3.0m thickness followed by bedrock. The drilled bore holes have proved poor to very good core recovery in general and very poor to very good RQD but in general the rock is falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50 to 1.50m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T1A from limited sub-surface findings is 46 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 32.541 MPa to 112 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 5.0m to 19.50m which may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any,

with the tape extensometer and the support system may be revised, if needed, accordingly

- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T1A and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.3 TUNNEL – T1B (CH. 13960M TO 14130M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled borehole at T1B revealed overburden up to 1.50m thickness followed by bedrock. The drilled bore hole have proved poor to very good core recovery and very poor to very good RQD in general, the rock is falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.

- ✓ The overburden ranging upto 1.50 in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T1B from limited sub-surface findings is 42 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 83.190 MPa to 88.449 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 25.50m to may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition,

hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.

- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T1B and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.4 TUNNEL – T2 (CH. 15380M TO 15570M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T1 revealed overburden ranging upto 3.0m thickness followed by bedrock. The drilled bore holes have proved fair to very good core recovery in general and very poor to very good RQD but in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging up to 3.0m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T2 from limited sub-surface findings is 49 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 38.36 MPa to 104.25 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part

with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.

- ✓ The water table met in the borehole during drilling at depths ranging from 3.50m to 17.20m which may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.

- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T2 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.5 TUNNEL – T3 (CH. 16010M TO 16370M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T3 revealed overburden ranging up to .50m thickness followed by bedrock. The drilled bore holes have proved good to very good core recovery and fair to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging from 1.50 m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T3 from limited sub-surface findings is 41 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 35.714 MPa to 95.278 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 3.50m to 17.20m which may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the

tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.

- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T3 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.6 TUNNEL – T4 (CH. 17020M TO 17550M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T4 revealed overburden ranging from 1.50m up to 3.50m thickness followed by bedrock. The drilled bore holes have proved good to very good core recovery and fair to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging from 1.50 m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T4 from limited sub-surface findings is 52 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 15.07 MPa to 316.539 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good to very goog in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 5.10m to 6.00m which may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any,

with the tape extensometer and the support system may be revised, if needed, accordingly

- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T3 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.7 TUNNEL – T5 (CH. 18660M TO 19090M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T5 revealed overburden up to 3.0m thickness followed by bedrock. The drilled bore holes have proved fair to very good core recovery in general and fair to very good RQD at tunnel grade, in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.

- ✓ The overburden ranging from 3.0m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T1 from limited sub-surface findings is 45 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 84.429 MPa to 105.95 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good to very good in the middle part with rock class-II to I. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 20.0m depth may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition,

hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.

- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T5 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.8 TUNNEL – T5A (CH. 198800M TO 20040M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T5A revealed overburden 0.50m up to 3.0m thickness followed by bedrock. The drilled bore holes have proved fair to very good core recovery in general and poor to fair to RQD at tunnel grade, in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50m to 3.0m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T5A from limited sub-surface findings is 43 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 16.05 MPa to 103.532 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good to very good in

the middle part with rock class-II to I. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.

- ✓ The water table met in the borehole during drilling at depths ranging from 11.0- 14.0m depth may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.

- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T5 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.9 TUNNEL – T6 (CH. 21150M TO 21450M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T6 revealed overburden ranging up to 1.50m thickness followed by bedrock. The drilled bore holes have proved good to very good core recovery and poor to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50m to 1.50 m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T6 from limited sub-surface findings is 51 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 12.846 MPa to 215.136 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table not met in the boreholes during drilling, but since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the

tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.

- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T3 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.10 TUNNEL – T7 (CH. 22580M TO 22870M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T7 revealed overburden up to 7.86m thickness followed by bedrock. The drilled bore holes have proved fair to very good core recovery in general and very poor to very good RQD but in general the rock is falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50 to 6.0m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T1 from limited sub-surface findings is 46 (Class Fair/III) which may slightly vary during construction stage.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths of 25m may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull &

preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.

- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T7 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.11 TUNNEL – T8 (CH. 27480M TO 27920M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T8 revealed overburden ranging from 0.50m to 4.89m thickness followed by bedrock. The drilled bore holes have proved very good core recovery and fair to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50 to 4.86m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.

- ✓ The tentative RMR value calculated for tunnel T8 from limited sub-surface findings is 46 (Class Fair/III) which may slightly vary during construction stage.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good to very good in the middle part with rock class-II to I. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 9.0m to 10.0m may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face

logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.

- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T8 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.12 TUNNEL – T8A (CH. 27480M TO 27920M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T8A revealed overburden ranging from 0.50m to 1.50m thickness followed by bedrock. The drilled bore holes have proved very good core recovery and fair to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50 to 1.50m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T8A from limited sub-surface findings is 64 (Class Good/II) which may slightly vary during construction stage. The UCS value of samples tested in lab is varying from 15.197 Mpa to 369.901 Mpa
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good to very good in the middle part with rock class-II to I. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 2.0m to 9.0m may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the

tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.

- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.

- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T8 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.13 TUNNEL – T9 (CH. 34140M TO 35610M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T9 revealed thin overburden ranging up to 0.50m thickness followed by bedrock. The drilled bore holes have proved good to very good core recovery and poor to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to good / very good in the mid-section of the tunnel.
- ✓ The overburden ranging up to 0.50m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T9 from limited sub-surface findings is 44 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 21.56 MPa to 107.368 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good to very good in the middle part with rock class-II -I. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 12.40m to 15.50m may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.

- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T9 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.14 TUNNEL – T9A (CH. 36290M TO 36540M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.

- ✓ The drilled boreholes at T9A revealed overburden ranging from 1.50m to 1.83m thickness followed by bedrock. The drilled bore holes have proved good to very good core recovery and fair to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.
- ✓ The overburden ranging from 1.50 to 1.83m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T9A from limited sub-surface findings is 48 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 46.33 MPa to 105.78 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the one borehole during drilling at depths 27.0m may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support

measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.

- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T9A and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.15 TUNNEL – T10 (CH. 36820M TO 37220M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T10 revealed overburden ranging from 0.50m to 1.95m thickness followed by bedrock. The drilled bore holes have proved poor to very good core recovery and very poor to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50 to 1.95m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T10 from limited sub-surface findings is 48 (Class Fair/III) which may slightly vary during construction stage.

- ✓ The UCS value of rock samples tested in the lab is ranging from 29.818 MPa to 103.96 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 3.0m to 10.12m which may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face

logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.

- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T10 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.16 TUNNEL – T11 (CH. 37380M TO 38190M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T10 revealed overburden ranging from 0.30m to 1.88m thickness followed by bedrock. The drilled bore holes have proved fair to very good core recovery and very fair to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.30 to 1.88m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T11 from limited sub-surface findings is 57 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 18.49 MPa to 112.33 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good to very good in the middle part with rock class-II -I. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 2.0m to 15.0m which may be interpreted as drill water / perched water table, since the rock

mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.

- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.

- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T11 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.17 TUNNEL – T12 (CH. 38510M TO 39790M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled borehole at T12 revealed overburden ranging up to 1.90m thickness followed by bedrock. The drilled bore holes have proved fair to very good core recovery and very poor to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to very good in the mid-section of the tunnel.
- ✓ The overburden ranging upto 1.90 in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T1 from limited sub-surface findings is 51 (Class Fair/III) which may slightly vary during construction stage.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good to very good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depth of 14m may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.

- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T12 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.18 TUNNEL – T12A (CH. 40540M TO 40680M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T1 revealed overburden ranging from 0.0m to 0.50m thickness followed by bedrock. The drilled bore holes have proved poor to very good core recovery and very poor to very good RQD at tunnel grade but in general the rock is

falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.

- ✓ The overburden ranging up to 0.50m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T12A from limited sub-surface findings is 51 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 7.22 MPa to 184.85 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 10.0m to 12.0m which may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.

- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T12A and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.19 TUNNEL – T13 (CH. 42800M TO 44400M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T13 revealed overburden ranging from 1.86m to 3.45m thickness followed by bedrock. The drilled bore holes have proved good to very good core recovery and fair to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.
- ✓ The overburden ranging from 1.86m to 3.45m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T13 from limited sub-surface findings is 52 (Class Fair/III) which may slightly vary during construction stage.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally

lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.

- ✓ The water table met in the boreholes during drilling at depth of 10.0m may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.
- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.

- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T13 and devoid of any major problem except minor wedge failures and minor inflow of water.

### 3.20 TUNNEL – T14 (CH. 55700M TO 57990M)

- ✓ The major rock layers incorporated during subsurface geological studies are the brownish grey to greyish black coloured, fine to coarse-grained basalt / amygdaloidal basalt with weathering grade I to III and even IV at places.
- ✓ The drilled boreholes at T14 revealed overburden ranging from 0.50m to 4.70m thickness followed by bedrock. The drilled bore holes have proved fair to very good core recovery and fair to very good RQD at tunnel grade but in general the rock is falling in poor to fair category at near portals and fair to good in the mid-section of the tunnel.
- ✓ The overburden ranging from 0.50 to 4.70m in thickness may be interpreted as slope wash cum slope debris material with thin topsoil which is loose to semi consolidated in nature and prone to sliding.
- ✓ The tentative RMR value calculated for tunnel T14 from limited sub-surface findings is 52 (Class Fair/III) which may slightly vary during construction stage.
- ✓ The UCS value of rock samples tested in the lab is ranging from 19.02 MPa to 61.28 MPa.
- ✓ As per the limited information's obtained from drilled boreholes & information from laboratory test results, it has been seen that in the rock mass classification generally lies between poor to fair at portals with rock class- IV to III and Good in the middle part with rock class-II. During tunnelling in such formation, an adequate support system may be required concurrently during excavation.
- ✓ The water table met in the borehole during drilling at depths ranging from 3.50m to 17.20m which may be interpreted as drill water / perched water table, since the rock mass is jointed & fractured at places, therefore water seepage / minor inflow of water is anticipated in the tunnels during construction of the tunnel and may be taken into consideration while designing the tunnel & its support system.

- ✓ It is recommended to carryout long probe holes on the tunnel face to know the nature & condition of the strata and presence of water bearing horizons, if any, ahead of the tunnel face so that the safety precautions & remedial measures can be adopted as per actual site condition, or the tunnel design may be modified accordingly.
- ✓ It is recommended to provide proper drainage system in the form of systematic drainage holes all along the tunnel to drain out the water from surroundings of the tunnel periphery and to release the hydrostatic pressure, if any.
- ✓ It is recommended to install MPBX / load cells at different chainages having very weak strata and studs may also be provided for monitor the movement / deformation, if any, with the tape extensometer and the support system may be revised, if needed, accordingly
- ✓ The strata being of poor nature at places may have low stand-up time, it is therefore recommended to carry out excavation very carefully with very restricted pull & preferably in two parts i.e. heading and benching along with proper concurrent support measures. Fore poling & pipe roofing may also be used in weak / sheared rock zones before tunnel advancement.
- ✓ Due to crosscut relationship of the joints, the problem of wedge failure is anticipated during tunnelling at places and the alignment of tunnel is also running almost parallel to the strike of the rock mass at places which is not a favourable geological disposition, hence the problem of plane failure may also be anticipated which needs to be tackled while excavating the tunnel accordingly.
- ✓ Even after the detailed geological studies and geotechnical investigation, geological surprises during excavation cannot be ruled out and it is required to carry out detailed examination of the nature of rock & condition of the rock strata by day to day face logging, 3D-logging and proper analysis of instrumentation data acquired during construction stage to understand the behaviour of strata w.r.t. structure under prevailing conditions so that the suitable technology and measures can be adopted accordingly.
- ✓ The proper timing for providing designed support system after each blast (within the stand-up time of rock strata) and proper installation of instruments might have a vital role in the safe & successful completion of any tunnel / underground structure.
- ✓ As this area falls in Zone - III of the Seismic Zonation Map of India and therefore it is recommended to adopt suitable seismic co-efficient in the design of tunnel.
- ✓ Prima facie, the site seems to be favourable for proposed Tunnel T14 and devoid of any major problem except minor wedge failures and minor inflow of water.

# ANNEXURE- I

# Geological Logs

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 8150 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=581451.936 Y= 2482685.110. | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 30 M |
| **DATE OF START:** | 25.10.2022 | **DATE OF COMPLETION:** | 19.11.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.5 | Brownish silty soil with pebbles | | | | | | | | | | | | | | | | | | | Casing up to 1.0 m | | | | | NA | NA | | | | | Brownish silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | NA | NA | | | | | |
| | 3.0 | Highly weathered greyish black and yellowish brown jointed and fractured amygdaloidal basalt | | 72 | 28 | 0 | 0 | 0 | JP-15°-20°-Rg-U | | 26 | | | | | 26 | | 7 | >15 | | | | | | | NA | NA | | 12 | | | Highly weathered greyish black and yellowish brown jointed and fractured amygdaloidal basalt |
| | 4.5 | | | 77 | 23 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 32 | | | | | 32 | | 7 | >15 | | | | | | | NA | NA | | 12 | | | |
| | 6.0 | | | 61 | 39 | 0 | 0 | 0 | JP-15°-Rg-Un-Clean | | 41 | | | | | 41 | | 16 | >15 | | | | | | | NA | NA | | 9 | | | |
| | 7.5 | | | 100 | 0 | 0 | 0 | 0 | JP-15°-25°-Rg-Un-stained | | 33 | | | | | 33 | | 0 | >15 | | | | | | | NA | NA | | 11 | | | |
| | 9.0 | | | 0 | 100 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 93 | | | | | 93 | | 93 | <1 | | | | | | | NA | NA | | 8 | | | |
| | 10.5 | | | 86 | 14 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 72 | | | | | 72 | | 10 | >15 | | | | | | | NA | NA | | 9 | | | |
| | 12.0 | | | 67 | 33 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 61 | | | | | 61 | | 20 | >15 | | | | | | | NA | NA | | 10 | | | |
| | 13.5 | | | 12 | 32 | 55 | 0 | 0 | JP-45°-Rg-Un-stained | | 87 | | | | | 87 | | 76 | 5-1 | | | | | | | NA | NA | | 9 | | | |
| | 15.0 | Fresh greyish black amygdaloidal basalt with secondary minerals in filling | | 18 | 59 | 23 | 0 | | JP-45°-Rg-Un-stained | | 87 | | | | | 87 | IMP | 71 | 8-5 | NX | Uncased | Water level met at 6.50 m down | | | | NA | NA | | 8 | Not Tested | Not Tested | Fresh greyish black amygdaloidal basalt with secondary minerals in filling |
| | 16.5 | | | 12 | 69 | 18 | 0 | | JP-60°-Rg-Un-stained | | 98 | | | | | 98 | | 86 | 5-1 | | | | | | | NA | NA | | 7 | | | |
| | 18.0 | | | 58 | 42 | 0 | 0 | | JP-10°-15°-Rg-Un-stained | | 95 | | | | | 95 | | 39 | 15-8 | | | | | | | NA | NA | | 10 | | | |
| | 19.5 | | | 32 | 68 | 0 | 0 | | JP-35°-25°-Rg-Un-stained | | 84 | | | | | 84 | | 57 | 15-8 | | | | | | | NA | NA | | 9 | | | |
| | 21.0 | | | 4 | 96 | 0 | 0 | | JP-0°-20°-Rg-Un-stained | | 89 | | | | | 89 | | 85 | 5-1 | | | | | | | NA | NA | | 9 | | | |
| | 22.5 | | | 16 | 45 | 40 | 0 | | JP-0°-15°-Rg-Un-stained | | 93 | | | | | 93 | | 78 | 5-1 | | | | | | | NA | NA | | 9 | | | |
| | 24.0 | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling | | 65 | 35 | 0 | 0 | | JP-0°-Rg-Un-stained | | 95 | | | | | 95 | | 33 | 15-8 | | | | | | | NA | NA | | 11 | | | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling |
| | 25.5 | | | 48 | 52 | 0 | 0 | | JP-0°-Rg-Un-stained | | 94 | | | | | 94 | | 49 | 15-8 | | | | | | | NA | NA | | 10 | | | |
| | 27.0 | | | 37 | 45 | 18 | 0 | | JP-0°-10°-Rg-Un-stained | | 95 | | | | | 95 | | 60 | 8-5 | | | | | | | NA | NA | | 10 | | | |
| | 28.5 | Fresh greyish black amygdaloidal basalt with secondary minerals in filling | | 69 | 31 | 0 | 0 | | JP-0°-45°-Rg-Un-stained | | 96 | | | | | 96 | | 30 | 15-8 | | | | | | | NA | NA | | 8 | | | Fresh greyish black amygdaloidal basalt with secondary minerals in filling |
| | 30.0 | | | 22 | 78 | 0 | 0 | | JP-0°-45°-Rg-Un-stained | | 92 | | | | | 92 | | 72 | 8-5 | | | | | | | NA | NA | | 8 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

BASALT ROCK

WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 2 | **LOCATION:** | B2 | **CHAINAGE:-** | 8350 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=581616.181. Y= 2482570.989. | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 37 M |
| **DATE OF START:** | 14.11.2022 | **DATE OF COMPLETION:** | 7.12.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish silty soil with pebbles | | | | | | | | | | | | | | | | | | | Casing up to 3.0 m | | | | | | NA | | | | | | Brownish silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | NA | | | | | | |
| | 3.0 | Highly weathered reddish brown jointed amygdaloidal basalt with secondary mineral infillingds | | 100 | 0 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 15 | | | | | 15 | | 0 | >15 | | | | | | | NA | NA | | | 10 | | | Highly weathered greyish black and yellowish brown jointed and fractured amygdaloidal basalt |
| | 4.5 | | | 100 | 0 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 17 | | | | | 17 | | 0 | >15 | | | | | | | NA | NA | | | 10 | | | |
| | 6.0 | | | 42 | 58 | 0 | 0 | 0 | JP-15°-Rg-Un-Clean | | 38 | | | | | 38 | | 22 | >15 | | | | | | | NA | | | | 7 | | | |
| | 7.5 | | | 58 | 42 | 0 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 35 | | | | | 35 | | 14.7 | >15 | | | | | | | NA | NA | | | 7 | | | |
| | 9.0 | | | 67 | 33 | 0 | 0 | 0 | JP-40°-Rg-Un-stained | | 43 | | | | | 43 | | 14 | >15 | | | | | | | NA | NA | | | 7 | | | |
| | 10.5 | | | 12 | 61 | 27 | 0 | 0 | JP-20°-Rg-Un-stained | | 84 | | | | | 84 | | 74 | 8-5 | | | | | | | NA | NA | | | 6 | | | |
| | 12.0 | | | 19 | 58 | 24 | 0 | 0 | JP-45°-Rg-Un-stained | | 71 | | | | | 71 | | 57.3 | 8-5 | | | | | | | NA | NA | | | 6 | | | |
| | 13.5 | | | 14 | 66 | 20 | 0 | 0 | JP-30°-Rg-Un-stained | | 98 | | | | | 98 | | 84 | 5-1 | | | | | | | NA | NA | | | 6 | | | |
| | 15.0 | Fresh greyish black amygdaloidal basalt with secondary minerals in filling | | 8 | 92 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 89 | | | | | 89 | IMP | 81.3 | 5-1 | NX | Uncased | Water level met at 5.10 m down | | | | NA | NA | | | 5 | Not Tested | Not Tested | Fresh greyish black amygdaloidal basalt with secondary minerals in filling |
| | 16.5 | | | 37 | 63 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 81 | | | | | 81 | | 50.7 | 8-5 | | | | | | | NA | NA | | | 5 | | | |
| | 18.0 | | | 39 | 61 | 0 | 0 | | JP-20°-25°-Rg-Un stained | | 89 | | | | | 89 | | 54.7 | 8-5 | | | | | | | NA | | | | 6 | | | |
| | 19.5 | | | 35 | 65 | 0 | 0 | | JP-30°-45°-Rg-Un stained | | 93 | | | | | 93 | | 60 | 8-5 | | | | | | | NA | NA | | | 7 | | | |
| | 21.0 | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling | | 56 | 44 | 0 | 0 | | JP-0°-15°-Rg-Un-stained | | 63 | | | | | 63 | | 27.3 | 15-8 | | | | | | | NA | NA | | | 6 | | | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling |
| | 22.5 | | | 67 | 33 | 0 | 0 | | JP-0°-15°-Rg-Un-stained | | 79 | | | | | 79 | | 26 | 15-8 | | | | | | | NA | NA | | | 6 | | | |
| | 24.0 | | | 47 | 53 | 0 | 0 | | JP-30°-Rg-Un-stained | | 89 | | | | | 89 | | 47.3 | 15-8 | | | | | | | NA | NA | | | 6 | | | |
| | 25.5 | | | 5 | 60 | 35 | 0 | | JP-0°-Rg-Un-stained | | 98 | | | | | 98 | | 92.7 | <1 | | | | | | | NA | NA | | | 6 | | | |
| | 27.0 | | | 6 | 58 | 36 | 0 | | JP-0°-10°-Rg-Un-stained | | 93 | | | | | 93 | | 87.3 | 5-1 | | | | | | | NA | NA | | | 6 | | | |
| | 28.5 | | | 43 | 57 | 0 | 0 | | JP-0°-45°-Rg-Un-stained | | 91 | | | | | 91 | | 51.3 | 8-5 | | | | | | | NA | NA | | | 5 | | | |
| | 30.0 | | | 32 | 49 | 19 | 0 | | JP-0°-45°-Rg-Un-stained | | 96 | | | | | 96 | | 65.3 | 8-5 | | | | | | | NA | NA | | | 5 | | | |
| | 31.5 | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling | | 30 | 70 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 67 | | | | | 67 | IMP | 47 | 15-8 | NX | Uncased | ter lev el met at 5.1 0 m do | | | | NA | NA | | | 6 | Not Tested | Not Tested | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling |
| | 33.0 | | | 25 | 75 | 0 | 0 | 0 | JP-10°-15°-Rg-Un-stained | | 67 | | | | | 67 | | 50 | 8-5 | | | | | | | NA | NA | | | 6 | | | |
| | 34.5 | | | 22 | 78 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 67 | | | | | 67 | | 52 | 8-5 | | | | | | | NA | NA | | | 6 | | | |
| | 36.0 | | | 18 | 61 | 21 | 0 | 0 | JP-15°-Rg-Un-Clean | | 67 | | | | | 67 | | 55 | 8-5 | | | | | | | NA | NA | | | 6 | | | |
| | 37.0 | | | 24 | 47 | 29 | 0 | 0 | JP-20°-Rg-Un-Clean | | 100 | | | | | 100 | | 76 | 5-1 | | | | | | | NA | | | | 5 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

BASALT ROCK

WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1A | **LOCATION:** | 1A | **CHAINAGE:-** | 7540m |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=580949.753, Y=2483034.037 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 24.65 M |
| **DATE OF START:** | 5.01.2023 | **DATE OF COMPLETION:** | 28.01.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish Silty Soil with pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish Silty Soil with pebbles |
| | 2.0 | Highly weathered greyish black jointed amygdaloidal basalt with secondary mineral in filling | | 100 | 0 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 30 | | | | | 30 | | 0 | >15 | | Casing up to 2.0m | | | | | NA | | | 6 | | | Highly weathered greyish black jointed amygdaloidal basalt with secondary mineral in filling |
| | 3.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 37 | | | | | 37 | | 0 | >15 | | | | | | | NA | | | 6 | | | |
| | 5.0 | | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-Clean | | 29 | | | | | 29 | | 0 | >15 | | | | | | | NA | | | 5 | | | |
| | 6.5 | | | 100 | 0 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 27 | | | | | 27 | | 0 | >15 | | | | | | | NA | | | 6 | | | |
| | 8.0 | Moderately weathered greyish brown mygdaloidal basalt | | 80 | 20 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 51 | | | | | 51 | | 10 | >15 | | | | | | | NA | | | 6 | | | Moderately weathered greyish brown mygdaloidal basalt |
| | 9.5 | | | 41 | 59 | 0 | 0 | 0 | JP-60°-Rg-Un-stained-VJ | | 78 | | | | | 78 | | 46 | 15-8 | | | | | | | NA | | | 4 | | | |
| | 11.0 | Fresh greyish black amygdaloidal basalt with white and green in filling | | 8 | 37 | 55 | 0 | 0 | JP-30°-Rg-Un-stained | | 87 | | | | | 87 | | 81 | 5-1 | | | | | | | NA | | | 4 | | | Fresh greyish black amygdaloidal basalt with white and green in filling |
| | 12.5 | | | 31 | 69 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 87 | | | | | 87 | IMP | 60 | 8-5 | NX | | | | | | NA | | | 4 | Not Tested | Not Tested | |
| | 14.0 | | | 55 | 45 | 0 | 0 | 0 | JP-0°-stained | | 85 | | | | | 85 | | 38 | 15-8 | | Uncased | Water level met at 6.15 m down | | | | NA | | | 4 | | | |
| | 15.5 | | | 19 | 57 | 24 | 0 | 0 | JP-30°-Rg-Un-stained-VJ | | 87 | | | | | 87 | | 71 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 17.0 | | | 5 | 51 | 44 | 0 | 0 | JP-45°-Rg-Un-stained | | 97 | | | | | 97 | | 92 | <1 | | | | | | | NA | | | 4 | | | |
| | 18.5 | | | 3 | 75 | 22 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 92 | | | | | 92 | | 89 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 20.0 | | | 28 | 72 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 87 | | | | | 87 | | 63 | 15-8 | | | | | | | NA | | | 4 | | | |
| | 21.5 | | | 9 | 69 | 22 | 0 | 0 | JP-30°-Rg-Un-stained | | 88 | | | | | 88 | | 80 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 23.0 | | | 0 | 82 | 18 | 0 | 0 | JP-25°-Rg-Un-stained | | 94 | | | | | 94 | | 94 | <1 | | | | | | | NA | | | 4 | | | |
| | 24.0 | | | 68 | 32 | 0 | 0 | 0 | JP-10°-Rg-Un-stained | | 79 | | | | | 79 | | 25 | 15-8 | | | | | | | NA | | | 4 | | | |
| | 24.65 | | | 17 | 83 | 0 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 80 | | | | | 80 | | 66 | 8-5 | | | | | | | NA | | | 4 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

SLIGHTLY WEATHERED ROCK

MODERATELY WEATHERED ROCK

HIGHLY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 18 | **LOCATION:** | B18 | **CHAINAGE:-** | 11570 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=584534.557 Y= 2481238.371. | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 36 M |
| **DATE OF START:** | 23.11.2022 | **DATE OF COMPLETION:** | 19.12.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.5 | Completely weathered greyish brown Basalt | | 0 | 0 | 0 | 0 | 0 | | | | | | | | 0 | IMP | 0 | >15 | NX | Casing up to 6.0 m | | | | >100 | | | R | 10 | Not Tested | Not Tested | Completely weathered greyish brown Basalt |
| | 1.5 | | | 0 | 0 | 0 | 0 | 0 | | | | | | | | 0 | | 0 | >15 | | | | | | >100 | | | R | 10 | | | |
| | 3.0 | | | 0 | 0 | 0 | 0 | 0 | | | | | | | | 0 | | 0 | >15 | | | | | | >100 | | | R | 10 | | | |
| | 4.5 | | | 0 | 0 | 0 | 0 | 0 | | | | | | | | 0 | | 0 | >15 | | | | | | >100 | | | R | 10 | | | |
| | 6.0 | | | 0 | 0 | 0 | 0 | 0 | | | | | | | | 0 | | 0 | >15 | | | | | | >100 | | | R | 10 | | | |
| | 7.5 | Highly weathered greyish to reddsh brown jointed and fractured amygdaloidal basalt with secondary mineral infillingds | | 100 | 0 | 0 | 0 | 0 | JP-30°-40°-Rg-Un-stained | | 19 | | | | | 19 | | 0 | >15 | | | | | | | | NA | | 7 | | | Highly weathered greyish to reddsh brown jointed and fractured amygdaloidal basalt with secondary mineral infillingds |
| | 9.0 | | | 65 | 35 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 32 | | | | | 32 | | 11 | >15 | | | | | | | | NA | | 7 | | | |
| | 10.5 | | | 32 | 68 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 23 | | | | | 23 | | 15 | >15 | | | | | | | | NA | | 7 | | | |
| | 12.0 | | | 49 | 51 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 27 | | | | | 27 | | 14 | >15 | | | | | | | | NA | | 7 | | | |
| | 13.5 | | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 28 | | | | | 28 | | 0 | >15 | | | | | | | | NA | | 7 | | | |
| | 15.0 | | | 34 | 66 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 37 | | | | | 37 | | 25 | >15 | | | | | | | | NA | | 7 | | | |
| | 16.5 | | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 47 | | | | | 47 | | 0 | >15 | | | | | | | | NA | | 6 | | | |
| | 18.0 | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling | | 40 | 60 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 73 | | | | | 73 | | 44 | 15-8 | | Uncased | Water level met at 4.10 m down | | | | | NA | | 6 | | | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling |
| | 19.5 | | | 14 | 62 | 24 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 73 | | | | | 73 | | 63 | 8-5 | | | | | | | | NA | | 6 | | | |
| | 21.0 | | | 46 | 54 | 0 | 0 | 0 | JP-0°-20°-Rg-Un-stained | | 83 | | | | | 83 | | 45 | 15-8 | | | | | | | | NA | | 6 | | | |
| | 22.5 | | | 6 | 94 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 90 | | | | | 90 | | 85 | 5-1 | | | | | | | | NA | | 6 | | | |
| | 24.0 | | | 18 | 56 | 26 | 0 | 0 | JP-30°-Rg-Un-stained | | 83 | | | | | 83 | | 69 | 8-5 | | | | | | | | NA | | 5 | | | |
| | 25.5 | | | 61 | 39 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 73 | | | | | 73 | | 29 | 15-8 | | | | | | | | NA | | 5 | | | |
| | 27.0 | | | 11 | 89 | 0 | 0 | 0 | JP-0°-10°-Rg-Un-stained | | 88 | | | | | 88 | | 78 | 5-1 | | | | | | | | NA | | 5 | | | |
| | 28.5 | | | 15 | 85 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 83 | | | | | 83 | | 71 | 8-5 | | | | | | | | NA | | 5 | | | |
| | 30.0 | | | 64 | 36 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 81 | | | | | 81 | | 29 | 15-8 | | | | | | | | NA | | 6 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
BASALT ROCK
WEATHERED ROCK
COMPLETELY WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 2

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 18 | **LOCATION:** | B18 | **CHAINAGE:-** | 11570 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=584534.557 Y= 2481238.371. | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 36 M |
| **DATE OF START:** | 23.11.2022 | **DATE OF COMPLETION:** | 19.12.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 31.5 | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling | | 8 | 92 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 75 | | | | | 75 | IMP | 69 | 8-5 | NX | Uncased | Water level met at 4.1 | | | | | NA | | 5 | Not Tested | Not Tested | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling |
| | 33.0 | | | 51 | 30 | 19 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 100 | | | | | 100 | | 49 | 15-8 | | | | | | | | NA | | 5 | | | |
| | 34.5 | | | 6 | 94 | 0 | 0 | 0 | JP-0°-15°-Rg-Un-stained | | 97 | | | | | 97 | | 91 | <1 | | | | | | | | NA | | 5 | | | |
| | 36.0 | | | 45 | 55 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 93 | | | | | 93 | | 51 | 8-5 | | | | | | | | NA | | 5 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
BASALT ROCK
WEATHERED ROCK
COMPLETELY WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 3 | **LOCATION:** | B3 | **CHAINAGE:-** | 8550 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=581782.464, Y=2482459.926 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 47 M |
| **DATE OF START:** | 24.09.2022 | **DATE OF COMPLETION:** | 14.10.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Reddish Brown silty soil with pebbles | | | | | | | | | | | | | | | | | | | Casing up to 1.0 m | | | | | NA | NA | | | | | Reddish Brown silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | NA | NA | | | | | |
| | 3.0 | Highly weathered reddish brown amygdaloidal basalt with large white green in filling | | 100 | 0 | 0 | 0 | 0 | JP-0°-10°-Rg-Un-Clean | | 24 | | | | | 24 | | 0 | >15 | | | | | | | NA | NA | | 10 | | | Highly weathered reddish brown amygdaloidal basalt with large white green in filling |
| | 4.5 | | | 64 | 36 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 45 | | | | | 45 | | 16 | >15 | | | | | | | NA | NA | | 10 | | | |
| | 6.0 | Highly weathered reddish brown to greyish black jointed and fractured amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | JP-0°-10°-Rg-Un-stained | | 27 | | | | | 27 | | 0 | >15 | | | | | | | NA | | | 9 | | | Highly weathered reddish brown to greyish black jointed and fractured amygdaloidal basalt |
| | 7.5 | | | 64 | 36 | 0 | 0 | 0 | JP-0°-10°-Rg-Un-stained | | 43 | | | | | 43 | | 16 | >15 | | | | | | | NA | | | 6 | | | |
| | 9.0 | Fresh to Slightly reddish brown amygdaloidal basalt with large white green in filling | | 4 | 43 | 53 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 99 | | | | | 99 | | 95 | <1 | | | | | | | NA | | | 5 | | | Fresh to Slightly reddish brown amygdaloidal basalt with large white green in filling |
| | 10.5 | | | 8 | 48 | 44 | 0 | 0 | JP-30°-Rg-Un-stained-VJ | | 95 | | | | | 95 | | 87 | <1 | | | | | | | NA | | | 5 | | | |
| | 12.0 | | | 9 | 50 | 41 | 0 | 0 | JP-10°-30°-Rg-Un-stained | | 83 | | | | | 83 | | 75 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 13.5 | | | 3 | 27 | 70 | 0 | 0 | JP-0°-Rg-Un-stained | | 97 | | | | | 97 | | 94 | <1 | | | | | | | NA | | | 6 | | | |
| | 15.0 | | | 9 | 29 | 62 | 0 | 0 | JP-0°-stained | | 93 | | | | | 93 | | 85 | 5-1 | | | | | | | NA | | | 6 | | | |
| | 16.5 | | | 12 | 49 | 39 | 0 | 0 | JP-30°-Rg-Un-stained | | 79 | | | | | 79 | | 70 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 18.0 | Fresh reddish brown to greyish brown amygdaloidal basalt with large white green in filling | | 0 | 18 | 82 | 0 | 0 | JP-10°-Rg-Un-stained | | 93 | | | | | 93 | | 93 | <1 | | | | | | | NA | | | 5 | | | Fresh reddish brown to greyish brown amygdaloidal basalt with large white green in filling |
| | 19.5 | Fresh reddish dark brown amygdaloidal basalt with large white green in filling | | 0 | 7 | 93 | 0 | 0 | JP-30°-45°-Rg-Unstained | | 93 | | | | | 93 | | 93 | <1 | | | | | | | NA | | | 6 | | | Fresh reddish dark brown amygdaloidal basalt with large white green in filling |
| | 21.0 | | | 6 | 32 | 62 | 0 | 0 | JP-30°-45°-Rg-Unstained | | 93 | | | | | 93 | | 87 | <1 | | | | | | | NA | NA | | 5 | | | |
| | 22.5 | | | 17 | 18 | 65 | 0 | 0 | JP-45°-Rg-Un-stained | | 84 | | | | | 84 | | 70 | 5-1 | | | | | | | NA | NA | | 4 | | | |
| | 24.0 | | | 11 | 30 | 59 | 0 | 0 | JP-15°-Rg-Un-stained | | 95 | | | | | 95 | | 85 | 5-1 | | | | | | | NA | NA | | 5 | | | |
| | 25.5 | | | 6 | 13 | 81 | 0 | 0 | JP-30°-Rg-Un-stained | | 95 | | | | | 95 | | 89 | 5-1 | | | | | | | NA | NA | | 5 | | | |
| | 27.0 | | | 21 | 49 | 30 | 0 | 0 | JP-10°-20°-Rg-Un-stained | | 97 | | | | | 97 | | 77 | 5-1 | | | | | | | NA | NA | | 5 | | | |
| | 28.5 | | | 0 | 26 | 74 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 94 | | | | | 94 | | 94 | <1 | | | | | | | NA | NA | | 5 | | | |
| | 30.0 | | | 0 | 58 | 42 | 0 | 0 | JP-45°-Rg-Un-stained | | 96 | | | | | 96 | | 96 | <1 | | | | | | | NA | NA | | 6 | | | |
| | 31.5 | | | 17 | 83 | 0 | 0 | 0 | JP-15°-45°-Rg-Un-stained | | 82 | | | | | 82 | | 68 | 8-5 | | | | | | | NA | NA | | 4 | | | |
| | 33.0 | | | 4 | 23 | 73 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 90 | | | | | 90 | | 86 | 5-1 | | | | | | | NA | NA | | 6 | | | |
| | 34.5 | Fresh greyish black basalt | | 6 | 47 | 47 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 96 | | | | | 96 | | 90 | <1 | | | | | | | NA | NA | | 7 | | | Fresh greyish black basalt |
| | 36.0 | | | 6 | 28 | 66 | 0 | 0 | JP-10°-30°-Rg-Un-stained | | 89 | | | | | 89 | | 84 | 5-1 | | | | | | | NA | NA | | 6 | | | |
| | 37.5 | | | 43 | 57 | 0 | 0 | 0 | JP-15°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 52 | 8-5 | | | | | | | NA | NA | | 5 | | | |
| | 39.0 | | | 4 | 41 | 55 | 0 | 0 | JP-0°-Rg-Un-stained | | 92 | | | | | 92 | | 88 | 5-1 | | | | | | | NA | NA | | 6 | | | |
| | 40.5 | | | 44 | 56 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 85 | | | | | 85 | | 48 | 15-8 | | | | | | | NA | NA | | 7 | | | |
| | 42.0 | Fresh reddish grey amygdaloidal basalt with small white green in filling | | 4 | 51 | 45 | 0 | 0 | JP-10°-20°-Rg-Un-stained | | 91 | | | | | 91 | | 87 | 5-1 | | | | | | | NA | NA | | 7 | | | Fresh reddish grey amygdaloidal basalt with small white green in filling |
| | 43.5 | | | 18 | 64 | 18 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 93 | | | | | 93 | | 77 | 5-1 | | | | | | | NA | NA | | 6 | | | |
| | 45.0 | | | 1 | 42 | 57 | 0 | 0 | JP-10°-20°-Rg-Un-stained | | 91 | | | | | 91 | | 90 | <1 | | | | | | | NA | NA | | 7 | | | |
| | 46.0 | | | 0 | 100 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 86 | | | | | 86 | | 86 | 5-1 | | | | | | | NA | NA | | 6 | | | |
| | 47.0 | | | 7 | 44 | 49 | 0 | 0 | JP-0°-Rg-Un-stained | | 95 | | | | | 95 | | 88 | 5-1 | | | | | | | NA | | | 6 | | | |

IMP

NX

Uncased

**Water level met at 3.7 m down**

Not Tested

Not Tested

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

BASALT ROCK

WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 4 | **LOCATION:** | B4 | **CHAINAGE:-** | 8750 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=581958.985, Y=2482366.134 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 46.5 M |
| **DATE OF START:** | 24.09.2022 | **DATE OF COMPLETION:** | 12.10.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Reddish Brown silty soil with pebbles | | | | | | | | | | | | | | | | | | | | Casing up | | | | | | | NA | NA | | | | | Reddish Brown silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | NA | NA | | | | | |
| | 3.0 | Highly weathered greyish black fractured and jointed amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | | JP-15°-Rg-Un-Clean | | 27 | | | | | 27 | | 0 | >15 | | | | | | | | NA | NA | | 11 | | | Highly weathered greyish black fractured and jointed amygdaloidal basalt |
| | 4.5 | | | 7 | 93 | 0 | 0 | 0 | | JP-25°-Rg-Un-Clean | | 46 | | | | | 46 | | 43 | >15 | | | | | | | | NA | NA | | 11 | | | |
| | 6.0 | Slightly weathered greyish black amygdaloidal basalt | | 6 | 64 | 30 | 0 | 0 | | JP-20°-Rg-Un-Clean | | 80 | | | | | 80 | | 72 | 5-1 | | | | | | | | NA | | | 8 | | | |
| | 7.5 | | | 18 | 63 | 20 | 0 | 0 | | JP-0°-20°-Rg-Un-stained | | 87 | | | | | 87 | | 72 | 8-5 | | | | | | | | NA | | | 8 | | | Slightly weathered greyish black amygdaloidal basalt |
| | 9.0 | Fresh greyish black amygdaloidal basalt | | 40 | 35 | 25 | 0 | 0 | | JP-0°-30°-Rg-Un-stained | | 94 | | | | | 94 | | 56 | 8-5 | | | | | | | | NA | | | 7 | | | Fresh greyish black amygdaloidal basalt |
| | 10.5 | | | 17 | 84 | 0 | 0 | 0 | | JP-30°-Rg-Un-stained-VJ | | 87 | | | | | 87 | | 73 | 8-5 | | | | | | | | NA | | | 8 | | | |
| | 12.0 | Fresh greyish to reddish brown amygdaloidal basalt with white green in filling | | 15 | 85 | 0 | 0 | 0 | | JP-40°-Rg-Un-stained | | 95 | | | | | 95 | | 81 | 5-1 | | | | | | | | NA | | | 10 | | | Fresh greyish to reddish brown amygdaloidal basalt with white green in filling |
| | 13.5 | | | 32 | 26 | 41 | 0 | 0 | | JP-15°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 61 | 8-5 | | | | | | | | NA | | | 8 | | | |
| | 15.0 | Fresh greyish amygdaloidal basalt with large white green in filling | | 0 | 80 | 20 | 0 | 0 | | JP-45°-Rg-Un-stained | | 94 | | | | | 94 | | 94 | <1 | | | | | | | | NA | | | 6 | | | Fresh greyish amygdaloidal basalt with large white green in filling |
| | 16.5 | | | 4 | 39 | 57 | 0 | 0 | | JP-50°-Rg-Un-stained | | 98 | | | | | 98 | | 94 | <1 | | | | | | | | NA | | | 6 | | | |
| | 18.0 | Fresh greyish brown to greyish black amygdaloidal basalt with large white green in filling | | 5 | 74 | 21 | 0 | 0 | | JP-20°-Rg-Un-stained | | 92 | | | | | 92 | | 87 | 5-1 | | | | | | | | NA | | | 7 | | | Fresh greyish brown to greyish black amygdaloidal basalt with large white green in filling |
| | 19.5 | | | 25 | 28 | 48 | 0 | 0 | | JP-15°-25°-Rg-Un-stained | | 92 | | | | | 92 | | 69 | 8-5 | | | | | | | | NA | | | 7 | | | |
| | 21.0 | Fresh greyish black to brown amygdaloidal basalt with large white green in filling | | 7 | 58 | 35 | 0 | 0 | | JP-0°-Rg-Un-stained | | 91 | | | | | 91 | | 85 | 5-1 | | | | | | | | NA | | | 6 | | | Fresh greyish black to brown amygdaloidal basalt with large white green in filling |
| | 22.5 | Fresh dark brown amygdaloidal basalt with secondary mineral in filling | | 16 | 65 | 19 | 0 | 0 | | JP-0°-Rg-Un-stained | | 97 | | | | | 97 | IMP | 81 | 5-1 | NX | Uncased | | | | | | NA | | | 5 | Not Tested | Not Tested | Fresh dark brown amygdaloidal basalt with secondary mineral in filling |
| | 24.0 | Fresh dark brown to greyish brown amygdaloidal basalt with secondary mineral in filling | | 3 | 62 | 35 | 0 | 0 | | JP-0°-Rg-Un-stained | | 97 | | | | | 97 | | 94 | <1 | | | | | | | | NA | | | 7 | | | Fresh dark brown to greyish brown amygdaloidal basalt with secondary mineral in filling |
| | 25.5 | Fresh greyish brown amygdaloidal basalt with secondary mineral in filling | | 20 | 80 | 0 | 0 | 0 | | JP-60°-Rg-Un-stained | | 80 | | | | | 80 | | 64 | 8-5 | | | Water level met at 4.5 m down | | | | | NA | | | 6 | | | Fresh greyish brown amygdaloidal basalt with secondary mineral in filling |
| | 27.0 | Fresh greyish black to brown amygdaloidal basalt with small white green in filling | | 4 | 53 | 43 | 0 | 0 | | JP-60°-Rg-Un-stained | | 91 | | | | | 92 | | 88 | 5-1 | | | | | | | | NA | | | 7 | | | Fresh greyish black to brown amygdaloidal basalt with small white green in filling |
| | 28.5 | | | 10 | 71 | 19 | 0 | 0 | | JP-45°-60°-Rg-Un-stained | | 98 | | | | | 98 | | 89 | 5-1 | | | | | | | | NA | | | 6 | | | |
| | 30.0 | | | 0 | 31 | 69 | 0 | 0 | | JP-30°-Rg-Un-stained | | 93 | | | | | 93 | | 93 | <1 | | | | | | | | NA | | | 6 | | | |
| | 31.5 | | | 0 | 8 | 92 | 0 | 0 | | JP-30°-45°-Rg-Un-stained | | 92 | | | | | 92 | | 92 | <1 | | | | | | | | NA | | | 5 | | | |
| | 33.0 | | | 15 | 40 | 44 | 0 | 0 | | JP-0°-20°-Rg-Un-stained | | 89 | | | | | 89 | | 75 | 5-1 | | | | | | | | NA | | | 7 | | | |
| | 34.5 | | | 5 | 95 | 0 | 0 | 0 | | JP-15°-20°-Rg-Un-stained | | 94 | | | | | 94 | | 89 | 5-1 | | | | | | | | NA | | | 7 | | | |
| | 36.0 | | | 30 | 49 | 20 | 0 | 0 | | JP-30°-45°-Rg-Un-stained | | 97 | | | | | 97 | | 67 | 8-5 | | | | | | | | NA | | | 7 | | | |
| | 37.5 | Fresh dark brown to reddish grey amygdaloidal basalt with small white green in filling | | 15 | 66 | 19 | 0 | 0 | | JP-15°-20°-Rg-Un-stained | | 96 | | | | | 96 | | 82 | 5-1 | | | | | | | | NA | | | 7 | | | Fresh dark brown to reddish grey amygdaloidal basalt with small white green in filling |
| | 39.0 | | | 11 | 66 | 23 | 0 | 0 | | JP-0°-20°-Rg-Un-stained | | 93 | | | | | 94 | | 83 | 5-1 | | | | | | | | NA | | | 6 | | | |
| | 40.5 | | | 0 | 65 | 35 | 0 | 0 | | JP-15°-30°-Rg-Un-stained | | 95 | | | | | 95 | | 95 | <1 | | | | | | | | NA | | | 6 | | | |
| | 42.0 | | | 2 | 34 | 64 | 0 | 0 | | JP-10°-20°-Rg-Un-stained | | 92 | | | | | 92 | | 90 | <1 | | | | | | | | NA | | | 7 | | | |
| | 43.5 | Fresh dark grey amygdaloidal basalt with small green in filling | | 12 | 57 | 31 | 0 | 0 | | JP-15°-25°-Rg-Un-stained | | 96 | | | | | 96 | | 85 | 5-1 | | | | | | | | NA | | | 7 | | | Fresh dark grey amygdaloidal basalt with small green in filling |
| | 45.0 | | | 39 | 61 | 0 | 0 | 0 | | JP-10°-20°-Rg-Un-stained | | 88 | | | | | 88 | | 54 | 8-5 | | | | | | | | NA | NA | | 7 | | | |
| | 46.5 | | | 70 | 30 | 0 | 0 | 0 | | JP-15°-20°-Rg-Un-stained | | 93 | | | | | 93 | | 28 | 15-8 | | | | | | | | NA | | | 6 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

SLIGHTLY WEATHERED ROCK

BASALT ROCK

WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 5 | **LOCATION:** | B5 | **CHAINAGE:-** | 8950 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=582143.389, Y=2482288.751 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 47 M |
| **DATE OF START:** | 18.10.2022 | **DATE OF COMPLETION:** | 12.11.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.5 | Reddish Brown silty soil with pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Reddish Brown silty soil with pebbles |
| | 2.0 | Highly weathered greyish black jointed and fractured amygdaloidal basalt | | 84 | 16 | 0 | 0 | 0 | | JP-25°-Rg-Un-Clean | | 41 | | | | | 41 | IMP | 7 | >15 | NX | Casing up to 1.0 m | Water level met at 4.0 m down | | Uncased | | NA | NA | | 11 | Not Tested | Not Tested | Highly weathered greyish black jointed and fractured amygdaloidal basalt |
| | 3.5 | | | 83 | 17 | 0 | 0 | 0 | | JP-15°-Rg-Un-Clean | | 51 | | | | | 51 | | 9 | >15 | | | | | | | NA | | | 10 | | | |
| | 5.0 | | | 35 | 65 | 0 | 0 | 0 | | JP-45°-Rg-Un-Clean | | 69 | | | | | 69 | | 45 | 15-8. | | | | | | | NA | | | 9 | | | |
| | 6.5 | Moderately weathered greyish black amygdaloidal basalt | | 45 | 55 | 0 | 0 | 0 | | JP-25°-Rg-Un-Clean | | 67 | | | | | 67 | | 37 | 15-8. | | | | | | | NA | | | 9 | | | Moderately weathered greyish black amygdaloidal basalt |
| | 8.0 | | | 25 | 34 | 41 | 0 | 0 | | JP-20°-Rg-Un-stained | | 79 | | | | | 79 | | 59 | 8-5. | | | | | | | NA | | | 8 | | | |
| | 9.5 | | | 3 | 59 | 38 | 0 | 0 | | JP-10°-Rg-Un-stained | | 89 | | | | | 89 | | 87 | 5-1. | | | | | | | NA | | | 6 | | | |
| | 11.0 | | | 35 | 39 | 26 | 0 | 0 | | JP-30°-Rg-Un-stained-VJ | | 83 | | | | | 83 | | 54 | 8-5. | | | | | | | NA | | | 8 | | | |
| | 12.5 | Fresh Greyish to Reddish Brown amygdaloidal basalt with large white green in filling | | 5 | 19 | 76 | 0 | 0 | | JP-45°-Rg-Un-stained | | 89 | | | | | 89 | | 85 | 5-1. | | | | | | | NA | | | 5 | | | Greyish to Reddish Brown amygdaloidal basalt with large white green in filling |
| | 14.0 | | | 0 | 39 | 61 | 0 | 0 | | JP-15°-Rg-Un-stained | | 93 | | | | | 93 | | 93 | <1 | | | | | | | NA | | | 6 | | | |
| | 15.5 | Fresh Reddish brown to Dark greyish brown amygdaloidal basalt with large white green in filling | | 7 | 93 | 0 | 0 | 0 | | JP-0°-stained | | 89 | | | | | 89 | | 82 | 5-1. | | | | | | | NA | | | 5 | | | Reddish brown to Dark greyish brown amygdaloidal basalt with large white green in filling |
| | 17.0 | | | 0 | 100 | 0 | 0 | 0 | | JP-0°-stained | | 97 | | | | | 97 | | 97 | <1 | | | | | | | NA | | | 5 | | | |
| | 18.5 | Fresh Dark greyish brown amygdaloidal basalt with secondary mineral in filling | | 12 | 88 | 0 | 0 | 0 | | JP-10°-Rg-Un-stained | | 91 | | | | | 91 | | 80 | 5-1. | | | | | | | NA | | | 6 | | | Dark greyish brown Fresh amygdaloidal basalt with secondary mineral in filling |
| | 20.0 | | | 12 | 88 | 0 | 0 | 0 | | JP-15°-25°-Rg-Un-stained | | 93 | | | | | 93 | | 82 | 5-1. | | | | | | | NA | | | 6 | | | |
| | 21.5 | | | 16 | 84 | 0 | 0 | 0 | | JP-15°-20°-Rg-Un-stained | | 94 | | | | | 94 | | 79 | 5-1. | | | | | | | NA | | | 7 | | | |
| | 23.0 | | | 5 | 76 | 19 | 0 | 0 | | JP-30°-Rg-Un-stained | | 97 | | | | | 97 | | 91 | <1 | | | | | | | NA | | | 5 | | | |
| | 24.5 | | | 45 | 55 | 0 | 0 | 0 | | JP-45°-Rg-Un-stained | | 93 | | | | | 93 | | 51 | 8-5. | | | | | | | NA | | | 5 | | | |
| | 26.0 | | | 8 | 52 | 40 | 0 | 0 | | JP-30°-Rg-Un-stained | | 84 | | | | | 84 | | 77 | 5-1. | | | | | | | NA | | | 7 | | | |
| | 27.5 | | | 22 | 24 | 54 | 0 | 0 | | JP-10°-20°-Rg-Un-stained | | 93 | | | | | 93 | | 72 | 8-5. | | | | | | | NA | | | 7 | | | |
| | 29.0 | | | 25 | 75 | 0 | 0 | 0 | | JP-15°-30°-Rg-Un-stained | | 93 | | | | | 93 | | 70 | 8-5. | | | | | | | NA | | | 7 | | | |
| | 30.5 | | | 28 | 53 | 19 | 0 | 0 | | JP-10°-20°-Rg-Un-stained | | 92 | | | | | 92 | | 66 | 8-5. | | | | | | | NA | | | 7 | | | |
| | 32.0 | | | 3 | 21 | 76 | 0 | 0 | | JP-0°-Rg-Un-stained | | 97 | | | | | 97 | | 94 | <1 | | | | | | | NA | | | 6 | | | |
| | 33.5 | Fresh greyish black amygdaloidal basalt with secondary mineral in filling | | 9 | 50 | 41 | 0 | 0 | | JP-10°-25°-Rg-Un-stained | | 89 | | | | | 89 | | 81 | 5-1. | | | | | | | NA | | | 7 | | | Greyish black Fresh amygdaloidal basalt with secondary mineral in filling |
| | 35.0 | | | 16 | 65 | 19 | 0 | 0 | | JP-15°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 77 | 5-1. | | | | | | | NA | | | 8 | | | |
| | 36.5 | Fresh Greyish black to Greyish brown amygdaloidal basalt with secondary mineral in filling | | 6 | 58 | 36 | 0 | 0 | | JP-10°-20°-Rg-Un-stained | | 97 | | | | | 97 | | 91 | <1 | | | | | | | NA | | | 5 | | | Greyish black to Greyish brown Fresh amygdaloidal basalt with secondary mineral in filling |
| | 38.0 | | | 20 | 38 | 42 | 0 | 0 | | JP-15°-30°-Rg-Un-stained | | 92 | | | | | 92 | | 73 | 8-5. | | | | | | | NA | | | 5 | | | |
| | 39.5 | | | 29 | 71 | 0 | 0 | 0 | | JP-10°-20°-Rg-Un-stained | | 93 | | | | | 93 | | 66 | 8-5. | | | | | | | NA | | | 7 | | | |
| | 41.0 | | | 13 | 87 | 0 | 0 | 0 | | JP-15°-20°-Rg-Un-stained | | 87 | | | | | 87 | | 76 | 5-1. | | | | | | | NA | | | 7 | | | |
| | 42.5 | | | 12 | 88 | 0 | 0 | 0 | | JP-10°-30°-Rg-Un-stained | | 98 | | | | | 98 | | 87 | 5-1. | | | | | | | NA | | | 5 | | | |
| | 44.0 | | | 43 | 32 | 25 | 0 | 0 | | JP-15°-45°-Rg-Un-stained | | 87 | | | | | 87 | | 49 | 15-8. | | | | | | | NA | | | 5 | | | |
| | 45.5 | | | 56 | 22 | 22 | 0 | 0 | | JP-10°-25°-Rg-Un-stained | | 95 | | | | | 95 | | 41 | 15-8. | | | | | | | NA | | | 5 | | | |
| | 47.0 | | | 100 | 0 | 0 | 0 | 0 | | JP-15°-20°-Rg-Un-stained | | 90 | | | | | 90 | | 0 | >15 | | | | | | | NA | | | 4 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

BASALT ROCK

WEATHERED ROCK

MODERATELY WEATHERED ROCK

| **Logged By:** | **Checked By:** |
|---|---|

## GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 6 | **LOCATION:** | B6 | **CHAINAGE:-** | 9150 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=582328.594. Y= 2482213.259 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 53 M |
| **DATE OF START:** | 19.10.2022 | **DATE OF COMPLETION:** | 23.11.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish silty soil with pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish silty soil with pebbles |
| | 1.5 | Highly weathered greyish brown jointed amygdaloidal basalt with secondary mineral infillings | | 74 | 26 | 0 | 0 | 0 | JP-60°-Rg-Un-Clean | | 38 | | | | | 38 | | 10 | >15 | | | | | | | NA | NA | | 12 | | | Highly weathered greyish brown jointed amygdaloidal basalt with secondary mineral infillings |
| | 3.0 | | | 78 | 22 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 43 | | | | | 43 | | 9 | >15 | | | | | | | NA | NA | | 12 | | | |
| | 4.5 | | | 20 | 80 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 71 | | | | | 71 | | 57 | 8-5 | | | | | | | NA | NA | | 10 | | | |
| | 6.0 | Fresh to slightly weathered greyish black amygdaloidal basalt with secondary mineral infillings | | 9 | 91 | 0 | 0 | 0 | JP-45°-Rg-Un-Clean | | 99 | | | | | 99 | | 90 | <1 | | | | | | | NA | | | 7 | | | Fresh to slightly weathered greyish black amygdaloidal basalt with secondary mineral infillings |
| | 7.5 | | | 0 | 21 | 79 | 0 | 0 | JP-25°-30°-Rg-Un stained | | 97 | | | | | 97 | | 97 | <1 | | | | | | | NA | | | 7 | | | |
| | 9.0 | | | 0 | 59 | 41 | 0 | 0 | JP-45°-Rg-Un-stained | | 91 | | | | | 91 | | 91 | <1 | | | | | | | NA | | | 7 | | | |
| | 10.5 | | | 0 | 43 | 57 | 0 | 0 | JP-15°-Rg-Un-stained | | 95 | | | | | 95 | | 95 | <1 | | | | | | | NA | | | 7 | | | |
| | 12.0 | | | 16 | 45 | 38 | 0 | 0 | JP-45°-Rg-Un-stained | | 97 | | | | | 97 | | 81 | 5-1 | | | | | | | NA | | | 7 | | | |
| | 13.5 | | | 33 | 18 | 50 | 0 | 0 | JP-15°-Rg-Un-stained | | 98 | | | | | 98 | | 66 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 15.0 | | | 33 | 24 | 43 | 0 | 0 | JP-30°-Rg-Un-stained | | 98 | | | | | 98 | | 65 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 16.5 | | | 59 | 9 | 31 | 0 | 0 | JP-45°-Rg-Un-stained | | 72 | | | | | 72 | | 29 | 15-8 | | | | | | | NA | | | 9 | | | |
| | 18.0 | Fresh to slightly weathered greyish black to redddish brown amygdaloidal basalt with secondary mineral in fillings | | 28 | 72 | 0 | 0 | 0 | JP-30°-60°-Rg-Un stained | | 94 | | | | | 94 | | 68 | 8-5 | | | | | | | NA | | | 8 | | | Fresh to slightly weathered greyish black to redddish brown amygdaloidal basalt with secondary mineral in fillings |
| | 19.5 | | | 23 | 77 | 0 | 0 | 0 | JP-30°-45°-Rg-Un stained | | 91 | | | | | 91 | | 70 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 21.0 | | | 16 | 52 | 32 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 76 | 5-1 | | | | | | | NA | | | 9 | | | |
| | 22.5 | | | 13 | 44 | 44 | 0 | 0 | JP-0°-25°-Rg-Un-stained | | 93 | | | | | 93 | | 81 | 5-1 | | | | | | | NA | | | 8 | | | |
| | 24.0 | | | 0 | 100 | 0 | 0 | 0 | JP-15°-Rg-Un-stained | | 93 | | | | | 93 | | 93 | <1 | | | | | | | NA | | | 7 | | | |
| | 25.5 | | | 12 | 88 | 0 | 0 | 0 | JP-25°-Rg-Un-stained | | 98 | | | | | 98 | | 86 | 5-1 | | | | | | | NA | | | 8 | | | |
| | 27.0 | | | 9 | 91 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 83 | 5-1 | | | | | | | NA | | | 8 | | | |
| | 28.5 | | | 16 | 61 | 23 | 0 | 0 | JP-0°-60°-Rg-Un-stained | | 93 | | | | | 93 | | 78 | 5-1. | | | | | | | NA | | | 7 | | | |
| | 30.0 | | | 32 | 46 | 22 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 85 | | | | | 85 | | 57 | 8-5. | | | | | | | NA | | | 7 | | | |

IMP

NX

Uncased

Water level met at 4.5 m down

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

HIGHLY WEATHERED ROCK

**Logged By:**

**Checked By:**

## GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 2

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 6 | **LOCATION:** | B6 | **CHAINAGE:-** | 9150 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=582328.594. Y= 2482213.259 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 53 M |
| **DATE OF START:** | 19.10.2022 | **DATE OF COMPLETION:** | 23.11.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 31.5 | Fresh to slightly weathered greyish black to redddish brown amygdaloidal basalt with secondary mineral in fillings | | 21 | 79 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 91 | | | | | 91 | | 72 | 8-5 | | | | | | | NA | | | 9 | | | Fresh to slightly weathered greyish black to redddish brown amygdaloidal basalt with secondary mineral in fillings |
| | 33.0 | | | 40 | 60 | 0 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 90 | | | | | 90 | | 54 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 34.5 | | | 33 | 49 | 18 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 93 | | | | | 93 | | 63 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 36.0 | | | 22 | 60 | 18 | 0 | 0 | JP-20°-Rg-Un-Clean | | 93 | | | | | 93 | | 72 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 37.5 | | | 33 | 47 | 20 | 0 | 0 | JP-30°-35°-Rg-Un-stained | | 85 | | | | | 85 | | 57 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 39.0 | | | 19 | 35 | 46 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 89 | | | | | 89 | | 72 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 40.5 | Fresh to slightly weathered greyish black to greyish brown amygdaloidal basalt withsecondary mineral in fillings | | 6 | 66 | 28 | 0 | 0 | JP-60°-Rg-Un-Clean | | 90 | | | | | 90 | | 85 | 5-1 | | | | | | | NA | | | 8 | | | Fresh to slightly weathered greyish black to greyish brown amygdaloidal basalt withsecondary mineral in fillings |
| | 42.0 | | | 46 | 9 | 45 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 89 | | | | | 89 | | 48 | 15-8 | | | | | | | NA | | | 9 | | | |
| | 43.5 | | | 38 | 22 | 40 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 85 | | | | | 85 | | 53 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 45.0 | | | 18 | 82 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 97 | | | | | 97 | | 79 | 5-1 | | | | | | | NA | | | 9 | | | |
| | 46.5 | | | 6 | 94 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 92 | | | | | 92 | | 87 | 5-1 | | | | | | | NA | | | 7 | | | |
| | 48.0 | | | 68 | 32 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 89 | | | | | 89 | | 29 | 15-8 | | | | | | | NA | | | 9 | | | |
| | 49.5 | | | 48 | 52 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 93 | | | | | 93 | | 48 | 15-8 | | | | | | | NA | | | 9 | | | |
| | 51.0 | | | 0 | 81 | 19 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 97 | | | | | 97 | | 97 | <1 | | | | | | | NA | | | 8 | | | |
| | 52.0 | | | 38 | 62 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 98 | | | | | 98 | | 61 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 53.0 | | | 89 | 11 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 96 | | | | | 96 | | 11 | >15 | | | | | | | NA | | | 10 | | | |

IMP

NX

Uncased

Water level met at 4.5 m down

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

HIGHLY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 7 | **LOCATION:** | B7 | **CHAINAGE:-** | 9350 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=582513.799, Y=2482137.766 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 52 M |
| **DATE OF START:** | 25.09.2022 | **DATE OF COMPLETION:** | 22.10.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 1.5 | Highly weathered greyish black jointed and fractured amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | JP-15°-Rg-Un-Clean | | 34 | | | | | 34 | | 0 | >15 | | ng up to | | | | | | | NA | 11 | | | Highly weathered greyish black jointed and fractured amygdaloidal basalt |
| | 3.0 | | | 69 | 31 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 41 | | | | | 41 | | 13 | >15 | | | | | | | | NA | NA | 10 | | | |
| | 4.5 | | | 33 | 67 | 0 | 0 | 0 | JP-25°-Rg-Un-Clean | | 53 | | | | | 53 | | 35 | 15-8 | | | | | | | | NA | | 10 | | | |
| | 6.0 | Moderately weathered greyish black jointed amygdaloidal basalt | | 72 | 28 | 0 | 0 | 0 | JP-60°-Rg-Un-Clean | | 65 | | | | | 65 | | 18 | >15 | | | | | | | | NA | | 9 | | | Moderately weathered greyish black jointed amygdaloidal basalt |
| | 7.5 | Slightly weathered greyish black amygdaloidal basalt | | 27 | 73 | 0 | 0 | 0 | JP-10°-20°-Rg-Unstained | | 88 | | | | | 88 | | 65 | 8-5 | | | | | | | | NA | | 8 | | | Slightly weathered greyish black amygdaloidal basalt |
| | 9.0 | Fresh greyish black amygdaloidal basalt | | 16 | 51 | 33 | 0 | 0 | JP-20°-Rg-Un-stained | | 90 | | | | | 90 | | 75 | 5-1 | | | | | | | | NA | | 7 | | | Fresh greyish black amygdaloidal basalt |
| | 10.5 | Slightly weathered greyish black amygdaloidal basalt | | 16 | 84 | 0 | 0 | 0 | JP-30°-Rg-Un-stained-VJ | | 74 | | | | | 74 | | 62 | 8-5 | | | | | | | | NA | | 6 | | | Slightly weathered greyish black amygdaloidal basalt |
| | 12.0 | Fresh greyish to reddish brown amygdaloidal basalt with secondary mineral in filling | | 6 | 26 | 68 | 0 | 0 | JP-50°-Rg-Un-stained | | 94 | | | | | 94 | | 89 | 5-1 | | | | | | | | NA | | 8 | | | Fresh greyish to reddish brown amygdaloidal basalt with secondary mineral in filling |
| | 13.5 | | | 0 | 0 | 100 | 0 | 0 | JP-0°-Rg-Un-stained | | 98 | | | | | 98 | | 98 | <1 | | | | | | | | NA | | 6 | | | |
| | 15.0 | Slightly weathered reddish brown to greyish black amygdaloidal basalt with secondary mineral in filling | | 26 | 40 | 34 | 0 | 0 | JP-0°-30°-Rg-Unstained | | 83 | | | | | 83 | | 61 | 8-5 | | | | | | | | NA | | 7 | | | Slightly weathered reddish brown to greyish black amygdaloidal basalt with secondary mineral in filling |
| | 16.5 | Fresh greyish black amygdaloidal basalt with secondary mineral in filling | | 27 | 73 | 0 | 0 | 0 | JP-45°-Rg-Un-stained-VJ | | 91 | | | | | 91 | | 67 | 8-5 | | | | | | | | NA | | 5 | | | Fresh greyish black amygdaloidal basalt with secondary mineral in filling |
| | 18.0 | | | 53 | 47 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 85 | | | | | 85 | | 41 | 15-8 | | | | | | | | NA | | 5 | | | |
| | 19.5 | Fresh greyish black amygdaloidal basalt with small white green in filling | | 3 | 55 | 42 | 0 | 0 | JP-45°-60°-Rg-Unstained | | 91 | | | | | 91 | | 89 | 5-1 | | | | | | | | NA | | 6 | | | Fresh greyish black amygdaloidal basalt with small white green in filling |
| | 21.0 | | | 26 | 49 | 25 | 0 | 0 | JP-0°-Rg-Un-stained | | 85 | | | | | 85 | | 63 | 8-5 | | | | | | | | NA | | 6 | | | |
| | 22.5 | | | 9 | 70 | 21 | 0 | 0 | JP-45°-Rg-Un-stained | | 91 | | | | | 91 | | 83 | 5-1 | | | | | | | | NA | | 5 | | | |
| | 24.0 | Fresh reddish grey amygdaloidal basalt with small white green in filling | | 21 | 56 | 23 | 0 | 0 | JP-30°-Rg-Un-stained | | 98 | | | | | 98 | | 78 | 5-1 | | | | | | | | NA | | 6 | | | Fresh reddish grey amygdaloidal basalt with small white green in filling |
| | 25.5 | Fresh greyish black amygdaloidal basalt with small white green in filling | | 0 | 77 | 23 | 0 | 0 | JP-60°-Rg-Un-stained | | 87 | | | | | 87 | | 87 | 5-1 | | | | | | | | NA | | 6 | | | Fresh greyish black amygdaloidal basalt with small white green in filling |
| | 27.0 | | | 35 | 65 | 0 | 0 | 0 | JP-60°-Rg-Un-stained | | 93 | | | | | 93 | | 60 | 8-5 | | | | | | | | NA | | 6 | | | |
| | 28.5 | | | 59 | 23 | 18 | 0 | 0 | JP-15°-30°-Rg-Unstained | | 95 | | | | | 95 | | 39 | 15-8 | | | | | | | | NA | | 5 | | | |
| | 30.0 | | | 62 | 16 | 22 | 0 | 0 | JP-0°-Rg-Un-stained | | 93 | | | | | 93 | | 35 | 15-8 | | | | | | | | NA | | 5 | | | |
| | 31.5 | Fresh greyish black fractured and jointed basalt | | 24 | 53 | 23 | 0 | 0 | JP-0°-Rg-Un-stained | | 90 | | | | | 90 | | 69 | 8-5 | | | | | | | | NA | | 6 | | | Fresh greyish black fractured and jointed basalt |
| | 33.0 | Fresh greyish black jointed basalt | | 40 | 60 | 0 | 0 | 0 | JP-30°-45°-Rg-Unstained | | 93 | | | | | 93 | | 55 | 8-5 | | | | | | | | NA | | 6 | | | Fresh greyish black jointed basalt |
| | 34.5 | | | 52 | 48 | 0 | 0 | 0 | JP-15°-45°-Rg-Unstained | | 89 | | | | | 89 | | 43 | 15-8 | | | | | | | | NA | | 5 | | | |
| | 36.0 | Fresh reddish grey amygdaloidal basalt with small white green in filling | | 92 | 8 | 0 | 0 | 0 | JP-10°-20°-Rg-Unstained | | 97 | | | | | 97 | | 7 | >15 | | | | | | | | NA | | 4 | | | Fresh reddish grey amygdaloidal basalt with small white green in filling |
| | 37.5 | | | 85 | 15 | 0 | 0 | 0 | JP-15°-30°-Rg-Unstained | | 97 | | | | | 97 | | 15 | >15 | | | | | | | | NA | | 4 | | | |
| | 39.0 | Moderately weathered greyish black jointed basalt | | 65 | 35 | 0 | 0 | 0 | JP-10°-20°-Rg-Unstained | | 67 | | | | | 67 | | 24 | >15 | | | | | | | | NA | | 4 | | | Moderately weathered greyish black jointed basalt |
| | 40.5 | Slightly weathered greyish black fractured & jointed basalt | | 91 | 9 | 0 | 0 | 0 | JP-15°-45°-Rg-Unstained | | 71 | | | | | 71 | | 7 | >15 | | | | | | | | NA | NA | 4 | | | Slightly weathered greyish black fractured & jointed basalt |
| | 42.0 | | | 100 | 0 | 0 | 0 | 0 | JP-15°-25°-Rg-Unstained | | 83 | | | | | 83 | | 0 | >15 | | | | | | | | NA | | 4 | | | |
| | 43.5 | | | 100 | 0 | 0 | 0 | 0 | JP-15°-20°-Rg-Unstained | | 71 | | | | | 71 | | 0 | >15 | | | | | | | | NA | | 4 | | | |
| | 45.0 | Moderately weathered greyish black fractured & jointed basalt | | 100 | 0 | 0 | 0 | 0 | JP-10°-30°-Rg-Unstained | | 69 | | | | | 69 | | 0 | >15 | | | | | | | | NA | | 4 | | | Moderately weathered greyish black fractured & jointed basalt |
| | 46.5 | Slightly weathered greyish black fractured & jointed basalt | | 100 | 0 | 0 | 0 | 0 | JP-15°-20°-Rg-Unstained | | 91 | | | | | 91 | | 0 | >15 | | | | | | | | NA | | 4 | | | Slightly weathered greyish black fractured & jointed basalt |
| | 48.0 | | | 45 | 55 | 0 | 0 | 0 | JP-10°-45°-Rg-Unstained | | 87 | | | | | 87 | | 48 | 15-8 | | | | | | | | NA | | 4 | | | |
| | 49.5 | | | 80 | 20 | 0 | 0 | 0 | JP-10°-45°-Rg-Unstained | | 81 | | | | | 81 | | 16 | >15 | | | | | | | | NA | | 4 | | | |
| | 51.0 | | | 92 | 8 | 0 | 0 | 0 | JP-10°-60°-Rg-Unstained | | 83 | | | | | 83 | | 7 | >15 | | | | | | | | NA | | 4 | | | |
| | 52.0 | Moderately weathered greyish black fractured & jointed basalt | | 77 | 23 | 0 | 0 | 0 | JP-15°-20°-Rg-Unstained | | 69 | | | | | 69 | | 16 | >15 | | | | | | | | NA | | 4 | | | Moderately weathered greyish black fractured & jointed basalt |

IMP

NX

Uncased

**Water level met at 3.5 m down**

Not Tested

Not Tested

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

SLIGHTLY WEATHERED ROCK

BASALT ROCK

WEATHERED ROCK

MODERATELY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 10 | **LOCATION:** | B10 | **CHAINAGE:-** | 9970 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=583087.935 Y= 2481903.740 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 69 M |
| **DATE OF START:** | 26.12.2022 | **DATE OF COMPLETION:** | 22.01.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.5 | Brownish Silty Soil With pebbles | | | | | | | | | | | | | | | | | | | Casing up to 4.0 m | | | | | | | | | | | | Brownish Silty Soil With pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | >100/10cm | | | R | | | | |
| | 3.0 | Brownish Completely weathered rock with boulders | | | | | | | | | | | | | | | | | | | | | | | | | >100/10cm | | | R | | | | Brownish Completely weathered rock with boulders |
| | 6.0 | Highly weathered greyish black jointed & fractured amygdaloidal basalt | | 61 | 39 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 51 | | | | | 51 | | 20 | >15 | | | | | | | NA | | | 7 | | | Highly weathered greyish black jointed & fractured amygdaloidal basalt |
| | 9.0 | | | 68 | 32 | 0 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 51 | | | | | 51 | | 16 | >15 | | | | | | | NA | | | 5 | | | |
| | 12.0 | | | 79 | 21 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 38 | | | | | 38 | | 8 | >15 | | | | | | | NA | | | 5 | | | |
| | 15.0 | Fresh greyish black amygdaloidal basalt with secondary mineral in filling | | 25 | 49 | 26 | 0 | 0 | JP-60°-Rg-Un-stained-VJ | | 87 | | | | | 87 | | 65 | 8-5 | | | | | | | NA | | | 4 | | | Fresh greyish black amygdaloidal basalt with secondary mineral in filling |
| | 18.0 | | | 37 | 63 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 90 | | | | | 90 | | 56 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 21.0 | | | 20 | 80 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 90 | | | | | 90 | | 72 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 24.0 | | | 5 | 60 | 35 | 0 | 0 | JP-0°-stained | | 85 | | | | | 85 | | 80 | 5-1 | | | | | | | NA | | | 6 | | | |
| | 27.0 | | | 19 | 68 | 13 | 0 | 0 | JP-45°-Rg-Un-stained-VJ | | 88 | | | | | 88 | | 71 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 30.0 | | | 23 | 67 | 10 | 0 | 0 | JP-30°-Rg-Un-stained | | 92 | | | | | 92 | | 71 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 33.0 | Fresh greyish black and reddish grey amygdaloidal basalt with secondary mineral in filling | | 2 | 55 | 43 | 0 | 0 | JP-45°-30°-Rg-Un-stained | | 98 | | | | | 98 | IMP | 96 | <1 | NX | Uncased | Water level met at 17.20 m down | | | | | NA | | | 4 | Not Tested | Not Tested | Fresh greyish black and reddish grey amygdaloidal basalt with secondary mineral in filling |
| | 36.0 | Fresh reddish grey amygdaloidal basalt with secondary mineral in filling | | 3 | 31 | 66 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 89 | | | | | 89 | | 87 | 5-1 | | | | | | | NA | | | 4 | | | Fresh reddish grey amygdaloidal basalt with secondary mineral in filling |
| | 39.0 | Fresh greyish black amygdaloidal basalt with secondary mineral in filling | | 27 | 51 | 22 | 0 | 0 | JP-30°-Rg-Un-stained | | 86 | | | | | 86 | | 63 | 8-5 | | | | | | | NA | | | 4 | | | Fresh greyish black amygdaloidal basalt with secondary mineral in filling |
| | 42.0 | | | 15 | 24 | 61 | 0 | 0 | JP-25°-Rg-Un-stained | | 91 | | | | | 91 | | 77 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 45.0 | | | 15 | 16 | 69 | 0 | 0 | JP-15°-Rg-Un-stained | | 89 | | | | | 89 | | 76 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 48.0 | | | 1 | 39 | 60 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 98 | | | | | 98 | | 97 | <1 | | | | | | | NA | | | 4 | | | |
| | 51.0 | | | 6 | 29 | 65 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 90 | | | | | 90 | | 85 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 54.0 | | | 3 | 52 | 14 | 31 | 0 | JP-15°-20°-Rg-Un-stained | | 96 | | | | | 96 | | 93 | <1 | | | | | | | NA | | | 4 | | | |
| | 57.0 | | | 12 | 76 | 12 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 94 | | | | | 94 | | 83 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 60.0 | | | 29 | 61 | 10 | 0 | 0 | JP-20°-25°-Rg-Un-stained | | 92 | | | | | 92 | | 65 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 63.0 | Fresh greyish black jointed & fractured amygdaloidal basalt | | 62 | 38 | 0 | 0 | 0 | JP-15°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 35 | 15-8 | | | | | | | NA | | | 4 | | | Fresh greyish black jointed & fractured amygdaloidal basalt |
| | 66.0 | | | 23 | 41 | 36 | 0 | 0 | JP-10°-30°-Rg-Un-stained | | 88 | | | | | 88 | | 68 | 8-5 | | | | | | | NA | | | 3 | | | |
| | 69.0 | | | 16 | 50 | 34 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 94 | | | | | 94 | | 79 | 5-1 | | | | | | | NA | | | 3 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

SLIGHTLY WEATHERED ROCK

MODERATELY WEATHERED ROCK

HIGHLY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 11 | **LOCATION:** | B11 | **CHAINAGE:-** | 10170 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=583273.140 Y= 2481828.248 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 61.50 M |
| **DATE OF START:** | 14.11.2022 | **DATE OF COMPLETION:** | 24.12.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish Silty Soil With pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish Silty Soil With pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | >100/10cm | | R | | | | | |
| | 3.0 | Brownish Completely weathered rock | | | | | | | | | | | | | | | | | | | | | | | | | >100/10cm | | R | | | | | Brownish Completely weathered rock |
| | 4.5 | Highly weathered greyish black jointed & fractured amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | | JP-30°-Rg-Un-Clean | | ## | | | | | 10 | | 0 | >15 | | Casing up to 8.50 m | | | | | NA | | | 8 | | | Highly weathered greyish black jointed & fractured amygdaloidal basalt |
| | 6.0 | | | 100 | 0 | 0 | 0 | 0 | | JP-20°-30°-Rg-Un-stained | | ## | | | | | 10 | | 0 | >15 | | | | | | | NA | | | 6 | | | |
| | 7.5 | | | 100 | 0 | 0 | 0 | 0 | | JP-30°-Rg-Un-stained | | ## | | | | | 13 | | 0 | >15 | | | | | | | NA | | | 6 | | | |
| | 9.0 | | | 100 | 0 | 0 | 0 | 0 | | JP-60°-Rg-Un-stained-VJ | | 53 | | | | | 53 | | 0 | >15 | | | | | | | NA | | | 6 | | | |
| | 12.0 | Fresh greyish black amygdaloidal basalt with secondary mineral in filling | | 12 | 31 | 31 | 26 | 0 | | JP-45°-Rg-Un-stained | | 98 | | | | | 98 | | 86 | 5-1 | | | | | | | NA | | | 5 | | | Fresh greyish black amygdaloidal basalt with secondary mineral in filling |
| | 15.0 | | | 0 | 15 | 85 | 0 | 0 | | JP-0°-Rg-Un-stained | | 90 | | | | | 90 | | 90 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 18.0 | | | 7 | 56 | 37 | 0 | 0 | | JP-0°-stained | | 92 | | | | | 92 | | 86 | 5-1 | | | | | | | NA | | | 6 | | | |
| | 21.0 | | | 30 | 45 | 25 | 0 | 0 | | JP-45°-Rg-Un-stained-VJ | | 88 | | | | | 88 | | 62 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 24.0 | | | 22 | 29 | 49 | 0 | 0 | | JP-30°-Rg-Un-stained | | 93 | | | | | 93 | | 72 | 8-5 | | | | | | | NA | | | 5 | | | |
| | 27.0 | Fresh greyish black and reddish grey amygdaloidal basalt with secondary mineral in filling | | 26 | 64 | 10 | 0 | 0 | | JP-45°-30°-Rg-Un-stained | | 94 | | | | | 94 | IMP | 69 | 8-5 | NX | | | | | | NA | | | 5 | Not Tested | Not Tested | Fresh greyish black and reddish grey amygdaloidal basalt with secondary mineral in filling |
| | 30.0 | Fresh brownish black amygdaloidal basalt with secondary mineral in filling | | 23 | 16 | 61 | 0 | 0 | | JP-25°-30°-Rg-Un-stained | | 92 | | | | | 92 | | 71 | 8-5 | | Uncased | Water level met at 15.80 m down | | | | NA | | | 5 | | | Fresh brownish black amygdaloidal basalt with secondary mineral in filling |
| | 33.0 | | | 13 | 55 | 32 | 0 | 0 | | JP-30°-Rg-Un-stained | | 99 | | | | | 99 | | 86 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 36.0 | | | 20 | 71 | 9 | 0 | 0 | | JP-45°-Rg-Un-stained | | 90 | | | | | 90 | | 72 | 8-5 | | | | | | | NA | | | 5 | | | |
| | 39.0 | Fresh greyish black to brown amygdaloidal basalt with secondary mineral in filling | | 16 | 44 | 40 | 0 | 0 | | JP-45°-Rg-Un-stained | | 100 | | | | | 100 | | 84 | 5-1 | | | | | | | NA | | | 4 | | | Fresh greyish black to brown amygdaloidal basalt with secondary mineral in filling |
| | 40.5 | | | 0 | 27 | 73 | 0 | 0 | | JP-30°-45°-Rg-Un-stained | | 100 | | | | | 100 | | 100 | <1 | | | | | | | NA | | | 4 | | | |
| | 42.0 | | | 29 | 22 | 49 | 0 | 0 | | JP-15°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 65 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 45.0 | Fresh greyish red amygdaloidal basalt with secondary mineral in filling | | 8 | 46 | 46 | 0 | 0 | | JP-15°-25°-Rg-Un-stained | | 95 | | | | | 95 | | 87 | 5-1 | | | | | | | NA | | | 4 | | | Fresh greyish red amygdaloidal basalt with secondary mineral in filling |
| | 48.0 | | | 21 | 33 | 46 | 0 | 0 | | JP-30°-45°-Rg-Un-stained | | 95 | | | | | 95 | | 75 | 5-1 | | | | | | | NA | | | 5 | | | |
| | 51.0 | | | 16 | 56 | 28 | 0 | 0 | | JP-25°-30°-Rg-Un-stained | | 89 | | | | | 89 | | 75 | 5-1 | | | | | | | NA | | | 5 | | | |
| | 54.0 | | | 0 | 54 | 46 | 0 | 0 | | JP-15°-30°-Rg-Un-stained | | 96 | | | | | 96 | | 96 | <1 | | | | | | | NA | | | 4 | | | |
| | 57.0 | | | 43 | 57 | 0 | 0 | 0 | | JP-20°-30°-Rg-Un-stained | | 88 | | | | | 88 | | 50 | 15-8 | | | | | | | NA | | | 8 | | | |
| | 60.0 | Fresh greyish black jointed & fractured amygdaloidal basalt | | 64 | 36 | 0 | 0 | 0 | | JP-10°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 33 | 15-8 | | | | | | | NA | NA | | 9 | | | Fresh greyish black jointed & fractured amygdaloidal basalt |
| | 61.5 | | | 46 | 54 | 0 | 0 | 0 | | JP-45°-30°-Rg-Un-stained | | 62 | | | | | 62 | | 33 | 15-8 | | | | | | | NA | | | 9 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
SLIGHTLY WEATHERED ROCK
MODERATELY WEATHERED ROCK
HIGHLY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 12 | **LOCATION:** | B12 | **CHAINAGE:-** | 10370 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=583458.345 Y= 2481752.756 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 77.0 M |
| **DATE OF START:** | 30.9.2022 | **DATE OF COMPLETION:** | 11.11.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish Silty Soil With pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish Silty Soil With pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | >100/10cm | R | | | | | |
| | 3.0 | Brownish Completely weathered rock | | | | | | | | | | | | | | | | | | | | | | | | | | >100/10cm | R | | | | | Brownish Completely weathered rock |
| | 4.0 | Highly weathered greyish black jointed & fractured amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 23 | | | | | 23 | | 0 | >15 | | Casing up to 8.50 m | | | | | NA | | | 11 | | | Highly weathered greyish black jointed & fractured amygdaloidal basalt |
| | 5.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-45°-Rg-Un stained | | 20 | | | | | 20 | | 0 | >15 | | | | | | | NA | | | 11 | | | |
| | 8.5 | | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 15 | | | | | 15 | | 0 | >15 | | | | | | | NA | | | 11 | | | |
| | 11.5 | | | 33 | 67 | 0 | 0 | 0 | JP-45°-Rg-Un-stained-VJ | | 30 | | | | | 30 | | 20 | >15 | | | | | | | NA | | | 10 | | | |
| | 14.5 | | | 49 | 24 | 27 | 0 | 0 | JP-30°-Rg-Un-stained | | 42 | | | | | 42 | | 22 | >15 | | | | | | | NA | | | 10 | | | |
| | 16.0 | | | 0 | 100 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 59 | | | | | 59 | | 59 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 19.0 | Slightly weathered greyish black amygdaloidal basalt with secondary mineral in filling | | 3 | 73 | 24 | 0 | 0 | JP-10°-stained | | 82 | | | | | 82 | | 79 | 5-1 | | | | | | | NA | | | 9 | | | Slightly weathered greyish black amygdaloidal basalt with secondary mineral in filling |
| | 22.0 | | | 9 | 51 | 40 | 0 | 0 | JP-45°-Rg-Un-stained-VJ | | 78 | | | | | 78 | | 71 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 25.0 | | | 21 | 30 | 49 | 0 | 0 | JP-30°-Rg-Un-stained | | 82 | | | | | 82 | | 65 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 28.0 | | | 37 | 39 | 24 | 0 | 0 | JP-45°-30°-Rg-Un stained | | 78 | | | | | 78 | | 49 | 15-8 | | | | | | | NA | | | 8 | | | |
| | 31.0 | | | 42 | 20 | 38 | 0 | 0 | JP-45°-60°-Rg-Un stained | | 90 | | | | | 90 | | 52 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 34.0 | | | 21 | 25 | 54 | 0 | 0 | JP-30°-Rg-Un-stained | | 81 | | | | | 81 | | 64 | 8-5 | | | | | | | NA | | | 5 | | | |
| | 37.0 | | | 23 | 19 | 58 | 0 | 0 | JP-60°-Rg-Un-stained | | 79 | | | | | 79 | | 60 | 8-5 | | | | | | | NA | | | 7 | | | |
| | 40.0 | | | 29 | 71 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 71 | | | | | 71 | | 50 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 43.0 | | | 76 | 24 | 0 | 0 | 0 | JP-30°-45°-Rg-Un stained | | 66 | | | | | 66 | | 16 | >15 | | | | | | | NA | | | 8 | | | |
| | 46.0 | | | 17 | 83 | 0 | 0 | 0 | JP-15°-20°-Rg-Un stained | | 83 | | | | | 83 | | 68 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 49.0 | | | 25 | 75 | 0 | 0 | 0 | JP-25°-30°-Rg-Un stained | | 69 | | | | | 69 | | 52 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 52.0 | | | 53 | 17 | 30 | 0 | 0 | JP-30°-45°-Rg-Un stained | | 74 | | | | | 74 | | 35 | 15-8 | | | | | | | NA | | | 8 | | | |
| | 55.0 | | | 24 | 53 | 23 | 0 | 0 | JP-25°-30°-Rg-Un stained | | 82 | | | | | 82 | | 62 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 58.0 | Fresh greyish black amygdaloidal basalt | | 9 | 43 | 48 | 0 | 0 | JP-15°-20°-Rg-Un stained | | 86 | | | | | 86 | | 78 | 5-1 | | | | | | | NA | | | 6 | | | Fresh greyish black amygdaloidal basalt |
| | 61.0 | | | 3 | 61 | 36 | 0 | 0 | JP-20°-30°-Rg-Un stained | | 84 | | | | | 84 | | 81 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 64.0 | | | 16 | 14 | 70 | 0 | 0 | JP-10°-20°-Rg-Un stained | | 79 | | | | | 79 | | 66 | 8-5 | | | | | | | NA | | | 5 | | | |
| | 67.0 | | | 0 | 58 | 42 | 0 | 0 | JP-45°-30°-Rg-Un stained | | 80 | | | | | 80 | | 80 | 5-1 | | | | | | | NA | | | 4 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
SLIGHTLY WEATHERED ROCK
MODERATELY WEATHERED ROCK
HIGHLY WEATHERED ROCK

**Logged By:** **Checked By:**


# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 12 | **LOCATION:** | B12 | **CHAINAGE:-** | 10370 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=583458.345 Y= 2481752.756 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 77.0 M |
| **DATE OF START:** | 30.9.2022 | **DATE OF COMPLETION:** | 11.11.2022 | **NAME OF AGENCY :** | Logic Geotech & Construction |


| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 70.0 | Slightly weathered to fresh greyish black jointed & fractured amygdaloidal basalt | | 42 | ### | ### | 0 | 0 | JP-45°-Rg-Un-Clean | | 94 | | | | | 94 | | 80 | 5-1 | | Uncased | | | | | NA | | | 4 | | | Slightly weathered to fresh greyish black jointed & fractured amygdaloidal basalt |
| | 73.0 | | | 107 | 39 | 100 | 0 | 0 | JP-60°-Rg-Un-Clean | | 82 | | | | | 82 | | 46 | 15-8 | | | | | | | NA | | | 5 | | | |
| | 76.0 | | | 76 | 130 | 38 | 0 | 0 | JP-45°-Rg-Un-Clean | | 81 | | | | | 81 | | 56 | 8-5 | | | | | | | NA | | | 5 | | | |
| | 77.0 | | | 0 | 96 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 96 | | | | | 96 | | 96 | <1 | | | | | | | NA | | | 4 | | | |


**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
SLIGHTLY WEATHERED ROCK
MODERATELY WEATHERED ROCK
HIGHLY WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 13 | **LOCATION:** | B13 | **CHAINAGE:-** | 10570 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=583643.550 Y= 2481677.263 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 81.0 M |
| **DATE OF START:** | 15.12.222 | **DATE OF COMPLETION:** | 7.1.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.5 | Brownish Silty Soil With pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish Silty Soil With pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | >100/10cm | | R | | | | |
| | 3.0 | Highly weathered greyish black jointed & fractured amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | JP-10°-Rg-Un-Clean | | 23 | | | | | 23 | | 0 | >15 | | Casing up to 4.0 m | | | | | NA | | | 11 | | | Highly weathered greyish black jointed & fractured amygdaloidal basalt |
| | 6.0 | | | 70 | 30 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 54 | | | | | 54 | | 16 | >15 | | | | | | | NA | | | 11 | | | |
| | 9.0 | | | 38 | 49 | 13 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 74 | | | | | 74 | | 46 | 15-8 | | | | | | | NA | | | 11 | | | |
| | 12.0 | | | 46 | 54 | 0 | 0 | 0 | JP-25°-Rg-Un-stained | | 65 | | | | | 65 | | 35 | 15-8 | | | | | | | NA | | | 11 | | | |
| | 15.0 | | | 33 | 47 | 20 | 0 | 0 | JP-30°-Rg-Un-stained-VJ | | 66 | | | | | 66 | | 44 | 15-8 | | | | | | | NA | | | 10 | | | |
| | 18.0 | | | 29 | 48 | 23 | 0 | 0 | JP-45°-Rg-Un-stained | | 77 | | | | | 77 | | 54 | 8-5 | | | | | | | NA | | | 10 | | | |
| | 21.0 | | | 12 | 16 | 72 | 0 | 0 | JP-30°-Rg-Un-stained | | 85 | | | | | 85 | | 75 | 5-1 | | | | | | | NA | | | 9 | | | |
| | 24.0 | Fresh greyish black amygdaloidal basalt with secondary mineral in filling | | 12 | 64 | 25 | 0 | 0 | JP-60°-stained | | 85 | | | | | 85 | | 75 | 5-1 | | | | | | | NA | | | 9 | | | Fresh greyish black amygdaloidal basalt with secondary mineral in filling |
| | 27.0 | | | 5 | 36 | 58 | 0 | 0 | JP-30°-Rg-Un-stained-VJ | | 88 | | | | | 88 | | 83 | 5-1 | | | | | | | NA | | | 9 | | | |
| | 30.0 | | | 0 | 34 | 66 | 0 | 0 | JP-45°-Rg-Un-stained | | 89 | | | | | 89 | | 89 | 5-1 | | | | | | | NA | | | 9 | | | |
| | 33.0 | | | 18 | 22 | 59 | 0 | 0 | JP-45°-30°-Rg-Un-stained | | 88 | | | | | 88 | | 72 | 8-5 | | | | | | | NA | | | 8 | | | |
| | 36.0 | Fresh reddish brown to greyish black amygdaloidal basalt with secondary mineral in filling | | 23 | 37 | 40 | 0 | 0 | JP-45°-60°-Rg-Un-stained | | 82 | | | | | 82 | | 64 | 8-5 | | | | | | | NA | | | 8 | | | Fresh reddish brown to greyish black amygdaloidal basalt with secondary mineral in filling |
| | 39.0 | | | 29 | 4 | 68 | 0 | 0 | JP-30°-Rg-Un-stained | | 78 | | | | | 78 | | 56 | 8-5 | | | | | | | NA | NA | | 5 | | | |
| | 42.0 | | | 2 | 16 | 82 | 0 | 0 | JP-60°-Rg-Un-stained | | 96 | | | | | 96 | | 93 | <1 | | | | | | | NA | NA | | 7 | | | |
| | 45.0 | | | 10 | 12 | 78 | 0 | 0 | JP-30°-Rg-Un-stained | | 97 | | | | | 97 | | 87 | 5-1 | | | | | | | NA | NA | | 8 | | | |
| | 48.0 | | | 64 | 23 | 13 | 0 | 0 | JP-30°-60°-Rg-Un-stained | | 83 | | | | | 83 | | 30 | 15-8 | | | | | | | NA | NA | | 8 | | | |
| | 51.0 | | | 18 | 37 | 45 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 89 | | | | | 89 | | 73 | 8-5 | | | | | | | NA | NA | | 8 | | | |
| | 54.0 | | | 1 | 12 | 87 | 0 | 0 | JP-30°-4°-Rg-Un-stained | | 98 | | | | | 98 | | 97 | <1 | | | | | | | NA | NA | | 8 | | | |
| | 57.0 | | | 33 | 16 | 51 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 82 | | | | | 82 | | 55 | 8-5 | | | | | | | NA | NA | | 8 | | | |
| | 60.0 | | | 23 | 66 | 11 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 70 | 8-5 | | | | | | | NA | NA | | 6 | | | |
| | 63.0 | Slightly weathered greyish black amygdaloidal basalt with secondary mineral in filling | | 20 | 50 | 30 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 85 | | | | | 85 | | 68 | 8-5 | | | | | | | NA | NA | | 6 | | | Slightly weathered greyish black amygdaloidal basalt with secondary mineral in filling |
| | 66.0 | | | 28 | 37 | 35 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 86 | | | | | 86 | | 62 | 8-5 | | | | | | | NA | NA | | 4 | | | |
| | 69.0 | | | 21 | 26 | 53 | 0 | 0 | JP-10°-30°-Rg-Un-stained | | 87 | | | | | 87 | | 69 | 8-5 | | | | | | | NA | NA | | 5 | | | |
| | 72.0 | | | 20 | 31 | 49 | 0 | 0 | JP-45°-30°-Rg-Un-stained | | 88 | | | | | 88 | | 71 | 8-5 | | | | | | | NA | NA | | 4 | | | |

IMP — NX — Uncased — Water level met at 16.900 m down

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
SLIGHTLY WEATHERED ROCK
MODERATELY WEATHERED ROCK
HIGHLY WEATHERED ROCK

**Logged By:** **Checked By:**


# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway


**SHEET NO.:** 2


| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 13 | **LOCATION:** | B13 | **CHAINAGE:-** | 10570 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=583643.550 Y= 2481677.263 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 81.0 M |
| **DATE OF START:** | 15.12.222 | **DATE OF COMPLETION:** | 7.1.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |


| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 75.0 | Slightly weathered to fresh greyish black jointed & fractured amygdaloidal basalt | | 27 | 73 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 90 | | | | | 90 | | 66 | 8-5 | | Uncased | Water level met at 16.90 m down | | | | NA | NA | | | 4 | Not Tested | Not Tested | Slightly weathered to fresh greyish black jointed & fractured amygdaloidal basalt |
| | 78.0 | | | 39 | 48 | 13 | 0 | 0 | JP-60°-Rg-Un-Clean | | 89 | | | | | 89 | | 54 | 8-5 | | | | | | | NA | NA | | 5 | | | |
| | 81.0 | | | 43 | 22 | 35 | 0 | 0 | JP-45°-Rg-Un-Clean | | 91 | | | | | 91 | | 52 | 8-5 | | | | | | | NA | NA | | 5 | | | |

IMP — NX — Uncased — Water level met at 16.90 m down


**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
SLIGHTLY WEATHERED ROCK
MODERATELY WEATHERED ROCK
HIGHLY WEATHERED ROCK


**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 14 | **LOCATION:** | B14 | **CHAINAGE:-** | 10770 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=583828.755 Y= 2481601.771 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 84.0 M |
| **DATE OF START:** | 10.1.2023 | **DATE OF COMPLETION:** | 1.2.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish Silty Soil With pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish Silty Soil With pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | >100/05cm | | R | | | | | |
| | 3.0 | Highly weathered greyish black to brown jointed & fractured amygdaloidal basalt with secondary mineral infillings | | 100 | 0 | 0 | 0 | 0 | | JP-10°-Rg-Un-Clean | | 75 | | | | | 75 | | 0 | >15 | | Casing up to 2.80 m | | | | | NA | | | 12 | | | |
| | 4.5 | | | 90 | 10 | 0 | 0 | 0 | | JP-30°-Rg-Un-Clean | | 70 | | | | | 70 | | 7 | >15 | | | | | | | NA | | | 11 | | | Highly weathered greyish black to brown jointed & fractured amygdaloidal basalt with secondary mineral infillings |
| | 6.0 | | | 39 | 13 | 48 | 0 | 0 | | JP-30°-45°-Rg-Un-stained | | 61 | | | | | 61 | | 37 | 15-8 | | | | | | | NA | | | 11 | | | |
| | 9.0 | Fresh to slightly wethered greyish black amygdaloidal basalt with secondary mineral in filling | | 35 | 65 | 0 | 0 | 0 | | JP-25°-Rg-Un-stained | | 88 | | | | | 88 | | 58 | 8-5 | | | | | | | NA | | | 10 | | | |
| | 12.0 | | | 49 | 51 | 0 | 0 | 0 | | JP-30°-Rg-Un-stained-VJ | | 92 | | | | | 92 | | 46 | 15-8 | | | | | | | NA | | | 9 | | | |
| | 15.0 | | | 17 | 53 | 30 | 0 | 0 | | JP-45°-Rg-Un-stained | | 91 | | | | | 91 | | 76 | 5-1 | | | | | | | NA | | | 8 | | | |
| | 18.0 | | | 21 | 66 | 13 | 0 | 0 | | JP-30°-Rg-Un-stained | | 80 | | | | | 80 | | 63 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 21.0 | | | 14 | 48 | 38 | 0 | 0 | | JP-60°-stained | | 87 | | | | | 87 | | 75 | 5-1 | | | | | | | NA | | | 8 | | | |
| | 24.0 | | | 3 | 4 | 93 | 0 | 0 | | JP-30°-Rg-Un-stained-VJ | | 86 | | | | | 86 | | 84 | 5-1 | | | | | | | NA | | | 6 | | | |
| | 27.0 | | | 25 | 64 | 11 | 0 | 0 | | JP-45°-Rg-Un-stained | | 89 | | | | | 89 | | 67 | 8-5 | | | | | | | NA | | | 9 | | | |
| | 30.0 | | | 20 | 58 | 22 | 0 | 0 | | JP-45°-30°-Rg-Un stained | | 97 | | | | | 97 | IMP | 78 | 5-1 | NX | Uncased | Water level met at 12.00 m down | | | | NA | | | 8 | Not Tested | Not Tested | |
| | 33.0 | Fresh greyish black amygdaloidal basalt with secondary mineral in filling | | 8 | 33 | 59 | 0 | 0 | | JP-45°-60°-Rg-Un stained | | 93 | | | | | 93 | | 85 | 8-5 | | | | | | | NA | | | 7 | | | Fresh greyish black amygdaloidal basalt with secondary mineral in filling |
| | 36.0 | | | 5 | 23 | 72 | 0 | 0 | | JP-30°-Rg-Un-stained | | 98 | | | | | 98 | | 93 | <1 | | | | | | | NA | NA | | 5 | | | |
| | 39.0 | | | 3 | 37 | 60 | 0 | 0 | | JP-60°-Rg-Un-stained | | 95 | | | | | 95 | | 92 | <1 | | | | | | | NA | NA | | 5 | | | |
| | 42.0 | | | 27 | 45 | 28 | 0 | 0 | | JP-30°-Rg-Un-stained | | 95 | | | | | 95 | | 69 | 8-5 | | | | | | | NA | NA | | 8 | | | |
| | 45.0 | | | 13 | 18 | 69 | 0 | 0 | | JP-30°-60°-Rg-Un stained | | 97 | | | | | 97 | | 85 | 5-1 | | | | | | | NA | NA | | 7 | | | |
| | 48.0 | | | 12 | 58 | 30 | 0 | 0 | | JP-25°-30°-Rg-Un stained | | 90 | | | | | 90 | | 79 | 5-1 | | | | | | | NA | NA | | 7 | | | |
| | 51.0 | | | 16 | 32 | 52 | 0 | 0 | | JP-30°-4°-Rg-Un-stained | | 94 | | | | | 94 | | 79 | 5-1 | | | | | | | NA | NA | | 7 | | | |
| | 54.0 | | | 3 | 35 | 62 | 0 | 0 | | JP-15°-20°-Rg-Un stained | | 93 | | | | | 93 | | 90 | <1 | | | | | | | NA | NA | | 6 | | | |
| | 57.0 | | | 7 | 13 | 52 | 29 | 0 | | JP-25°-30°-Rg-Un stained | | 97 | | | | | 97 | | 91 | <1 | | | | | | | NA | NA | | 6 | | | |
| | 60.0 | | | 3 | 32 | 65 | 0 | 0 | | JP-15°-20°-Rg-Un stained | | 96 | | | | | 96 | | 93 | <1 | | | | | | | NA | NA | | 6 | | | |
| | 63.0 | | | 24 | 53 | 23 | 0 | 0 | | JP-20°-30°-Rg-Un stained | | 90 | | | | | 90 | | 69 | 8-5 | | | | | | | NA | NA | | 7 | | | |
| | 66.0 | | | 6 | 32 | 61 | 0 | 0 | | JP-10°-30°-Rg-Un stained | | 90 | | | | | 90 | | 84 | 5-1 | | | | | | | NA | NA | | 6 | | | |
| | 69.0 | | | 15 | 23 | 31 | 31 | 0 | | JP-45°-30°-Rg-Un stained | | 94 | | | | | 94 | | 79 | 5-1 | | | | | | | NA | | | 6 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
SLIGHTLY WEATHERED ROCK
MODERATELY WEATHERED ROCK
HIGHLY WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 2

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 14 | **LOCATION:** | B14 | **CHAINAGE:-** | 10770 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=583828.755 Y= 2481601.771 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 84.0 M |
| **DATE OF START:** | 10.1.2023 | **DATE OF COMPLETION:** | 1.2.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 72.0 | Slightly weathered to fresh greyish black jointed & fractured amygdaloidal basalt | | 19 | 48 | 33 | 0 | 0 | | JP-30°-Rg-Un-Clean | | 89 | | | | | 89 | | 72 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 75.0 | | | 0 | 45 | 55 | 0 | 0 | | JP-60°-Rg-Un-Clean | | 82 | | | | | 82 | | 82 | 5-1 | | | | | | | NA | | | 5 | | | |
| | 78.0 | | | 4 | 50 | 46 | 0 | 0 | | JP-45°-Rg-Un-Clean | | 92 | | | | | 92 | | 88 | 5-1 | | | | | | | NA | | | 5 | | | |
| | 81.0 | | | 10 | 67 | 23 | 0 | 0 | | JP-30°-Rg-Un-Clean | | 91 | | | | | 91 | | 82 | 5-1 | | | | | | | NA | | | 5 | | | |
| | 84.0 | | | 0 | 36 | 64 | 0 | 0 | | JP-60°-Rg-Un-Clean | | 93 | | | | | 93 | | 93 | <1 | | | | | | | NA | | | 5 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
SLIGHTLY WEATHERED ROCK
MODERATELY WEATHERED ROCK
HIGHLY WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 12590 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=585096.084. Y= 2480399.604 | **FEATURE** | Tunnel_T1(A) |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 37 M |
| **DATE OF START:** | 31.12.2022 | **DATE OF COMPLETION:** | 14.2.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish silty soil with pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | 100/12CM | R | | | | | |
| | 3.0 | Completely to highly weathered greyish brown amygdaloidal basalt with secondary mineral infillingds | | 100 | 0 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 17 | | | | | 17 | IMP | 0 | >15 | NX | Casing up to 9.0 m | | | | | NA | | | 7 | Not Tested | Not Tested | Completely to highly weathered greyish brown amygdaloidal basalt with secondary mineral infillingds |
| | 4.5 | | | 100 | 0 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | ## | | | | | 13 | | 0 | >15 | | | | | | NA | | | 7 | | | |
| | 6.0 | | | 36 | 64 | 0 | 0 | 0 | JP-15°-Rg-Un-Clean | | ## | | | | | 11 | | 7 | >15 | | | | | | NA | | | 7 | | | |
| | 7.5 | | | 100 | 0 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | ## | | | | | 10 | | 0 | >15 | | | | | | NA | | | 7 | | | |
| | 9.0 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 28 | | | | | 28 | | 0 | >15 | | | | | | NA | | | 6 | | | |
| | 10.5 | Highly weathered reddish brown laterites | | 100 | 0 | 0 | 0 | 0 | 5 | | 28 | | | | | 28 | | 0 | >15 | | | | | | NA | | | 6 | | | Highly weathered reddish brown laterites |
| | 12.0 | | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 31 | | | | | 31 | | 0 | >15 | | | | | | NA | | | 6 | | | |
| | 13.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 27 | | | | | 27 | | 0 | >15 | | | | | | NA | | | 6 | | | |
| | 15.0 | Highly weathered reddish brown laterites and greyish brown amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 31 | | | | | 31 | | 0 | >15 | | | | | | NA | | | 6 | | | Highly weathered reddish brown laterites and greyish brown amygdaloidal basalt |
| | 16.5 | | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 37 | | | | | 37 | | 0 | >15 | | | | | | NA | | | 6 | | | |
| | 18.0 | | | 56 | 44 | 0 | 0 | 0 | JP-20°-20°-Rg-Un-stained | | 50 | | | | | 50 | | 22 | >15 | | | | | | NA | | | 5 | | | |
| | 19.5 | | | 87 | 13 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 61 | | | | | 61 | | 8 | >15 | | | | | | NA | | | 5 | | | |
| | 21.0 | Highly weathered greyish black amygdaloidal basalt with secondary in filling | | 47 | 53 | 0 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 54 | | | | | 54 | | 29 | 15-8 | | | | | | NA | | | 5 | | | Highly weathered greyish black amygdaloidal basalt with secondary in filling |
| | 22.5 | | | 74 | 26 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 29 | | | | | 29 | | 7 | >15 | | | | | | NA | | | 5 | | | |
| | 24.0 | Fresh greyish black amygdaloidal basalt with secondary in filling | | 53 | 47 | 0 | 0 | 0 | JP-25°-Rg-Un-stained | | 91 | | | | | 91 | | 43 | 15-8 | | | | | | NA | | | 4 | | | Fresh greyish black amygdaloidal basalt with secondary in filling |
| | 25.5 | | | 21 | 79 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 91 | | | | | 91 | | 72 | 8-5 | | | | | | NA | | | 4 | | | |
| | 27.0 | | | 6 | 25 | 69 | 0 | 0 | JP-0°-10°-Rg-Un-stained | | 91 | | | | | 91 | | 86 | 5-1 | | | | | | NA | | | 4 | | | |
| | 28.5 | | | 5 | 49 | 46 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 91 | | | | | 91 | | 87 | 5-1 | | | | | | NA | | | 4 | | | |
| | 30.0 | | | 30 | 47 | 23 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 92 | | | | | 92 | | 65 | 8-5 | | | | | | NA | | | 4 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
HIGHLY WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 2

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 12590 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=585096.084. Y= 2480399.604 | **FEATURE** | Tunnel_T1(A) |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 37 M |
| **DATE OF START:** | 31.12.2022 | **DATE OF COMPLETION:** | 14.2.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 31.5 | Fresh greyish black amygdaloidal basalt with secondary in filling | | 34 | 41 | 25 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 89 | | | | | 89 | IMP | 59 | 15-8 | NX | Uncased | Water level met at 19.50 m down | | | | NA | | | 6 | Not Tested | Not Tested | Fresh greyish black amygdaloidal basalt with secondary in filling |
| | 33.0 | | | 30 | 70 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 91 | | | | | 91 | | 63 | 8-5 | | | | | | NA | | | 6 | | | |
| | 34.5 | | | 77 | 23 | 0 | 0 | 0 | JP-15°-30°-Rg-Un-stained | | 91 | | | | | 91 | | 21 | >15 | | | | | | NA | | | 6 | | | |
| | 36.0 | | | 15 | 66 | 19 | 0 | 0 | JP-45°-Rg-Un-Clean | | 88 | | | | | 88 | | 75 | 5-1 | | | | | | NA | | | 6 | | | |
| | 37.0 | | | 0 | 59 | 41 | 0 | 0 | JP-30°-Rg-Un-Clean | | 83 | | | | | 83 | | 83 | 5-1 | | | | | | NA | | | 5 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
HIGHLY WEATHERED ROCK

**Logged By:** **Checked By:**

## GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 2 | **LOCATION:** | B2 | **CHAINAGE:-** | 12650 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=585108.277 Y= 2480340.859 | **FEATURE** | Tunnel_T1(A) |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 35.5 M |
| **DATE OF START:** | 31.12.2022 | **DATE OF COMPLETION:** | 17.1.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish silty soil with pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | 100/35CM | R | | | | | |
| | 3.0 | | | 0 | 0 | 0 | 0 | 0 | JP-10°-20°-Rg-Un-stained | | | | | | | 0 | | 0 | >15 | | | | | | | 100/10CM | R | | 8 | | | |
| | 4.5 | Completely to highly weathered greyish brown amygdaloidal basalt with secondary mineral infillings | | 100 | 0 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 21 | | | | | 21 | | 0 | >15 | | Casing up to 4.0 m | | | | | | NA | | | 7 | | Completely to highly weathered greyish brown amygdaloidal basalt with secondary mineral infillings |
| | 6.0 | | | 100 | 0 | 0 | 0 | 0 | JP-15°-Rg-Un-Clean | | 30 | | | | | 30 | | 0 | >15 | | | | | | | NA | | | 7 | | |
| | 7.5 | | | 83 | 17 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 39 | | | | | 39 | | 7 | >15 | | | | | | | NA | | | 7 | | |
| | 9.0 | Moderately weathered greyish black amygdaloidal basalt with secondary mineral infillings | | 74 | 26 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 69 | | | | | 69 | | 18 | >15 | | | | | | | NA | | | 6 | | Moderately weathered greyish black amygdaloidal basalt with secondary mineral infillings |
| | 10.5 | | | 38 | 63 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | | | | | | 85 | | 53 | 8-5 | | | | | | | NA | | | 6 | | |
| | 12.0 | | | 88 | 12 | 0 | 0 | 0 | JP-25°-Rg-Un-stained | | 82 | | | | | 82 | | 10 | >15 | | | | | | | NA | | | 6 | | |
| | 13.5 | | | 22 | 78 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 74 | | | | | 74 | | 58 | 8-5 | | | | | | | NA | | | 6 | | |
| | 15.0 | | | 45 | 55 | 0 | 0 | 0 | JP-15°-Rg-Un-stained | | 72 | | | | | 72 | IMP | 39 | 15-8 | NX | | | | | | NA | | | 6 | | |
| | 16.5 | | | 41 | 59 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 64 | | | | | 64 | | 38 | 15-8 | | Uncased | Water level met at 5.0 m down | | | | NA | | | 6 | Not Tested | Not Tested | |
| | 18.0 | | | 44 | 56 | 0 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 83 | | | | | 83 | | 46 | 15-8 | | | | | | | NA | | | 5 | | |
| | 19.5 | | | 32 | 68 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 86 | | | | | 86 | | 59 | 8-5 | | | | | | | NA | | | 5 | | |
| | 21.0 | | | 15 | 64 | 20 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 88 | | | | | 88 | | 75 | 5-1 | | | | | | | NA | | | 5 | | |
| | 22.5 | | | 11 | 70 | 19 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 92 | | | | | 92 | | 82 | 5-1 | | | | | | | NA | | | 5 | | |
| | 24.0 | Fresh greyish black amygdaloidal basalt with secondary in filling | | 8 | 92 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 74 | | | | | 74 | | 68 | 8-5 | | | | | | | NA | | | 4 | | Fresh greyish black amygdaloidal basalt with secondary in filling |
| | 25.5 | | | 29 | 71 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 82 | | | | | 82 | | 58 | 8-5 | | | | | | | NA | | | 4 | | |
| | 27.0 | | | 0 | 100 | 0 | 0 | 0 | JP-0°-15°-Rg-Un-stained | | 93 | | | | | 93 | | 93 | <1 | | | | | | | NA | | | 4 | | |
| | 28.5 | | | 6 | 94 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 95 | | | | | 95 | | 89 | 5-1 | | | | | | | NA | | | 4 | | |
| | 30.0 | | | 0 | 100 | 0 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 98 | | | | | 98 | | 98 | <1 | | | | | | | NA | | | 4 | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
SLIGHTLY WEATHERED ROCK
FRESH ROCK
HIGHLY WEATHERED ROCK
MODERATELY WEATHERED ROCK

**Logged By:** **Checked By:**

## GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 2

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 2 | **LOCATION:** | B2 | **CHAINAGE:-** | 12650 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=585108.277 Y= 2480340.859 | **FEATURE** | Tunnel_T1(A) |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 35.5 M |
| **DATE OF START:** | 31.12.2022 | **DATE OF COMPLETION:** | 17.1.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 31.5 | Slightly to moderately weathered greyish black amygdaloidal basalt with secondary in filling | | 30 | 70 | 0 | 0 | 0 | JP-15°-25°-Rg-Un-stained | | 97 | | | | | 97 | | 68 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 33.0 | | | 50 | 50 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 57 | | | | | 57 | | 29 | 15-8 | | | | | | | NA | | | 6 | | | |
| | 34.5 | | | 63 | 37 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 67 | | | | | 67 | IMP | 25 | 15-8 | NX | | | | | | NA | | | 6 | | | |
| | 35.5 | | | 36 | 64 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 58 | | | | | 58 | | 37 | 15-8 | | Uncased | Water level met at 5.0 m down | | | | NA | | | 6 | Not Tested | Not Tested | Slightly to moderately weathered greyish black amygdaloidal basalt with secondary in filling |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
FRESH ROCK
HIGHLY WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 13990 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=585679.623. Y= 2479208.697. | **FEATURE** | Tunnel_T1B |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 37 M |
| **DATE OF START:** | 19.2.2023 | **DATE OF COMPLETION:** | 1.3.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish silty soil with pebbles | | | | | | | | | | | | | | | | | | | Casing up to 4.500 m | | | | | | NA | | | | | Brownish silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | 100/13CM | | R | | | | |
| | 3.0 | | | 100 | 0 | 0 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 17 | | | | | 17 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 4.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 20 | | | | | 20 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 6.0 | | | 100 | 0 | 0 | 0 | 0 | JP-15°-Rg-Un-Clean | | 20 | | | | | 20 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 7.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-35°-Rg-Un-stained | | 27 | | | | | 27 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 9.0 | | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 17 | | | | | 17 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 10.5 | | | 100 | 0 | 0 | 0 | 0 | JP-15°-Rg-Un-stained | | 19 | | | | | 19 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 12.0 | | | 100 | 0 | 0 | 0 | 0 | JP-25°-Rg-Un-stained | | | | | | | 25 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 13.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 29 | | | | | 29 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 15.0 | | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 22 | | | | | 22 | IMP | 0 | >15 | NX | | | | | | NA | | | 12 | Not Tested | Not Tested | |
| | 16.5 | Highly weathered greyish black to reddish brown jointed basalt | | 50 | 50 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 48 | | | | | 48 | | 24 | >15 | | Uncased | | | | | NA | | | 12 | | | Highly weathered greyish black to reddish brown jointed basalt |
| | 18.0 | | | 100 | 0 | 0 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 27 | | | | | 27 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 19.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 18 | | | | | 18 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 21.0 | | | 100 | 0 | 0 | 0 | 0 | JP-0°-15°-Rg-Un-stained | | 30 | | | | | 30 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 22.5 | | | 100 | 0 | 0 | 0 | 0 | JP-0°-20°-Rg-Un-stained | | 23 | | | | | 23 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 24.0 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 27 | | | | | 27 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 25.5 | | | 100 | 0 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 26 | | | | | 26 | | 0 | >15 | | | | | | | NA | | | 12 | | | |
| | 27.0 | | | 60 | 40 | 0 | 0 | 0 | JP-0°-15°-Rg-Un-stained | | 35 | | | | | 35 | | 14 | >15 | | Water level met at 25.50 m | | | | | NA | | | 12 | | | |
| | 28.5 | | | 75 | 25 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 35 | | | | | 35 | | 9 | >15 | | | | | | | NA | | | 12 | | | |
| | 30.0 | | | 100 | 0 | 0 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 37 | | | | | 37 | | 0 | >15 | | | | | | | NA | | | 12 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
BASALT ROCK
WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 2

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 13990 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=585679.623. Y= 2479208.697. | **FEATURE** | Tunnel_T1B |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 37 M |
| **DATE OF START:** | 19.2.2023 | **DATE OF COMPLETION:** | 1.3.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 31.5 | Moderately to slightly weathered greyish black amygdaloidal basalt withsecondary mineral in filling | | 84 | 16 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | | | | | | 67 | | 11 | >15 | | | Water level met at 25.50 m down | | | | NA | | | 7 | | | |
| | 33.0 | | | 37 | 18 | 45 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 80 | | | | | 80 | | 51 | 8-5 | | | | | | | NA | | | 7 | | | |
| | 34.5 | | | 7 | 73 | 20 | 0 | 0 | JP-15°-30°-Rg-Un-stained | | 85 | | | | | 85 | IMP | 79 | 5-1 | NX | | | | | | NA | | | 8 | Not Tested | Not Tested | Moderately to slightly weathered greyish black amygdaloidal basalt withsecondary mineral in filling |
| | 36.0 | | | 9 | 91 | 0 | 0 | 0 | JP-45°-Rg-Un-Clean | | 85 | | | | | 85 | | 78 | 5-1 | | Uncased | | | | | NA | | | 6 | | | |
| | 37.0 | | | 0 | 13 | 87 | 0 | 0 | JP-0°-Rg-Un-Clean | | 92 | | | | | 92 | | 92 | <1 | | | | | | | NA | | | 6 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
BASALT ROCK
WEATHERED ROCK

**Logged By:** **Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 01 B | **LOCATION:** | 1B | **CHAINAGE:-** | 7740 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=581113.998, Y=2482919.918 | **FEATURE** | Tunnel_T1 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 27 M |
| **DATE OF START:** | 01.01.2023 | **DATE OF COMPLETION:** | 19.01.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Brownish Silty Soil with pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Brownish Silty Soil with pebbles |
| | 2.0 | Highly weathered greyish black fractured amygdaloidal basalt with secondary mineral in filling | | 100 | 0 | 0 | 0 | 0 | | JP-30°-Rg-Un-Clean | | 20 | | | | | 20 | | 0 | >15 | | Casing up to 1.5m | | | | | NA | | | 6 | | | Highly weathered greyish black fractured amygdaloidal basalt with secondary mineral in filling |
| | 3.5 | | | 52 | 0 | 48 | 0 | 0 | | JP-45°-Rg-Un-Clean | | 36 | | | | | 36 | | 17 | >15 | | | | | | | NA | | | 6 | | | |
| | 5.0 | | | 75 | 25 | 0 | 0 | 0 | | JP-25°-Rg-Un-Clean | | 32 | | | | | 32 | | 8 | >15 | | | | | | | NA | | | 5 | | | |
| | 6.5 | Moderately weathered greyish black fractured amygdaloidal basalt with secondary mineral in filling | | 87 | 13 | 0 | 0 | 0 | | JP-25°-30°-Rg-Un-stained | | 52 | | | | | 52 | | 7 | >15 | | | | | | | NA | | | 6 | | | Moderately weathered greyish black fractured amygdaloidal basalt with secondary mineral in filling |
| | 8.0 | | | 69 | 31 | 0 | 0 | 0 | | JP-30°-Rg-Un-stained | | 59 | | | | | 59 | | 18 | >15 | | | | | | | NA | | | 6 | | | |
| | 9.5 | Fresh greyish black amygdaloidal basalt with white and green in filling | | 3 | 78 | 19 | 0 | 0 | | JP-60°-Rg-Un-stained-VJ | | 99 | | | | | 99 | | 95 | <1 | | | | | | | NA | | | 4 | | | Fresh greyish black amygdaloidal basalt with white and green in filling |
| | 11.0 | | | 7 | 73 | 20 | 0 | 0 | | JP-45°-Rg-Un-stained | | 88 | | | | | 88 | | 82 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 12.5 | | | 12 | 88 | 0 | 0 | 0 | | JP-0°-Rg-Un-stained | | 99 | | | | | 99 | | 87 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 14.0 | | | 4 | 96 | 0 | 0 | 0 | | JP-0°-stained | | 91 | | | | | 91 | | 87 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 15.5 | | | 13 | 60 | 27 | 0 | 0 | | JP-45°-Rg-Un-stained-VJ | | 93 | | | | | 93 | | 81 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 17.0 | | | 8 | 66 | 26 | 0 | 0 | | JP-50°-Rg-Un-stained | | 81 | | | | | 81 | | 74 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 18.5 | | | 58 | 42 | 0 | 0 | 0 | | JP-35°-45°-Rg-Un-stained | | 86 | | | | | 86 | | 36 | 15-8 | | | | | | | NA | | | 4 | | | |
| | 20.0 | Fresh greyish black jointed and fractured amygdaloidal basalt with white and green in filling | | 70 | 30 | 0 | 0 | 0 | | JP-15°-10°-Rg-Un-stained | | 86 | | | | | 86 | | 26 | 15-8 | | | | | | | NA | | | 4 | | | Fresh greyish black jointed and fractured amygdaloidal basalt with white and green in filling |
| | 21.5 | | | 13 | 87 | 0 | 0 | 0 | | JP-30°-Rg-Un-stained | | 90 | | | | | 90 | | 79 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 23.0 | | | 39 | 61 | 0 | 0 | 0 | | JP-45°-Rg-Un-stained | | 88 | | | | | 88 | | 54 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 24.5 | | | 5 | 9 | 86 | 0 | 0 | | JP-10°-Rg-Un-stained | | 87 | | | | | 87 | | 83 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 26.0 | Fresh greyish black amygdaloidal basalt with small green in filling | | 22 | 78 | 0 | 0 | 0 | | JP-20°-30°-Rg-Un-stained | | 87 | | | | | 87 | | 67 | 8-5 | | | | | | | NA | | | 4 | | | Fresh greyish black amygdaloidal basalt with small green in filling |
| | 27.0 | | | 10 | 90 | 0 | 0 | 0 | | JP-15°-20°-Rg-Un-stained | | 90 | | | | | 90 | IMP | 81 | 5-1 | NX | Uncased | Water level met at 7.7 m down | | | | NA | | | 4 | Not Tested | Not Tested | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

SLIGHTLY WEATHERED ROCK

MODERATELY WEATHERED ROCK

HIGHLY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 2 | **LOCATION:** | B2 | **CHAINAGE:-** | 14090 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=585774.435 Y= 24879177.124 | **FEATURE** | Tunnel_T1B |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 30 M |
| **DATE OF START:** | 28.4.2023 | **DATE OF COMPLETION:** | 10.6.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.5 | Brownish red comletely weathered Basalt | | | | | | | | | | | | | | | | | | | Casing up to 1.0 m | | | | | | | | | 12 | | | Brownish red comletely weathered Basalt |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 12 | | | |
| | 3.0 | Highly to moderately weathered greyish black jointed and fractured amygdaloidal basalt | | 46 | 54 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 23 | | | | | 23 | IMP | 12.7 | >15 | NX | Uncased | Water level met at 10.50 m down | | | | NA | NA | | | 12 | Not Tested | Not Tested | Highly to moderately weathered greyish black jointed and fractured amygdaloidal basalt |
| | 4.5 | | | 39 | 61 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 47 | | | | | 47 | | 28.7 | 15-8 | | | | | | | NA | | | 12 | | | |
| | 6.0 | | | 69 | 31 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 61 | | | | | 61 | | 18.7 | >15 | | | | | | | NA | | | 9 | | | |
| | 7.5 | | | 74 | 26 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 78 | | | | | 78 | | 20.7 | >15 | | | | | | | NA | | | 11 | | | |
| | 9.0 | | | 63 | 37 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 63 | | | | | 63 | | 23.3 | >15 | | | | | | | NA | | | 8 | | | |
| | 10.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 73 | | | | | 73 | | 0 | >15 | | | | | | | NA | | | 9 | | | |
| | 12.0 | | | 76 | 24 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 87 | | | | | 87 | | 20.7 | >15 | | | | | | | NA | | | 10 | | | |
| | 13.5 | | | 92 | 8 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 89 | | | | | 89 | | 7 | >15 | | | | | | | NA | | | 9 | | | |
| | 15.0 | | | 53 | 47 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 87 | | | | | 87 | | 40.7 | 15-8 | | | | | | | NA | | | 8 | | | |
| | 16.5 | Fresh to slightly weathered greyish black amygdaloidal basalt with secondary minerals infillings | | 45 | 55 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 82 | | | | | 82 | | 45.3 | 15-8 | | | | | | | NA | | | 7 | | | Fresh to slightly weathered greyish black amygdaloidal basalt with secondary minerals infillings |
| | 18.0 | | | 27 | 73 | 0 | 0 | 0 | JP-10°-15°-Rg-Un-stained | | 72 | | | | | 72 | | 52.7 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 19.5 | | | 6 | 31 | 63 | 0 | 0 | JP-35°-45°-Rg-Un-stained | | 91 | | | | | 91 | | 85.3 | 5-1 | | | | | | | NA | | | 5 | | | |
| | 21.0 | | | 8 | 56 | 36 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 88 | | | | | 88 | | 80.7 | 5-1 | | | | | | | NA | | | 5 | | | |
| | 22.0 | | | 77 | 23 | 0 | 0 | 0 | JP-0°-15°-Rg-Un-stained | | 57 | | | | | 57 | | 13 | >15 | | | | | | | NA | | | 9 | | | |
| | 23.0 | | | 56 | 44 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 62 | | | | | 62 | | 27 | 15-8 | | | | | | | NA | | | 11 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

HIGHLY WEATHERED ROCK

COMPLETELYLY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 15410 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=587090.373. Y= 2479088.533 | **FEATURE** | Tunnel_T2 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 40 M |
| **DATE OF START:** | 16.2.2023 | **DATE OF COMPLETION:** | 20.3.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Completely weathered greyish brown amygdaloidal basalt | | | | | | | | | | | | | | | | | | Casing up to 3.0 m | | | | | | | | | 9 | | | Completely weathered greyish brown amygdaloidal basalt |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | 100/14CM | R | 9 | | | | | |
| | 3.0 | | | | | | | | | | | | | | | | | | | | | | | | 100/11CM | R | 9 | | | | | |
| | 4.5 | Highly weathered greyish black jointed and fractured amygdaloidal basalt with secondary in filling | 100 | 0 | 0 | 0 | 0 | JP-10°-Rg-Un-Clean | | 18 | | | | | 18 | | 0 | >15 | | | | | | | NA | | | 7 | | | |
| | 6.0 | | 55 | 45 | 0 | 0 | 0 | JP-15°-Rg-Un-Clean | | 22 | | | | | 22 | | 10 | >15 | | | | | | | NA | | | 7 | | | Highly weathered greyish black jointed and fractured amygdaloidal basalt with secondary in filling |
| | 7.5 | | 14 | 86 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 24 | | | | | 24 | | 21 | >15 | | | | | | | NA | | | 7 | | | |
| | 9.0 | | 43 | 57 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 34 | | | | | 34 | | 19 | >15 | | | | | | | NA | | | 6 | | | |
| | 10.5 | | 18 | 82 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 34 | | | | | 34 | | 28 | >15 | | | | | | | NA | | | 6 | | | |
| | 12.0 | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-stained | | 24 | | | | | 24 | | 0 | >15 | | | | | | | NA | | | 6 | | | |
| | 13.5 | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 18 | | | | | 18 | | 0 | >15 | | | | | | | NA | | | 6 | | | |
| | 15.0 | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 16 | | | | | 16 | IMP | 0 | >15 | NX | Uncased | | | | | NA | | | 6 | Not Tested | Not Tested | |
| | 16.5 | | 100 | 0 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 28 | | | | | 28 | | 0 | >15 | | | | | | | NA | | | 6 | | | |
| | 18.0 | | 100 | 0 | 0 | 0 | 0 | JP-20°-30°-Rg-Un-stained | | 26 | | | | | 26 | | 0 | >15 | | | | | | | NA | | | 5 | | | |
| | 19.5 | Highly weathered reddish brown amygdaloidal basalt | 100 | 0 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 38 | | | | | 38 | | 0 | >15 | | | Water level met at 19.50 m down | | | | NA | | | 5 | | | Highly weathered reddish brown amygdaloidal basalt |
| | 21.0 | | 38 | 62 | 0 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 42 | | | | | 42 | | 26 | 15-8 | | | | | | | NA | | | 5 | | | |
| | 22.5 | | 49 | 51 | 0 | 0 | 0 | JP-0°-15°-Rg-Un-stained | | 62 | | | | | 62 | | 31 | 15-8 | | | | | | | NA | | | 5 | | | |
| | 24.0 | | 25 | 75 | 0 | 0 | 0 | JP-20°-Rg-Un-stained | | 69 | | | | | 69 | | 52 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 25.5 | | 4 | 47 | 49 | 0 | 0 | JP-0°-Rg-Un-stained | | 68 | | | | | 68 | | 65 | 8-5 | | | | | | | NA | | | 4 | | | |
| | 27.0 | | 40 | 60 | 0 | 0 | 0 | JP-0°-10°-Rg-Un-stained | | 57 | | | | | 57 | | 34 | 15-8 | | | | | | | NA | | | 4 | | | |
| | 28.5 | | 36 | 64 | 0 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 64 | | | | | 64 | | 41 | 15-8 | | | | | | | NA | | | 4 | | | |
| | 30.0 | | 64 | 36 | 0 | 0 | 0 | JP-0°-60°-Rg-Un-stained | | 50 | | | | | 50 | | 18 | >15 | | | | | | | NA | | | 4 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

HIGHLY WEATHERED ROCK

COMPLETELY WEATHERED ROCK

**Logged By:**

**Checked By:**


# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway


**SHEET NO.:** 2


| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 15410 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=587090.373. Y= 2479088.533 | **FEATURE** | Tunnel_T2 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 40 M |
| **DATE OF START:** | 16.2.2023 | **DATE OF COMPLETION:** | 20.3.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |


| 1 | 2 | 3 | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 31.5 | Fresh greyish black amygdaloidal basalt with secondary in filling | 11 | 89 | 0 | 0 | 0 | JP-15°-25°-Rg-Un-stained | | 95 | | | | | 95 | IMP | 85 | 5-1 | NX | Uncased | Water level met at 19.50 m down | | | | NA | | | 6 | Not Tested | Not Tested | Fresh greyish black amygdaloidal basalt with secondary in filling |
| | 33.0 | | 0 | 100 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 88 | | | | | 88 | | 88 | 5-1 | | | | | | | NA | | | 6 | | | |
| | 34.5 | | 11 | 89 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 90 | | | | | 90 | | 80 | 5-1 | | | | | | | NA | | | 6 | | | |
| | 36.0 | | 28 | 72 | 0 | 0 | 0 | JP-45°-Rg-Un-Clean | | 95 | | | | | 95 | | 68 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 37.5 | | 22 | 78 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 85 | | | | | 85 | | 66 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 39.0 | | 35 | 65 | 0 | 0 | 0 | JP-60°-Rg-Un-Clean | | 89 | | | | | 89 | | 58 | 8-5 | | | | | | | NA | | | 6 | | | |
| | 40.0 | | 7 | 93 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 94 | | | | | 94 | | 87 | 5-1 | | | | | | | NA | | | 6 | | | |


**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

HIGHLY WEATHERED ROCK


**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 2 | **LOCATION:** | B2 | **CHAINAGE:-** | 15510 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=587189.216 Y= 2479073.447. | **FEATURE** | Tunnel_T2 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 31.5 M |
| **DATE OF START:** | 16.2.2023 | **DATE OF COMPLETION:** | 20.3.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces | | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.5 | Brownish silty soil with pebbles | | | | | | | | | | | | | | | | | | | | Casing up to 1.50 m | | | | | | | | | | | Brownish silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | 100/13CM | | R | | | | |
| | 3.0 | Completely weathered greyish black and yellowish brown jointed and fractured amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | | JP-15°-20°-Rg-Un-stained | | 10 | | | | | 10 | | 0 | >15 | | | | | | | NA | | | 6 | | Completely weathered greyish black and yellowish brown jointed and fractured amygdaloidal basalt |
| | 4.5 | | | 100 | 0 | 0 | 0 | 0 | | JP-35°-Rg-Un-Clean | | 13 | | | | | 13 | | 0 | >15 | | | | | | | NA | | | 6 | | |
| | 6.0 | | | 100 | 0 | 0 | 0 | 0 | | JP-25°-Rg-Un-Clean | | 15 | | | | | 15 | | 0 | >15 | | | | | | | NA | | | 6 | | |
| | 7.5 | Highly weathered greyish black and yellowish brown jointed and fractured amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | | JP-15°-25°-Rg-Un-stained | | 17 | | | | | 17 | | 0 | >15 | | | | | | | NA | | | 6 | | Highly weathered greyish black and yellowish brown jointed and fractured amygdaloidal basalt |
| | 9.0 | | | 100 | 0 | 0 | 0 | 0 | | JP-45°-Rg-Un-stained | | 24 | | | | | 24 | | 0 | <1 | | | | | | | NA | | | 6 | | |
| | 10.5 | | | 100 | 0 | 0 | 0 | 0 | | JP-30°-Rg-Un-stained | | 17 | | | | | 17 | | 0 | >15 | | | | | | | NA | | | 6 | | |
| | 12.0 | | | 100 | 0 | 0 | 0 | 0 | | JP-30°-Rg-Un-stained | | 20 | | | | | 20 | | 0 | >15 | | | | | | | NA | | | 6 | | |
| | 13.5 | | | 100 | 0 | 0 | 0 | 0 | | JP-45°-Rg-Un-stained | | 17 | | | | | 17 | | 0 | >15 | | | | | | | NA | | | 6 | | |
| | 15.0 | | | 100 | 0 | 0 | 0 | 0 | | JP-45°-Rg-Un-stained | | 13 | | | | | 13 | IMP | 0 | >15 | NX | Uncased | Water level met at 13.50 m down | | | | NA | | | 6 | Not Tested | Not Tested | |
| | 16.5 | | | 47 | 53 | 0 | 0 | 0 | | JP-30°-Rg-Un-stained | | 29 | | | | | 29 | | 15 | >15 | | | | | | | NA | | | 5 | | | |
| | 18.0 | Moderately weathered greyish black amygdaloidal basalt | | 16 | 24 | 60 | 0 | 0 | | JP-20°-25°-Rg-Un stained | | 60 | | | | | 60 | | 51 | 8-5 | | | | | | | NA | | | 5 | | | Moderately weathered greyish black amygdaloidal basalt |
| | 19.5 | | | 23 | 46 | 30 | 0 | 0 | | JP-30°-45°-Rg-Un stained | | 55 | | | | | 55 | | 42 | 15-8 | | | | | | | NA | | | 4 | | | |
| | 21.0 | Slightly weathered greyish black amygdaloidal basalt with secondary minerals in filling | | 0 | 23 | 77 | 0 | 0 | | JP-0°-30°-Rg-Un-stained | | 94 | | | | | 94 | | 94 | <1 | | | | | | | NA | | | 4 | | | Slightly weathered greyish black amygdaloidal basalt with secondary minerals in filling |
| | 22.5 | | | 6 | 18 | 76 | 0 | 0 | | JP-0°-15°-Rg-Un-stained | | 93 | | | | | 93 | | 88 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 24.0 | | | 6 | 42 | 52 | 0 | 0 | | JP-0°-Rg-Un-stained | | 86 | | | | | 86 | | 81 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 25.5 | | | 10 | 68 | 22 | 0 | 0 | | JP-0°-Rg-Un-stained | | 93 | | | | | 93 | | 83 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 27.0 | | | 11 | 42 | 47 | 0 | 0 | | JP-0°-20°-Rg-Un-stained | | 96 | | | | | 96 | | 85 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 28.5 | | | 12 | 70 | 19 | 0 | 0 | | JP-0°-45°-Rg-Un-stained | | 90 | | | | | 90 | | 79 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 30.0 | | | 13 | 67 | 20 | 0 | 0 | | JP-0°-30°-Rg-Un-stained | | 85 | | | | | 85 | | 75 | 5-1 | | | | | | | NA | | | 4 | | | |
| | 31.5 | | | 16 | 44 | 40 | 0 | 0 | | JP-0°-60°-Rg-Un-stained | | 91 | | | | | 91 | | 76 | 5-1 | | | | | | | NA | | | 4 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

COMPLETELY WEATHERED ROCK

SLIGHTLY WEATHERED ROCK

HIGHLY WEATHERED ROCK

MODERATELY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 16090 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=587754.003. Y= 2478945.364. | **FEATURE** | Tunnel_T3 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 35 M |
| **DATE OF START:** | 1.4.2023 | **DATE OF COMPLETION:** | 22.4.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 15 | 16 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.5 | Brownish silty soil with pebbles | | | | | | | | | | | | | | | | | | | Casing up to 3.0 m | | | | | | | NA NA | | | | Brownish silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3.0 | Highly weathered reddish brown jointed amygdaloidal basalt with secondary mineral infillingds | | 100 | 0 | 0 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 13 | | | | | 13 | | 0 | >15 | | | | | | | | NA | NA | 6 | | | Highly weathered greyish black and yellowish brown jointed and fractured amygdaloidal basalt |
| | 4.5 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 20 | | | | | 20 | | 0 | >15 | | | | | | | | NA | NA | 6 | | | |
| | 6.0 | | | 100 | 0 | 0 | 0 | 0 | JP-25°-Rg-Un-Clean | | 17 | | | | | 17 | | 0 | >15 | | | | | | | | NA | | 6 | | | |
| | 7.5 | | | 100 | 0 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 28 | | | | | 28 | | 0 | >15 | | | | | | | | NA | NA | 6 | | | |
| | 9.0 | Fresh greyish black amygdaloidal basalt with secondary minerals in filling | | 16 | 58 | 26 | 0 | 0 | JP-45°-Rg-Un-stained | | 76 | | | | | 76 | | 64 | 8-5. | | | | | | | | NA | NA | 4 | | | Fresh greyish black amygdaloidal basalt with secondary minerals in filling |
| | 10.5 | | | 12 | 48 | 40 | 0 | 0 | JP-15°-Rg-Un-stained | | 89 | | | | | 89 | | 78 | 8-5. | | | | | | | | NA | NA | 4 | | | |
| | 12.0 | | | 26 | 54 | 20 | 0 | 0 | JP-45°-Rg-Un-stained | | 83 | | | | | 83 | | 61.3 | 8-5. | | | | | | | | NA | NA | 4 | | | |
| | 13.5 | | | 0 | 62 | 38 | 0 | 0 | JP-30°-Rg-Un-stained | | 95 | | | | | 95 | | 94.7 | <1 | | | | | | | | NA | | 4 | | | |
| | 15.0 | | | 4 | 37 | 59 | 0 | 0 | JP-30°-Rg-Un-stained | | 95 | | | | | 95 | IMP | 91.3 | <1 | NX | Uncased | Water level met at 15.25 m down | | | | | NA | | 4 | Not Tested | Not Tested | |
| | 16.5 | | | 23 | 77 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 97 | | | | | 97 | | 74 | 8-5. | | | | | | | | NA | | 4 | | | |
| | 18.0 | | | 6 | 26 | 68 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 97 | | | | | 97 | | 90.7 | <1 | | | | | | | | NA | | 4 | | | |
| | 19.5 | | | 0 | 9 | 91 | 0 | 0 | JP-30°-45°-Rg-Un-stained | | 91 | | | | | 91 | | 91.3 | <1 | | | | | | | | NA | | 4 | | | |
| | 21.0 | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling | | 20 | 80 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 94 | | | | | 94 | | 75.3 | 8-5. | | | | | | | | NA | | 4 | | | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling |
| | 22.5 | | | 51 | 49 | 0 | 0 | 0 | JP-0°-25°-Rg-Un-stained | | 94 | | | | | 94 | | 46 | 15-8. | | | | | | | | NA | | 4 | | | |
| | 24.0 | | | 66 | 34 | 0 | 0 | 0 | JP-25°-Rg-Un-stained | | 81 | | | | | 81 | | 28 | 15-8. | | | | | | | | NA | | 4 | | | |
| | 25.5 | | | 23 | 77 | 0 | 0 | 0 | JP-20°-Rg-Un-stained | | 85 | | | | | 85 | | 65.3 | 8-5. | | | | | | | | NA | | 4 | | | |
| | 27.0 | | | 12 | 88 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 89 | | | | | 89 | | 78.7 | 5-1. | | | | | | | | NA | | 4 | | | |
| | 28.5 | | | 10 | 90 | 0 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 98 | | | | | 98 | | 88 | 5-1. | | | | | | | | NA | | 4 | | | |
| | 30.0 | | | 22 | 78 | 0 | 0 | 0 | JP-0°-45°-Rg-Un-stained | | 81 | | | | | 81 | | 62.7 | 8-5. | | | | | | | | NA | | 4 | | | |

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JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

HIGHLY WEATHERED ROCK

**Logged By:**

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# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 2

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 1 | **LOCATION:** | B1 | **CHAINAGE:-** | 16090 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=587754.003. Y= 2478945.364. | **FEATURE** | Tunnel_T3 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 35 M |
| **DATE OF START:** | 1.4.2023 | **DATE OF COMPLETION:** | 22.4.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 15 | 16 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | | SPT-Number of Blows | | | | | Permeability | | |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s or LUGEON | Special Observations and interpretations / Weathering Grade |
| | 31.5 | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling | | 20 | 80 | 0 | 0 | 0 | JP-15°-20°-Rg-Un-stained | | 92 | | | | | 92 | IMP | 74 | 8-5. | NX | Uncased | Water level met at 15.25 m down | | | | | NA | | 4 | Not Tested | Not Tested | Fresh to slightly weathered greyish brown amygdaloidal basalt with large white green in filling |
| | 33.0 | | | 13 | 69 | 18 | 0 | 0 | JP-20°-25°-Rg-Un-stained | | 95 | | | | | 95 | | 82.7 | 5-1. | | | | | | | | NA | | 4 | | | |
| | 34.0 | | | 43 | 57 | 0 | 0 | 0 | JP-25°-30°-Rg-Un-stained | | 92 | | | | | 92 | | 52 | 8-5. | | | | | | | | NA | NA | 4 | | | |
| | 35.0 | | | 43 | 57 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 79 | | | | | 79 | | 45 | 15-8. | | | | | | | | NA | | 5 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION

CR- CORE RECOVERY

V - VERTICAL JOINT

Un- UNDULATING

Rg- ROUGH

JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY

ROCK MASS (BASALT)

FRESH ROCK

HIGHLY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

**PROJECT :** Geotechnical investigation fo (Drilling of boreholes in) soil and rock and conducting in-situ tests at Bridges & Tunnels location for Final Location Survey of existing/new detour BG line in connection with gauge conversion of existing Ratlam - Khandwa MG section of Western Railway

**SHEET NO.:** 1

| | | | | | |
|---|---|---|---|---|---|
| **BH HOLE NO.** | 2 | **LOCATION:** | B2 | **CHAINAGE:-** | 16290 |
| **BEARING OF HOLE (Degree):** | 90˚ | **CO-ORDINATES:** | X=587928.751, Y=2478848.984 | **FEATURE** | Tunnel_T3 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE_150 mm | **ANGLE W.R.T HORIZONTAL:** | 90˚ | **DEPTH OF BOREHOLE** | 46.0 M |
| **DATE OF START:** | 1.4.2023 | **DATE OF COMPLETION:** | 29.4.2023 | **NAME OF AGENCY :** | Logic Geotech & Construction |

| 1 | 2 | 3 | | 4 | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces | | | | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Nil | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s or LUGEON | |
| | 0.5 | Reddish Brown silty soil with pebbles | | | | | | | | | | | | | | | | | | | | | | | | NA | | | | | | | Reddish Brown silty soil with pebbles |
| | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | | 100/12CM | | | R | | | | |
| | 3.0 | Highly weathered brownish grey to greyish black fractured and jointed amygdaloidal basalt | | 100 | 0 | 0 | 0 | 0 | JP-20°-Rg-Un-Clean | | 15 | | | | | 15 | | 0 | >15 | | | | | | NA | NA | | | 7 | | | Highly weathered brownish grey to greyish black fractured and jointed amygdaloidal basalt |
| | 4.5 | | | 100 | 0 | 0 | 0 | 0 | JP-15°-Rg-Un-Clean | | 34 | | | | | 34 | | 0 | >15 | | | | | | NA | NA | | | 7 | | | |
| | 6.0 | | | 100 | 0 | 0 | 0 | 0 | JP-30°-Rg-Un-Clean | | 25 | | | | | 25 | | 0 | 5-1 | | | | | | NA | | | | 7 | | | |
| | 7.5 | | | 47 | 53 | 0 | 0 | 0 | JP-0°-25°-Rg-Un-stained | | 37 | | | | | 37 | | 19 | 8-5 | | | | | | NA | | | | 7 | | | |
| | 9.0 | | | 64 | 36 | 0 | 0 | 0 | JP-0°-30°-Rg-Un-stained | | 43 | | | | | 43 | | 15 | 8-5 | | | | | | NA | NA | | | 6 | | | |
| | 10.5 | Moderately weathered greyish black fractured and jointed amygdaloidal basalt | | 38 | 62 | 0 | 0 | 0 | JP-45°-Rg-Un-stained-VJ | | 92 | | | | | 92 | | 57 | 8-5 | | | | | | NA | NA | | | 6 | | | Moderately weathered greyish black fractured and jointed amygdaloidal basalt |
| | 12.0 | | | 33 | 67 | 0 | 0 | 0 | JP-60°-Rg-Un-stained | | 92 | | | | | 92 | | 62 | 5-1 | | | | | | NA | NA | | | 5 | | | |
| | 13.5 | | | 24 | 76 | 0 | 0 | 0 | JP-15°-30°-Rg-Un stained | | 84 | | | | | 84 | | 64 | 8-5 | | | | | | NA | NA | | | 5 | | | |
| | 15.0 | | | 19 | 81 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 83 | | | | | 83 | | 67 | <1 | | | | | | NA | | | | 5 | | | |
| | 16.5 | | | 49 | 51 | 0 | 0 | 0 | JP-60°-Rg-Un-stained | | 79 | | | | | 79 | | 41 | <1 | | | | | | NA | | | | 5 | | | |
| | 18.0 | | | 22 | 78 | 0 | 0 | 0 | JP-10°-Rg-Un-stained | | 88 | | | | | 88 | | 69 | 5-1 | | | | | | NA | NA | | | 4 | | | |
| | 19.5 | | | 58 | 42 | 0 | 0 | 0 | JP-15°-20°-Rg-Un stained | | 83 | | | | | 83 | | 35 | 8-5 | | | | | | NA | NA | | | 4 | | | |
| | 21.0 | | | 35 | 46 | 20 | 0 | 0 | JP-0°-Rg-Un-stained | | 91 | | | | | 91 | | 59 | 5-1 | | | | | | NA | | | | 4 | | | |
| | 22.5 | | | 53 | 47 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 87 | | | | | 87 | IMP | 41 | 5-1 | NX | Uncased | | | | NA | | | | 4 | 8% | Not Tested | |
| | 24.0 | | | 86 | 14 | 0 | 0 | 0 | JP-0°-Rg-Un-stained | | 60 | | | | | 60 | | 9 | <1 | | | | | | NA | | | | 5 | | | |
| | 25.5 | | | 17 | 83 | 0 | 0 | 0 | JP-60°-Rg-Un-stained | | 73 | | | | | 73 | | 61 | 8-5 | | | | | | NA | | | | 4 | | | |
| | 27.0 | | | 45 | 55 | 0 | 0 | 0 | JP-45°-Rg-Un-stained | | 73 | | | | | 73 | | 41 | 5-1 | | | | | | NA | | | | 4 | | | |
| | 28.5 | | | 30 | 70 | 0 | 0 | 0 | JP-45°-60°-Rg-Un stained | | 81 | | | | | 81 | | 57 | 5-1 | | | | | | NA | | | | 4 | | | |
| | 30.0 | Fresh greyish black amygdaloidal basalt with secondary mineral in fillings | | 0 | 23 | 77 | 0 | 0 | JP-30°-Rg-Un-stained | | 95 | | | | | 95 | | 95 | <1 | | | | | | NA | NA | | | 4 | | | Fresh greyish black amygdaloidal basalt with secondary mineral in fillings |
| | 31.5 | | | 34 | 47 | 19 | 0 | 0 | JP-30°-45°-Rg-Un stained | | 88 | | | | | 88 | | 58 | <1 | | | | | | NA | NA | | | 4 | | | |
| | 33.0 | | | 18 | 63 | 18 | 0 | 0 | JP-10°-15°-Rg-Un stained | | 91 | | | | | 91 | | 74 | 5-1 | | | | | | NA | NA | | | 4 | | | |
| | 34.5 | | | 10 | 24 | 65 | 0 | 0 | JP-15°-20°-Rg-Un stained | | 95 | | | | | 95 | | 85 | 5-1 | | | | | | NA | NA | | | 4 | | | |
| | 36.0 | | | 16 | 58 | 26 | 0 | 0 | JP-30°-45°-Rg-Un stained | | 95 | | | | | 95 | | 79 | 8-5 | | | | | | NA | NA | | | 4 | | | |
| | 37.5 | | | 2 | 33 | 65 | 0 | 0 | JP-15°-20°-Rg-Un stained | | 95 | | | | | 95 | | 93 | 5-1 | | | | | | NA | NA | | | 4 | | | |
| | 39.0 | | | 4 | 57 | 40 | 0 | 0 | JP-0°-10°-Rg-Un-stained | | 94 | | | | | 94 | | 91 | 5-1 | | | | | | NA | NA | | | 4 | | | |
| | 40.5 | | | 19 | 81 | 0 | 0 | 0 | JP-15°-30°-Rg-Un stained | | 97 | | | | | 97 | | 79 | <1 | | | | | | NA | NA | | | 4 | | | |
| | 42.0 | | | 4 | 96 | 0 | 0 | 0 | JP-10°-15°-Rg-Un stained | | 92 | | | | | 92 | | 88 | <1 | | | | | | NA | NA | | | 4 | | | |
| | 43.5 | | | 10 | 90 | 0 | 0 | 0 | JP-15°-20°-Rg-Un stained | | 95 | | | | | 95 | | 85 | 5-1 | | | | | | NA | NA | | | 4 | | | |
| | 45.0 | | | 0 | 34 | 66 | 0 | 0 | JP-20°-30°-Rg-Un stained | | 94 | | | | | 94 | | 94 | 8-5 | | | | | | NA | NA | | | 4 | | | |
| | 46.0 | | | 0 | 33 | 67 | 0 | 0 | JP-15°-20°-Rg-Un stained | | 86 | | | | | 86 | | 86 | 15-8 | | | Water level met at 21.10 m down | | | NA | | | | 4 | | | |

**ABBREVIATION**

RQD - ROCK QUALITY DESIGNATION
CR- CORE RECOVERY
V - VERTICAL JOINT
Un- UNDULATING
Rg- ROUGH
JP- JOINT PLANE

**LEGEND : LITHOLOGY**

SAND/SILT/CLAY
ROCK MASS (BASALT)
MODERATELY WEATHERED ROCK
FRESH ROCK
HIGHLY WEATHERED ROCK

**Logged By:**

**Checked By:**

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | ***BH HOLE NO.*** | BH-1 |
| | | ***SHEET NO.:*** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa MG section of Westren Railway. | **LOCATION:** | T-04 | **CHAINAGE:-** | 17010 |
| **BEARING OF HOLE (Degree):** | 90° | **CO-ORDINATES:** | N-0588464, E-2478359 | **FEATURE** | Tunnel-04 |
| **COLLAR ELEVATION (m):** | 5 CM | **ANGLE W.R.T HORIZONTAL:** | 90° Degree | **BOREHOLE NO.** | BH-01 |
| **TYPE(S) OF CORE BARREL:** | NWT | **GROUND ELEVATION(m):** | 550 M | **DEPTH OF BOREHOLE** | 25.00M |
| **STARTED :** | 20.11.2024 | **COMPLETED:** | 25.11.2024 | **DRILLING AGENCY :** | Goma Engineerin and Consultancy |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Bit use | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering |
| | 0.50 | From GL to 1.5m Brownish colour silty sand with gravels pebbles, fregments of basalt Overburden. | | DS-1 | | | | | | | NA | Overburden | 46 | | | | | N A | N A | N A | N A | | | NX-2.0 METER | 5.10 METER | PARTIAL | | | | | | 7 | | | |
| | 1.50 | | | 50 | 30 | 20 | | | | | | | | | | | | 46 | | Nill | Nill | | | | | | | | | | | 11 | | | **From GL to 1.5m** Brownish colour silty sand with gravels pebbles, fregments of basalt Overburden. |
| | 3.00 | | | 10 | 50 | 40 | | | | | JN-20° RG-UN | | 44 | | | | | 44 | | Nill | >15 | | | | | | | | | | | 15 | | | |
| | 4.50 | **Bedrock encountered at 1.50m** Moderately to highly weathered, highly fractured, medium to weak, brown / grey colour fine grain basalt. | | 20 | 20 | 22 | | 38 | | | JN-30° RG-UN Iron staining | | 42 | | | | | 42 | | 16 | >15 | | | | | | | | | | | 14 | | | **Bedrock encountered at 1.50m From 1.50 to 6.0m** Moderately to highly weathered, highly fractured, medium to weak, brown / grey colour fine grain basalt |
| | 6.00 | | | 30 | 20 | 50 | | | | | JN-10° RG-UN | | 21 | | | | | 21 | | Nill | 5 | | | | | | | | | | | 14 | | | |
| | 7.50 | Moderately to slightly weathered, Moderately fractured, strong to very strong, grey colour fine grain basalt | | | 20 | 57 | | 23 | | | 'JN-40° RG-UN cleen | | 43 | | | | | 43 | | 10 | 5 | | | | | | | | | | | 12 | | | **From 6.00 to 9.0m** Moderately to slightly weathered, Moderately fractured, strong to very strong, grey colour fine grain basalt |
| | 9.00 | | | | | 51 | | 49 | | | JN-40°RG-UN | | 61 | | | | | 61 | | 31 | 4 | | | | | | Complete | | | | | 12 | | | |
| | 10.50 | Fresh to slighty weathered slightly fractured hard strong to very strong, grey colour, fine grain amygdaloidal basalt. | | | | | | 100 | | | JN-50°RG-UN | | 58 | | | | | 58 | | 51 | 3 | | | | | | | | | | | 12 | | | **From 9.00 to 12.0m** Fresh to slighty weathered slightly fractured hard strong to very strong, grey colour, fine grain amygdaloidal basalt. |
| | 12.00 | | | | | | 22 | 78 | | | JN-40° RG-UN | | 56 | | | | | 56 | | 51 | 3 | | | | | | | | | | | 11 | | | |
| | 13.50 | Moderately weathered, highly fractured medium strong grey colour, fine grain basalt | | | 10 | | 47 | 43 | | | "JN-10° RG-UN | | 25 | | | | | 25 | | 9 | 2 | | | | | | | | | | | 11 | | | **From 12.00 to 19.0m** Moderately weathered, highly fractured medium strong grey colour, fine grain basalt |
| | 15.00 | | | | 20 | 60 | 20 | | | | "JN-10° RG-UN Iron stained | | 47 | | | | | 47 | | Nill | >15 | NX | IMP DIAMOND | Uncasd | | | | | | | | 12 | | | |
| | 16.00 | | | | | 29 | 71 | | | | "JN-30° RG-UN | | 62 | | | | | 62 | | 12 | 7 | | | | | | | | | | | 8 | | | |
| | 17.00 | | | | | 50 | 50 | | | | "JN-30° RG-UN Vertical | | 76 | | | | | 76 | | Nill | 6 | | | | | | | | | | | 7 | | | |
| | 18.00 | | | | | 31 | 69 | | | | "JN-30° RG-UN Vertical | | 90 | | | | | 90 | | 14 | 10 | | | | | | | | | | | 7 | | | |
| | 19.00 | | | | | 80 | 20 | | | | JN-40° RG-UN | | 90 | | | | | 90 | | Nill | 14 | | | | | | | | | | | 9 | | | |
| | 20.00 | Fresh to slightly weathered, hard strong to very strong, slightly fractured fine grain grey colour basalt. | | | | | 25 | 75 | | | JN-20° RG-UN cleen | | 81 | | | | | 81 | | 63 | 5 | | | | | | | | | | | 8 | | | **From 19.00 to 25.0m** Fresh to slightly weathered, hard strong to very strong, slightly fractured fine grain grey colour basalt. |
| | 21.00 | | | | | 44 | 30 | 26 | | | JN-20° RG-UN | | 80 | | | | | 80 | | 31 | 9 | | | | | | | | | | | 8 | | | |
| | 22.00 | | | | | | 38 | 62 | | | JN-10° SM-PLVertical | | 87 | | | | | 87 | | 62 | 6 | | | | | | | | | | | 8 | | | |
| | 23.00 | | | | | | 11 | 89 | | | 'JN-30° RG-UN | | 92 | | | | | 92 | | 70 | 5 | | | | | | | | | | | 8 | | | |
| | 24.00 | | | | | 21 | 26 | 53 | | | JN-40° RG-UN | | 88 | | | | | 88 | | 50 | 6 | | | | | | | | | | | 8 | | | |
| | 25.00 | | | | | | | 100 | | | JN-20° RG-UN | | 76 | | | | | 76 | | 76 | 2 | | | | | | | | | | | 8 | | | |

INDEX

| | | | | | |
|---|---|---|---|---|---|
| | HILL SLOPE DEBRIS | | CORE RECOVERY | | MODERATELY FRACTURED |
| | BED ROCK | | SLIGHTLY FRACTURED | | HIGHLY FRACTURED |

LOGGED BY -

CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | |
|---|---|
| ***BH HOLE NO.*** | BH-2 |
| ***SHEET NO.:*** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa MG section of Westren Railway. | **LOCATION:** | T4 BH-2 | **CHAINAGE:-** | 17550 |
| **BEARING OF HOLE (Degree):** | Vertical | **CO-ORDINATES:** | N-2477853 E-588624 | **FEATURE** | Ratlam Khandawa Tunnel |
| **COLLAR ELEVATION (m):** | 10cm | **ANGLE W.R.T HORIZONTAL:** | 90 Degrees | **BOREHOLE NO.** | BH-2 |
| **TYPE(S) OF CORE BARREL:** | NX SIZE-150 | **GROUND ELEVATION(m):** | 534m | **DEPTH OF BOREHOLE** | 40M |
| **STARTED :** | 17.02.2024 | **COMPLETED:** | 02.03.2024 | **DRILLING AGENCY :** | Goma Engineerin and Consultancy |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | Permeability | | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.50 | From GL TO 3.50M Top Soil Consisting at mainly heterogeneous matrix (sand, silty & clay) with some angular to sub angular gravels pebble size fregments of basalt. | | 100 | | | | | | | NOT APPLICABLE | Overburden | 30 | | | | | NIL | | | | | | | | | | | | 33 | | | **From GL TO 3.50M** Top Soil Consisting at mainly heterogeneous matrix (sand, silty & clay) with some angular to sub angular gravels pebble size fregments of basalt. |
| | 1.00 | | | 50 | 50 | | | | | | | | 30 | | | | | 30 | | NILL | NA | HX-5.50 M | NX-3.50M | 6.00M | | | | | | 20 | | | |
| | 2.00 | | | 25 | 75 | | | | | | | | 37 | | | | | 37 | | | | | | | | | | | | 14 | | | |
| | 3.00 | | | 10 | 70 | 20 | | | | | | | 40 | | | | | 40 | | | | | | | | | | | | 10 | | | |
| | 4.00 | | | 10 | 35 | 55 | | | | | JN-20°-30° RG-UN Vertical | | 52 | | | | | 52 | | | 15 | | | | | | | | | 8 | | | |
| | 5.00 | | | | 11 | 20 | 22 | 47 | | | JN-30°RG-UN Vertical iron stained | | 44 | | | | | 44 | | 43 | 4 | | | | Complete | | | | | 8 | | | |
| | 6.00 | | | | 75 | 25 | | | | | JN-20°-30° RG-UN Vertical | | 55 | | | | | 55 | | NILL | 12 | | | | | | | | | 8 | | | |
| | 7.00 | Bed Rock Encountred 3.50m 3.00m to 14.00m Modeterly to highly weathered highly fractured medium strong to weak open spaced, iron staining gre/ shiny colour fine to medium grained basalt | | | | 81 | 90 | | | | JN-50°-40° RG-UN Iron Stained | | 46 | | | | | 46 | | NILL | 8 | | | | | | | | | 8 | | | **Bed Rock Encountred 3.00m to 14.00m** Modeterly to highly weathered highly fractured medium strong to weak open spaeed, iron staining gre/ shiny colour fine to medium gravel basalt |
| | 8.00 | | | | 20 | 28 | 32 | 30 | | | JN-30°-40° RG-UN Iron Stained vertical | | 53 | | | | | 53 | | 16 | 10 | | | | | | | | | 8 | | | |
| | 9.00 | | | | 34 | 44 | 22 | | | | JN-10°-20° RG-UN | | 45 | | | | | 45 | | NILL | 7 | | | | | | | | | 7 | | | |
| | 10.00 | | | | | 38 | 62 | | | | JN-30°-40° RG-UN | | 51 | | | | | 51 | | NILL | 6 | | | | From 9.00-10.00m cement grauting | | | | | 8 | | | |
| | 11.00 | | | | | 27 | 73 | | | | JN-30° RG-UN | | 53 | | | | | 53 | | 25 | 7 | | | | | | | | | 8 | | | |
| | 12.00 | | | | | 62 | 38 | | | | JN-20°-30° RG-UN | | 42 | | | | | 42 | | NILL | 3 | | | | | Complete | | | | 8 | | | |
| | 13.00 | | | | | | 100 | | | | JN-30°-40° SM-PL CLEAN | | 47 | | | | | 47 | | 15 | 4 | | | | | | | | | 8 | | | |
| | 14.00 | Modeterly to slightly weathered slightly fractured strong to very strong grey colour fine grain basalt | | | | | 64 | 36 | | | JN-30°-40° RG-UN | | 50 | | | | | 50 | | 13 | 5 | | | | | | | | | 7 | | | **14.00m to 17.00m** Modeterly to slightly weathered slightly fractured strong to very strong grey colour fine grain basalt |
| | 15.00 | | | | | | 50 | 50 | | | JN-10°-20° RG-UN | | 69 | | | | | 69 | | 66 | 6 | | | | | | | | | 7 | | | |
| | 16.00 | | | | | 37 | 20 | 43 | | | JN-20° RG-UN CLEAN | | 73 | | | | | 73 | | 45 | 9 | | | | | | | | | 8 | | | |
| | 17.00 | Fresh to slightly weathered slightly fractured strong to very strong gre colour basalt | | | | 25 | 60 | 15 | | | JN-10°-20° RG-UN Vertical | | 85 | | | | | 85 | DIAMOND CORE BIT | 29 | 6 | NX | UNCASED | | | | | | | 8 | | | **17.00m to 18.00m** Fresh to slightly weathered slightly fractured strong to very strong gre colour basalt |
| | 18.00 | | | | | | 64 | 36 | | | JN_10° RG-UN CLEAN | | 75 | | | | | 75 | | 63 | 5 | | | | | | | | | 8 | | | |
| | 19.00 | Modeterly to highly weathered highly fractured medium strong fine grain grey colour amygdaloidal basalt | | | | | 19 | 81 | | | JN-40°-50° RG-UN Clean | | 74 | | | | | 74 | | 60 | 15 | | | | | | | | | 8 | | | **19.00m to 20.00m** Modeterly to highly weathered highly fractured medium strong fine grain grey colour amygdaloidal basalt |
| | 20.00 | | | | 20 | 80 | | | | | JN-20°-30° RG-UN Iron stained | | 71 | | | | | 71 | | NILL | 5 | | | | | | | | | 8 | | | |
| | 21.00 | | | | | | 14 | 86 | | | JN-10° RG-UN | | 87 | | | | | 87 | | 86 | 6 | | | | | | | | | 7 | | | |
| | 22.00 | | | | | 20 | 42 | 38 | | | JN-20°-30° RG-UN CLEAN | | 88 | | | | | 88 | | 86 | 6 | | | | | | | | | 8 | | | |
| | 23.00 | | | | | 24 | 25 | 51 | | | JN-10° SMPL | | 93 | | | | | 93 | | 88 | 5 | | | | | | | | | 8 | | | |
| | 24.00 | | | | | 32 | 47 | 21 | | | JN-10° RG-UN | | 73 | | | | | 73 | | 73 | 7 | | | | | | | | | 8 | | | |
| | 25.00 | | | | | 40 | 36 | 24 | | | JN-10° RG-UN | | 79 | | | | | 79 | | 43 | 6 | | | | | | | | | 5 | | | |
| | 26.00 | | | | | 7 | 66 | 27 | | | JN-10° SMPL | | 74 | | | | | 74 | | 34 | 6 | | | | | | | | | 7 | | | |
| | 27.00 | | | | | 17 | 60 | 23 | | | JN-50° RG-UN | | 69 | | | | | 69 | | 34 | 7 | | | | | | | | | 8 | | | |
| | 28.00 | | | | | | 20 | 80 | | | JN-40° RG-UN P2 | | 99 | | | | | 99 | | 92 | 5 | | | | | | | | | 8 | | | |
| | 29.00 | | | | | | 57 | 43 | | | JN-10° SMPL | | 88 | | | | | 88 | | 53 | 4 | | | | | | | | | 8 | | | |
| | 30.00 | Fresh to slightly weathered hard strong to very strong grey colour clausely spaeed fine grain grey colour amygdaloidal basalt with quartz veins | | | | | 18 | 82 | | | JN-60° RG-UN | | 99 | | | | | 99 | | 98 | 5 | | | | | | | | | 8 | | | **21.00m to 40.00m** Fresh to slightly weathered hard strong to very strong grey colour clausely spaeed fine grain grey colour amygdaloidal basalt with quartz vains. |
| | 31.00 | | | | | | 41 | 59 | | | JN-40° RG-UN | | 81 | | | | | 81 | | 79 | 5 | | | | | | | | | 8 | | | |
| | 32.00 | | | | | | 55 | 45 | | | JN-10°-20° RG-UN | | 76 | | | | | 76 | | 65 | 7 | | | | | | | | | 9 | | | |
| | 33.00 | | | | | | 100 | | | | JN-50° RG-UN | | 81 | | | | | 81 | | 36 | 5 | | | | | | | | | 9 | | | |
| | 34.00 | | | | | | 69 | 31 | | | JN-30° RG-UN | | 79 | | | | | 79 | | 65 | 4 | | | | | | | | | 9 | | | |
| | 35.00 | | | | | | 33 | 67 | | | JN-40°-50° RG-UN | | 74 | | | | | 74 | | 65 | 4 | | | | | Complete | | | | 8 | | | |
| | 36.00 | | | | | | 22 | 78 | | | JN-20°SM PL | | 91 | | | | | 91 | | 90 | 5 | | | | | | | | | 7 | | | |
| | 37.00 | | | | | | 38 | 62 | | | JN-20°-30° RG-UN | | 89 | | | | | 89 | | 82 | 7 | | | | | | | | | 8 | | | |
| | 38.00 | | | | | | 100 | | | | JN-20°RG-UN | | 85 | | | | | 85 | | 49 | 4 | | | | | | | | | 7 | | | |
| | 39.00 | | | | | | | 100 | | | JN-30°RG-UN | | 98 | | | | | 98 | | 98 | 4 | | | | | | | | | 9 | | | |
| | 40.00 | | | | | | 29 | 71 | | | JN-40° SMPL | | 83 | | | | | 83 | | 76 | 4 | | | | | | | | | 8 | | | |

INDEX

| | | | |
|---|---|---|---|
| HILL SLOPE DEBRIS | CORE RECOVERY | MODERATELY FRACTURED | |
| BED ROCK | SLIGHTLY FRACTURED | HIGHLY FRACTURED | |

LOGGED BY -

CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | | | | | |
|---|---|---|---|---|---|
| | | | | ***BH HOLE NO.*** | BH-2 |
| | | | | ***SHEET NO.:*** | 1 |
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa MG section of Westren Railway. | **LOCATION:** | TUNNEL -T-5 PORTAL-02 | **CHAINAGE:-** | 19090 |
| **BEARING OF HOLE (Degree):** | Vertical | **CO-ORDINATES:** | N-2476436, E-589071 | **FEATURE** | TUNNEL L-5 |
| **COLLAR ELEVATION (m):** | 10cm | **ANGLE W.R.T HORIZONTAL:** | 90° Degrees | **BOREHOLE NO.** | PORTAL-02 |
| **TYPE(S) OF CORE BARREL:** | NWT | **GROUND ELEVATION(m):** | 547 | **DEPTH OF BOREHOLE** | 30.00M |
| **STARTED :** | 28.01.2024 | **COMPLETED:** | 05.02.2024 | **DRILLING AGENCY :** | Goma Engineerin and Consultancy |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | From GL to 1.50m Top soil consistancy at mainly heterogeneous matrix (sand silt & clay) with same angular to sub angular rounded to sub rounded gravels pebbles size fregments at basalt | | 100 | | | | | | | Nill | Overburden | | | | | 36 | - | - | - | HX-1.00 M | NX-1.00M | 11.00 M | | | | | | 75 | | | **From GL to 1.50m** Top soil consistancy at mainly heterogeneous matrix (sand silt & clay) with same angular to sub angular rounded to sub rounded gravels pebbles size fregments at basalt |
| | 1.50 | | | 10 | 90 | | | | | | JN-20°-30° RG-UN | | 36 | | | | | 36 | | Nill | >15 | | | | | | | | 30 | | | |
| | 3.00 | Bedrock- Encountred 1.50m From 1.50m to 4.50m Modeterly to Highly weathered highly fractured medium strong to weak iron staining brown grey shine colour fine to medium grain basalt with Quartz veins | | | 10 | 90 | | | | | JN-20° RG-UN | | 25 | | | | | 25 | | Nill | 5 | | | | | | | | 25 | | | Bedrock- Encountred 1.50m to 4.50m Modeterly to Highly weathered highly fractured medium strong to weak iron staining brown grey shine colour fine to medium grain basalt with Quartz veins. |
| | 4.50 | | | | 20 | 80 | | | | | JN-20°-30° RG-UN | | 24 | | | | | 24 | | Nill | >15 | | | | | | | | 18 | | | |
| | 6.00 | 4.50m to 9.00m Slightly to modeterly weathered medium strong to very strong Modeterly to fractured grey shiney in colour fine to medium grain basalt with Quartzm veins | | | | 100 | | | | | JN-20° RG-UN | | 23 | | | | | 23 | | Nill | 6 | | | | | | | | 18 | | | 4.50m to 9.00m slightly to modeterly weathered medium strong to very strong Modeterly to fractured grey shiney in colour fine to medium grain basalt with Quartzvains |
| | 7.50 | | | | | 57 | 43 | | | | JN-30° RG-UN | | 35 | | | | | 35 | | 15 | 3 | | | | | | | | 16 | | | |
| | 9.00 | | | | | | 33 | 67 | | | JN-20°-30° RG-UN | | 33 | | | | | 33 | | 31 | 2 | | | | | | | | 13 | | | |
| | 10.50 | 9.00m to 10.50m Modeterly to highly wathered highly fractured angular to sub sngular fregments medium to fine grain basalt with Quartz vins | | | 10 | 90 | | | | | JN-10°-20° RG-UN | | 31 | | | | | 31 | | Nill | >15 | | | | | | | | 13 | | | 9.00m to 10.50m Modeterly to highly fractured angular to sub sngular fregments medium to fine grain basalt with Quartz veins. |
| | 12.00 | | | | | 76 | 22 | | | | JN-30°-40° RG-UN | | 47 | | | | | 47 | | Nill | 6 | | | | | | | | 13 | | | |
| | 13.50 | 10.50m to 19.50m Slightly to modeterly weathered medium strong modeterly fractured grey shiny colour fine to medium grain basalt with Quartz veins. | | | | 28 | 31 | 41 | | | JN-20° RG-UN Vertical Iron stained | | 63 | | | | | 63 | | 33 | 5 | NX | UNCASED | | | | | | | 12 | | | 10.50m to 19.50m Slightly to modeterly weathered medium strong modeterly fractured grey shiny colour fine to medium grain basalt with Quartz veins. |
| | 15.00 | | | | | 38 | 13 | 49 | | | JN-30° SM-PL | | 66 | | | | | 66 | | 32 | 7 | | | | | | | | 12 | | | |
| | 16.50 | | | | | 21 | 20 | 59 | | | JN-20° SM-PL | | 73 | | | | | 73 | | 51 | 5 | | | | | | | | 12 | | | |
| | 18.00 | | | | | 10 | 90 | | | | JN-20°-30° SM-PL | | 77 | | | | | 77 | | 39 | 6 | | | | | | | | 12 | | | |
| | 19.50 | | | | | | 51 | 49 | | | JN-20°-30° JN-40°-50° RG-UN | | 85 | | | | | 85 | | 41 | 7 | | | | | | | | 11 | | | |
| | 21.00 | 19.50m to 25.50m Modeterly to Highly weathered highly fractured fregment size pices medium to fine grain grey colour basalt iron staining with Quartz veins | | | 10 | 65 | 25 | | | | JN-30°-40° RG-UN | | 77 | | | | | 77 | | 17 | >15 | | | | | | | | 10 | | | 25.50m to 30.00m Modeterly to Highly weathered highly fractured fregment size pices medium to fine grain grey colour basalt iron staining with Quartz veins. |
| | 22.50 | | | | 18 | 50 | 14 | 18 | | | JN-30°-40° RG-UN Iron stained | | 79 | | | | | 79 | | 13 | >15 | | | | | | | | 10 | | | |
| | 24.00 | | | | | 10 | 34 | 56 | | | JN-20° RG-UN Vertical Iron stained | | 77 | | | | | 77 | | 29 | 14 | | | | | | | | 11 | | | |
| | 25.50 | | | | | 100 | | | | | JN-20° RG-UN | | 51 | | | | | 51 | | 13 | >15 | | | | | | | | 11 | | | |
| | 27.00 | 25.50m to 30.00m slightly to medium weathered medium strong modeterly fractured grey/shiney colour fine to medium grain basalt with iron stain vertical joint Quartz veins | | | | 60 | | 40 | | | JN-20° RG-UN vertical iron stained | | 43 | | | | | 43 | | 18 | 8 | | | | | | | | 12 | | | 25.50m to 30.00m slightly to medium weathered medium strong modeterly fractured grey/shiney colour fine to medium grain basalt with iron stain vertical joint Quartz veins |
| | 28.50 | | | | | 29 | 50 | 21 | | | JN-30°-40° SM-PL Vertical Iron stained | | 52 | | | | | 52 | | Nill | 5 | | | | | | | | 11 | | | |
| | 30.00 | | | | | 54 | 46 | | | | JN-30°-40° SM-PL Vertical Iron stained | | 60 | | | | | 60 | | Nill | 6 | | | | | | | | 11 | | | |

INDEX

HILL SLOPE DEBRIS | BED ROCK | CORE RECOVERY | SLIGHTLY FRACTURED | MODERATELY FRACTURED | HIGHLY FRACTURED

LOGGED BY -

CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | | | | | |
|---|---|---|---|---|---|
| | | | | BH HOLE NO. | T5 BH-01 |
| | | | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-5 | CHAINAGE:- | 18+690 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E58821.665, N2476732.406 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | T5 - BH-01 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 42.00 |
| STARTED : | 18.11.2022 | COMPLETED: | 04.12.2022 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | LUGEON mm/s OR | Special Observations and interpretations / Weathering Grade |
| | | | | DS-01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Brownish- Greyish Medium Dense Sandy Gravel | | SPT-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | 4 | 18 | 10 | 28 | | | | **Overburden:-** **0.00m-3.00m** The borehole has been drilled in overburden from 0.00m - 3.00mtr. having with Brownish-Greyish Medium Dense Sandy Gravel |
| | 3.00 | | | SPT-02 | | | | | | | | | | | | | | | | | | | | | | | 7 | 10 | 15 | 25 | | | | |
| | 4.50 | | | | 100 | | | | | | | | | | | | | 15 | | NIL | >15 | | | | | | | | | | 21 | | | |
| | 6.00 | | | | 100 | | | | | | | | | | | | | 27 | | NIL | >15 | | | | | | | | | | 33 | | | |
| | 7.50 | Greyish Weathered rock Moderately Weak to Strong Basalt | | | 100 | | | | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 27 | | NIL | >15 | | | | | | | | | | 31 | | | **Weathered Bedrock-** Completely to Highly weathered Bedrock encountered between between 3.00 to 10.50mtr. which is Greyish Weathered rock Moderately Weak to Strong Basalt |
| | 9.00 | | | | 100 | | | | | | | | | | | | | 31 | | NIL | >15 | | | | | | | | | | 25 | | | |
| | 10.50 | | | | | 80 | 20 | | | | | | | | | | | 43 | | 13 | >15 | | | | | | | | | | 22 | | | |
| | 12.00 | | | | | | 100 | | | | | | | | | | | 100 | | 73 | 7 | | | | | | | | | | 15 | | | |
| | 13.50 | | | | | | 70 | 30 | | | | | | | | | | 75 | | 50 | 13 | | | | | | | | | | 15 | | | |
| | 15.00 | | | | | | | 100 | | | | | | | | | | 85 | | 85 | 4 | | | | | | | | | | 15 | | | |
| | 16.50 | | | | | | 70 | 30 | | | | | | | | | | 90 | | 47 | 14 | | | | | | | | | | 11 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 10.50 to 42.00mtr. which is Greyish Slightly Weathered to Fresh Fracture Strong Basalt |
| | 18.00 | | | | | | | 100 | | | | | | | | | | 100 | | 97 | <1 | | | | | | | | | | 11 | | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | | 82 | | 73 | 8 | | | | | | | | | | 10 | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 87 | | 80 | 4 | | | | | | | | | | 10 | | | |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 100 | NX Size Diamond Bit | 97 | <1 | NX | NX | 20.0 | Partial | | | | | | 12 | | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 91 | | 65 | 13 | | | | | | | | | | 12 | | | |
| | 25.50 | | | | | | | 100 | | | | | | | | | | 97 | | 65 | 12 | | | | | | | | | | 11 | | | |
| | 27.00 | Greyish Slightly Weathered to Fresh jointed Strong Basalt | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 93 | | 77 | 9 | | | | | | | | | | 12 | | | The core recovery percentage in bedrock varies between 15% to 100% with RQD varies from 13% to 97%. |
| | 28.50 | | | | | | | 100 | | | | | | | | | | 92 | | 75 | 8 | | | | | | | | | | 11 | | | |
| | 30.00 | | | | | | | 100 | | | | | | | | | | 93 | | 89 | 6 | | | | | | | | | | 10 | | | |
| | 31.50 | | | | | | | 100 | | | | | | | | | | 98 | | 95 | <1 | | | | | | | | | | 9 | | | |
| | 33.00 | | | | | | | 100 | | | | | | | | | | 99 | | 91 | <1 | | | | | | | | | | 10 | | | |
| | 34.50 | | | | | | | 100 | | | | | | | | | | 95 | | 95 | <1 | | | | | | | | | | 10 | | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 36.00 | | | | | | | 100 | | | | | | | | | | 92 | | 75 | 10 | | | | | | | | | | 11 | | | |
| | 37.50 | | | | | | | 100 | | | | | | | | | | 97 | | 67 | 8 | | | | | | | | | | 11 | | | |
| | 39.00 | | | | | | | 100 | | | | | | | | | | 95 | | 90 | <1 | | | | | | | | | | 11 | | | |
| | 40.50 | | | | | | | 100 | | | | | | | | | | 94 | | 89 | 4 | | | | | | | | | | 11 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 42.00 | | | | | | | 100 | | | | | | | | | | 99 | | 76 | 6 | | | | | | | | | | 11 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | **BH HOLE NO.** | BH-01 |
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa MG section of Westren Railway. | **LOCATION:** T-5A | **CHAINAGE:-** 19880.000 |
| **BEARING OF HOLE (Degree):** | Vertical | **CO-ORDINATES:** N-2476306, E-589831 | **FEATURE** Ratlam Khandawa Tunnel |
| **COLLAR ELEVATION (m):** | 5.00cm | **ANGLE W.R.T HORIZONTAL:** 90 Degrees | **BOREHOLE NO.** BH-01 |
| **TYPE(S) OF CORE BARREL:** | NWT | **GROUND ELEVATION(m):** 557m | **DEPTH OF BOREHOLE** 40.00m |
| **STARTED :** | 25-01-2024 | **COMPLETED:** 02-02-2024 | **DRILLING AGENCY :** Goma Enginering and Consultanc |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial (colour) | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Top Soil consisting of mainly heterogeneous matrix (sand, silt & clay) with some angular to sub angular,gravels, pebble size fragments of Basalt. | | 100 | DS-1 | | | | | | NOT APPLICABLE | Overburden | 92 | | | | | NIL | | NA | NILL | HX-2 M | NX-2.00M | | | Complete | | | | 33 | | | **From G.L to 3.00m** Top Soil consisting of mainly heterogeneous matrix (sand, silt & clay) with some angular to sub angular,gravels, pebble size fragments of Basalt. |
| | 1.00 | | | 20 | 60 | 20 | | | | | | | 39 | | | | | 92 | | | | | | | | | | | | 20 | | | |
| | 2.00 | | | 10 | 50 | 90 | | | | | | | 40 | | | | | 39 | | | | | | | | | | | | 14 | | | |
| | 3.00 | | | 10 | 40 | 50 | | | | | | | 46 | | | | | 40 | | | | | | | | | | | | 12 | | | |
| | 4.00 | | | | | 24 | 78 | | | | Jn-10°2O° RG-UN, | | 44 | | | | | 46 | | 37 | 4 | | | | | | | | | 11 | | | |
| | 5.00 | Slightly to moderaterly weathered, medium strong to strong, Slightly fractured, Iron staining grey colour fine grain Basalt. | | | | 44 | 54 | | | | Jn-10°RG-UN, Jn 60°RG-UN° | | 47 | | | | | 44 | | 11 | 4 | | | | | | | | | 9 | | | **BEDROCK-ENCOUNTERED:- at 3.00m.** From 3.00m to 9.00m Slightly to moderately weathered, medium strong to strong, Slightly fractured, Iron staining grey colour fine grain Basalt. |
| | 6.00 | | | | | 45 | 55 | | | | Jn-10°-20°RG-UN, | | 53 | | | | | 47 | | 24 | 6 | | | | | | | | | 8 | | | |
| | 7.00 | | | | | 33 | 35 | 32 | | | Jn-40°-50°RG-UN, | | 99 | | | | | 53 | | 28 | 4 | | | | | | | | | 8 | | | |
| | 8.00 | | | | | 44 | 35 | 21 | | | Jn-20°-30°RG-UN, | | 60 | | | | | 99 | | 11 | 10 | | | | | | | | | 8 | | | |
| | 9.00 | | | | | | 29 | 71 | | | Jn-30°RG-UN | | 38 | | | | | 60 | | 59 | 3 | | | | From 8.00-9.00m cement grouting | | | | | 8 | | | |
| | 10.00 | Moderaterly to highly weathered, highly fractured, medium strong to weak, Iron staining grey colour fine to medium grained, Amygdaloidal Basalt With quartz vains. | | 10 | 40 | 50 | | | | | Jn- 20-30°SM-PL | | 70 | | | | | 38 | | Nill | 12 | | | | | Complete | | | | | 8 | | | **09.00-16.00m Depth** Moderately to highly weathered, highly fractured, medium strong to weak, Iron staining grey colour fine to medium grained, Amygdaloidal Basalt With quartz vains. |
| | 11.00 | | | | | 49 | 33 | 28 | | | Jn-10°-20°RG-UN Iron stained | | 55 | | | | | 70 | | 20 | >15 | | | | | | | | | 8 | | | |
| | 12.00 | | | 10 | 29 | 40 | 21 | | | | Jn- 10°-20°RG-UN, Jn 20°RG-UN Iron stained | | 42 | | | | | 55 | | 12 | >15 | | | | | | | | | 8 | | | |
| | 13.00 | | | 10 | 40 | 40 | 10 | | | | Jn40°-60° RG-UN Iron stained | | 49 | | | | | 42 | | Nill | >15 | | | | | | | | | 8 | 18.00-21.00m | | |
| | 14.00 | | | 10 | 12 | 50 | 28 | | | | Jn- 10°-20°RG-UN, Iron stained | | 42 | | | | | 49 | | 11 | 8 | | | | | | | | | 8 | | | |
| | 15.00 | | | | 30 | 70 | | | | | Jn 10°-20 RG-UN vertical Iron stained | | 54 | | | | | 42 | | Nill | 8 | | | | | | | | | 8 | | | |
| | 16.00 | | | | 30 | 70 | | | | | Jn - 20°RG-UN clean | | 64 | | | | | 54 | | Nill | >15 | | | | | | | | | 8 | | | |
| | 17.00 | | | | | 33 | 15 | 62 | | | Jn 20°- 30 RG-UN vertical Iron stains | | 98 | | | | | 64 | | 35 | 5 | | | | | | | | | 8 | | | |
| | 18.00 | | | | | | | 100 | | | Jn- 10°-20°RG-UN, Iron stained | | 97 | | | | | 98 | | 97 | 5 | | | | | | | | | 8 | | | |
| | 19.00 | | | | | | 23 | 77 | | | Jn20° RG-UN Iron stained | | 95 | | | | | 97 | | 47 | 7 | | | | | | | | | 8 | | | |
| | 20.00 | | | | | | 28 | 72 | | | Jn-20°-30 RG-UN vertical Iron stained | | 93 | | | | | 95 | | 79 | 7 | | | | | | | | | 8 | | | |
| | 21.00 | | | | | | 20 | 80 | | | Jn-20°-30 RG-UN vertical Iron stained | | 95 | | | | | 93 | | 78 | 4 | | | | | | | | | 8 | | | |
| | 22.00 | | | | | | 20 | 80 | | | Jn- 10°-20°RG-UN,Iron stained | | 98 | | | | | 95 | | 66 | 4 | | | | | | | | | 8 | | | |
| | 23.00 | | | | | | 26 | 74 | | | Jn - 20°- 30° RG-UN, | | 95 | | | | | 98 | | 77 | 4 | | | | | | | | | 8 | | | |
| | 24.00 | | | | | | 32 | 68 | | | Jn 20° RG-UN Iron stained | | 90 | | | | | 95 | | 34 | 3 | | | | | | | | | 8 | | | |
| | 25.00 | Fresh to Slightly to moderaterly weathered,strong to very strong, Slightly fractured, quartz rich, grey colour fine to medium grained, horzental jointed Amygdaloidal Basalt | | | | 14 | 30 | 56 | | | Jn20,-30° RG-UN Clean | | 89 | | | | | 90 | | 67 | 7 | | | | | | | | | 8 | | | |
| | 26.00 | | | | | | 26 | 74 | | | Jn-20° RG-UN, Iron stained | | 94 | | | | | 89 | | 67 | 5 | | | | | | | | | 8 | | | |
| | 27.00 | | | | | | | 100 | | | Jn- 20-30° RG-UN Iron stained | | 86 | | | | | 94 | | 80 | 3 | | | | | | | | | 8 | | | |
| | 28.00 | | | | | | 24 | 76 | | | Jn-10°-20° RG-UN | | 90 | | | | | 86 | | 83 | 4 | | | | | | | | | 8 | | | **34.00- 35.00m Depth:-** Slightly to moderaterly weathered, strong to very strong, Slightly fractured, quartz rich, grey colour fine to medium grained, Amygdaloidal Basalt. |
| | 29.00 | | | | | 10 | 26 | 64 | | | Jn 10° RG-UN | | 98 | | | | | 90 | | 59 | 5 | | | | | | | | | 8 | | | |
| | 30.00 | | | | | | 27 | 73 | | | Jn-20°-30°RG-UN | | 96 | | | | | 98 | | 73 | 4 | | | | | | | | | 8 | | | |
| | 31.00 | | | | | 27 | 40 | 33 | | | Jn-20°-30°RG-UN | | 98 | | | | | 96 | | 32 | 9 | | | | | | | | | 8 | | | |
| | 32.00 | | | | | 19 | 24 | 57 | | | Jn 30° RG-UN | | 90 | | | | | 98 | | 71 | 8 | | | | | | | | | 8 | | | |
| | 33.00 | | | | | 27 | 56 | 17 | | | Jn 20° RG-UN | | 94 | | | | | 90 | | 53 | 3 | | | | | | | | | 8 | | | |
| | 34.00 | | | | | | | 100 | | | jn 20-30° RG-UN | | 98 | | | | | 94 | | 91 | 9 | | | | | | | | | 8 | | | |
| | 35.00 | Slightly to moderately weathered,strong to very strong, Slightly fractured, quartz rich, grey colour fine to medium grained,Amygdaloidal Basalt. | | | | 30 | 53 | 17 | | | jn 20-30° RG-UN | | 98 | | | | | 98 | | 15 | 9 | | | | | | | | | 8 | | | **34.00- 35.00m Depth:-** Slightly to moderately weathered,strong to very strong, Slightly fractured, quartz rich, grey colour fine to medium grained,Amygdaloidal Basalt. |
| | 36.00 | Fresh to moderately weathered,strong to very strong, Slightly fractured, quartz rich, grey colour fine to medium grained, Amygdaloidal Basalt. | | | | | | 100 | | | jn 20-30° RG-UN | | 98 | | | | | 98 | | 82 | 5 | | | | | | | | | 8 | | | **35.00- 36.00m Depth:-** Fresh to moderately weathered,strong to very strong, Slightly fractured, quartz rich, grey colour fine to medium grained, Amygdaloidal Basalt. |
| | 37.00 | Moderately to highly weathered, highly fractured, medium strong to weak, Iron staining grey colour fine to medium grained, Amygdaloidal Basalt With quartz vains. | | 27 | 20 | 20 | 33 | | | | jn 10-20° RG-UN | | 98 | | | | | 98 | | 14 | >15 | | | | | | | | | 8 | | | |
| | 38.00 | | | | 20 | 40 | 40 | | | | Jn-20°-30°RG-UN, | | 80 | | | | | 80 | | 46 | 6 | | | | | | | | | 8 | | | **35.00- 36.00m Depth:-**Moderately to highly weathered, highly fractured, medium strong to weak, Iron staining grey colour fine to medium grained, Amygdaloidal Basalt With quartz vains. |
| | 39.00 | | | 15 | 30 | 32 | 23 | | | | Jn-20°-30° RG-UN, Vertical | | 78 | | | | | 78 | | 18 | 12 | | | | | | | | | 8 | | | |
| | 40.00 | | | | 23 | 40 | 37 | | | | Jn-20°-30°RG-UN, Vertical | | 57 | | | | | 57 | | 11 | 7 | | | | | | | | | 8 | | | |

DIAMOND CORE BIT — NX — UNCASED — 14.00m — Partial — Complete

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| | HILL SLOPE DEBRIS | | CORE RECOVERY | | MODERATELY FRACTURED |
| | BED ROCK | | SLIGHTLY FRACTURED | | HIGHLY FRACTURED |

LOGGED BY - CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | ***BH HOLE NO.*** | BH-2 |
| | | ***SHEET NO.:*** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa MG section of Westren Railway. | **LOCATION:** | T-5A, BH-02 | **CHAINAGE:-** | 20040 |
| **BEARING OF HOLE (Degree):** | Vertical | **CO-ORDINATES:** | N-2476374 E-0589977 | **FEATURE** | T-5A |
| **COLLAR ELEVATION (m):** | 12cm | **ANGLE W.R.T HORIZONTAL:** | 90° Degree | **BOREHOLE NO.** | BH-02 |
| **TYPE(S) OF CORE BARREL:** | NWT | **GROUND ELEVATION(m):** | 505 | **DEPTH OF BOREHOLE** | 35.00M |
| **STARTED :** | 10.01.2024 | **COMPLETED:** | 22.01.2024 | **DRILLING AGENCY :** | Goma Engineerin and Consultancy |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | From GL to 0.50m Top soil consisting of mainly hetregenious matrix (sand, silt & Clay with Gravels | | 100 | | | | | | | NOT APPLICABLE | Overburden | | | | | | - | - | NIL | HX-1.50 M | NX-1.50m | 11.00m | Partial | | | | | | 75 | | | **From GT to 0.50m** Top soil consisting of mainly hetregenious matrix (sand, silt & Clay with Gravels |
| | 1.50 | BED-ROCK ENCOUTERED at0.50m From 0.00 to 9.00m Modaterly to highly weathered highly fractured medium strong to weak, Angular to sub angular fregrnment Basalt grey colour fine grain Basalt Iron stain | | 10 | 60 | 30 | | | | | NIL | | 34 | | | | | 34 | | NIL | >15 | | | | | | | | | 37 | | | **From 0.50 to 9.00m** Modaterly to highly weathered highly fractured medium strong to weak, Angular to sub angular fregrnment Basalt grey colour fine grain Basalt Iron stain |
| | 3.00 | | | 10 | 70 | 20 | | | | | JN-30°-40° RG-UN | | 36 | | | | | 36 | | NIL | >15 | | | | | | | | | 25 | | | |
| | 4.50 | | | 20 | 50 | 30 | | | | | JN-20°:RG-UN | | 30 | | | | | 30 | | NIL | >15 | | | | | | | | | 18 | | | |
| | 6.00 | | | | 20 | 80 | | | | | JN-40°RG-UN JN-10°RG-UN | | 36 | | | | | 36 | | NIL | >15 | | | | | | | | | 16 | | | |
| | 7.50 | | | | 70 | 30 | | | | | JN-20°-40° RG-UN Iron Stained | | 39 | | | | | 39 | | NIL | >15 | | | Complete | | | | | | 18 | | | |
| | 9.00 | | | | 20 | 80 | | | | | NIL' | | 65 | | | | | 65 | | NIL | >15 | | | | | | | | | 15 | | | |
| | 10.50 | 9.00 to 16.50m Modaterly to Slightly weathered slightly freactured strong to very strong fine grain grey colour Basalt with iren stain | | | | 43 | 57 | | | | JN-40°-50° RG-UN Iron stained | | 55 | | | | | 55 | | 25 | 9 | | | | Complete | | | | | 13 | | | **9.00 to 16.50m** Modaterly to Slightly weathered slightly freactured strong to very strong fine grain grey colour Basalt with iron stain |
| | 12.00 | | | | | 41 | 39 | 20 | | | JN-30°RG-UN vertical Iron stained | | 57 | | | | | 57 | | 20 | 5 | | | | | | | | | 12 | | | |
| | 13.50 | | | | | 28 | 28 | 44 | | | JN-30°SM-PL | | 65 | | | | | 65 | | 29 | 7 | | | | | | | | | 11 | | | |
| | 15.00 | | | | | 10 | 20 | 70 | | | JN-20°RG-UN | | 66 | | | | | 66 | | 39 | 6 | | | | | | | | | 12 | | | |
| | 16.50 | | | | | | 45 | 55 | | | JN-10°-20° RG-UN | | 83 | | | | | 83 | | 50 | 4 | | | | | | | | | 12 | | | |
| | 18.00 | 16.50 to 19.50m Modaterly To highly weathered highly fractured fregments silee piece medium to week medium to fine grain iron stain grey colour Basalt with quernts vains | | | | 78 | 22 | | | | JN-20° RG-UN | | 42 | | | | | 42 | | NIL | >15 | | | | | | | | | 12 | | | **16.50 to 19.50m** Modaterly To highly weathered highly fractured fregments silee piece medium to week medium to fine grain iron stain grey colour Basalt with quernts vains |
| | 19.50 | | | | | 41 | 59 | | | | JN-40°-50°RG-UN Vertical | | 76 | | | | | 76 | | 8 | >15 | NX | UNCASED | | | | | | | 11 | | | |
| | 21.00 | 19.50 to 21.00 m Modaterly slightly weathered fine grain slightly fractured grey colour basalt | | | | 34 | 24 | 42 | | | JN-20°SM-PL Vertical Iron Stained | | 51 | | | | | 51 | | 24 | 4 | | | | | | | | | 12 | | | **19.50 to 21.00 m** Modaterly slightly weathered fine grain slightly fractured grey colour basalt |
| | 22.50 | 21.00 to 22.50 m Modaterly to Highly weathered Highly fractured grey colour fine grain Basalt | | | | 52 | 27 | 21 | | | JN-30° RG-UN Iron Stained | | 52 | | | | | 52 | | 12 | >15 | | | | Complete | | | | | 12 | | | **21.00 to 22.50 m** Modaterly to Highly weathered Highly fractured grey colour fine grain Basalt |
| | 24.00 | 22.50 to 35.00m Fresh to slighlly weathered hard strong to very strong medium to fine grain grey colour anygdaldial Basalt with quart & Vains | | | | 54 | 46 | | | | JN-10° RG-UN | | 51 | | | | | 51 | | NIL | 5 | | | | | | | | | 12 | | | **22.50 to 35.00m** Fresh to slighlly weathered hard strong to very strong medium to fine grain grey colour anygdaldial Basalt with quartz Vains |
| | 25.50 | | | | | | 55 | 45 | | | JN-20° RG-UN | | 72 | | | | | 72 | | 39 | 6 | | | | | | | | | 12 | | | |
| | 27.00 | | | | | | | 100 | | | JN-20° RG-UN Clean | | 71 | | | | | 71 | | 65 | 4 | | | | | | | | | 11 | | | |
| | 28.50 | | | | | 38 | 25 | 37 | | | JN-30°-40° RG-UN | | 72 | | | | | 72 | | 25 | 6 | | | | | | | | | 11 | | | |
| | 30.00 | | | | | | | 100 | | | JN-30° RG-UN | | 71 | | | | | 71 | | 73 | 3 | | | | | | | | | 13 | | | |
| | 31.50 | | | | | | 35 | 65 | | | JN-20°-30° RG-UN | | 63 | | | | | 63 | | 48 | 4 | | | | | | | | | 12 | | | |
| | 33.00 | | | | | | 14 | 86 | | | JN-20°RG-UN | | 64 | | | | | 64 | | 61 | 3 | | | | | | | | | 12 | | | |
| | 34.50 | | | | | | 6 | 94 | | | JN-10°-20° RG-UN | | 79 | | | | | 79 | | 73 | 3 | | | | | | | | | 12 | | | |
| | 35.00 | | | | | | 27 | 73 | | | JN-20°RG-UN | | 90 | | | | | 90 | | 64 | 1 | | | | | | | | | 18 | | | |

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| | HILL SLOPE DEBRIS | | CORE RECOVERY | | MODERATELY FRACTURED |
| | BED ROCK | | SLIGHTLY FRACTURED | | HIGHLY FRACTURED |

LOGGED BY -

CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | ***BH HOLE NO.*** | BH-1 |
| | | ***SHEET NO.:*** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa MG section of Westren Railway. | **LOCATION:** | T-06, BH-01 | **CHAINAGE:-** | 21150 |
| **BEARING OF HOLE (Degree):** | Vertical | **CO-ORDINATES:** | N-2476819 E-0590973 | **FEATURE** | T-06 |
| **COLLAR ELEVATION (m):** | 5 CM | **ANGLE W.R.T HORIZONTAL:** | 90° Degree | **BOREHOLE NO.** | BH-01 |
| **TYPE(S) OF CORE BARREL:** | NWT | **GROUND ELEVATION(m):** | 525 M | **DEPTH OF BOREHOLE** | 40.00M |
| **STARTED :** | 17.02.2024 | **COMPLETED:** | 03.03.2024 | **DRILLING AGENCY :** | Goma Engineerin and Consultancy |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Top soil consisting of mainly heterogeneous matrix (sand,silt & cley) sum pices of angular to sub angular gravels, pebble,cobble size fregments of Basalt. | | 100 | DS-1 | | | | | | NIL | Overburden | | | | | | NIL | | NA | NIL | HX-1.50 M | NX-1.50 M | WATER TABLE 8.00 METER | | | | | | | 75 | | | Top soil consisting of mainly heterogeneous matrix (sand,silt & cley) sum pices of angular to sub angular gravels, pebble,cobble size fregments of Basalt. |
| | 1.50 | | | 100 | DS-2 | | | | | | | | | | | | | NIL | | NA | NIL | | | | | | | | | | 30 | | | |
| | 3.00 | Moderately to highly fractured medium strong to weak iron stain fine grain grey colour Basalt | | 20 | 50 | 30 | | | | | JN-20°-30° RG-UN Iron stained Vertical | | 27 | | | | | 27 | | NIL | >15 | | | | Partial | | | | | | 18 | | | **Bed rock encounterd at 1.50 m 0.50m to 4.50m** Moderately to highly fractured medium strong to weak iron stain fine grain grey colour Basalt |
| | 4.50 | | | 10 | 40 | 50 | | | | | JN-20°,RG-UN Vertical Iron stained | | 32 | | | | | 32 | | NIL | >15 | | | | | | | | | | 16 | | | |
| | 6.00 | Slightly to modaterly weathered medium strong slightly fractured fine grein grey colour Basalt | | | | 10 | 90 | | | | JN-40°,RG-UN Iron stained Vertical | | 30 | | | | | 30 | | 8 | 2 | | | | | | | | | | 12 | | | **4.50 to 9.00** Slightly to modaterly weathered medium strong slightly fractured fine grein grey colour Basalt |
| | 7.50 | | | | | | 63 | 37 | | | JN-30°,RG-UN Iron stained | | 36 | | | | | 36 | | 13 | 3 | | | | | | | | | | 12 | | | |
| | 9.00 | | | | | 26 | 30 | 44 | | | JN-40°,RG-UN Vertical | | 28 | | | | | 28 | | 12 | 4 | | | | | | | | | | 12 | | | |
| | 10.50 | Moderately to highly weathered, highly fractured medium to weak, medium to fine grain colour amygdaloidal Basalt with quartz vains Iron stain. | | | 30 | 40 | 30 | | | | JN-20°,RG-UN vertical | | 36 | | | | | 36 | | 8 | >15 | | | | | Complete | | | | | 12 | | | **9.00m to 24.00m** Moderately to highly weathered, highly fractured medium to weak, medium to fine grain colour amygdaloidal Basalt with quartz vains Iron stain. |
| | 12.00 | | | | 14 | 50 | | 36 | | | JN-20°-30°,RG-UN vertical | | 31 | | | | | 31 | | 10 | >15 | | | | | | | | | | 11 | | | |
| | 13.50 | | | | 31 | 20 | 10 | 39 | | | JN-10°-20°,RG-UN iron vertical | | 34 | | | | | 34 | | 13 | >15 | | | | | | | | | | 11 | | | |
| | 15.00 | | | | | 59 | 41 | | | | JN-10°-20°,RG-UN Iron stained | | 29 | | | | | 29 | | 9 | 5 | | | | | | | | | | 12 | | | |
| | 16.50 | | | | | 68 | 32 | | | | JN-20°-30°,RG-UN Iron stained | | 35 | | | | | 35 | | 8 | 4 | | | | Partial | | | | | | 12 | | | |
| | 18.00 | | | | 34 | 40 | 26 | | | | JN-10°-20°,RG-UN Iron stained | | 66 | | | | | 66 | | NIL | >15 | | | | | | | | | | 12 | | | |
| | 19.50 | | | 17 | 20 | 30 | 33 | | | | JN-30°-40°,RG-UN vertical Iron stained | | 64 | | | | | 64 | | NIL | >15 | | | | | | | | | | 12 | | | |
| | 21.00 | | | | 20 | 80 | | | | | JN-40°-50°,RG-UN Iron Stained | | 55 | | | | | 55 | | NIL | >15 | NX | UNCASED | | | | | | | | 12 | | | |
| | 22.50 | | | 18 | 20 | 40 | 22 | | | | JN-20°-30°,RG-UN Iron stained | | 53 | | | | | 53 | | NIL | >15 | | | | | Complete | | | | | 11 | | | |
| | 24.00 | | | | 18 | 50 | 32 | | | | JN-20°-30°,RG-UN | | 64 | | | | | 64 | | 8 | >15 | | | | | | | | | | 12 | | | |
| | 25.50 | Fresh to slightly weathered hard strong to very strong fine grain grey colour Basalt | | | | | 5 | 95 | | | JN-40°,RG-UN | | 81 | | | | | 81 | | 64 | 3 | | | | | | | | | | 12 | | | **24.00 to 25.50 M** Moderately to highly weathered, highly fractured medium to weak, medium to fine grain colour amygdaloidal Basalt with quartz vains Iron stain. |
| | 27.00 | 25.50 to 28.50 m Medium to highly weathered highly fractured medium strong fine grain grey colour Basalt. | | | | 10 | 30 | 60 | | | JN-30°-40° RG-UN | | 74 | | | | | 74 | | 40 | >15 | | | | | | | | | | 12 | | | **25.50 to 28.50 m** Medium to highly weathered highly fractured medium strong fine grain grey colour Basalt. |
| | 28.50 | | | | | 28 | 29 | 43 | | | JN-10°-30°,RG-UN vertical | | 68 | | | | | 68 | | 37 | 8 | | | | | | | | | | 12 | | | |
| | 30.00 | Slightly weathered medium strong slightly fractured grey colour fine grain amygdaloidal Basalt | | | | | 31 | 34 | 35 | | JN-20°-30° RG-UN | | 80 | | | | | 80 | | 40 | 8 | | | | | | | | | | 12 | | | **28.50 to 33.00 M** Slightly weathered medium strong slightly fractured grey colour fine grain amygdaloidal Basalt |
| | 31.50 | | | | | | 49 | 51 | | | JN-20°-30°,RG-UN vertical | | 84 | | | | | 84 | | 16 | >15 | | | | | | | | | | 12 | | | |
| | 33.00 | | | | | | 26 | 45 | 29 | | JN-30°-40°,RG-UN vertical | | 82 | | | | | 82 | | 36 | >15 | | | | | | | | | | 11 | | | |
| | 34.50 | Fresh to Slightly weathered, strong to Very Strong fine grained grey colour any amygdaloidal Basalt with Quartz vains. | | | | | | 10 | 90 | | JN-20°-30°,RG-UN | | 80 | | | | | 80 | | 76 | 3 | | | | Partial | | | | | | 12 | | | **33.00 to 40.00 M** Fresh to Slightly weathered, strong to Very Strong fine grained grey colour any amygdaloidal Basalt with Quartz vains. |
| | 36.00 | | | | | | | 21 | 79 | | JN-10°,RG-UN | | 80 | | | | | 80 | | 64 | 2 | | | | | | | | | | 12 | | | |
| | 37.50 | | | | | | 19 | 12 | 69 | | JN-30°-40°,RG-UN | | 83 | | | | | 83 | | 73 | 4 | | | | | | | | | | 12 | | | |
| | 39.00 | | | | | | | 44 | 56 | | JN-40°-50°RG-UN | | 84 | | | | | 84 | | 61 | 6 | | | | | | | | | | 12 | | | |
| | 40.00 | | | | | | 11 | 30 | 59 | | JN-30°-40°,RG-UN Iron stained | | 77 | | | | | 77 | | 64 | 2 | | | | | | | | | | 12 | | | |

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|---|---|---|---|---|---|
| | HILL SLOPE DEBRIS | | CORE RECOVERY | | MODERATELY FRACTURED |
| | BED ROCK | | SLIGHTLY FRACTURED | | HIGHLY FRACTURED |

LOGGED BY -

CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | |
|---|---|
| ***BH HOLE NO.*** | BH-2 |
| ***SHEET NO.:*** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa MG section of Westren Railway. | **LOCATION:** | T-06, BH-02 | **CHAINAGE:-** | 21450 |
| **BEARING OF HOLE (Degree):** | Vertical | **CO-ORDINATES:** | N-2476859 E-591275 | **FEATURE** | T-06 |
| **COLLAR ELEVATION (m):** | 5 CM | **ANGLE W.R.T HORIZONTAL:** | 90° Degree | **BOREHOLE NO.** | BH-02 |
| **TYPE(S) OF CORE BARREL:** | NWT | **GROUND ELEVATION(m):** | 519 M | **DEPTH OF BOREHOLE** | 35.00M |
| **STARTED :** | 10.04.2024 | **COMPLETED:** | 13.05.2024 | **DRILLING AGENCY :** | Goma Engineerin and Consultancy |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Bit use | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Top soil consisting of mainly heterogeneous matrix (sand,silt & cley) sum pices of angular to sub angular gravels, pebble,cobble size fregments of Basalt. | | 100 | DS-1 | | | | | | soil | Overburden | | | | | | | | NA | NIL | | | NX-2.0 METER | WATER TABLE 6.00 METER | PARTIAL | | | | | | 12 | | | Top Soil Consisting at mainly heterogeneous matrix (sand, silty & clay) with some angular to sub angular gravels pebble size fregments of basalt. |
| | 1.50 | | | | | | | | | | | | 15 | | | | | 15 | | NIL | NIL | | | | | | | | | | | 14 | | | |
| | 3.00 | | | 10 | 30 | 60 | | | | | JN-10°-20° RG-UN Vertical | | 22 | | | | | 22 | | NIL | 4 | | | | | | | | | | | 15 | | | |
| | 4.50 | | | | | 68 | 32 | | | | JN-10°-20° RG-UN Vertical | | 28 | | | | | 28 | | NIL | 8 | | | | | | | | | | | 12 | | | |
| | 6.00 | From 1.50m to 13.50m Moderately to Highly weathered highly fractured medium to weak brown grey colour fine grain anygdalaidal Basalt. | | | | 23 | 40 | 37 | | | JN-30°-40° RG-UN | | 30 | | | | | 30 | | NIL | >15 | | | | | | | | | | | 12 | | | **Bed rock encounterd at 1.50m** **From 1.50m to 13.50m** Moderately to Highly weathered highly fractured medium to weak brown grey colour fine grain anygdalaidal Basalt. |
| | 7.50 | | | | 20 | 60 | 20 | | | | JN-20°-30° RG-UN | | 35 | | | | | 35 | | NIL | >15 | | | | | | | | | | | 11 | | | |
| | 9.00 | | | | | | 20 | 80 | | | JN-20°-30°,RG-UN Iron stained | | 29 | | | | | 29 | | 8 | >15 | | | | | | Complete | | | | | 12 | | | |
| | 10.50 | | | | 40 | 60 | | | | | JN-10°-20° RG-UN | | 38 | | | | | 38 | | NIL | >15 | | | | | | | | | | | 12 | | | |
| | 12.00 | | | | 20 | 80 | | | | | JN-10°-20° RG-UN | | 40 | | | | | 40 | | 27 | >15 | | | | | | | | | | | 12 | | | |
| | 13.50 | | | | 20 | 80 | | | | | JN-10°-20° RG-UN | | 33 | | | | | 33 | | NILL | >15 | | | | | | | | | | | 12 | | | |
| | 15.00 | 13.50 to 16.50 Slightly weathered slightly freactured strong to very strong fine grain grey colour amygdaloidal Basalt. | | | | | 60 | 40 | | | JN-10°-20° SM-PL | | 48 | | | | | 48 | | 27 | 4 | | | | | | | | | | | 12 | | | **13.50 to 16.50** Slightly weathered slightly freactured strong to very strong fine grain grey colour amygdaloidal Basalt. |
| | 16.50 | | | | 20 | 30 | 50 | | | | JN-30°-40° SM-PL | | 54 | | | | | 54 | | 7 | 6 | | | | | | | | | | | 12 | | | |
| | 18.00 | 16.50 to 35.00m Fresh to slightly weathered, Slightly fractured, hard strong to very strong, medium to fine grain grey colour amygdaloidal Basalt with Quartz vains. | | | | 32 | 43 | 25 | | | JN-30°-40° RG-UN | | 54 | | | | | 54 | | 40 | 4 | | | | | | | | | | | 12 | | | |
| | 19.50 | | | | | | 14 | 86 | | | JN-30°,RG-UN | | 67 | | | | | 67 | | 67 | 3 | | | | | | | | | | | 12 | | | |
| | 21.00 | | | | | 11 | 30 | 59 | | | JN-10°,RG-UN | | 54 | | | | | 54 | | 40 | 4 | | | | | | | | | | | 12 | | | |
| | 22.50 | | | | | | 16 | 84 | | | JN-20°-30° RG-UN | | 50 | | | | | 50 | | 49 | 2 | | | | | | | | | | | 12 | | | |
| | 24.00 | | | | 40 | 60 | | | | | JN-10°,RG-UN | | 34 | | | | | 34 | | NIL | 6 | | | | | | | | | | | 12 | | | |
| | 25.50 | | | | 10 | | 17 | 73 | | | JN-10°-20° RG-UN | | 50 | | | | | 50 | | 36 | 3 | | | | | | | | | | | 12 | | | **16.50 to 35.00m** Fresh to slightly weathered, Slightly fractured, hard strong to very strong, medium to fine grain grey colour amygdaloidal Basalt with Quartz vains. |
| | 27.00 | | | | | 20 | 80 | | | | JN-10°,RG-UN | | 51 | | | | | 51 | | 26 | 6 | | | | | | | | | | | 12 | | | |
| | 28.50 | | | | | | 34 | 66 | | | JN-10°-20°,SM-PL | | 57 | | | | | 57 | | 46 | 3 | | | | | | | | | | | 12 | | | |
| | 30.00 | | | | | 20 | 80 | | | | JN-10°,SM-PL | | 50 | | | | | 50 | | 16 | 6 | | | | | | | | | | | 12 | | | |
| | 31.50 | | | | | | 44 | 56 | | | JN-40°-50°,RG-UN Iron stained | | 60 | | | | | 60 | | 55 | 4 | | | | | | | | | | | 12 | | | |
| | 33.00 | | | | | | 17 | 83 | | | JN-30°-40°,RG-UN Iron stained | | 70 | | | | | 70 | | 68 | 4 | | | | | | | | | | | 12 | | | |
| | 34.50 | | | | | | 44 | 56 | | | JN-20°,RG-UN Iron stained | | 54 | | | | | 54 | | 48 | 3 | | | | | | | | | | | 12 | | | |
| | 35.00 | | | | | | 100 | | | | JN-40°-50°,SM-PL | | 100 | | | | | 100 | | 98 | 4 | | | | | | | | | | | 12 | | | |

IMP DIAMOND

PARTIAL

INDEX

| | | | |
|---|---|---|---|
| HILL SLOPE DEBRIS | | CORE RECOVERY | MODERATELY FRACTURED |
| BED ROCK | | SLIGHTLY FRACTURED | HIGHLY FRACTURED |

LOGGED BY -

CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | |
|---|---|
| ***BH HOLE NO.*** | BH-1 |
| ***SHEET NO.:*** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa MG section of Westren Railway. | **LOCATION:** | T-07 BH-01 | **CHAINAGE:-** | 22580 |
| **BEARING OF HOLE (Degree):** | 90° | **CO-ORDINATES:** | N-2476729, E-0592387 | **FEATURE** | Tunnel-07 |
| **COLLAR ELEVATION (m):** | 10CM | **ANGLE W.R.T HORIZONTAL:** | 90° Degree | **BOREHOLE NO.** | BH-01 |
| **TYPE(S) OF CORE BARREL:** | NWT | **GROUND ELEVATION(m):** | 497 M | **DEPTH OF BOREHOLE** | 25.00M |
| **STARTED :** | 15.10.2024 | **COMPLETED:** | 27.10.2024 | **DRILLING AGENCY :** | Goma Engineerin and Consultancy |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 8 | 9 | 10 | | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | RQD(%) | Fracture Frequency / m | Size of hole | Bit use | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| 0.00 | 0.50 | From GL TO 3.50M Brownish silty sand with gravels,pebbles, cobble size fregments basalt,Overburden. | | 100 | DS-1 | | | | | | soil | Overburden | | | | | | N A | N A | N A | NX | NX-1.50 METER | 12.00 METER | PARTIAL | | | | | | 30 | | | **From GL TO 0.50M** Brownish silty sand with gravels,pebbles |
| 0.50 | 1.00 | | | | 100 | | | | | | Nill | | 46 | | | | | 46 | Nill | >15 | | | | | | | | | | 14 | | | |
| 1.00 | 2.00 | | | | 80 | 20 | | | | | Nill | | 24 | | | | | 24 | Nill | >15 | | | | | | | | | | 11 | | | **From GL TO 3.50M** Brownish silty sand with gravels,pebbles, cobble size fregments basalt,Overburden. |
| 2.00 | 3.00 | | | | 100 | | | | | | Nill | | 34 | | | | | 34 | Nill | >15 | | | | | | | | | | 10 | | | |
| 3.00 | 4.00 | | | | 50 | 50 | | | | | Nill | | 40 | | | | | 40 | Nill | >15 | | | | | | | | | | 9 | | | |
| | | | | | | | | | | | JN-10° RG-UN Iron stained | | | | | | | | | | | | | | | | | | | | | | |
| 4.00 | 5.00 | **BED-ROCK ENCOUTERED at 3.50m From 3.50 to 6.00m** Moderately to highly weathered, highly fractured, medium to week, medium to coarse grain, Brown/grey colour Vesicular Basalt. | | 20 | 60 | 20 | | | | | JN-10° RG-UN | | 51 | | | | | 51 | Nill | >15 | | | | | | | | | | 8 | | | **BED-ROCK ENCOUTERED at 3.50m From 3.50 to 6.00m** Moderately to highly weathered, highly fractured, medium to week, medium to coarse grain, Brown/grey colour Vesicular Basalt. |
| 5.00 | 6.00 | | | | 10 | 90 | | | | | JN 10°-20°RG-UN | | 37 | | | | | 37 | Nill | >15 | | | | | | | | | | 8 | | | |
| 6.00 | 7.00 | 6.00 to 14.00m Moderately weathered, moderately fractured,medium strong, fine grain grey colour Basalt with quartz vains. | | | | 90 | 10 | | | | JN-20°RG-UN | | 36 | | | | | 36 | Nill | >15 | | | | | | | | | | 7 | | | **6.00 to 14.00m** Moderately weathered, moderately fractured,medium strong, fine grain grey colour Basalt with quartz vains. |
| 7.00 | 8.00 | | | | | 100 | | | | | JN-10° RG-UN | | 30 | | | | | 30 | Nill | 4 | | | | | | | | | | 7 | | | |
| 8.00 | 9.00 | | | | | 100 | | | | | JN-20° RG-UN | | 25 | | | | | 25 | Nill | 8 | | | | | | | | | | 8 | | | |
| 9.00 | 10.00 | | | | | 34 | 66 | | | | "JN-10° SMPL | | 51 | | | | | 51 | 11 | 4 | | | | | | | | | | 8 | | | |
| 10.00 | 11.00 | | | | | 100 | | | | | JN-10° SMPL | | 36 | | | | | 36 | Nill | 9 | | | | | | | | | | 7 | | | |
| 11.00 | 12.00 | | | 10 | | 90 | | | | | JN-20° RG-UN | | 37 | | | | | 37 | Nill | 8 | | | | | | | | | | 7 | | | |
| 12.00 | 13.00 | | | | | 100 | | | | | JN--10° RG-UN | | 35 | | | | | 35 | Nill | >15 | | | | | | | | | | 6 | | | |
| 13.00 | 14.00 | | | | | 100 | | | | | JN--10° RG-UN | | 43 | | | | | 43 | Nill | 9 | | | | | | | | | | 8 | | | |
| 14.00 | 15.00 | | | | | 100 | | | | | JN-15°-20° RG-UN Iron stain | | 36 | | | | | 36 | Nill | 5 | | | | | | | | | | 8 | | | |
| 15.00 | 16.00 | **14.00 to 18.00m** Moderately to slightly weathered, slightly fractured, strong to very strong, , fine grain grey colour Basalt.(16.00 to16.27cm highly weathered, highly fractured) | | | | | 72 | 28 | | | JN-20° RG-UN | | 57 | | | | | 57 | 40 | 4 | | | | | | | | | | 8 | | | **14.00 to 18.00m** Moderately to slightly weathered, slightly fractured, strong to very strong, , fine grain grey colour Basalt.(16.00 to16.27cm highly weathered, highly fractured) |
| 16.00 | 17.00 | | | | | 20 | 57 | 23 | | | JN-40° RG-UN | | 76 | | | | | 76 | 16 | 8 | | | | | | | | | | 8 | | | |
| 17.00 | 18.00 | | | | | 20 | 80 | | | | JN-35° RG-UN | | 69 | | | | | 69 | 24 | 6 | | | | | | | | | | 7 | | | |
| 18.00 | 19.00 | | | | | | 33 | 67 | | | JN-10°RG-UN | | 95 | | | | | 95 | 90 | 5 | | | | | | | | | | 7 | | | |
| 19.00 | 20.00 | **18.00 to 22.00m** Fresh to slightly weathered hard strong to very strong, slightly fractured greyish colour, Amygdaloidal Basalt. | | | | | | 100 | | | JN-30° RG-UN | | 80 | | | | | 80 | 76 | 3 | | | | | | | | | | 8 | | | **18.00 to 22.00m** Fresh to slightly weathered hard strong to very strong, slightly fractured greyish colour, Amygdaloidal Basalt. |
| 20.00 | 21.00 | | | | | | 80 | 20 | | | JN-35°-40° RG-UN | | 80 | | | | | 80 | 26 | 7 | | | | | | | | | | 8 | | | |
| 21.00 | 22.00 | | | | | 20 | 16 | 64 | | | JN-20° RG-UN | | 81 | | | | | 81 | 50 | 5 | | | | | | | | | | 8 | | | |
| 22.00 | 23.00 | 22.00 to 25.00m Moderately to slightly weathered, Moderately fractured, strong to very strong, medium grain grey colour Basalt. | | | | 50 | 50 | | | | JN-20° RG-UN | | 83 | | | | | 83 | NIll | >15 | | | | | | | | | | 9 | | | **22.00 to 25.00m** Moderately to slightly weathered, Moderately fractured, strong to very strong, medium grain grey colour Basalt. |
| 23.00 | 24.00 | | | | | 70 | 30 | | | | JN-45° RG-UN | | 76 | | | | | 76 | Nill | 8 | | | | | | | | | | 8 | | | |
| 24.00 | 25.00 | | | | | | 61 | 39 | | | JN-40° RG-UN | | 61 | | | | | 61 | Nill | 8 | | | | | | | | | | 9 | | | |

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|---|---|---|---|
| HILL SLOPE DEBRIS | CORE RECOVERY | MODERATELY FRACTURED | |
| BED ROCK | SLIGHTLY FRACTURED | HIGHLY FRACTURED | |

LOGGED BY -

CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B2 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-7 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E592610.551, N2476769.846 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 24.02.2023 | COMPLETED: | 21.03.2023 |

| | | | |
|---|---|---|---|
| CHAINAGE:- | 22+800 | | |
| FEATURE | TUNNEL | | |
| BOREHOLE NO. | B2 | | |
| DEPTH OF BOREHOLE | 41.00 m | | |
| DRILLING AGENCY : | IGPL | | |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Black Cotton Soil | | DS-1 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 1.95 | Dense Brownish Sand | | SPT-1 | | | | | | | | | | | | | | | | | | | | | | 3 | 5 | 7 | 12 | | | | |
| | 3.45 | | | SPT-2 | | | | | | | | | | | | | | | | | | | | | | 3 | 6 | 8 | 14 | | | | Overburden : 0.00m-7.86m The borehole has been drilled in overburden from 0.00m - 7.86m having Black Cotton Soil & Dense Brownish Sand |
| | 4.95 | | | SPT-3 | | | | | | | | | | | | | | | | | | | | | | 4 | 7 | 10 | 17 | | | | |
| | 6.45 | | | SPT-4 | | | | | | | | | | | | | | | | | | | | | | 4 | 7 | 11 | 18 | | | | |
| | 7.86 | | | SPT-5 | | | | | | | | | | | | | | | | | | | | | | 20 | 0 | 0 | R | | | | |
| | 9.00 | Completely Weathered, Greyish Basalt | | | | 100 | | | | | | | | | | | | 17 | Nil | >15 | | | | | | | | | 10 | | | |
| | 10.50 | Highly Weathered, Greyish Basalt | | | | 60 | 40 | | | | | | | | | | | 57 | 7 | 12 | | | | | | | | | 10 | | | |
| | 12.00 | | | | | | | 100 | | | | | | | | | | 96 | 96 | <1 | | | | | | | | | 12 | | | |
| | 13.50 | | | | | | | 100 | | | | | | | | | | 100 | 96 | <1 | | | | | | | | | 11 | | | |
| | 15.00 | | | | | | | 100 | | | | | | | | | | 96 | 96 | <1 | | | | | | | | | 15 | | | Weathered Bedrock- Weathered Bedrock encountered between 7.86 to 10.50mtr., which is Greyish Completely to Highly Weathered Weak Basalt |
| | 16.50 | | | | | | | 100 | | | | | | | | | | 100 | 100 | <1 | | | | | | | | | 12 | | | |
| | 18.00 | | | | | | | 100 | | | | | | | | | | 100 | 82 | <1 | | | | | | | | | 10 | | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | | 97 | 90 | <1 | | | | | | | | | 13 | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 99 | 81 | <1 | | | | | | | | | 10 | | | |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 100 | 96 | <1 | | | | | | | | | 12 | | | |
| | 24.00 | | | | | | 70 | 30 | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{O}$C | | | | | | | 96 | 63 | <1 | | | | | | | | | 11 | | | |
| | 25.50 | | | | | | | 100 | | | | | | | | | | 100 | 94 | <1 | | | | | | | | | 13 | | | Slightly Weathered to Fresh Bedrock- Slightly Weathered Bedrock encountered between 10.50to 41.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 27.00 | Slightly Weathered, Greyish, strong Fresh Basalt | | | | | | 100 | | | | | | | | | | 97 | 97 | <1 | | | | | | | | | 12 | | | |
| | 28.50 | | | | | | 50 | 50 | | | | | | | | | | 95 | 57 | 7 | | | | | | | | | 12 | | | |
| | 30.00 | | | | | | | 100 | | | | | | | | | | 90 | 73 | 3 | | | | | | | | | 14 | | | |
| | 31.50 | | | | | | | 100 | | | | | | | | | | 89 | 74 | 5 | | | | | | | | | 17 | | | |
| | 33.00 | | | | | | | 100 | | | | | | | | | | 93 | 77 | 4 | | | | | | | | | 14 | | | The core recovery percentage in bedrock varies between 17% to 100% with RQD varies from 7% to 100%. |
| | 34.50 | | | | | | | 100 | | | | | | | | | | 100 | 95 | <1 | | | | | | | | | 12 | | | |
| | 36.00 | | | | | | | 100 | | | | | | | | | | 100 | 100 | <1 | | | | | | | | | 17 | | | |
| | 37.50 | | | | | | | 100 | | | | | | | | | | 89 | 83 | 3 | | | | | | | | | 13 | | | |
| | 39.00 | | | | | | | 100 | | | | | | | | | | 91 | 91 | <1 | | | | | | | | | 14 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 40.00 | | | | | | 60 | 40 | | | | | | | | | | 93 | 93 | <1 | | | | | | | | | 16 | | | |
| | 41.00 | | | | | | 80 | 20 | | | | | | | | | | 82 | 65 | 7 | | | | | | | | | 12 | | | |

NX Diamond Bit

NX casing- 9.00 m

25.00

Partial

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B1 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-8 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E591171.883, N2478373.111 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 08.02.2023 | COMPLETED: | 20.02.2023 |

| CHAINAGE:- | 27+530 |
|---|---|
| FEATURE | TUNNEL |
| BOREHOLE NO. | B1 |
| DEPTH OF BOREHOLE | 34.00 m |
| DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | LUGEON OR mm/s | |
| | 0.50 | Black Cotton Soil | | DS-1 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Completely Weathered, Brownish, Grey weak Basalt | | | | 100 | | | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40°C | | | | | | 12 | | NIL | >15 | | NX | NX casing- 6.00 m | 10m | Partial | | | | | 14 | | | Overburden : 0.00m-0.50m The borehole has been drilled in overburden from 0.00m - 0.50 m having Black Cotton Soil |
| | 3.00 | | | | | 100 | | | | | | | | | | | 14 | | NIL | >15 | | | | | | | | | 12 | | | |
| | 4.50 | | | | | 100 | | | | | | | | | | | 15 | | NIL | >15 | | | | | | | | | 14 | | | |
| | 6.00 | | | | | 70 | 30 | | | | | | | | | | 16 | | 13 | >15 | | | | | | | | | 18 | | | Weathered Bedrock- Weathered Bedrock encountered between 0.50 to 9.00mtr., which is Brownish-Greyish Completely to Highly Weathered Weak Basalt |
| | 7.50 | Highly Weathered, Greyish moderate strong Basalt | | | | 50 | 50 | | | | | | | | | | 37 | | 30 | 13 | | | | | | | | | 14 | | | |
| | 9.00 | | | | | 70 | 30 | | | | | | | | | | 42 | | 17 | 10 | | | | | | | | | 15 | | | |
| | 10.50 | | | | | | 30 | 70 | | | | | | | | | 83 | | 70 | 4 | | | | | | | | | 13 | | | |
| | 12.00 | | | | | | 10 | 90 | | | | | | | | | 91 | | 85 | 3 | | | | | | | | | 11 | | | |
| | 13.50 | | | | | | 10 | 90 | | | | | | | | | 93 | | 86 | 4 | | | | | | | | | 16 | | | Slightly Weathered to Fresh Bedrock- Slightly Weathered Bedrock encountered between 9.00 to 34.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 15.00 | | | | | | 10 | 90 | | | | | | | | | 100 | | 87 | 4 | | | | | | | | | 9 | | | |
| | 16.50 | | | | | | 10 | 90 | | | | | | | | | 90 | | 85 | 3 | | | | | | | | | 13 | | | |
| | 18.00 | | | | | | 20 | 80 | | | | | | | | | 92 | | 82 | 4 | | | | | | | | | 10 | | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | 100 | | 96 | <1 | | | | | | | | | 14 | | | |
| | 21.00 | Slightly Weathered, Greyish, moderate strong Fresh Basalt | | | | | 20 | 80 | | | | | | | | | 90 | | 77 | 4 | | | | | | | | | 14 | | | The core recovery percentage in bedrock varies between 12% to 100% with RQD varies from 0% to 96%. |
| | 22.50 | | | | | | 20 | 80 | | | | | | | | | 97 | | 77 | 4 | | | | | | | | | 15 | | | |
| | 24.00 | | | | | | 20 | 80 | | | | | | | | | 97 | | 75 | 5 | | | | | | | | | 14 | | | |
| | 25.50 | | | | | | 30 | 70 | | | | | | | | | 97 | | 72 | 5 | | | | | | | | | 11 | | | |
| | 27.00 | | | | | | 40 | 60 | | | | | | | | | 96 | | 63 | 6 | | | | | | | | | 15 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 28.50 | | | | | | | 100 | | | | | | | | | 93 | | 96 | <1 | | | | | | | | | 13 | | | |
| | 30.00 | | | | | | 40 | 60 | | | | | | | | | 95 | | 63 | 6 | | | | | | | | | 15 | | | |
| | 31.50 | | | | | | 30 | 70 | | | | | | | | | 91 | | 69 | 8 | | | | | | | | | 12 | | | |
| | 33.00 | | | | | | 50 | 50 | | | | | | | | | 100 | | 52 | 8 | | | | | | | | | 14 | | | Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 34.00 | | | | | 90 | 10 | | | | | | | | | | 100 | | 30 | 12 | | | | | | | | | 11 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B2 |
| | | SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-8 | CHAINAGE:- | 27+790 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E590913.81, N2478341.515 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | B2 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 30.00 m |
| STARTED : | 18.02.2023 | COMPLETED: | 24.02.2023 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | Permeability | | |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | | | DS-1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.95 | Dense Brownish Sand | | | | SPT-1 | | | | | | | | | | | | | | | | | | | | | 13 | 15 | 18 | 33 | | | | **Overburden :** 0.00m-4.89m The borehole has been drilled in overburden from 0.00m - 4.89m having Black Cotton Soil & Dense Brownish Sand |
| | 3.45 | | | | | SPT-2 | | | | | Residual Soil | | | | | | | | | | | | | | | | 18 | 21 | 25 | 46 | | | | |
| | 4.89 | | | | | SPT-3 | | | | | | | | | | | | | | | | | | | | | 24 | 31 | 50 | 81 | | | | |
| | 6.00 | Completely Weathered, Greyish Weak Basalt | | | | 100 | | | | | | | | | | | | 18 | NIL | >15 | | | | | | | | | | 24 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 4.89 to 7.50mtr., which is Brownish-Greyish Completely Weathered Weak Basalt |
| | 7.50 | | | | | 100 | | | | | | | | | | | | 31 | NIL | >15 | | | | | | | | | | 13 | | | |
| | 9.00 | | | | | 60 | | 40 | | | | | | | | | | 98 | 40 | 7 | | | | | | | | | | 12 | | | |
| | 10.50 | | | | | | 60 | 40 | | | | | | | | | | 100 | 39 | 8 | | | | | | | | | | 12 | | | |
| | 12.00 | | | | | | 40 | 60 | | | | | | | | | | 96 | 63 | 6 | | | | | | | | | | 14 | | | |
| | 13.50 | | | | | | 10 | 90 | | | | | | | | | | 94 | 89 | 3 | | | | | | | | | | 13 | | | |
| | 15.00 | | | | | | 10 | 90 | | | | | | | | | | 94 | 89 | 3 | | | | | | | | | | 9 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered Bedrock encountered between 7.50 to 30.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 16.50 | | | | | | | 100 | | | | | | | | | | 100 | 97 | <1 | | | | | | | | | | 11 | | | |
| | 18.00 | | | | | | 40 | 60 | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{O}$C | | | | | | | 98 | 61 | 8 | | | | | | | | | | 9 | | | |
| | 19.50 | Slightly Weathered, Greyish, strong Fresh Basalt | | | | | 40 | 60 | | | | | | | | | | 99 | 58 | 7 | | | | | | | | | | 11 | | | |
| | 21.00 | | | | | | 10 | 90 | | | | | | | | | | 100 | 91 | <1 | | | | | | | | | | 7 | | | The core recovery percentage in bedrock varies between 18% to 100% with RQD varies from 0% to 100%. |
| | 22.50 | | | | | | 20 | 80 | | | | | | | | | | 98 | 76 | 6 | | | | | | | | | | 12 | | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 100 | 100 | <1 | | | | | | | | | | 13 | | | |
| | 25.50 | | | | | | 40 | 60 | | | | | | | | | | 93 | 57 | 8 | | | | | | | | | | 11 | | | |
| | 27.00 | | | | | | 30 | 70 | | | | | | | | | | 100 | 75 | 6 | | | | | | | | | | 10 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 28.50 | | | | | | 20 | 80 | | | | | | | | | | 100 | 77 | 6 | | | | | | | | | | 11 | | | |
| | 30.00 | | | | | | 60 | 40 | | | | | | | | | | 98 | 38 | 9 | | | | | | | | | | 5 | | | |

NX Diamond Bitr

NX casing- 5.00 m

9.00

Partial

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | T9 BH-01 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-9 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E593637.362, N2479283.596 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 17.11.2022 | COMPLETED: | 22.11.2022 |

| CHAINAGE:- | 35+090 |
|---|---|
| FEATURE | TUNNEL |
| BOREHOLE NO. | T9 - BH-01 |
| DEPTH OF BOREHOLE | 28.00 |
| DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | LUGEON OR mm/s | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Brownish Sandy Soil | | DS-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Brownish Highly Weathered Weak Basalt | | | 100 | | | | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 10 | NX Size Diamond Bit | NIL | >15 | NX | NX | 12.40 | Partial | | | | | 18 | | | **Overburden:-** **0.00m-0.50m** The borehole has been drilled in overburden from 0.00m - 0.50mtr. having with Brownish Sandy Soil |
| | 3.00 | | | | 100 | | | | | | | | | | | | | 15 | | NIL | >15 | | | | | | | | | 23 | | | |
| | 4.50 | | | | 100 | | | | | | | | | | | | | 13 | | NIL | >15 | | | | | | | | | 50 | | | |
| | 6.00 | | | | 100 | | | | | | | | | | | | | 25 | | NIL | >15 | | | | | | | | | 12 | | | |
| | 7.50 | Brownish Moderately Weathered Moderately Strong Basalt | | | | 100 | | | | | | | | | | | | 82 | | NIL | >15 | | | | | | | | | 16 | | | **Weathered Bedrock-** **W**eathered Bedrock encountered between between 0.50 to 18.00mtr. which is Brownish Highly to Moderately Weathered Weak to Strong Basalt |
| | 9.00 | | | | | 100 | | | | | | | | | | | | 33 | | NIL | >15 | | | | | | | | | 15 | | | |
| | 10.50 | Brownish Highly Weathered Weak Basalt | | | | 100 | | | | | | | | | | | | 18 | | NIL | >15 | | | | | | | | | 10 | | | |
| | 12.00 | | | | | 100 | | | | | | | | | | | | 22 | | NIL | >15 | | | | | | | | | 14 | | | |
| | 13.50 | | | | | 70 | 20 | 10 | | | | | | | | | | 27 | | 6 | >15 | | | | | | | | | 13 | | | |
| | 15.00 | Greyish Moderately Weathered Moderately Strong Basalt | | | | | 60 | 40 | | | | | | | | | | 65 | | 40 | 14 | | | | | | | | | 10 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 18.00 to 28.00mtr. which is Greyish Slightly Weathered to Fresh Fracture Strong Basalt |
| | 16.50 | | | | 70 | 20 | 10 | | | | | | | | | | | 29 | | 8 | >15 | | | | | | | | | 15 | | | |
| | 18.00 | | | | | | 50 | 50 | | | | | | | | | | 65 | | 49 | 13 | | | | | | | | | 19 | | | |
| | 19.50 | Greyish Slightly Weathered to Fresh Fracture Strong Basalt | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 95 | | 86 | 4 | | | | | | | | | 14 | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 97 | | 90 | 3 | | | | | | | | | 10 | | | The core recovery percentage in bedrock varies between 10% to 100% with RQD varies from 6% to 100%. |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 87 | | 87 | 7 | | | | | | | | | 18 | | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 96 | | 85 | 7 | | | | | | | | | 13 | | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 25.50 | | | | | | | 100 | | | | | | | | | | 90 | | 85 | 6 | | | | | | | | | 10 | | | |
| | 27.00 | | | | | | | 100 | | | | | | | | | | 100 | | 87 | 7 | | | | | | | | | 13 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 28.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 8 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

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| BH HOLE NO. | T9 BH-02 |
| SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation for Ratlam-Khandwa BG Rail. | **LOCATION:** | Tunnel-9 | **CHAINAGE:-** | 35+325 |
| **BEARING OF HOLE (Degree):** | Verticle | **CO-ORDINATES:** | E593359.364, N2479358.746 | **FEATURE** | TUNNEL |
| **COLLAR ELEVATION (m):** | -- | **ANGLE W.R.T HORIZONTAL:** | 90 Degrees | **BOREHOLE NO.** | T9 - BH-02 |
| **TYPE(S) OF CORE BARREL:** | DT | **GROUND ELEVATION(m):** | -- | **DEPTH OF BOREHOLE** | 33.50 |
| **STARTED :** | 24.11.2022 | **COMPLETED:** | 03.12.2022 | **DRILLING AGENCY :** | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | LUGEON OR mm/s | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Brownish Sandy Soil | | DS-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Brownish Highly Weathered Weak Basalt | | | 100 | | | | | | | | | | | | | 24 | | NIL | >15 | | | | | | | | | | 15 | | | **Overburden:-** **0.00m-0.50m** The borehole has been drilled in overburden from 0.00m - 0.50mtr. having with Brownish Sandy Soil |
| | 3.00 | | | | 100 | | | | | | | | | | | | | 21 | | NIL | >15 | | | | | | | | | | 13 | | | |
| | 4.50 | | | | 100 | | | | | | | | | | | | | 30 | | NIL | >15 | | | | | | | | | | 12 | | | |
| | 6.00 | Brownish Moderately Weathered Moderately Strong Basalt | | | | | 60 | 40 | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 45 | | 17 | >15 | | | | | | | | | | 18 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 0.50 to 10.50mtr. which is Greyish Highly to Moderately Weathered Moderately Strong Basalt |
| | 7.50 | | | | | | 60 | 40 | | | | | | | | | | 52 | | 9 | >15 | | | | | | | | | | 15 | | | |
| | 9.00 | | | | | | 60 | 40 | | | | | | | | | | 59 | | 11 | >15 | | | | | | | | | | 18 | | | |
| | 10.50 | | | | | | 50 | 50 | | | | | | | | | | 71 | | 27 | >15 | | | | | | | | | | 13 | | | |
| | 12.00 | Greyish Slightly Weathered to Fresh Fracture Strong Basalt | | | | | 50 | 50 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 85 | NX Size Diamond Bit | 52 | >15 | NX | NX | 12.40 | Partial | | | | | | 10 | | | |
| | 13.50 | | | | | | 90 | 10 | | | | | | | | | | 91 | | 55 | >15 | | | | | | | | | | 12 | | | |
| | 15.00 | | | | | | 60 | 40 | | | | | | | | | | 78 | | 81 | 4 | | | | | | | | | | 13 | | | |
| | 16.50 | | | | | 70 | 20 | 10 | | | | | | | | | | 78 | | 87 | <1 | | | | | | | | | | 10 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 10.50 to 33.50mtr. which is Greyish Slightly Weathered to Fresh Fracture Strong Basalt |
| | 18.00 | | | | | | 50 | 50 | | | | | | | | | | 89 | | 75 | 7 | | | | | | | | | | 12 | | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | | 97 | | 44 | 10 | | | | | | | | | | 12 | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 97 | | 70 | 8 | | | | | | | | | | 8 | | | |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 98 | | 63 | 9 | | | | | | | | | | 11 | | | The core recovery percentage in bedrock varies between 21% to 100% with RQD varies from 9% to 87%. |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 95 | | 46 | 12 | | | | | | | | | | 12 | | | |
| | 25.50 | | | | | | 60 | 40 | | | | | | | | | | 90 | | 31 | 13 | | | | | | | | | | 11 | | | |
| | 27.00 | | | | | | 70 | 30 | | | | | | | | | | 99 | | 28 | 13 | | | | | | | | | | 12 | | | |
| | 28.50 | | | | | | | 100 | | | | | | | | | | 97 | | 59 | 12 | | | | | | | | | | 12 | | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 30.00 | | | | | | | 100 | | | | | | | | | | 100 | | 83 | 4 | | | | | | | | | | 5 | | | |
| | 31.50 | | | | | | | 100 | | | | | | | | | | 84 | | 51 | 8 | | | | | | | | | | 9 | | | |
| | 32.50 | | | | | | | 100 | | | | | | | | | | 97 | | 51 | 9 | | | | | | | | | | 9 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 33.50 | | | | | | | 100 | | | | | | | | | | 97 | | 51 | 9 | | | | | | | | | | 8 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

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| BH HOLE NO. | B3 |
| SHEET NO.: | 1 of 1 |

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| **PROJECT :** | Geotechnical investigation for Ratlam-Khandwa BG Rail. | **LOCATION :** | Tunnel-9 | **CHAINAGE:-** | 35+550 |
| **BEARING OF HOLE (Degree):** | Verticle | **CO-ORDINATES :** | E:594073.165, N:2479430.824 | **FEATURE** | Tunnel |
| **COLLAR ELEVATION (m):** | --- | **ANGLE W.R.T HORIZONTAL :** | 90 Degrees | **BOREHOLE NO.** | BH-3 |
| **TYPE(S) OF CORE BARREL:** | DT | **GROUND ELEVATION(m) :** | --- | **DEPTH OF BOREHOLE** | 29.00m |
| **STARTED :** | 04.12.2022 | **COMPLETED :** | 10.12.2022 | **DRILLING AGENCY :** | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Black Cotton Soil | | DS-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Brownish Highly Weathered, Intensely Fracture Weak Basalt | | | 50 | 50 | | | | | | | | | | | 22 | | NIL | >15 | | | | | | | | | 11 | | | **Overburden:- 0.00m-0.50m** The borehole has been drilled in overburden from 0.00m - 0.50m having Black Cotton Soil |
| | 3.00 | | | | 50 | 50 | | | | | | | | | | | 16 | | NIL | >15 | | | | | | | | | 12 | | | |
| | 4.50 | | | | 50 | 50 | | | | | | | | | | | 20 | | NIL | >15 | | | | | | | | | 12 | | | |
| | 6.00 | | | | | | 40 | 60 | | | | | | | | | 39 | | 22 | >15 | | | | | | | | | 10 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 0.50 to 16.50mtr., which comprises Brownish Highly to Moderately Weathered, Intensely Fracture Weak Basalt |
| | 7.50 | | | | | | 50 | 50 | | | | | | | | | 56 | | 35 | 13 | | | | | | | | | 18 | | | |
| | 9.00 | | | | | | 50 | 50 | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | 63 | | 27 | 14 | | | | | | | | | 13 | | | |
| | 10.50 | Greyish Moderately Weathered, Intensely Fracture Very Weak, Basalt | | | | | 20 | 80 | | | | | | | | | 73 | | 56 | 7 | | | | | | | | | 10 | | | |
| | 12.00 | | | | | | 40 | 60 | | | | | | | | | 56 | | 15 | >15 | | | | | | | | | 12 | | | |
| | 13.50 | | | | 50 | 50 | | | | | | | | | | | 46 | | NIL | >15 | | | | | | | | | 13 | | | **Slightly to Moderately weathered Bedrock-** Slightly to Moderately weathered Bedrock encountered between 16.50 to 29.00mtr. which Comprises Greyish Slightly Weathered Fresh Strong Basalt |
| | 15.00 | | | | | | 30 | 70 | | | | | | | | | 85 | | 48 | 10 | NX | NX | 15.50m | Partial | | | | | 12 | | | |
| | 16.50 | | | | 50 | 50 | | | | | | | | | | | 48 | | NIL | >15 | | | | | | | | | 18 | | | |
| | 18.00 | Greyish Slightly Weathered Fresh Strong Basalt | | | | | 30 | 70 | | | | | | | | | 72 | | 35 | 11 | | | | | | | | | 12 | | | |
| | 19.50 | | | | | | 20 | 80 | | | | | | | | | 65 | | 20 | >15 | | | | | | | | | 10 | | | The core recovery percentage in bedrock varies between 16% to 99% with RQD varies from 8 to 69%. |
| | 21.00 | | | | | | 40 | 60 | | | | | | | | | 89 | | 20 | >15 | | | | | | | | | 18 | | | |
| | 22.50 | | | | | | 20 | 80 | | | | | | | | | 87 | | 47 | 9 | | | | | | | | | 11 | | | |
| | 24.00 | | | | | | 40 | 60 | | | Very close irregular joints gently dipping rough fracture | | | | | | 92 | | 43 | 9 | | | | | | | | | 14 | | | The partial drill water loss has been observed during drilling depth which indicates tight to partly open nature of joints |
| | 25.50 | | | | | | 20 | 80 | | | | | | | | | 95 | | 69 | 8 | | | | | | | | | 15 | | | |
| | 27.00 | | | | | | 30 | 70 | | | | | | | | | 75 | | 23 | >15 | | | | | | | | | 11 | | | |
| | 28.50 | | | | | | 20 | 80 | | | | | | | | | 99 | | 39 | 9 | | | | | | | | | 11 | | | Rock mass class encountered at Tunnel grade may be interpreted as poor to fair rock. |
| | 29.00 | | | | | | 20 | 80 | | | | | | | | | 96 | | 39 | 10 | | | | | | | | | 13 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B1 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-9A |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E594812.115, N2479680.531 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 17.12.2022 | COMPLETED: | 07.01.2022 |

| | | | |
|---|---|---|---|
| CHAINAGE:- | 36330 | | |
| FEATURE | TUNNEL | | |
| BOREHOLE NO. | B1 | | |
| DEPTH OF BOREHOLE | 31.50 m | | |
| DRILLING AGENCY : | IGPL | | |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD (%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) / Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Black Cotton Soil | | DS-1 | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Dense Black Cotton Soil | | SPT-1 | | | | | | | | | | | | | | | | | | | | | | 11 | 18 | 29 | 47 | | | | **Overburden :** 0.00m-1.50m The borehole has been drilled in overburden from 0.00m - 1.50 m having Black Cotton Soil |
| | 3.00 | Highly Weathered, Brownish, Grey weak Basalt | | 100 | | | | | | | | | | | | | 43 | | NIL | >15 | | | | | | | | | 12 | | | |
| | 4.50 | | | 60 | | | | 40 | | | | | | | | | 57 | | 25 | >25 | | | | | | | | | 18 | | | |
| | 6.00 | | | 100 | | | | | | | | | | | | | 39 | | NIL | >25 | | | | | | | | | 12 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 1.50 to 27.00mtr., which is Brownish Completely to Moderately Weathered Weak to Strong Basalt |
| | 7.50 | Moderate Weathered, Greyish moderate strong Basalt | | | 60 | | 40 | | | | | | | | | | 76 | | 36 | 12 | | | | | | | | | 10 | | | |
| | 9.00 | | | | | | 70 | 30 | | | | | | | | | 81 | | 35 | 12 | | | | | | | | | 8 | | | |
| | 10.50 | | | 100 | | | | | | | | | | | | | 15 | | NIL | >15 | | | | | | | | | 16 | | | |
| | 12.00 | | | 100 | | | | | | | | | | | | | 9 | | NIL | >15 | | | | | | | | | 15 | | | |
| | 13.50 | Completely Weathered Brownish sandy silt with clay | | 100 | | | | | | | | | | | | | 5 | | NIL | >15 | | | | | | | | | 11 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered Bedrock encountered between 27.00 to 31.50mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 15.00 | | | 100 | | | | | | | | | | | | | 11 | | NIL | >15 | | | | | | | | | 11 | | | |
| | 16.50 | | | | 100 | | | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{O}$C | | | | | | | 27 | NX Size Diamond Bit | NIL | >15 | NX | NX casing- 3.00 m | Not Met | Partial | | | | | 13 | | | |
| | 18.00 | Completely Weathered Brownish weak Basalt | | 100 | | | | | | | | | | | | | 15 | | NIL | >15 | | | | | | | | | 18 | | | |
| | 19.50 | | | | 100 | | | | | | | | | | | | 36 | | NIL | >15 | | | | | | | | | 18 | | | |
| | 21.00 | Slightly to Moderate Weathered, Greyish, moderate strong Basalt | | | | 60 | 40 | | | | | | | | | | 68 | | 47 | 9 | | | | | | | | | 13 | | | The core recovery percentage in bedrock varies between 5% to 92% with RQD varies from 25% to 77%. |
| | 22.50 | Highly Weathered, Greyish, fractured, weak Basalt | | | | 100 | | | | | | | | | | | 43 | | NIL | >15 | | | | | | | | | 10 | | | |
| | 24.00 | Moderately Weathered, Greyish, Basalt | | | | | 40 | 60 | | | | | | | | | 76 | | 53 | 8 | | | | | | | | | 12 | | | |
| | 25.50 | | | | | | 40 | 60 | | | | | | | | | 59 | | 53 | 8 | | | | | | | | | 10 | | | |
| | 27.00 | | | | | | 40 | 60 | | | | | | | | | 76 | | 31 | 13 | | | | | | | | | 8 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 28.50 | Slightly Weathered, Greyish, fractured Moderate Strong Basalt | | | | | 20 | 80 | | | | | | | | | 88 | | 77 | 4 | | | | | | | | | 8 | | | |
| | 30.00 | | | | | | 20 | 80 | | | | | | | | | 92 | | 64 | 6 | | | | | | | | | 10 | | | Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 31.50 | | | | | | 20 | 80 | | | | | | | | | 85 | | 77 | 4 | | | | | | | | | 13 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B2 |
| | | SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION : | Tunnel-9A | CHAINAGE:- | 36+490 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES : | E:594963.694, N:2479731.752 | FEATURE | Tunnel |
| COLLAR ELEVATION (m): | --- | ANGLE W.R.T HORIZONTAL : | 90 Degrees | BOREHOLE NO. | BH-2 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m) : | --- | DEPTH OF BOREHOLE | 33.00m |
| STARTED : | 07.12.2022 | COMPLETED : | 15.12.2022 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | | | DS-01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.83 | Black Cotton Soil | | SPT-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | 12 | 25 | 50 | 75 | | | | **Overburden:-** **0.00m-1.83m** The borehole has been drilled in overburden from 0.00m - 1.83m having Black Cotton Soil |
| | 3.00 | | | | 50 | 50 | | | | | | | | | | | | 36 | | NIL | >15 | | | | | | | | | 16 | | | |
| | 4.50 | | | | | | 50 | 50 | | | | | | | | | | 42 | | 31 | 14 | | | | | | | | | 15 | | | |
| | 6.00 | | | | | | 40 | 60 | | | | | | | | | | 57 | | 51 | 8 | | | | | | | | | 10 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 1.83 to 16.50mtr., which comprises Greyish Brown Highly to Moderately Weathered Intesenaly Fracture Weak Basalt |
| | 7.50 | | | | | | 50 | 50 | | | | | | | | | | 80 | | 21 | >15 | | | | | | | | | 12 | | | |
| | 9.00 | Greyish Brown Highly to Moderately Weathered Intesenaly Fracture Weak Basalt | | | | | 50 | 50 | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 60 | | 44 | 9 | | | | | | | | | 10 | | | |
| | 10.50 | | | | 100 | | | | | | | | | | | | | 32 | | NIL | >15 | | | | | | | | | 14 | | | |
| | 12.00 | | | | | | 40 | 60 | | | | | | | | | | 39 | | 19 | >15 | | | | | | | | | 15 | | | |
| | 13.50 | | | 50 | 50 | | | | | | | | | | | | | 9 | | NIL | >15 | | | | | | | | | 10 | | | **Slightly Weathered to Fresh Bedrock-** Slightly weathered to Fresh Bedrock encountered between 16.50 to 33.00mtr., which comprises Greyish Slightly to Fresh Weathered Strong Basalt |
| | 15.00 | | | | | | 30 | 70 | | | | | | | | | | 51 | | 13 | >15 | | | | | | | | | 15 | | | |
| | 16.50 | | | | | | 20 | 80 | | | | | | | | | | 50 | | 22 | >15 | NX | NX | 27.00m | Partial | | | | | 10 | | | |
| | 18.00 | | | | | | 40 | 70 | | | | | | | | | | 81 | | 58 | 8 | | | | | | | | | 18 | | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | | 78 | | 51 | 4 | | | | | | | | | 12 | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 99 | | 93 | <1 | | | | | | | | | 10 | | | |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 95 | | 89 | 1 | | | | | | | | | 13 | | | The core recovery percentage in bedrock varies between 9% to 100% with RQD varies from 9 to 100%. |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 100 | | 87 | 3 | | | | | | | | | 12 | | | |
| | 25.50 | Greyish Slightly to Fresh Weathered Strong Basalt | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 99 | | 99 | <1 | | | | | | | | | 13 | | | |
| | 27.00 | | | | | | | 100 | | | | | | | | | | 80 | | 70 | 7 | | | | | | | | | 12 | | | The partial drill water loss has been observed during drilling depth . which indicates tight to partly open nature of joints |
| | 28.50 | | | | | | 80 | 20 | | | | | | | | | | 45 | | 9 | >15 | | | | | | | | | 18 | | | |
| | .30.00 | | | | | | 20 | 80 | | | | | | | | | | 96 | | 66 | 8 | | | | | | | | | 13 | | | |
| | 31.50 | | | | | | | 100 | | | | | | | | | | 100 | | 95 | <1 | | | | | | | | | 12 | | | Rock mass class encountered at Tunnel grade may be interpreted as poor to fair rock. |
| | 33.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 10 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | T10 BH-01 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-10 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E595456.309, N2979898.277 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 31.07.2022 | COMPLETED: | 17.08.2022 |

| | | | |
|---|---|---|---|
| CHAINAGE:- | 37040 | | |
| FEATURE | TUNNEL | | |
| BOREHOLE NO. | T10 - BH-02 | | |
| DEPTH OF BOREHOLE | 30.00 | | |
| DRILLING AGENCY : | IGPL | | |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | DS-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 1.95 | Brownish Hard Silty Clay | | SPT-01 | | | | | | | | | | | | | | | | | | | | | | 15 | 8 | 30 | 55 | | | | Overburden:- 0.00m-1.95m The borehole has been drilled in overburden from 0.00m - 1.95mtr. having with Black Cotton Soil & Brownish Hard Silty Clay |
| | 3.00 | Greyish Completely Weathered Weak Basalt | | | 100 | | | | | | | | | | | | | 15 | | NIL | >15 | | | | | | | | | 21 | | | |
| | 4.50 | Greyish Slightly Weathered to Fresh Strong Basalt | | | | | 100 | | | | | | | | | | | 96 | | 93 | 1 | | | | | | | | | 6 | | | |
| | 6.00 | | | | | | 100 | | | | | | | | | | | 88 | | 79 | 1 | | | | | | | | | 7 | | | |
| | 7.50 | | | | | | 100 | | | | | | | | | | | 87 | | 82 | 2 | | | | | | | | | 7 | | | Weathered Bedrock- Weathered Bedrock encountered between 1.95 to 3.00mtr. 7.50 to 21.00mtr., which is Greyish Highly to moderately Weathered Weak Fracture Basalt |
| | 9.00 | | | | | 70 | 30 | | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 37 | | 7 | 12 | | | | | | | | | 18 | | | |
| | 10.50 | | | | | 100 | | | | | | | | | | | | 29 | | NIL | >15 | | | | | | | | | 16 | | | |
| | 12.00 | Greyish Moderately Weathered Weak Fracture Basalt | | | | 70 | 30 | | | | | | | | | | | 45 | | 33 | 9 | | | | | | | | | 12 | | | |
| | 13.50 | | | | | 80 | 20 | | | | | | | | | | | 19 | | 9 | >15 | | | | | | | | | 19 | | | |
| | 15.00 | | | | | 60 | 40 | | | | | | | | | | | 32 | | | 13 | | | | | | | | | 13 | | | |
| | 16.50 | | | | | 60 | 40 | | | | | | | | | | | 37 | NX Size Diamond Bit | 8 | 12 | NX | NX | 3.0 | Partial | | | | | 15 | | | Slightly Weathered to Fresh Bedrock- Slightly Weathered to Fresh Bedrock encountered between 3.00 to 7.50m & 25.50 to 30.00mtr., which is Greyish Slightly Weathered to Fresh Strong Basalt |
| | 18.00 | Greyish Completely Weathered Weak Basalt | | | 100 | | | | | | | | | | | | | 11 | | NIL | >15 | | | | | | | | | 20 | | | |
| | 19.50 | | | | 100 | | | | | | | | | | | | | 12 | | NIL | >15 | | | | | | | | | 20 | | | |
| | 21.00 | | | | | 100 | | | | | | | | | | | | 21 | | NIL | >15 | | | | | | | | | 21 | | | |
| | 22.50 | Greyish Moderately Weathered Moderately Weak Basalt | | | | | 100 | | | | | | | | | | | 60 | | 45 | 7 | | | | | | | | | 12 | | | The core recovery percentage in bedrock varies between 11% to 97% with RQD varies from 7% to 93%. |
| | 24.00 | | | | | | 100 | | | | Very close irregular joints gently dipping rough fracture | | | | | | | 66 | | 52 | 6 | | | | | | | | | 16 | | | |
| | 25.50 | | | | | | 100 | | | | | | | | | | | 56 | | 35 | 7 | | | | | | | | | 14 | | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 27.00 | Greyish Slightly Weathered to Fresh Strong Basalt | | | | | 100 | | | | | | | | | | | 97 | | 77 | 1 | | | | | | | | | 8 | | | |
| | 28.50 | | | | | | 100 | | | | | | | | | | | 89 | | 87 | 1 | | | | | | | | | 6 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 30.00 | | | | | | 100 | | | | | | | | | | | 95 | | 74 | 1 | | | | | | | | | 5 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B3 |
| | | SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-10 | CHAINAGE:- | 37+170 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E595604.589, N2479958.065 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | B3 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 36.00 m |
| STARTED : | 29.12.2022 | COMPLETED: | 10.01.2023 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Black cotton Soil | | DS-1 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Completely Weathered Brownish weak Basalt | | 20 | 50 | 30 | | | | | | | | | | | | 23 | | NIL | >15 | | | | | | | | | 15 | | | **Overburden :** 0.00m-0.50m The borehole has been drilled in overburden from 0.00m - 0.50 m having Black Cotton Soil |
| | 3.00 | | | 20 | 30 | 50 | | | | | | | | | | | | 18 | | NIL | >15 | | | | | | | | | 13 | | | |
| | 4.50 | | | 30 | 30 | 25 | | 15 | | | | | | | | | | 21 | | 15 | >15 | | | | | | | | | 12 | | | |
| | 6.00 | Highly Weathered Greyish Brown weak Basalt | | 50 | 10 | 40 | | | | | | | | | | | | 29 | | NIL | >15 | | | | | | | | | 18 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 0.50 to 19.50mtr., which is Brownish Highly to Moderately Weathered Weak to Strong Basalt |
| | 7.50 | | | 50 | 30 | 11 | | 9 | | | | | | | | | | 28 | | 9 | >15 | | | | | | | | | 13 | | | |
| | 9.00 | | | | | | 70 | 30 | | | | | | | | | | 57 | | 31 | 10 | | | | | | | | | 18 | | | |
| | 10.50 | Moderately Weathered, Greyish, fractured Basalt | | | | | 70 | 30 | | | | | | | | | | 67 | | 64 | 7 | | | | | | | | | 15 | | | |
| | 12.00 | | | | | | 70 | 30 | | | | | | | | | | 51 | | 24 | >15 | | | | | | | | | 18 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 19.50 to 36.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 13.50 | | | | | | 60 | 40 | | | | | | | | | | 50 | | 45 | 11 | | | | | | | | | 13 | | | |
| | 15.00 | Completely Weathered Brownish weak Basalt | | | 100 | | | | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40°C | | | | | | | 16 | NX Size Diamond Bit | NIL | >15 | NX | NX | Water level - 10.12m | Partial | | | | | | 10 | | | |
| | 16.50 | Highly Weathered Greyish Brown weak Basalt | | | | 100 | | | | | | | | | | | | 28 | | NIL | >15 | | | | | | | | | 12 | | | |
| | 18.00 | | | | | 100 | | | | | | | | | | | | 22 | | NIL | >15 | | | | | | | | | 13 | | | |
| | 19.50 | Moderately Weathered, Greyish, Moderate strong Basalt | | | | | 70 | 30 | | | | | | | | | | 62 | | 26 | 14 | | | | | | | | | 15 | | | |
| | 21.00 | Slightly Weathered Greyish Moderate strong Basalt | | | | | 60 | 40 | | | | | | | | | | 100 | | 63 | 7 | | | | | | | | | 18 | | | The core recovery percentage in bedrock varies between 16% to 100% with RQD varies from 9% to 95%. |
| | 22.50 | | | | | 60 | 20 | 20 | | | | | | | | | | 95 | | 29 | 13 | | | | | | | | | 13 | | | |
| | 24.00 | | | | | 60 | 20 | 20 | | | | | | | | | | 95 | | 47 | 11 | | | | | | | | | 10 | | | |
| | 25.50 | | | | | | 60 | 40 | | | | | | | | | | 87 | | 39 | 12 | | | | | | | | | 12 | | | |
| | 27.00 | | | | | | | 100 | | | | | | | | | | 87 | | 73 | 5 | | | | | | | | | 13 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 28.50 | Fresh, Greyish strong Basalt | | | | | | 100 | | | | | | | | | | 96 | | 90 | <1 | | | | | | | | | 10 | | | |
| | 30.00 | | | | | | | 100 | | | | | | | | | | 100 | | 95 | <1 | | | | | | | | | 18 | | | |
| | 31.50 | | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 93 | | 81 | 2 | | | | | | | | | 10 | | | |
| | 33.00 | | | | | | | 100 | | | | | | | | | | 97 | | 94 | <1 | | | | | | | | | 12 | | | Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 34.50 | | | | | | | 100 | | | | | | | | | | 98 | | 92 | <1 | | | | | | | | | 10 | | | |
| | 36.00 | | | | | | | 100 | | | | | | | | | | 98 | | 87 | 2 | | | | | | | | | 13 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B1 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-11 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E595802.288, N2480092.806 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 08.01.2023 | COMPLETED: | 20.01.2023 |

| | | |
|---|---|---|
| CHAINAGE:- | | 37+410 |
| FEATURE | | TUNNEL |
| BOREHOLE NO. | | B1 |
| DEPTH OF BOREHOLE | | 33.00 m |
| DRILLING AGENCY : | | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability Test section | | LUGEON | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) / Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | | mm/s | OR | |
| | 0.50 | Black cotton Soil | | DS-1 | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Very dense, Brownish Grey soil & Sand | | SPT-1 | | | | | | | | | | | | | | | | | | | | | | 13 | 22 | 50 | 72 | | | | | **Overburden :** 0.00m-0.1.50m The borehole has been drilled in overburden from 0.00m - 1.500 m having Black Cotton Soil, & Very dense, Brownish & Grey soil & Sand |
| | 3.00 | Completely Weathered Brownish Grey weak Basalt | | | 100 | | | | | | | | | | | | 11 | | NIL | >15 | | | | | | | | | 12 | | | | |
| | 4.50 | | | | 100 | | | | | | | | | | | | 19 | | NIL | >15 | | | | | | | | | 18 | | | | |
| | 6.00 | Moderately Weathered Greyish Moderate strong Basalt | | | | 60 | | 40 | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{O}$C | | | | | | | 51 | | 22 | >15 | | | | | | | | | 13 | | | | **Weathered Bedrock-** Weathered Bedrock encountered between 1.50 to 19.50mtr., which is Brownish Highly to Moderately Weathered Weak to Strong Basalt |
| | 7.50 | | | | | 60 | | 40 | | | | | | | | | 93 | | 55 | 7 | | | | | | | | | 13 | | | | |
| | 9.00 | | | | | 60 | | 40 | | | | | | | | | 91 | | 66 | 6 | | | | | | | | | 12 | | | | |
| | 10.50 | | | | 70 | | | 30 | | | | | | | | | 71 | | 12 | >15 | | | | | | | | | 13 | | | | |
| | 12.00 | Highly Weathered, Greyish, weak Basalt | | | 80 | | | 20 | | | | | | | | | 50 | | 9 | >15 | | | | | | | | | 10 | | | | |
| | 13.50 | | | | 70 | | | 30 | | | | | | | | | 35 | | 22 | >15 | | | | | | | | | 12 | | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 19.50 to 33.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 15.00 | Completely Weathered Brownish weak Basalt | | 100 | | | | | | | | | | | | | 17 | NX Size Diamond Bit | NIL | >15 | NX | NX -CASING 4.50 m | Water level - 8.00 m | Partial | | | | | 10 | | | | |
| | 16.50 | | | 100 | | | | | | | | | | | | | 23 | | NIL | >15 | | | | | | | | | 10 | | | | |
| | 18.00 | Moderately Weathered Greyish Moderate strong Basalt | | | | 60 | | 40 | | | | | | | | | 66 | | 29 | 14 | | | | | | | | | 18 | | | | |
| | 19.50 | | | | | 60 | | 40 | | | | | | | | | 93 | | 41 | 11 | | | | | | | | | 15 | | | | |
| | 21.00 | Slightly Weathered to Fresh Greyish strong Basalt | | | | | | 100 | | | | | | | | | 89 | | 83 | 3 | | | | | | | | | 13 | | | | The core recovery percentage in bedrock varies between 11% to 100% with RQD varies from 8% to 100%. |
| | 22.50 | | | | | | | 100 | | | | | | | | | 100 | | 88 | 1 | | | | | | | | | 12 | | | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | 100 | | 97 | 1 | | | | | | | | | 18 | | | | |
| | 25.50 | | | | | | | 100 | | | | | | | | | 81 | | 81 | 3 | | | | | | | | | 13 | | | | |
| | 27.00 | | | | | | | 100 | | Very close irregular joints gently dipping rough fracture | | | | | | | 81 | | 81 | 3 | | | | | | | | | 10 | | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 28.50 | | | | | | | 100 | | | | | | | | | 86 | | 83 | 3 | | | | | | | | | 10 | | | | |
| | 30.00 | | | | | | | 100 | | | | | | | | | 89 | | 89 | 1 | | | | | | | | | 10 | | | | |
| | 31.50 | Fresh, Greyish strong Basalt | | | | | | 100 | | | | | | | | | 98 | | 98 | 1 | | | | | | | | | 13 | | | | Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 33.00 | | | | | | | 100 | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | 12 | | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | T11 BH-01 |
| | | SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-11 | CHAINAGE:- | 37600 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E595934.048, N2480292.691 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | T11 - BH-02 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 35.00 |
| STARTED : | 01.08.2022 | COMPLETED: | 20.08.2022 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | DS-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | | | | | 70 | 30 | | | | | | | | | | | 53 | | 11 | >15 | | | | | | | | | | | | | Overburden:- 0.00m-0.50m The borehole has been drilled in overburden from 0.00m - 0.50mtr. having with Black Cotton Soil |
| | 3.00 | | | | | 70 | 30 | | | | | | | | | | | 55 | | 7 | >15 | | | | | | | | | 17 | | | | |
| | 4.50 | | | | | | 100 | | | | | | | | | | | 89 | | 65 | 6 | | | | | | | | | 10 | | | | |
| | 6.00 | Greyish Moderately Weathered Moderately Weak Basalt | | | | 60 | 40 | | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 57 | | 25 | >15 | | | | | | | | | 13 | | | | |
| | 7.50 | | | | | | 100 | | | | | | | | | | | 85 | | 81 | 3 | | | | | | | | | 8 | | | | Weathered Bedrock- Weathered Bedrock encountered between between 18.00 to 21.00m, which is Greyish Moderately Weathered Moderately Weak Basalt |
| | 9.00 | | | | | | 100 | | | | | | | | | | | 76 | | 62 | 7 | | | | | | | | | 10 | | | | |
| | 10.50 | | | | | 60 | 40 | | | | | | | | | | | 59 | | 19 | >15 | | | | | | | | | 16 | | | | |
| | 12.00 | | | | | 60 | 40 | | | | | | | | | | | 40 | | 22 | >15 | | | | | | | | | 14 | | | | |
| | 13.50 | | | | | | 100 | | | | | | | | | | | 79 | | 69 | 6 | | | | | | | | | 7 | | | | |
| | 15.00 | | | | | | 100 | | | | | | | | | | | 88 | | 61 | 7 | | | | | | | | | 10 | | | | |
| | 16.50 | | | | | | 100 | | | | | | | | | | | 95 | | 83 | 3 | | | | | | | | | 7 | | | | |
| | 18.00 | | | | | | 100 | | | | | | | | | | | 81 | NX Size Diamond Bit | 53 | 8 | NX | NX | 2.0 | Partial | | | | | 12 | | | | Slightly Weathered to Fresh Bedrock- Slightly Weathered to Fresh Bedrock encountered between 12.00 to 35.00mtr., which is Greyish Slightly Weathered to Fresh Strong Basalt |
| | 19.50 | | | | 100 | | | | | | | | | | | | | 37 | | NIL | - | | | | | | | | | 20 | | | | |
| | 21.00 | | | | 100 | | | | | | | | | | | | | 28 | | NIL | >15 | | | | | | | | | 18 | | | | |
| | 22.50 | | | | | | 100 | | | | | | | | | | | 98 | | 31 | 3 | | | | | | | | | 7 | | | | |
| | 24.00 | Greyish Moderately Weathered Moderately Weak Basalt | | | | | 100 | | | | Very close irregular joints gently dipping rough fracture | | | | | | | 85 | | 69 | 6 | | | | | | | | | 10 | | | | |
| | 25.50 | | | | | | 100 | | | | | | | | | | | 99 | | 99 | 1 | | | | | | | | | 5 | | | | The core recovery percentage in bedrock varies between 28% to 100% with RQD varies from 7% to 100%. |
| | 27.00 | | | | | | 100 | | | | | | | | | | | 85 | | 77 | 4 | | | | | | | | | 10 | | | | |
| | 28.50 | | | | | | 100 | | | | | | | | | | | 97 | | 97 | 1 | | | | | | | | | 5 | | | | |
| | 30.00 | | | | | | 100 | | | | | | | | | | | 98 | | 98 | 1 | | | | | | | | | 5 | | | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 31.50 | | | | | | 100 | | | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | 4 | | | | |
| | 33.00 | | | | | | 100 | | | | | | | | | | | 65 | | 65 | 4 | | | | | | | | | 6 | | | | |
| | 34.50 | | | | | | 100 | | | | | | | | | | | 91 | | 86 | 2 | | | | | | | | | 4 | | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 35.00 | | | | | | 100 | | | | | | | | | | | 94 | | 94 | 1 | | | | | | | | | 5 | | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | | | |
|---|---|---|---|---|---|
| | | | | BH HOLE NO. | B3 |
| | | | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-11 | CHAINAGE:- | 37+780 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E596016.864, N2480390.849 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | B3 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 54.00 m |
| STARTED : | 12.01.2023 | COMPLETED: | 23.01.2023 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | Permeability | | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s | OR | LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.30 | Brownish-Black soil & Sand | | DS-1 | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Highly Weathered, Brownish Grey, fractured weak Basalt | | 50 | 20 | 30 | | | | | | | | | | | | 30 | | NIL | >15 | | | | | | | | | 8 | | | | |
| | 3.00 | | | | | | | 100 | | | | | | | | | | 92 | | 86 | 2 | | | | | | | | | 12 | | | | **Overburden :** 0.00m-0.30m The borehole has been drilled in overburden from 0.00m - 0.50 m having Black Cotton Soil & sand |
| | 4.50 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | 10 | | | | |
| | 6.00 | | | | | | | 100 | | | | | | | | | | 99 | | 88 | 1 | | | | | | | | | 12 | | | | |
| | 7.50 | | | | | | | 100 | | | | | | | | | | 100 | | 96 | 1 | | | | | | | | | 10 | | | | |
| | 9.00 | | | | | | | 100 | | | | | | | | | | 97 | | 89 | 1 | | | | | | | | | 11 | | | | |
| | 10.50 | | | | | | | 100 | | | | | | | | | | 97 | | 97 | 1 | | | | | | | | | 11 | | | | |
| | 12.00 | | | | | | | 100 | | | | | | | | | | 96 | | 93 | 1 | | | | | | | | | 13 | | | | **Weathered Bedrock-** Weathered Bedrock encountered between 0.30 to 1.50mtr., which is Brownish Highly Weathered Weak to Strong Basalt |
| | 13.50 | | | | | | | 100 | | | | | | | | | | 98 | | 98 | 1 | | | | | | | | | 11 | | | | |
| | 15.00 | Slightly to Fresh Weathered, Greyish Fractured Moderate strong Basalt | | | | | | 100 | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{0}$C | | | | | | | | 99 | NX Size Diamond Bit | 99 | 1 | | | | | | | | | 11 | | | | |
| | 16.50 | | | | | | | 100 | | | | | | | | | | 95 | | 92 | 1 | | | | | | | | | 10 | | | | |
| | 18.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | 18 | | | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | | 95 | | 89 | 1 | | | | | | | | | 18 | | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | 18 | | | | |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 93 | | 93 | 1 | | | | | | | | | 13 | | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 1.50 to 54.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 98 | | 95 | 1 | | | | | | | | | 16 | | | | |
| | 25.50 | | | | | | | 100 | | | | | | | | | | 93 | | 93 | 1 | | | | | | | | | 10 | | | | |
| | 27.00 | | | | | | | 100 | | | | | | | | | | 95 | | 81 | 3 | | | | | | | | | 18 | | | | |
| | 28.50 | | | | | | | 100 | | | | | | | | | | 92 | | 65 | 6 | NX | NX -CASING 4.50 m | Water le vel - 8.00 m | Partial | | | | | 13 | | | | |
| | 30.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | 16 | | | | |
| | 31.50 | | | | | | | 100 | | | | | | | | | | 90 | | 85 | 3 | | | | | | | | | 10 | | | | |
| | 33.00 | | | | | | | 100 | | | | | | | | | | 97 | | 97 | 1 | | | | | | | | | 15 | | | | The core recovery percentage in bedrock varies between 30% to 100% with RQD varies from 65% to 100%. |
| | 34.50 | | | | | | | 100 | | | | | | | | | | 91 | | 91 | 1 | | | | | | | | | 13 | | | | |
| | 36.00 | | | | | | | 100 | | | | | | | | | | 91 | | 91 | 1 | | | | | | | | | 16 | | | | |
| | 37.50 | | | | | | | 100 | | | | | | | | | | 100 | | 97 | 1 | | | | | | | | | 10 | | | | |
| | 39.00 | | | | | | | 100 | | | | | | | | | | 97 | | 85 | 2 | | | | | | | | | 12 | | | | |
| | 40.50 | | | | | | | 100 | | | | | | | | | | 100 | | 84 | 3 | | | | | | | | | 18 | | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 42.00 | Fresh, Greyish strong Basalt | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 100 | | 100 | 1 | | | | | | | | | 13 | | | | |
| | 43.50 | | | | | | | 100 | | | | | | | | | | 93 | | 93 | 1 | | | | | | | | | 16 | | | | |
| | 45.00 | | | | | | | 100 | | | | | | | | | | 98 | | 93 | 1 | | | | | | | | | 10 | | | | |
| | 46.50 | | | | | | | 100 | | | | | | | | | | 91 | | 75 | 5 | | | | | | | | | 18 | | | | |
| | 48.00 | | | | | | | 100 | | | | | | | | | | 100 | | 67 | 6 | | | | | | | | | 16 | | | | |
| | 49.50 | | | | | | | 100 | | | | | | | | | | 93 | | 69 | 6 | | | | | | | | | 10 | | | | Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 51.00 | | | | | | | 100 | | | | | | | | | | 96 | | 96 | 1 | | | | | | | | | 18 | | | | |
| | 52.50 | | | | | | | 100 | | | | | | | | | | 93 | | 93 | 1 | | | | | | | | | 13 | | | | |
| | 54.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | 10 | | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B4 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-11 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E596069.517, N2480552.208 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 24.01.2023 | COMPLETED: | 06.02.2023 |

| | | | |
|---|---|---|---|
| CHAINAGE:- | 37+950 | | |
| FEATURE | TUNNEL | | |
| BOREHOLE NO. | B4 | | |
| DEPTH OF BOREHOLE | 51.00 m | | |
| DRILLING AGENCY : | IGPL | | |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | DS-1 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Completely Weathered, Brownish fractured Weak Basalt | | | | 100 | | | | | | | | | | | | 22 | | NIL | >15 | | | | | | | | | 15 | | |
| | 3.00 | | | | | 100 | | | | | | | | | | | | 16 | | NIL | >15 | | | | | | | | | 18 | | |
| | 4.50 | Greyish Moderatewly Weathered Strong Basalt | | | | | 40 | 60 | | | | | | | | | | 62 | | 56 | 10 | | | | | | | | | 13 | | |
| | 6.00 | | | | | | 20 | 80 | | | | | | | | | | 97 | | 81 | 6 | | | | | | | | | 16 | | |
| | 7.50 | | | | | | 20 | 80 | | | | | | | | | | 91 | | 81 | 6 | | | | | | | | | 15 | | |
| | 9.00 | | | | | | 10 | 90 | | | | | | | | | | 95 | | 88 | 5 | | | | | | | | | 15 | | |
| | 10.50 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 13 | | |
| | 12.00 | | | | | | 20 | 80 | | | | | | | | | | 88 | | 82 | 4 | | | | | | | | | 10 | | |
| | 13.50 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 17 | | |
| | 15.00 | | | | | | 10 | 90 | | | | | | | | | | 99 | | 89 | <1 | | | | | | | | | 18 | | |
| | 16.50 | | | | | | 10 | 90 | | | | | | | | | | 99 | | 93 | <1 | | | | | | | | | 13 | | |
| | 18.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 10 | | |
| | 19.50 | | | | | | 10 | 90 | | | | | | | | | | 100 | | 92 | <1 | | | | | | | | | 12 | | |
| | 21.00 | | | | | | 10 | 90 | | | | | | | | | | 96 | | 89 | 3 | | | | | | | | | 13 | | |
| | 22.50 | | | | | | 80 | 20 | | | | | | | | | | 95 | | 15 | 13 | | | | | | | | | 15 | | |
| | 24.00 | | | | | | 70 | 30 | | | | | | | | | | 93 | | 35 | 10 | | | | | | | | | 13 | | |
| | 25.50 | | | | | | 20 | 80 | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{0}$C | | | | | | | 90 | | 85 | 7 | | | | | | | | | 13 | | |
| | 27.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | NX | | | | | | | | 13 | | |
| | 28.50 | Greyish Slightly Weathered to Fresh Strong Basalt | | | | | 10 | 90 | | | | | | | | | | 99 | NX Size Diamond Bit | 94 | <1 | | NX -CASING 3.00 m | | | | | | | 18 | | |
| | 30.00 | | | | | | | 100 | | | | | | | | | | 98 | | 98 | <1 | | | | | | | | | 15 | | |
| | 31.50 | | | | | | | 100 | | | | | | | | | | 97 | | 97 | <1 | | Water level - 7.50m | | | | | | | 15 | | |
| | 33.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 19 | | |
| | 34.50 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 16 | | |
| | 36.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 12 | | |
| | 37.50 | | | | | | 10 | 90 | | | | | | | | | | 98 | | 93 | <1 | | | | | | | | | 13 | | |
| | 39.00 | | | | | | 10 | 90 | | | | | | | | | | 98 | | 93 | <1 | | | | | | | | | 16 | | |
| | 40.50 | | | | | | 20 | 80 | | | | | | | | | | 89 | | 83 | <1 | | | | | | | | | 13 | | |
| | 42.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 10 | | |
| | 43.50 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 16 | | |
| | 45.00 | | | | | | 10 | 90 | | | | | | | | | | 97 | | 93 | <1 | | | | | | | | | 17 | | |
| | 46.50 | | | | | | 10 | 90 | | | | | | | | | | 95 | | 95 | <1 | | | | | | | | | 15 | | |
| | 48.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 14 | | |
| | 49.50 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 15 | | |
| | 51.00 | | | | | | | 100 | | | | | | | | | | 97 | | 97 | <1 | | | | | | | | | 12 | | |

**Overburden :**
0.00m-0.50m The borehole has been drilled in overburden from 0.00m - 0.50 m havingBlack Cotton Soil

**Weathered Bedrock-**
Weathered Bedrock encountered between 0.50 to 4.50mtr., which is Brownish Completely to Moderately Weathered Weak to Strong Basalt

**Slightly Weathered to Fresh Bedrock-**
Slightly Weathered to Fresh Bedrock encountered between 4.50 to 51.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt

The core recovery percentage in bedrock varies between 16% to 100% with RQD varies from 0% to 100%.

Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock.

Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B5 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-11 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E596092.782, N2480709.824 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 21.01.2023 | COMPLETED: | 04.02.2023 |

| | |
|---|---|
| CHAINAGE:- | 38+120 |
| FEATURE | TUNNEL |
| BOREHOLE NO. | B5 |
| DEPTH OF BOREHOLE | 35.00 m |
| DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) / Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | DS-1 | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.88 | Very Dense Black Cotton Soil | | SPT-1 | | | | | | | | | | | | | | | | | | | | | 18 | 22 | 50 | 72 | | | | | |
| | 3.00 | Completely Weathered, Brownish fractured Weak Basalt | | | 100 | | | | | | | | | | | | 19 | | NIL | <15 | | | | | | | | | 10 | | | **Overburden :** 0.00m-1.88m The borehole has been drilled in overburden from 0.00m - 1.88 m having Black Cotton Soil |
| | 4.50 | | | | | 70 | | 30 | | | | | | | | | 43 | | 33 | 12 | | | | | | | | | 15 | | | |
| | 6.00 | | | | | 90 | | 10 | | | | | | | | | 27 | | 7 | 13 | | | | | | | | | 19 | | | |
| | 7.50 | | | | | 60 | | 40 | | | | | | | | | 46 | | 39 | 10 | | | | | | | | | 10 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 1.88 to 18.00mtr., which is Brownish Completely to Moderately Weathered Weak to Strong Basalt |
| | 9.00 | | | | | 90 | | 10 | | | | | | | | | 65 | | 30 | 8 | | | | | | | | | 13 | | | |
| | 10.50 | Greyish Highly Weathered Weak to Strong Basalt | | | | 100 | | | | | | | | | | | 43 | | 10 | 12 | | | | | | | | | 10 | | | |
| | 12.00 | | | | | 100 | | | | | | | | | | | 36 | | NIL | <15 | | | | | | | | | 18 | | | |
| | 13.50 | | | | | 100 | | | | | | | | | | | 16 | | NIL | <15 | | | | | | | | | 13 | | | |
| | 15.00 | | | | | 100 | | | | | | | | | | | 29 | | NIL | <15 | | | | | | | | | 10 | | | |
| | 16.50 | | | | | 100 | | | | | | | | | | | 13 | | NIL | <15 | | | | | | | | | 15 | | | |
| | 18.00 | | | | | 100 | | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{O}$C | | | | | | | 28 | NX Size Diamond Bit | NIL | <15 | NX | NX -CASING 5.00 m | Water level - 15.00m | Partial | | | | | 12 | | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 12 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 18.00 to 35.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 21.00 | | | | | | | 100 | | | | | | | | | 99 | | 99 | <1 | | | | | | | | | 18 | | | |
| | 22.50 | | | | | | 30 | 70 | 1 | | | | | | | | 86 | | 75 | <1 | | | | | | | | | 12 | | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | 99 | | 99 | <1 | | | | | | | | | 11 | | | |
| | 25.50 | | | | | | 30 | 70 | | | | | | | | | 83 | | 73 | 8 | | | | | | | | | 11 | | | The core recovery percentage in bedrock varies between 13% to 100% with RQD varies from 0% to 100%. |
| | 27.00 | Greyish Slightly Weathered to Fresh Strong Basalt | | | | | 40 | 60 | | | | | | | | | 78 | | 63 | 9 | | | | | | | | | 12 | | | |
| | 28.50 | | | | | | 10 | 90 | | | | | | | | | 91 | | 91 | <1 | | | | | | | | | 8 | | | |
| | 30.00 | | | | | | 30 | 70 | | | | | | | | | 95 | | 74 | 7 | | | | | | | | | 11 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 31.50 | | | | | | 10 | 90 | | | | | | | | | 93 | | 89 | 4 | | | | | | | | | 10 | | | |
| | 33.00 | | | | | | | 100 | | | | | | | | | 100 | | 96 | <1 | | | | | | | | | 10 | | | |
| | 34.00 | | | | | | 10 | 90 | | | | | | | | | 90 | | 90 | <1 | | | | | | | | | 12 | | | Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 35.00 | | | | | | | 100 | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 11 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | | | |
|---|---|---|---|---|---|
| | | | | BH HOLE NO. | B1 |
| | | | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-10 | CHAINAGE:- | 36+850 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E595304.748, N2479847.001 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | BH-2 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 35.00 m |
| STARTED : | 12.12.2022 | COMPLETED: | 27.12.2022 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability Test section | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | | | |
| | 0.50 | Black cotton rich Soil | | DS-1 | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Completely Weathered Brownish weak Basalt | | 20 | 50 | 30 | | | | | | | | | | | 30 | | NIL | >15 | | | | | | | | | 11 | | | **Overburden :** 0.00m-0.50m The borehole has been drilled in overburden from 0.00m - 0.50 m having Black Cotton Soil |
| | 3.00 | Highly Weathered Greyish weak Basalt | | 20 | 30 | 43 | | 7 | | | | | | | | | 36 | | 7 | >15 | | | | | | | | | 12 | | | |
| | 4.50 | | | 30 | 30 | 28 | | 12 | | | | | | | | | 45 | | 12 | >15 | | | | | | | | | 8 | | | |
| | 6.00 | Moderatly Weathered Greyish strong Basalt | | 16 | 10 | | | 74 | | | | | | | | | 81 | | 74 | 5 | | | | | | | | | 12 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 0.50 to 18.00mtr., which is Brownish Highly to Moderately Weathered Weak to Strong Basalt |
| | 7.50 | | | 10 | 5 | | | 85 | | | | | | | | | 95 | | 85 | 2 | | | | | | | | | 18 | | | |
| | 9.00 | | | 30 | 23 | 24 | | 23 | | | | | | | | | 51 | | 23 | >15 | | | | | | | | | 13 | | | |
| | 10.50 | Highly Weathered, Greyish, very weak Basalt | | 20 | 30 | 50 | | | | | | | | | | | 33 | | NIL | >15 | | | | | | | | | 13 | | | |
| | 12.00 | | | 20 | 30 | 50 | | | | | | | | | | | 33 | | NIL | >15 | | | | | | | | | 10 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 18.00 to 35.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 13.50 | | | 50 | 20 | 30 | | | | | | | | | | | 27 | | NIL | >15 | | | | | | | | | 17 | | | |
| | 15.00 | | | 20 | 60 | 20 | | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{O}$C | | | | | | | 35 | | NIL | >15 | | | | | | | | | 12 | | | |
| | 16.50 | | | 50 | 15 | 35 | | | | | | | | | | | 35 | | NIL | >15 | | | | | | | | | 12 | | | |
| | 18.00 | Highly Weathered, Greyish Moderate strong Basalt | | 35 | 20 | 10 | | 35 | | | | | | | | | 45 | | 35 | 12 | | | | | | | | | 11 | | | |
| | 19.50 | Slightly Weathered to Fresh Black Greyish strong Basalt | | | | | | 100 | | | | | | | | | 95 | | 79 | 3 | | | | | | | | | 8 | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | 100 | | 89 | 1 | | | | | | | | | 15 | | | The core recovery percentage in bedrock varies between 27% to 100% with RQD varies from 7% to 96%. |
| | 22.50 | | | | | | | 100 | | | | | | | | | 94 | | 86 | 2 | | | | | | | | | 19 | | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | 100 | | 68 | 6 | | | | | | | | | 14 | | | |
| | 25.50 | | | | | | | 100 | | | | | | | | | 96 | | 85 | 2 | | | | | | | | | 12 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 27.00 | | | | | | | 100 | | | | | | | | | 96 | | 96 | 1 | | | | | | | | | 16 | | | |
| | 28.50 | | | | | | | 100 | | | | | | | | | 96 | | 81 | 3 | | | | | | | | | 10 | | | |
| | 30.00 | | | | | | | 100 | | | | | | | | | 86 | | 74 | 5 | | | | | | | | | 8 | | | |
| | 31.50 | | | | | | | 100 | | Very close irregular joints gently dipping rough fracture | | | | | | | 99 | | 87 | 2 | | | | | | | | | 12 | | | |
| | 33.00 | | | | | | | 100 | | | | | | | | | 100 | | 95 | 1 | | | | | | | | | 10 | | | Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 34.00 | | | | | | | 100 | | | | | | | | | 100 | | 89 | 1 | | | | | | | | | 15 | | | |
| | 35.00 | | | | | | | 100 | | | | | | | | | 100 | | 93 | 1 | | | | | | | | | 8 | | | |

NX Size Diamond Bit

NX

NX

Water level - 7.00 m

Partial

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | B1 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-12 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E596133.601, N2481148.445 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 05.02.2023 | COMPLETED: | 15.02.2023 |

| | |
|---|---|
| CHAINAGE:- | 38+550 |
| FEATURE | TUNNEL |
| BOREHOLE NO. | B1 |
| DEPTH OF BOREHOLE | 30.00 m |
| DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) / Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Black Cotton Soil | | | | DS-1 | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.90 | Very Dense Sandy Gravel | | | | SPT-1 | | | | | | | | | | | | | | | | | | | | 13 | 17 | 50 | 67 | | | | |
| | 3.00 | Completely Weathered, Brownish fractured Weak Basalt | | | 100 | | | | | | | | | | | | 28 | | NIL | | | | | | | | | | 10 | | | Overburden : 0.00m-1.90m The borehole has been drilled in overburden from 0.00m - 1.90 m having Black Cotton Soil & Very Dense Sandy Gravel |
| | 4.50 | | | | | 40 | 60 | | | | | | | | | | 84 | | 57 | | | | | | | | | | 9 | | | |
| | 6.00 | | | | | 70 | 30 | | | | | | | | | | 54 | | 29 | | | | | | | | | | 7 | | | |
| | 7.50 | | | | | 70 | 30 | | | | | | | | | | 60 | | 27 | | | | | | | | | | 9 | | | Weathered Bedrock- Weathered Bedrock encountered between 1.90 to 22.50mtr., which is Brownish Completely to Moderately Weathered Weak to Strong Basalt |
| | 9.00 | Greyish Moderately Weathered Weak to Strong Basalt | | | | 50 | 50 | | | | | | | | | | 78 | | 46 | | | | | | | | | | 7 | | | |
| | 10.50 | | | | | 60 | 40 | | | | | | | | | | 66 | | 47 | | | | | | | | | | 6 | | | |
| | 12.00 | | | | | 80 | 20 | | | | | | | | | | 40 | | 13 | | | | | | | | | | 8 | | | |
| | 13.50 | | | | | 80 | 20 | | | | | | | | | | 82 | | 17 | | | | | | | | | | 11 | | | |
| | 15.00 | | | | | 60 | 40 | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40$^{O}$C | | | | | | | 57 | NX Size Diamond Bit | 35 | | | NX | NX -CASING 3.00 m | Water level - 14.00m | Partial | | | | | 12 | | | Slightly Weathered to Fresh Bedrock- Slightly Weathered to Fresh Bedrock encountered between 22.50 to 30.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 16.50 | Highly Weathered, Brownish fractured Weak Basalt | | | 100 | | | | | | | | | | | | 15 | | NIL | | | | | | | | | | 27 | | | |
| | 18.00 | | | | 100 | | | | | | | | | | | | 31 | | NIL | | | | | | | | | | 33 | | | |
| | 19.50 | | | | | 90 | 10 | | | | | | | | | | 37 | | 11 | | | | | | | | | | 14 | | | |
| | 21.00 | | | | 100 | | | | | | | | | | | | 27 | | NIL | | | | | | | | | | 17 | | | |
| | 22.50 | Greyish Moderately Weathered Weak to Strong Basalt | | | | 80 | 20 | | | | | | | | | | 46 | | 19 | | | | | | | | | | 25 | | | The core recovery percentage in bedrock varies between 15% to 100% with RQD varies from 0% to 97%. |
| | 24.00 | Greyish Slightly Weathered to Fresh Strong Basalt | | | | 50 | 50 | | | | | | | | | | 97 | | 47 | | | | | | | | | | 14 | | | |
| | 25.50 | | | | | 70 | 30 | | | | | | | | | | 57 | | 29 | | | | | | | | | | 7 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 27.00 | | | | | 50 | 50 | | | | | | | | | | 82 | | 55 | | | | | | | | | | 9 | | | |
| | 28.50 | | | | | 50 | 50 | | | | | | | | | | 100 | | 48 | | | | | | | | | | 12 | | | Partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 30.00 | | | | | | 100 | | | | | | | | | | 100 | | 97 | | | | | | | | | | 8 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | |
|---|---|
| **BH HOLE NO.** | P-2 |
| **SHEET NO.:** | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation Ratam-Khandawa section of Westren Railway. | **LOCATION:** | T-12 | **CHAINAGE:-** | 39810 |
| **BEARING OF HOLE (Degree):** | 90° | **CO-ORDINATES:** | N-2479646 E-0594711 | **FEATURE** | Tunnel-12 |
| **COLLAR ELEVATION (m):** | 5 CM | **ANGLE W.R.T HORIZONTAL:** | 90° Degree | **BOREHOLE NO.** | BH-01 |
| **TYPE(S) OF CORE BARREL:** | NWT | **GROUND ELEVATION(m):** | 447m | **DEPTH OF BOREHOLE** | 30.00M |
| **STARTED :** | 03.06.2024 | **COMPLETED:** | 13.06.2024 | **DRILLING AGENCY :** | Goma Engineerin and Consultancy |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Bit use | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| 0.00 | 0.50 | Brownish colour, medium to fine grain, silty sand with gravels, fragments pieces of basalt. | | 100 | | | | | | | Nill | Overburden | | | | | | Nil | Nil | Nil | | NX | | NX-1.5 METER | 7.00 M | | | | | | 16 | | | **From GL TO 1.50M** Brownish colour, medium to fine grain, silty sand with gravels, fragments pieces of basalt. |
| 0.50 | 1.50 | | | 50 | 50 | | | | | | Nill | | 21 | | | | | 21 | | Nill | >15 | | | | | | | | | | 11 | | | |
| 1.50 | 3.00 | Moderately to highly weathered, highly fractured, Medium Strong, Medium to fine-grain Basalt. | | | | 90 | 10 | | | | JN-40°-50° RG-UN | | 22 | | | | | 22 | | Nill | 5 | | | | | | | | | | 13 | | | |
| 3.00 | 4.50 | | | | 80 | 20 | | | | | JN-10°-20° RG-UN | | 21 | | | | | 21 | | Nill | >15 | | | | | | | | | | 12 | | | |
| 4.50 | 6.00 | | | | 50 | 50 | | | | | JN-10° RG-UN | | 24 | | | | | 24 | | Nill | 6 | | | | | | | | | | 11 | | | **Bedrock encountered 1.5m From 1.50m to 12.0m.** Moderately to highly weathered, highly fractured, Medium Strong, Medium to fine-grain Basalt. |
| 6.00 | 7.50 | | | | | 76 | 24 | | | | JN-25°-30° RG-UN | | 36 | | | | | 36 | | 8 | 6 | | | | | | | | | | 11 | | | |
| 7.50 | 9.00 | | | | 60 | 40 | | | | | JN-20°,RG-UN | | 24 | | | | | 24 | | Nill | >15 | | | | | | | | | | 12 | | | |
| 9.00 | 10.50 | | | | 20 | 20 | 18 | 42 | | | JN-10° RG-UN vertical Iron stained | | 46 | | | | | 46 | | 30 | >15 | | | | | | | | | | 12 | | | |
| 10.50 | 12.00 | | | | | 30 | 70 | | | | JN-40°RG-UN vertical | | 56 | | | | | 56 | | 8 | 8 | | | | | | | | | | 12 | | | **12.00m to 13.50m** Moderately to slightly weathered, highly fractured, medium strong fine-grain brown colour basalt with bands of red boel basalt. |
| 12.00 | 13.50 | Moderately to slightly weathered, Hard to very strong, slightly fractured, Brown colour basalt | | | | 22 | 25 | 53 | | | JN-30° RG-UN | | 50 | | | | | 50 | | 28 | 8 | | | | | | | | | | 12 | | | |
| 13.50 | 15.00 | Moderately to slightly weathered, highly fractured, medium strong fine-grain brown colour basalt with bands of red boel basalt. | | | 40 | 23 | | 37 | | | JN-35°-40° RG-UN | | 54 | | | | | 54 | | 22 | 4 | | | | | | | | | | 11 | | | |
| 15.00 | 16.50 | | | | 10 | 40 | | 50 | | | JN-20° SMPL | | 55 | | | | | 55 | | 28 | >15 | | | | | | | | | | 11 | | | **13.50 m to 18.00m** Moderate to slightly weathered, highly fractured, medium strong fine-grain brown colour basalt with bands of red basalt. |
| 16.50 | 18.00 | | | 10 | 40 | 50 | | | | | JN-30° RG-UN Vertical | | 42 | | | | | 42 | | Nill | >15 | | | | | | | | | | 12 | | | |
| 18.00 | 19.50 | Fresh to slightly weathered, hard, strong, slightly fractured, medium to fine-grain grey colour Basalt with quartz bands. | | | | | 20 | 80 | | | JN-50° RG-UN | | 43 | | | | | 43 | | 11 | 8 | | | | | | | | | | 12 | | | |
| 19.50 | 21.00 | | | | | | 48 | 52 | | | JN-40°-45° RG-UN | | 47 | | | | | 47 | | 47 | 3 | | | | | | | | | | 12 | | | |
| 21.00 | 22.50 | | | | | | 31 | 69 | | | JN-10° RG-UN | | 70 | | | | | 70 | | 69 | 3 | | | | | | | | | | 12 | | | **18.0m to 25.50m .** Fresh to slightly weathered, hard, strong, slightly fractured, medium to fine-grain grey colour Basalt with quartz bands. |
| 22.50 | 24.00 | | | | | | 43 | 57 | | | JN-30° RG-UN | | 82 | | | | | 82 | | 56 | 2 | | | | | | | | | | 10 | | | |
| 24.00 | 25.50 | | | | | | 29 | 71 | | | JN-45° SMPL | | 67 | | | | | 67 | | 58 | 6 | | | | | | | | | | 12 | | | |
| 25.50 | 27.00 | . Moderately to highly fractured, grey colour, fine-grain Basalt. | | | | 20 | 55 | 25 | | | JN-30°-35° RG-UN | | 88 | | | | | 88 | | 32 | 5 | | | | | | | | | | 12 | | | **25.50m to 27.00m** . Moderately to highly fractured, grey colour, fine-grain Basalt. |
| 27.00 | 28.50 | . Fresh to slightly weathered, hard/strong to very strong slightly fractured, fine-grain grey colour basalt with quartz vains. | | | | | 11 | 89 | | | JN-20° RG-UN | | 86 | | | | | 86 | | 84 | 15 | | | | | | | | | | 11 | | | **27.0m to 30.00m .** Fresh to slightly weathered, hard/strong to very strong slightly fractured, fine-grain grey colour basalt with quartz vains. |
| 28.50 | 30.00 | | | | | | 20 | 80 | | | JN-10°-20° RG-UN | | 86 | | | | | 86 | | 77 | 4 | | | | | | | | | | 10 | | | |

IMP DIAMOND

Uncasd

PARTIAL

INDEX

| | | | |
|---|---|---|---|
| HILL SLOPE DEBRIS | | CORE RECOVERY | MODERATELY FRACTURED |
| BED ROCK | | SLIGHTLY FRACTURED | HIGHLY FRACTURED |

LOGGED BY -

CHECKED BY -

# GEOLOGICAL LOG OF DRILL HOLE

| | | | | | |
|---|---|---|---|---|---|
| | | | | BH HOLE NO. | T12A BH-01 |
| | | | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-12A | CHAINAGE:- | 40605 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E594548.024, N2481989.85 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | T12A - BH-01 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 36.00 |
| STARTED : | 27.09.2022 | COMPLETED: | 05.10.2022 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | LUGEON mm/s OR | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | DS-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 2.00 | Brownish Completely to Highly Weathered Weak Basalt | | | 100 | | | | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 11 | NX Size Diamond Bit | NIL | >15 | NX | NX | 10.0 | Partial | | | | | | 16.66 | | **Overburden:- 0.00m-0.50m** The borehole has been drilled in overburden from 0.00m - 0.50mtr. having with Black Cotton Soil. |
| | 3.50 | | | | 100 | | | | | | | | | | | | | 9 | | NIL | >15 | | | | | | | | | | 14.28 | | |
| | 5.00 | | | | 100 | | | | | | | | | | | | | 16 | | NIL | >15 | | | | | | | | | | 10.34 | | **Weathered Bedrock-** Weathered Bedrock encountered between 0.50 to 6.50mtr., 8.00 to 9.50 which is Brownish Completely to Highly Weathered Weak Basalt |
| | 6.50 | | | | 100 | | | | | | | | | | | | | 33 | | NIL | >15 | | | | | | | | | | 21.4 | | |
| | 8.00 | Brownish Slightly Weathered Strong Basalt | | | | | 50 | 50 | | | | | | | | | | 83 | | 57 | 7 | | | | | | | | | | 16.66 | | |
| | 9.50 | Greyish Highly Weathered Weak Fracture Basalt | | | | 100 | | | | | | | | | | | | 39 | | NIL | >15 | | | | | | | | | | 21.42 | | |
| | 11.00 | Greyish Moderately to Slightly Weathered Weak to Strong Fine grained Basalt | | | | | 60 | 40 | | | | | | | | | | 90 | | 58 | 6 | | | | | | | | | | 16.66 | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 6.50 to 8.00mtr., 9.50 to 36.00mtr., which is Greyish Moderately to Slightly Weathered Weak to Strong Fresh Fine grained Basalt |
| | 12.50 | | | | | 70 | 10 | 20 | | | | | | | | | | 50 | | 28 | 10 | | | | | | | | | | 16.66 | | |
| | 14.00 | | | | | | 50 | 50 | | | | | | | | | | 75 | | 71 | 3 | | | | | | | | | | 16.66 | | |
| | 15.50 | | | | | | 20 | 80 | | | | | | | | | | 88 | | 60 | 3 | | | | | | | | | | 10 | | |
| | 17.00 | | | | | | 30 | 70 | | | | | | | | | | 81 | | 61 | 2 | | | | | | | | | | 11.11 | | |
| | 18.50 | | | | | | 50 | 50 | | | | | | | | | | 63 | | 48 | 11 | | | | | | | | | | 12.5 | | |
| | 20.00 | Greyish Fresh Strong Fine grained Basalt | | | | | 30 | 70 | | | | | | | | | | 100 | | 57 | 10 | | | | | | | | | | 13.65 | | The core recovery percentage in bedrock varies between 9% to 100% with RQD varies from 0% to 100%. |
| | 21.50 | | | | | | | 100 | | | | | | | | | | 93 | | 93 | 1 | | | | | | | | | | 12.5 | | |
| | 23.00 | | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 91 | | 85 | 3 | | | | | | | | | | 23 | | |
| | 24.50 | | | | | | | 100 | | | | | | | | | | 92 | | 92 | 1 | | | | | | | | | | 25 | | |
| | 26.00 | Greyish Moderately to Slightly Weathered Weak to Strong Fine grained Basalt | | | | | 50 | 50 | | | | | | | | | | 87 | | 52 | 9 | | | | | | | | | | 23 | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 27.50 | | | | | 20 | 40 | 40 | | | | | | | | | | 58 | | 40 | 11 | | | | | | | | | | 25 | | |
| | 29.00 | | | | | | 50 | 50 | | | | | | | | | | 71 | | 42 | 10 | | | | | | | | | | 25 | | |
| | 30.50 | | | | | 50 | 30 | 20 | | | | | | | | | | 71 | | 21 | 12 | | | | | | | | | | 25 | | |
| | 32.00 | | | | | 40 | 40 | 20 | | | | | | | | | | 36 | | 13 | 13 | | | | | | | | | | 16.66 | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 33.50 | Greyish Fresh Strong Basalt | | | | | | 100 | | | | | | | | | | 99 | | 85 | 3 | | | | | | | | | | 25 | | |
| | 35.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | | 25 | | |
| | 36.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | 1 | | | | | | | | | | 11 | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | |
|---|---|
| BH HOLE NO. | T12A BH-02 |
| SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel - 12A | CHAINAGE:- | 40670 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E594483.091, N2481992.812 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | T12A - BH-02 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 34.00 |
| STARTED : | 07.10.2022 | COMPLETED: | 12.10.2022 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| | 1.50 | Brownish<br>Completely to Highly Weathered<br>Weak<br>Basalt | | | 100 | | | | | | Close to Medium irregular joints<br>gently dipping rough fracture | | | | | | | 10 | | NIL | >15 | | | | | | | | | | | 19 | | |
| | 3.00 | | | | 100 | | | | | | | | | | | | | 13 | | NIL | >15 | | | | | | | | | | | 21 | | |
| | 4.50 | | | | 100 | | | | | | | | | | | | | 15 | | NIL | >15 | | | | | | | | | | | 17 | | Bed rock encountered from ground Surface . Weathered Bedrock-<br>Weathered Bedrock encountered between 0.00 to 9.00mtr., which is Brownish<br>Completely to Highly Weathered<br>Weak<br>Basalt |
| | 6.00 | | | | 100 | | | | | | | | | | | | | 18 | | NIL | >15 | | | | | | | | | | | 13 | | |
| | 7.50 | | | | | 100 | | | | | | | | | | | | 19 | | NIL | >15 | | | | | | | | | | | 20 | | |
| | 9.00 | | | | | 60 | 20 | 20 | | | | | | | | | | 29 | | 9 | >15 | | | | | | | | | | | 17 | | |
| | 10.50 | Greyish<br>Slightly Weathered to Fresh<br>Strong<br>Fine grained<br>Basalt | | | | | 40 | 60 | | | Very close<br>irregular joints gently dipping<br>rough fracture | | | | | | | 86 | | 73 | 6 | | | | | | | | | | | 12 | | |
| | 12.00 | | | | | | 20 | 80 | | | | | | | | | | 100 | | 83 | 4 | | | | | | | | | | | 14 | | Slightly Weathered to Fresh Bedrock-<br>Slightly Weathered to Fresh Bedrock encountered between 9.00 to 34.00mtr., which is<br>Greyish<br>Slightly Weathered to Fresh<br>Strong<br>Fine grained<br>Basalt |
| | 13.50 | | | | | | 30 | 70 | | | | | | | | | | 98 | | 76 | 5 | | | | | | | | | | | 16 | | |
| | 15.00 | | | | | | 30 | 70 | | | | | | | | | | 87 | | 77 | 5 | | | | | | | | | | | 21 | | |
| | 16.50 | | | | | | 50 | 50 | | | | | | | | | | 83 | | 57 | 10 | | | | | | | | | | | 17 | | |
| | 18.00 | | | | | | 20 | 80 | | | | | | | | | | 88 | NX Size Diamond Bit | 78 | 5 | NX | NX | 12.00 | Partial | | | | | | | 10 | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | | 97 | | 89 | 4 | | | | | | | | | | | 8 | | The core recovery percentage in bedrock varies between 10% to 100% with RQD varies from 0% to 100%. |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 95 | | 95 | 1 | | | | | | | | | | | 14 | | |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 97 | | 89 | 3 | | | | | | | | | | | 15 | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | | | 10 | | |
| | 25.50 | | | | | | 40 | 60 | | | | | | | | | | 91 | | 67 | 7 | | | | | | | | | | | 10 | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 27.00 | | | | | | 50 | 50 | | | | | | | | | | 83 | | 49 | 13 | | | | | | | | | | | 13 | | |
| | 28.50 | | | | | | 60 | 40 | | | | | | | | | | 88 | | 15 | >15 | | | | | | | | | | | 20 | | |
| | 30.00 | | | | | | 50 | 50 | | | | | | | | | | 97 | | 46 | 10 | | | | | | | | | | | 12 | | |
| | 31.50 | | | | | | 50 | 50 | | | | | | | | | | 75 | | 54 | 8 | | | | | | | | | | | 13 | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 33.00 | | | | | | 50 | 50 | | | | | | | | | | 76 | | 52 | 8 | | | | | | | | | | | 17 | | |
| | 34.00 | | | | | | | 100 | | | | | | | | | | 99 | | 99 | <1 | | | | | | | | | | | 33 | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | | | |
|---|---|---|---|---|---|
| | | | | BH HOLE NO. | T13 B1 |
| | | | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-13 | CHAINAGE:- | 42+910 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E59268.614, N2482790.713 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | T13 B1 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 25.00 m |
| STARTED : | 04.03.2023 | COMPLETED: | 07.03.2023 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water Loss | | SPT-Number of Blows | | | | | Permeability | | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) / Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | | | DS-1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.95 | Very Dense Sandy Gravel | | | | SPT-1 | | | | Residual Soil | | | | | | | | | | | | | | | | 14 | 15 | 18 | 33 | | | | | |
| | 3.45 | | | | | SPT-2 | | | | | | | | | | | | | | | | | | | | 24 | 31 | 30 | 61 | | | | | **Overburden :** 0.00m-3.45m The borehole has been drilled in overburden from 0.00m - 3.45m having Black Cotton Soil & Very Dense Sandy Gravel |
| | 4.50 | Highly Weathered, Brownish fractured Weak Basalt | | | 100 | | | | | | | | | | | | 44 | | NIL | 8 | | | | | | | | | 12 | | | | |
| | 6.00 | | | | | 70 | 30 | | | | | | | | | | 69 | | 19 | 7 | | | | | | | | | 24 | | | | |
| | 7.50 | Greyish Moderately Weathered Strong Basalt | | | | 50 | 50 | | | | | | | | | | 74 | | 62 | 4 | | | | | | | | | 13 | | | | |
| | 9.00 | | | | | 50 | 50 | | | | | | | | | | 100 | | 61 | 5 | | | | | | | | | 12 | | | | |
| | 10.50 | | | | | | 100 | | | | | | | | | | 89 | | 87 | 3 | | | | | | | | | 12 | | | | **Weathered Bedrock-** Weathered Bedrock encountered between 3.45 to 10.50mtr., which is Brownish Highly to Moderately Weathered Weak to Strong Basalt |
| | 12.00 | Greyish Fresh Strong Basalt | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 14 | | | | |
| | 13.50 | | | | | | 100 | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40°C | | | | | | | 97 | NX Size Diamond Bit | 90 | <1 | NX | Casing 3.00 | Water level - 10.00m | Partial | | | | | 13 | | | | |
| | 15.00 | | | | | | 100 | | | | | | | | | | 100 | | 89 | <1 | | | | | | | | | 9 | | | | |
| | 16.50 | | | | | | 100 | | | | | | | | | | 96 | | 94 | <1 | | | | | | | | | 11 | | | | |
| | 18.00 | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 9 | | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 10.50to 25.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 19.50 | | | | | | 100 | | | | | | | | | | 87 | | 77 | <1 | | | | | | | | | 11 | | | | |
| | 21.00 | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 9 | | | | |
| | 22.50 | | | | | | 100 | | | | | | | | | | 99 | | 99 | <1 | | | | | | | | | 11 | | | | |
| | 24.00 | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 9 | | | | The core recovery percentage in bedrock varies between 44% to 100% with RQD varies from 19% to 100%. |
| | 25.00 | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | 11 | | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | | | |
|---|---|---|---|---|---|
| | | | | BH HOLE NO. | T13 B8 |
| | | | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-13 | CHAINAGE:- | 44+410 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E593242763.00, N2484076.309 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | T13 B8 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 25.00 m |
| STARTED : | 16.02.2023 | COMPLETED: | 24.03.2023 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground Elevation (m) | Depth (m) | Lithology | | Size of core pieces (%) | | | | | Ratio | Structural Condition | | Percent Core Recovery (%) | | | | | | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Drill Water Loss | | SPT-Number of Blows | | | | Penetration Rate (mm/min) | Permeability | | Special Observations and interpretations / Weathering Grade |
| | | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) / Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | | | | | | | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | | Test section | mm/s OR LUGEON | |
| | 0.50 | Black Cotton Soil | | | | DS-1 | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.86 | Very Dense Sandy Gravel | | | | SPT-1 | | | | | | | | | | | | | | | | | | | | 9 | 15 | 21 | 36 | | | | **Overburden :** 0.00m-1.86m The borehole has been drilled in overburden from 0.00m - 1.86m having Black Cotton Soil & Very Dense Sandy Gravel |
| | 3.00 | | | | 100 | | | | | | | | | | | | 9 | | Nil | >15 | | | | | | | | | 8 | | | |
| | 4.50 | | | | 100 | | | | | | | | | | | | 7 | | Nil | 14 | | | | | | | | | 8 | | | |
| | 6.00 | | | | 100 | | | | | | | | | | | | 12 | | Nil | 13 | | | | | | | | | 5 | | | |
| | 7.50 | Completely to Highly Weathered, Brownish fractured Weak Basalt | | | 70 | 30 | | | | | | | | | | | 30 | | 18 | 12 | | | | | | | | | 7 | | | |
| | 9.00 | | | | 100 | | | | | | | | | | | | 51 | | Nil | 14 | | | | | | | | | 8 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 1.86 to 12.00mtr., which is Brownish Completely to Highly Weathered, Brownish fractured Weak Basalt |
| | 10.50 | | | | 60 | 40 | | | | | | | | | | | 46 | | 13 | 8 | | | | | | | | | 10 | | | |
| | 12.00 | | | | 100 | | | | | | | | | | | | 68 | | Nil | 11 | | | | | | | | | 9 | | | |
| | 13.50 | | | | | 60 | 40 | | | Heavily to Moderately Shear Closey to Very Closely spaced planes, Very rough to rough wall rock, Gently diping joint plane 30 to 40°C | | | | | | | 81 | NX Size Diamond Bit | 67 | 7 | NX | Casing 3.00 | Water level - 10.00m | Partial | | | | | | | 9 | | | |
| | 15.00 | | | | | | 100 | | | | | | | | | | 98 | | 95 | <1 | | | | | | | | | 7 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 12.00to 25.00mtr., which is Greyish Slightly Weathered Strong Fine grained Basalt |
| | 16.50 | | | | | | 100 | | | | | | | | | | 82 | | 80 | 2 | | | | | | | | | 8 | | | |
| | 18.00 | | | | | | 100 | | | | | | | | | | 92 | | 85 | 4 | | | | | | | | | 10 | | | |
| | 19.50 | Greyish Slightly Weathered Strong Basalt | | | | | 100 | | | | | | | | | | 73 | | 55 | 7 | | | | | | | | | 7 | | | |
| | 21.00 | | | | | | 100 | | | | | | | | | | 100 | | 81 | 5 | | | | | | | | | 9 | | | The core recovery percentage in bedrock varies between 7% to 100% with RQD varies from 13% to 95%. |
| | 22.50 | | | | | | 100 | | | | | | | | | | 81 | | 77 | 6 | | | | | | | | | 9 | | | |
| | 22.50 | | | | | | 100 | | | | | | | | | | 70 | | 70 | 5 | | | | | | | | | 10 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 25.00 | | | | | | 100 | | | | | | | | | | 89 | | 84 | 4 | | | | | | | | | 8 | | | |

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | T14 BH-01 |
| | | SHEET NO.: | 1 of 1 |
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-14 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E599526.06, N2480197.036 |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- |
| STARTED : | 25.09.2022 | COMPLETED: | 01.10.2022 |

| | | | |
|---|---|---|---|
| CHAINAGE:- | 57470 | | |
| FEATURE | TUNNEL | | |
| BOREHOLE NO. | T14 - BH-01 | | |
| DEPTH OF BOREHOLE | 30.00 | | |
| DRILLING AGENCY : | IGPL | | |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | DS-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.95 | | | SPT-01 | | | | | | | | | | | | | | | | | | | | | | | 5 | 7 | 10 | 17 | | | | | **Overburden:-** 0.00m-4.70m The borehole has been drilled in overburden from 0.00m - 4.70mtr. having with Black Cotton Soil & Medium Dense coarse grain sand |
| | 3.45 | Medium Dense coarse grain sand | | SPT-02 | | | | | | | | | | | | | | | | | | | | | | | 7 | 11 | 13 | 24 | | | | | |
| | 4.70 | | | SPT-03 | | | | | | | | | | | | | | | | | | | | | | | 15 | 50 | - | R | | | | | |
| | 6.00 | Brownish Completely to Highly Weathered Weak Basalt | | | 100 | | | | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 31 | | NIL | >15 | | | | | | | | | | 14 | | | |
| | 7.50 | | | | 100 | | | | | | | | | | | | | 17 | | NIL | >15 | | | | | | | | | | 17 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 4.50 to 7.50mtr., which is Brownish Completely to Highly Weathered Weak Basalt |
| | 9.00 | Greyish Slightly Weathered to Fresh Strong Fine grained Basalt | | | | | 50 | 50 | | | | | | | | | | 72 | | 72 | 6 | | | | | | | | | | 10 | | | |
| | 10.50 | | | | | | 40 | 60 | | | | | | | | | | 100 | | 70 | 5 | | | | | | | | | | 9 | | | |
| | 12.00 | | | | | | 50 | 50 | | | | | | | | | | 85 | | 55 | 5 | | | | | | | | | | 6 | | | |
| | 13.50 | | | | | | 20 | 80 | | | | | | | | | | 100 | | 80 | 5 | | | | | | | | | | 13 | | | |
| | 15.00 | | | | | | 40 | 60 | | | | | | | | | | 93 | | 69 | 10 | | | | | | | | | | 11 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 7.50 to 30.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 16.50 | | | | | | 20 | 80 | | | | | | | | | | 95 | | 86 | 4 | | | | | | | | | | 14 | | | |
| | 18.00 | | | | | | 20 | 80 | | | | | | | | | | 97 | | 86 | 4 | | | | | | | | | | 10 | | | |
| | 19.50 | | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 97 | | 94 | <1 | | | | | | | | | | 6 | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 100 | | 80 | 5 | | | | | | | | | | 10 | | | The core recovery percentage in bedrock varies between 17% to 100% with RQD varies from 0% to 96%. |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 99 | | 89 | 4 | | | | | | | | | | 14 | | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 93 | | 91 | <1 | | | | | | | | | | 8 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 25.50 | | | | | | | 100 | | | | | | | | | | 97 | | 96 | <1 | | | | | | | | | | 13 | | | |
| | 27.00 | | | | | | | 100 | | | | | | | | | | 96 | | 96 | <1 | | | | | | | | | | 11 | | | |
| | 28.50 | | | | | | 30 | 70 | | | | | | | | | | 99 | | 53 | 10 | | | | | | | | | | 14 | | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 30.00 | | | | | | 20 | 80 | | | | | | | | | | 99 | | 72 | 7 | | | | | | | | | | 11 | | | |

NX Size Diamond Bit

NX

Not Met

Partial

# GEOLOGICAL LOG OF DRILL HOLE

| | | | |
|---|---|---|---|
| | | BH HOLE NO. | T14 BH-02 |
| | | SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-14 | CHAINAGE:- | 57650 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E599362.677, N2480272.569 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | T14 - BH-02 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 35.00 |
| STARTED : | 01.10.2022 | COMPLETED: | 10.10.2022 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | | Special Observations and interpretations / Weathering Grade |
| | 0.50 | | | DS-01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.85 | Black Cotton Soil | | SPT-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | 10 | 25 | 50 | 75 | | | | | **Overburden:-** 0.00m-1.85m The borehole has been drilled in overburden from 0.00m - 1.85mtr. having with Black Cotton Soil |
| | 3.00 | Brownish Completely to Highly Weathered Weak Basalt | | | 100 | | | | | | | | | | | | | 11 | | 9 | >15 | | | | | | | | | | 13 | | | |
| | 4.50 | | | | | 100 | | | | | | | | | | | | 19 | | 15 | >15 | | | | | | | | | | 10 | | | |
| | 6.00 | | | | | 100 | | | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 19 | | 8 | >15 | | | | | | | | | | 10 | | | **Weathered Bedrock-** Weathered Bedrock encountered between 1.85 to 10.50mtr., which is Brownish Completely to Highly Weathered Weak Basalt |
| | 7.50 | Greyish Moderately Weathered Weak to Strong Fine grained Basalt | | | | 40 | 60 | | | | | | | | | | | 49 | | 46 | 12 | | | | | | | | | | 10 | | | |
| | 9.00 | | | | | 40 | 60 | | | | | | | | | | | 44 | | 41 | 13 | | | | | | | | | | 19 | | | |
| | 10.50 | | | | | 20 | 60 | 20 | | | | | | | | | | 51 | | 43 | 11 | | | | | | | | | | 10 | | | |
| | 12.00 | | | | | | 50 | 50 | | | | | | | | | | 69 | | 69 | 8 | | | | | | | | | | 11 | | | |
| | 13.50 | | | | | 60 | 40 | 20 | | | | | | | | | | 60 | | 49 | 12 | | | | | | | | | | 14 | | | |
| | 15.00 | | | | | | 20 | 80 | | | | | | | | | | 72 | | 60 | 7 | | | | | | | | | | 12 | | | |
| | 16.50 | | | | | | | 100 | | | | | | | | | | 85 | | 85 | 4 | | | | | | | | | | 10 | | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 10.50 to 35.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 18.00 | | | | | | 50 | 50 | | | | | | | | | | 77 | | 52 | 8 | | | | | | | | | | 9 | | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | | 93 | | 89 | 4 | | | | | | | | | | 7 | | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 95 | | 71 | 7 | | | | | | | | | | 11 | | | |
| | 22.50 | Greyish Slightly Weathered to Fresh Strong Fine grained Basalt | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 95 | | 95 | <1 | | | | | | | | | | 12 | | | |
| | 24.00 | | | | | | | 100 | | | | | | | | | | 85 | | 75 | 4 | | | | | | | | | | 9 | | | |
| | 25.50 | | | | | | | 100 | | | | | | | | | | 95 | | 77 | 4 | | | | | | | | | | 10 | | | The core recovery percentage in bedrock varies between 11% to 100% with RQD varies from 0% to 100%. |
| | 27.00 | | | | | | | 100 | | | | | | | | | | 94 | | 71 | 6 | | | | | | | | | | 13 | | | |
| | 28.50 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | | 14 | | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 30.00 | | | | | | | 100 | | | | | | | | | | 89 | | 86 | 3 | | | | | | | | | | 11 | | | |
| | 31.50 | | | | | | | 100 | | | | | | | | | | 99 | | 89 | 3 | | | | | | | | | | 14 | | | |
| | 33.00 | | | | | | | 100 | | | | | | | | | | 100 | | 93 | <1 | | | | | | | | | | 12 | | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 34.00 | | | | | | 30 | 70 | | | | | | | | | | 97 | | 51 | 12 | | | | | | | | | | 11 | | | |
| | 35.00 | | | | | | | 100 | | | | | | | | | | 94 | | 81 | 4 | | | | | | | | | | 9 | | | |

NX Size Diamond Bit

NX

Not Met

Complete

# GEOLOGICAL LOG OF DRILL HOLE

| | |
|---|---|
| BH HOLE NO. | T14 BH-03 |
| SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT :** | Geotechnical investigation for Ratlam-Khandwa BG Rail. | **LOCATION:** | Tunnel-14 | **CHAINAGE:-** | 57830 |
| **BEARING OF HOLE (Degree):** | Verticle | **CO-ORDINATES:** | E599192.544, N2480330.31 | **FEATURE** | TUNNEL |
| **COLLAR ELEVATION (m):** | -- | **ANGLE W.R.T HORIZONTAL:** | 90 Degrees | **BOREHOLE NO.** | T14 - BH-03 |
| **TYPE(S) OF CORE BARREL:** | DT | **GROUND ELEVATION(m):** | -- | **DEPTH OF BOREHOLE** | 42.00 |
| **STARTED :** | 11.10.2022 | **COMPLETED:** | 19.10.2022 | **DRILLING AGENCY :** | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.50 | | | DS-01 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.85 | Black Cotton Soil | | SPT-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | 5 | 15 | 50 | 65 | | | | **Overburden:-** 0.00m-1.85m The borehole has been drilled in overburden from 0.00m - 1.85mtr. having with Black Cotton Soil |
| | 3.00 | Brownish Highly Weathered Weak Basalt | | | 100 | | | | | | | | | | | | | 26 | | NIL | >15 | | | | | | | | | | 14 | | |
| | 4.50 | | | | | 60 | 40 | | | | | | | | | | | 45 | | 13 | >15 | | | | | | | | | | 11 | | |
| | 6.00 | | | | | | 50 | 50 | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 89 | | 52 | 8 | | | | | | | | | | 17 | | **Weathered Bedrock-** Weathered Bedrock encountered between 1.85 to 10.50mtr., which is Brownish Highly Weathered Weak Basalt |
| | 7.50 | Greyish Moderately Weathered Weak to Strong Fine grained Basalt | | | | 80 | 20 | | | | | | | | | | | 57 | | 16 | >15 | | | | | | | | | | 16 | | |
| | 9.00 | | | | | | 20 | 80 | | | | | | | | | | 93 | | 60 | 8 | | | | | | | | | | 16 | | |
| | 10.50 | | | | | | 50 | 50 | | | | | | | | | | 73 | | 69 | 8 | | | | | | | | | | 17 | | |
| | 12.00 | | | | | | | 100 | | | | | | | | | | 95 | | 95 | <1 | | | | | | | | | | 16 | | **Moderately Weathered Bedrock-** Moderately Weathered to Fresh Bedrock encountered between 10.50 to 10.50mtr., which is Greyish Moderately Weathered Weak to Strong Fine grained Basalt |
| | 13.50 | | | | | | | 100 | | | | | | | | | | 95 | | 81 | 3 | | | | | | | | | | 19 | | |
| | 15.00 | | | | | | | 100 | | | | | | | | | | 89 | | 85 | 3 | | | | | | | | | | 15 | | |
| | 16.50 | | | | | | | 100 | | | | | | | | | | 84 | | 84 | 3 | | | | | | | | | | 11 | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 10.50 to 42.00mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 18.00 | | | | | | | 100 | | | | | | | | | | 89 | | 89 | 3 | | | | | | | | | | 7 | | |
| | 19.50 | | | | | | | 100 | | | | | | | | | | 100 | | 97 | <1 | | | | | | | | | | 12 | | |
| | 21.00 | | | | | | | 100 | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | | 16 | | |
| | 22.50 | | | | | | | 100 | | | | | | | | | | 100 | | 94 | <1 | | | | | | | | | | 13 | | |
| | 24.00 | | | | | | 30 | 70 | | | | | | | | | | 100 | NX Size Diamond Bit | 76 | 5 | NX | | | | | | | | | 9 | | |
| | 25.50 | | | | | | | 100 | | | | | | | | | | 99 | | 99 | <1 | | | | | | | | | | 16 | | The core recovery percentage in bedrock varies between 26% to 100% with RQD varies from 0% to 100%. |
| | 27.00 | Greyish Slightly Weathered to Fresh Strong Fine grained Basalt | | | | | | 100 | | | Very close irregular joints gently dipping rough fracture | | | | | | | 100 | | 95 | <1 | | | | | | | | | | 10 | | |
| | 28.50 | | | | | | | 100 | | | | | | | | | | 97 | | 83 | 3 | | | | | | | | | | 8 | | |
| | 30.00 | | | | | | | 100 | | | | | | | | | | 96 | | 87 | 2 | | | | | | | | | | 10 | | |
| | 31.50 | | | | | | | 100 | | | | | | | | | | 98 | | 92 | <1 | | | | | | | | | | 10 | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 33.00 | | | | | | | 100 | | | | | | | | | | 89 | | 89 | 3 | | | | | | | | | | 9 | | |
| | 34.50 | | | | | | | 100 | | | | | | | | | | 99 | | 91 | <1 | | | | | | | | | | 10 | | |
| | 36.00 | | | | | | 30 | 70 | | | | | | | | | | 94 | | 75 | 5 | | | | | | | | | | 10 | | |
| | 37.50 | | | | | | | 100 | | | | | | | | | | 100 | | 89 | 4 | | | | | | | | | | 10 | | |
| | 39.00 | | | | | | | 100 | | | | | | | | | | 89 | | 89 | 4 | | | | | | | | | | 8 | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 40.50 | | | | | | | 100 | | | | | | | | | | 100 | | 89 | 3 | | | | | | | | | | 10 | | |
| | 42.00 | | | | | | | 100 | | | | | | | | | | 97 | | 97 | <1 | | | | | | | | | | 11 | | |

Not Met

Partial

# GEOLOGICAL LOG OF DRILL HOLE

| | |
|---|---|
| BH HOLE NO. | T14 BH-04 |
| SHEET NO.: | 1 of 1 |

| | | | | | |
|---|---|---|---|---|---|
| PROJECT : | Geotechnical investigation for Ratlam-Khandwa BG Rail. | LOCATION: | Tunnel-14 | CHAINAGE:- | 58010 |
| BEARING OF HOLE (Degree): | Verticle | CO-ORDINATES: | E599013.845, N2480348.261 | FEATURE | TUNNEL |
| COLLAR ELEVATION (m): | -- | ANGLE W.R.T HORIZONTAL: | 90 Degrees | BOREHOLE NO. | T14 - BH-04 |
| TYPE(S) OF CORE BARREL: | DT | GROUND ELEVATION(m): | -- | DEPTH OF BOREHOLE | 41.50 |
| STARTED : | 20.10.2022 | COMPLETED: | 28.10.2022 | DRILLING AGENCY : | IGPL |

| 1 | 2 | 3 | | 4 | | | | | | | 5 | | 6 | | | | | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | 14 | | | | 15 | 16 | | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lithology | | Size of core pieces (%) | | | | | Ratio | | Structural Condition | | Percent Core Recovery (%) | | | | | | | | | | | | Drill Water | | SPT-Number of Blows | | | | | Permeability | | |
| Ground Elevation (m) | Depth (m) | Description | Log | < 10 mm | 10 to 25 mm | 25 to 75 mm | 75 to 150 mm | >150 mm | Interpreted %age of matrix (fine) | Interpreted %age of rock fragments | Description | Log | 0.00 - 19.99 | 20.00 - 39.99 | 40.00 - 59.99 | 60.00 - 79.99 | 80.00 - 100.00 | In figures | Type of Bit | RQD(%) | Fracture Frequency / m | Size of hole | Casing | Depth of water level(m) | Partial | Complete | 0-15 | 15-30 | 30-45 | N-Value | Penetration Rate (mm/min) | Test section | mm/s OR LUGEON | Special Observations and interpretations / Weathering Grade |
| | 0.50 | Black Cotton Soil | | DS-01 | | | | | | | Residual Soil | | | | | | | | | | | | | | | | | | | | | | |
| | 1.50 | Brownish Highly Weathered Weak Basalt | | | 100 | | | | | | Close to Medium irregular joints gently dipping rough fracture | | | | | | | 40 | | NIL | >15 | | | | | | | | | | 14 | | **Overburden:-** 0.00m-0.50m The borehole has been drilled in overburden from 0.00m - 0.50mtr. having with Black Cotton Soil |
| | 3.00 | | | | 100 | | | | | | | | | | | | | 29 | | NIL | >15 | | | | | | | | | | 13 | | |
| | 4.50 | | | | 100 | | | | | | | | | | | | | 31 | | NIL | >15 | | | | | | | | | | 13 | | |
| | 6.00 | Greyish Moderately Weathered Weak to Strong Basalt | | | 100 | | | | | | | | | | | | | 78 | | 7 | >15 | | | | | | | | | | 12 | | **Weathered Bedrock-** Weathered Bedrock encountered between 0.50 to 7.50mtr., which is Brownish Highly Weathered Weak Basalt |
| | 7.50 | | | | | 100 | | | | | | | | | | | | 58 | | NIL | >15 | | | | | | | | | | 12 | | |
| | 9.00 | | | | | | 100 | | | | | | | | | | | 96 | | 84 | 4 | | | | | | | | | | 15 | | |
| | 10.50 | | | | | | 100 | | | | | | | | | | | 100 | | 75 | 5 | | | | | | | | | | 10 | | |
| | 12.00 | | | | | | 100 | | | | | | | | | | | 100 | | 85 | 4 | | | | | | | | | | 8 | | **Slightly Weathered to Fresh Bedrock-** Slightly Weathered to Fresh Bedrock encountered between 7.50 to 41.50mtr., which is Greyish Slightly Weathered to Fresh Strong Fine grained Basalt |
| | 13.50 | | | | | | 100 | | | | | | | | | | | 98 | | 98 | <1 | | | | | | | | | | 12 | | |
| | 15.00 | | | | | | 100 | | | | | | | | | | | 95 | | 95 | <1 | | | | | | | | | | 12 | | |
| | 16.50 | | | | | | 100 | | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | | 11 | | |
| | 18.00 | | | | | | 100 | | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | | 9 | | |
| | 19.50 | | | | | | 100 | | | | | | | | | | | 100 | | 97 | <1 | | | | | | | | | | 12 | | |
| | 21.00 | | | | | | 100 | | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | | 14 | | |
| | 22.50 | | | | | | 100 | | | | | | | | | | | 100 | NX Size Diamond Bit | 92 | <1 | NX | Not Met | | Partial | | | | | | 11 | | |
| | 24.00 | Greyish Slightly Weathered to Fresh Strong Fine grained Basalt | | | | | 100 | | | | | | | | | | | 99 | | 95 | <1 | | | | | | | | | | 9 | | |
| | 25.50 | | | | | | 100 | | | | Very close irregular joints gently dipping rough fracture | | | | | | | 100 | | 85 | 4 | | | | | | | | | | 11 | | |
| | 27.00 | | | | | | 100 | | | | | | | | | | | 100 | | 93 | <1 | | | | | | | | | | 9 | | |
| | 28.50 | | | | | | 100 | | | | | | | | | | | 99 | | 91 | <1 | | | | | | | | | | 9 | | |
| | 30.00 | | | | | | 100 | | | | | | | | | | | 95 | | 73 | 7 | | | | | | | | | | 13 | | Rock mass class encountered at Tunnel grade may be interpreted as good-strong rock. |
| | 31.50 | | | | | | 100 | | | | | | | | | | | 100 | | 73 | 7 | | | | | | | | | | 12 | | |
| | 33.00 | | | | | | 100 | | | | | | | | | | | 100 | | 100 | <1 | | | | | | | | | | 6 | | |
| | 34.50 | | | | | | 100 | | | | | | | | | | | 96 | | 80 | 5 | | | | | | | | | | 10 | | |
| | 36.00 | | | | | | 100 | | | | | | | | | | | 95 | | 95 | <1 | | | | | | | | | | 18 | | |
| | 37.50 | | | | | | 100 | | | | | | | | | | | 89 | | 89 | 3 | | | | | | | | | | 11 | | The partial drill water loss has been observed during drilling throughout the drilled depth which indicates tight to partly open nature of joints |
| | 39.00 | | | | | | 100 | | | | | | | | | | | 90 | | 90 | <1 | | | | | | | | | | 9 | | |
| | 40.50 | | | | | 50 | 80 | | | | | | | | | | | 93 | | 59 | 8 | | | | | | | | | | 26 | | |
| | 41.50 | Greyish Moderately Weathered Weak to Strong Basalt | | | 100 | | | | | | | | | | | | | 60 | | NIL | <1 | | | | | | | | | | 17 | | |

# ANNEXURE -III

# Lab Test Results

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

| | |
|---|---|
| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.23 | 43 | TUNNEL - 01 | 7540 | 1A | 11.21 | 11.44 | 2304/14/21 | 0.508 | 2.797 | 2.783 | 1.410 | 71.428 | ----- | |
| 2 | 0.31 | 62 | TUNNEL - 01 | 7540 | 1A | 14.25 | 14.56 | 2304/14/22 | 0.905 | 2.706 | 2.682 | 2.430 | 76.137 | ----- | |
| 3 | 0.26 | 73 | TUNNEL - 01 | 7540 | 1A | 17.56 | 17.82 | 2304/14/23 | 0.811 | 2.753 | 2.731 | 2.220 | 93.816 | ----- | |
| 4 | 0.22 | 93 | TUNNEL - 01 | 7540 | 1A | 20.00 | 20.22 | 2304/14/24 | 3.620 | 2.618 | 2.527 | 9.150 | 72.525 | ----- | |
| 5 | 0.20 | 105 | TUNNEL - 01 | 7540 | 1A | 22.17 | 22.37 | 2304/14/25 | 0.611 | 2.617 | 2.602 | 1.590 | ----- | 7.875 | |
| 6 | 0.19 | 116 | TUNNEL - 01 | 7540 | 1A | 24.11 | 24.30 | 2304/14/26 | 0.587 | 2.773 | 2.757 | 1.620 | 80.121 | ----- | |
| 7 | 0.21 | 69 | TUNNEL - 01 | 7740 | 1B | 13.65 | 13.86 | 2304/14/16 | 0.865 | 2.737 | 2.713 | 2.350 | 74.988 | ----- | |
| 8 | 0.15 | 87 | TUNNEL - 01 | 7740 | 1B | 17.17 | 17.32 | 2304/14/17 | 0.598 | 2.749 | 2.733 | 1.630 | 78.057 | ----- | |
| 9 | 0.31 | 131 | TUNNEL - 01 | 7740 | 1B | 23.00 | 23.31 | 2304/14/18 | 0.524 | 2.77 | 2.755 | 1.440 | 82.637 | ----- | |
| 10 | 0.22 | 140 | TUNNEL - 01 | 7740 | 1B | 24.79 | 25.01 | 2304/14/19 | 7.016 | 2.273 | 2.124 | 14.900 | ----- | 1.599 | |
| 11 | 0.14 | 151 | TUNNEL - 01 | 7740 | 1B | 26.62 | 26.76 | 2304/14/20 | 3.557 | 2.643 | 2.552 | 9.090 | ----- | 1.599 | |
| 12 | 0.22 | 59 | TUNNEL - 01 | 8150.00 | 1 | 15.52 | 15.74 | 2212/29/65 | 4.632 | 2.642 | 2.525 | 11.690 | 27.225 | ----- | |
| 13 | 0.16 | 85 | TUNNEL - 01 | 8150.00 | 1 | 18.95 | 19.11 | 2212/29/66 | 0.97 | 2.852 | 2.824 | 2.740 | 71.712 | ----- | |
| 14 | 0.22 | 97 | TUNNEL - 01 | 8150.00 | 1 | 21.28 | 21.50 | 2212/29/67 | 0.849 | 2.784 | 2.760 | 2.340 | 102.266 | ----- | |
| 15 | 0.26 | 142 | TUNNEL - 01 | 8150.00 | 1 | 26.03 | 26.29 | 2212/29/68 | 14.412 | 2.346 | 2.051 | 29.560 | ----- | 0.885 | |
| 16 | 0.20 | 176 | TUNNEL - 01 | 8150.00 | 1 | 29.38 | 29.58 | 2212/29/69 | 1.449 | 2.772 | 2.733 | 3.960 | 51.305 | ----- | |
| 17 | 0.25 | 123 | TUNNEL - 01 | 8350.00 | 2 | 23.53 | 23.78 | 2301/03/49 | 0.554 | 2.904 | 2.888 | 1.600 | 106.580 | ----- | |
| 18 | 0.18 | 135 | TUNNEL - 01 | 8350.00 | 2 | 25.69 | 25.87 | 2301/03/50 | 0.614 | 2.820 | 2.802 | 1.720 | 105.774 | ----- | |
| 19 | 0.27 | 157 | TUNNEL - 01 | 8350.00 | 2 | 28.87 | 29.14 | 2301/03/51 | 5.670 | 2.350 | 2.224 | 12.610 | 49.594 | ----- | |
| 20 | 0.18 | 193 | TUNNEL - 01 | 8350.00 | 2 | 33.14 | 33.32 | 2301/03/52 | 4.320 | 2.603 | 2.495 | 10.780 | 54.824 | ----- | |
| 21 | 0.29 | 201 | TUNNEL - 01 | 8350.00 | 2 | 34.50 | 34.79 | 2301/03/53 | 1.102 | 2.735 | 2.705 | 2.980 | 62.472 | ----- | |
| 22 | 0.16 | 125 | TUNNEL - 01 | 8550.00 | 3 | 30.00 | 30.16 | 2212/29/70 | 4.251 | 2.624 | 2.517 | 10.700 | 23.157 | ----- | |
| 23 | 0.22 | 142 | TUNNEL - 01 | 8550.00 | 3 | 33.50 | 33.72 | 2212/29/71 | 1.275 | 2.756 | 2.721 | 3.470 | 41.521 | ----- | |
| 24 | 0.23 | 173 | TUNNEL - 01 | 8550.00 | 3 | 38.65 | 38.88 | 2212/29/72 | 1.109 | 2.72 | 2.690 | 2.980 | 81.907 | ----- | |
| 25 | 0.19 | 188 | TUNNEL - 01 | 8550.00 | 3 | 40.92 | 41.11 | 2212/29/73 | 13.199 | 2.551 | 2.253 | 29.860 | 11.121 | ----- | |
| 26 | 0.25 | 198 | TUNNEL - 01 | 8550.00 | 3 | 42.68 | 42.93 | 2212/29/74 | 18.654 | 2.228 | 1.878 | 35.060 | ----- | 0.874 | |
| 27 | 0.21 | 211 | TUNNEL - 01 | 8550.00 | 3 | 45.43 | 45.64 | 2212/29/75 | 4.076 | 2.68 | 2.575 | 10.500 | ----- | 3.731 | |
| 28 | 0.20 | 179 | TUNNEL - 01 | 8750.00 | 4 | 32.63 | 32.83 | 2212/29/76 | 1.827 | 2.776 | 2.726 | 4.980 | 26.567 | ----- | |
| 29 | 0.16 | 185 | TUNNEL - 01 | 8750.00 | 4 | 33.44 | 33.60 | 2212/29/77 | 0.829 | 2.866 | 2.842 | 2.360 | 55.418 | ----- | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

| | |
|---|---|
| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 0.24 | 202 | TUNNEL - 01 | 8750.00 | 4 | 36.03 | 36.27 | 2212/29/78 | 15.128 | 2.326 | 2.020 | 30.590 | ----- | 0.886 | |
| 31 | 0.15 | 216 | TUNNEL - 01 | 8750.00 | 4 | 38.52 | 38.67 | 2212/29/79 | 12.251 | 2.375 | 2.116 | 25.930 | ----- | 0.355 | |
| 32 | 0.20 | 229 | TUNNEL - 01 | 8750.00 | 4 | 41.49 | 41.69 | 2212/29/80 | 2.722 | 2.709 | 2.637 | 7.180 | 58.882 | ----- | |
| 33 | 0.14 | 252 | TUNNEL - 01 | 8750.00 | 4 | 44.61 | 44.75 | 2212/29/81 | 10.26 | 2.296 | 2.082 | 21.370 | ----- | 1.060 | |
| 34 | 0.18 | 187 | TUNNEL - 01 | 8950.00 | 5 | 33.15 | 33.33 | 2212/29/82 | 0.954 | 2.899 | 2.872 | 2.740 | 59.216 | ----- | |
| 35 | 0.28 | 210 | TUNNEL - 01 | 8950.00 | 5 | 37.30 | 37.58 | 2212/29/83 | 8.949 | 2.489 | 2.285 | 20.450 | ----- | 0.528 | |
| 36 | 0.18 | 230 | TUNNEL - 01 | 8950.00 | 5 | 40.30 | 40.48 | 2212/29/84 | 2.472 | 2.552 | 2.490 | 6.160 | 26.035 | ----- | |
| 37 | 0.32 | 247 | TUNNEL - 01 | 8950.00 | 5 | 43.08 | 43.40 | 2212/29/85 | 0.91 | 2.952 | 2.925 | 2.660 | 58.080 | ----- | |
| 38 | 0.31 | 258 | TUNNEL - 01 | 8950.00 | 5 | 44.50 | 44.81 | 2212/29/86 | 6.44 | 2.523 | 2.370 | 15.280 | 32.517 | ----- | |
| 39 | 0.17 | 210 | TUNNEL - 01 | 9150.00 | 6 | 38.66 | 38.83 | 2301/03/44 | 0.895 | 2.761 | 2.737 | 2.450 | 53.136 | ----- | |
| 40 | 0.18 | 235 | TUNNEL - 01 | 9150.00 | 6 | 42.95 | 43.13 | 2301/03/45 | 2.200 | 2.666 | 2.609 | 5.740 | ----- | 3.017 | |
| 41 | 0.17 | 257 | TUNNEL - 01 | 9150.00 | 6 | 46.13 | 46.30 | 2301/03/46 | 1.635 | 2.778 | 2.733 | 4.470 | 60.100 | ----- | |
| 42 | 0.21 | 289 | TUNNEL - 01 | 9150.00 | 6 | 49.70 | 49.91 | 2301/03/47 | 0.817 | 2.839 | 2.816 | 2.300 | 121.347 | ----- | |
| 43 | 0.13 | 301 | TUNNEL - 01 | 9150.00 | 6 | 51.59 | 51.72 | 2301/03/48 | 3.477 | 2.683 | 2.593 | 9.020 | ----- | 8.102 | |
| 44 | 0.14 | 257 | TUNNEL - 01 | 9350.00 | 7 | 37.77 | 37.91 | 2212/29/87 | 7.505 | 2.454 | 2.283 | 17.130 | ----- | 1.769 | |
| 45 | 0.07 | 308 | TUNNEL - 01 | 9350.00 | 7 | 43.59 | 43.66 | 2212/29/88 | 0.892 | 2.837 | 2.812 | 2.510 | ----- | 7.061 | |
| 46 | 0.13 | 346 | TUNNEL - 01 | 9350.00 | 7 | 47.39 | 47.52 | 2212/29/89 | 0 | 0 | 0.000 | 0.000 | ----- | ----- | |
| 47 | 0.12 | 354 | TUNNEL - 01 | 9350.00 | 7 | 48.44 | 48.56 | 2212/29/90 | 0.691 | 2.7323 | 2.713 | 1.880 | ----- | 7.098 | |
| 48 | 0.07 | 368 | TUNNEL - 01 | 9350.00 | 7 | 49.67 | 49.74 | 2212/29/91 | 0.884 | 2.787 | 2.763 | 2.440 | ----- | 6.984 | |
| 49 | 0.06 | 388 | TUNNEL - 01 | 9350.00 | 7 | 51.63 | 51.69 | 2212/29/92 | 0.587 | 2.758 | 2.742 | 1.610 | 8.929 | ----- | |
| 50 | 0.33 | 275 | TUNNEL - 01 | 9970 | 10 | 55.88 | 56.21 | 2304/14/33 | 7.059 | 2.350 | 2.195 | 15.430 | ----- | 0.702 | |
| 51 | 0.23 | 293 | TUNNEL - 01 | 9970 | 10 | 57.95 | 58.18 | 2304/14/34 | 5.557 | 2.250 | 2.132 | 12.190 | ----- | 0.860 | |
| 52 | 0.15 | 317 | TUNNEL - 01 | 9970 | 10 | 61.10 | 61.25 | 2304/14/35 | 0.417 | 2.790 | 2.778 | 1.160 | 103.097 | ----- | |
| 53 | 0.22 | 358 | TUNNEL - 01 | 9970 | 10 | 64.98 | 65.20 | 2304/14/36 | 0.919 | 2.683 | 2.659 | 2.440 | 78.623 | ----- | |
| 54 | 0.33 | 380 | TUNNEL - 01 | 9970 | 10 | 68.48 | 68.81 | 2304/14/37 | 0.512 | 2.775 | 2.761 | 1.420 | 71.308 | ----- | |
| 55 | 0.17 | 201 | TUNNEL - 01 | 10170.00 | 11 | 46.54 | 46.71 | 2301/03/54 | 8.661 | 2.158 | 1.986 | 17.200 | ----- | 1.092 | |
| 56 | 0.22 | 229 | TUNNEL - 01 | 10170.00 | 11 | 49.87 | 50.09 | 2301/03/55 | 5.001 | 2.511 | 2.392 | 11.960 | ----- | 1.108 | |
| 57 | 0.29 | 239 | TUNNEL - 01 | 10170.00 | 11 | 52.47 | 52.76 | 2301/03/56 | 0.513 | 2.841 | 2.826 | 1.450 | ----- | 2.368 | |
| 58 | 0.13 | 265 | TUNNEL - 01 | 10170.00 | 11 | 56.34 | 56.47 | 2301/03/57 | 4.910 | 2.489 | 2.372 | 11.650 | ----- | 1.625 | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

| | |
|---|---|
| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa | **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) | | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | From | To | | | | | | | | |
| 59 | 0.15 | 303 | TUNNEL - 01 | 10170.00 | 11 | 60.00 | 60.15 | 2301/03/58 | 2.039 | 2.752 | 2.697 | 5.500 | ----- | 5.413 | |
| 60 | 0.30 | 239 | TUNNEL - 01 | 10370.00 | 12 | 61.33 | 61.63 | 2301/03/39 | 6.446 | 2.559 | 2.404 | 15.490 | ----- | 0.740 | |
| 61 | 0.27 | 254 | TUNNEL - 01 | 10370.00 | 12 | 66.06 | 66.33 | 2301/03/40 | 5.073 | 2.529 | 2.407 | 12.210 | ----- | 0.652 | |
| 62 | 0.30 | 260 | TUNNEL - 01 | 10370.00 | 12 | 68.00 | 68.30 | 2301/03/41 | 3.219 | 2.657 | 2.574 | 8.290 | ----- | 1.303 | |
| 63 | 0.20 | 272 | TUNNEL - 01 | 10370.00 | 12 | 70.48 | 70.68 | 2301/03/42 | 1.152 | 2.808 | 2.776 | 3.200 | ----- | 5.844 | |
| 64 | 0.17 | 308 | TUNNEL - 01 | 10370.00 | 12 | 75.06 | 75.23 | 2301/03/43 | 0.210 | 2.946 | 2.940 | 0.620 | ----- | 3.634 | |
| 65 | 0.30 | 301 | TUNNEL - 01 | 10570.00 | 13 | 66.31 | 66.61 | 2301/03/64 | 2.949 | 2.607 | 2.532 | 7.4700 | 70.845 | ----- | |
| 66 | 0.17 | 325 | TUNNEL - 01 | 10570.00 | 13 | 71.38 | 71.55 | 2301/03/65 | 2.097 | 2.704 | 2.648 | 5.550 | 102.145 | ----- | |
| 67 | 0.17 | 332 | TUNNEL - 01 | 10570.00 | 13 | 72.61 | 72.78 | 2301/03/66 | 0.660 | 2.899 | 2.880 | 1.900 | 115.150 | ----- | |
| 68 | 0.19 | 353 | TUNNEL - 01 | 10570.00 | 13 | 75.14 | 75.33 | 2301/03/67 | 0.783 | 2.896 | 2.874 | 2.250 | 88.559 | ----- | |
| 69 | 0.20 | 393 | TUNNEL - 01 | 10570.00 | 13 | 79.48 | 79.68 | 2301/03/68 | 0.722 | 2.895 | 2.874 | 2.080 | 79.759 | ----- | |
| 70 | 0.16 | 327 | TUNNEL - 01 | 10770 | 14 | 67.71 | 67.87 | 2304/14/27 | 3.038 | 2.369 | 2.299 | 6.990 | ----- | 5.768 | |
| 71 | 0.29 | 337 | TUNNEL - 01 | 10770 | 14 | 70.43 | 70.72 | 2304/14/28 | 1.386 | 2.568 | 2.533 | 3.510 | 70.672 | ----- | |
| 72 | 0.27 | 352 | TUNNEL - 01 | 10770 | 14 | 74.10 | 74.37 | 2304/14/29 | 1.201 | 2.729 | 2.697 | 3.240 | 79.846 | ----- | |
| 73 | 0.26 | 365 | TUNNEL - 01 | 10770 | 14 | 77.16 | 77.42 | 2304/14/30 | 0.430 | 2.601 | 2.590 | 1.110 | 85.677 | ----- | |
| 74 | 0.18 | 385 | TUNNEL - 01 | 10770 | 14 | 80.56 | 80.74 | 2304/14/31 | 0.450 | 2.650 | 2.638 | 1.190 | 78.845 | ----- | |
| 75 | 0.26 | 396 | TUNNEL - 01 | 10770 | 14 | 83.54 | 83.80 | 2304/14/32 | 0.617 | 2.673 | 2.656 | 1.640 | 74.481 | ----- | |
| 76 | 0.19 | 67 | TUNNEL - 01 | 11570 | 18 | 21.59 | 21.78 | 2301/03/59 | 6.803 | 2.450 | 2.940 | 15.600 | ----- | 0.351 | |
| 77 | 0.17 | 72 | TUNNEL - 01 | 11570 | 18 | 22.50 | 22.67 | 2301/03/60 | 5.745 | 2.551 | 2.413 | 13.060 | ----- | 0.878 | |
| 78 | 0.20 | 94 | TUNNEL - 01 | 11570 | 18 | 26.16 | 26.36 | 2301/03/61 | 0.527 | 2.689 | 2.675 | 1.410 | 50.106 | ----- | |
| 79 | 0.47 | 145 | TUNNEL - 01 | 11570 | 18 | 32.59 | 33.06 | 2301/03/62 | 0.746 | 2.856 | 2.835 | 2.120 | 67.867 | ----- | |
| 80 | 0.19 | 169 | TUNNEL - 01 | 11570 | 18 | 35.71 | 35.90 | 2301/03/63 | 0.950 | 2.632 | 2.607 | 2.480 | 87.740 | ----- | |
| 81 | 0.21 | 59 | TUNNEL-1A | 12590 | 1 | 22.65 | 22.86 | 2304/14/38 | 2.057 | 2.540 | 2.489 | 5.120 | 32.541 | ----- | |
| 82 | 0.24 | 85 | TUNNEL-1A | 12590 | 1 | 25.66 | 25.90 | 2304/14/39 | 4.221 | 2.676 | 2.567 | 10.840 | ----- | 2.683 | |
| 83 | 0.22 | 100 | TUNNEL-1A | 12590 | 1 | 29.25 | 29.47 | 2304/14/40 | 0.380 | 2.911 | 2.900 | 1.100 | 67.624 | ----- | |
| 84 | 0.13 | 108 | TUNNEL-1A | 12590 | 1 | 30.43 | 30.56 | 2304/14/41 | 0.552 | 2.812 | 2.797 | 1.550 | 63.032 | ----- | |
| 85 | 0.14 | 148 | TUNNEL-1A | 12590 | 1 | 34.50 | 34.64 | 2304/14/42 | 0.386 | 2.753 | 2.742 | 1.060 | 63.746 | ----- | |
| 86 | 0.23 | 155 | TUNNEL-1A | 12590 | 1 | 35.59 | 35.82 | 2304/14/43 | 0.599 | 2.780 | 2.763 | 1.660 | 88.953 | ----- | |
| 87 | 0.18 | 106 | TUNNEL-1A | 12690 | 2 | 19.50 | 19.68 | 2304/14/44 | 0.515 | 2.709 | 2.695 | 1.390 | 112.000 | ----- | |
| 88 | 0.22 | 127 | TUNNEL-1A | 12690 | 2 | 23.59 | 23.81 | 2304/14/45 | 0.498 | 2.737 | 2.724 | 1.360 | 89.815 | ----- | |
| 89 | 0.14 | 153 | TUNNEL-1A | 12690 | 2 | 26.02 | 26.16 | 2304/14/46 | 0.556 | 2.972 | 2.955 | 1.640 | ----- | 6.968 | |
| 90 | 0.16 | 165 | TUNNEL-1A | 12690 | 2 | 28.02 | 28.18 | 2304/14/47 | 0.547 | 2.831 | 2.816 | 1.540 | 111.206 | ----- | |
| 91 | 0.14 | 172 | TUNNEL-1A | 12690 | 2 | 29.13 | 29.27 | 2304/14/48 | 1.168 | 2.847 | 2.814 | 3.290 | 102.827 | ----- | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

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|---|---|
| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 92 | 0.10 | 190 | TUNNEL-1A | 12690 | 2 | 31.83 | 31.93 | 2304/14/49 | 6.370 | 2.452 | 2.305 | 14.680 | ----- | 0.350 | |
| 93 | 0.16 | 198 | TUNNEL-1A | 12690 | 2 | 33.25 | 33.41 | 2304/14/50 | 5.212 | 2.268 | 2.156 | 11.240 | ----- | 0.880 | |
| 94 | 0.08 | 36 | TUNNEL-1B | 13990 | 1 | 24.00 | 24.08 | 2304/14/08 | 2.607 | 3.503 | 2.414 | 6.380 | ----- | 1.755 | |
| 95 | 0.13 | 48 | TUNNEL-1B | 13990 | 1 | 27.00 | 27.13 | 2304/14/09 | 0.806 | 2.605 | 2.584 | 2.080 | ----- | 7.020 | |
| 96 | 0.25 | 74 | TUNNEL-1B | 13990 | 1 | 32.36 | 32.61 | 2304/14/10 | 1.697 | 2.706 | 2.661 | 4.510 | 83.190 | ----- | |
| 97 | 0.26 | 79 | TUNNEL-1B | 13990 | 1 | 33.58 | 33.84 | 2304/14/11 | 0.68 | 2.713 | 2.694 | 1.830 | 88.449 | | |
| 98 | 0.13 | 93 | TUNNEL-1B | 13990 | 1 | 35.48 | 35.61 | 2304/14/12 | 0.852 | 2.716 | 2.693 | 2.290 | ----- | 7.897 | |
| 99 | 0.16 | 62 | TUNNEL-2 | 15410 | 1 | 25.70 | 25.86 | 2304/14/01 | 0.526 | 2.829 | 2.814 | 1.480 | 103.284 | ----- | |
| 100 | 0.14 | 72 | TUNNEL-2 | 15410 | 1 | 27.47 | 27.61 | 2304/14/02 | 3.010 | 2.315 | 2.248 | 6.760 | ----- | 0.900 | |
| 101 | 0.19 | 91 | TUNNEL-2 | 15410 | 1 | 31.24 | 31.43 | 2304/14/03 | 2.830 | 2.410 | 2.344 | 6.630 | ----- | 1.264 | |
| 102 | 0.19 | 103 | TUNNEL-2 | 15410 | 1 | 33.17 | 33.36 | 2304/14/04 | 0.680 | 2.735 | 2.717 | 1.850 | ----- | ----- | |
| 103 | 0.14 | 115 | TUNNEL-2 | 15410 | 1 | 34.79 | 34.93 | 2304/14/05 | 1.037 | 2.684 | 2.656 | 2.760 | 66.354 | ----- | |
| 104 | 0.20 | 136 | TUNNEL-2 | 15410 | 1 | 37.50 | 37.70 | 2304/14/06 | 0.925 | 2.804 | 2.778 | 2.570 | 38.360 | ----- | |
| 105 | 0.19 | 154 | TUNNEL-2 | 15410 | 1 | 39.75 | 39.94 | 2304/14/07 | 0.575 | 2.795 | 2.779 | 1.600 | 100.347 | ----- | |
| 106 | 0.26 | 24 | TUNNEL-2 | 15510 | 2 | 16.76 | 17.02 | 2304/14/63 | 1.134 | 2.760 | 2.729 | 3.090 | ----- | 5.368 | |
| 107 | 0.29 | 33 | TUNNEL-2 | 15510 | 2 | 19.50 | 19.79 | 2304/14/64 | 1.570 | 2.676 | 2.634 | 4.140 | 72.160 | ----- | |
| 108 | 0.16 | 49 | TUNNEL-2 | 15510 | 2 | 23.38 | 23.54 | 2304/14/65 | 0.729 | 2.838 | 2.817 | 2.050 | 64.474 | ----- | |
| 109 | 0.20 | 61 | TUNNEL-2 | 15510 | 2 | 25.50 | 25.70 | 2304/14/66 | 0.621 | 2.825 | 2.807 | 1.740 | 103.507 | ----- | |
| 110 | 0.25 | 75 | TUNNEL-2 | 15510 | 2 | 27.97 | 28.22 | 2304/14/67 | 1.090 | 2.744 | 2.714 | 2.960 | 104.255 | ----- | |
| 111 | 0.18 | 94 | TUNNEL-2 | 15510 | 2 | 31.18 | 31.36 | 2304/14/68 | 0.534 | 2.813 | 2.798 | 1.500 | 80.686 | ----- | |
| 112 | 0.18 | 73 | TUNNEL-3 | 16090 | 1 | 20.05 | 20.23 | 2304/14/69 | 5.885 | 2.540 | 2.399 | 14.120 | ----- | 0.678 | |
| 113 | 0.21 | 114 | TUNNEL-3 | 16090 | 1 | 26.13 | 26.34 | 2304/14/70 | 1.533 | 2.718 | 2.677 | 4.100 | 54.361 | ----- | |
| 114 | 0.27 | 124 | TUNNEL-3 | 16090 | 1 | 27.75 | 28.02 | 2304/14/71 | 1.684 | 2.734 | 2.689 | 4.530 | 91.494 | ----- | |
| 115 | 0.25 | 147 | TUNNEL-3 | 16090 | 1 | 31.50 | 31.75 | 2304/14/72 | 2.986 | 2.655 | 2.578 | 7.700 | 35.714 | ----- | |
| 116 | 0.08 | 161 | TUNNEL-3 | 16090 | 1 | 33.59 | 33.67 | 2304/14/73 | 3.220 | 2.591 | 2.510 | 8.080 | ----- | 6.482 | |
| 117 | 0.21 | 168 | TUNNEL-3 | 16290 | 2 | 32.26 | 32.47 | 2304/14/74 | 3.629 | 2.597 | 2.506 | 9.090 | ----- | 2.815 | |
| 118 | 0.23 | 193 | TUNNEL-3 | 16290 | 2 | 36.91 | 37.14 | 2304/14/75 | 1.291 | 2.832 | 2.796 | 3.610 | 70.962 | ----- | |
| 119 | 0.21 | 202 | TUNNEL-3 | 16290 | 2 | 38.70 | 38.91 | 2304/14/76 | 0.639 | 2.745 | 2.728 | 1.740 | 88.539 | ----- | |
| 120 | 0.19 | 226 | TUNNEL-3 | 16290 | 2 | 42.51 | 42.70 | 2304/14/77 | 0.712 | 2.698 | 2.679 | 1.910 | 76.109 | ----- | |
| 121 | 0.26 | 237 | TUNNEL-3 | 16290 | 2 | 45.00 | 45.26 | 2304/14/78 | 0.454 | 2.729 | 2.717 | 1.230 | 95.278 | ----- | |
| 122 | 0.16 | 16 | TUNNEL-4 | 17010 | 1 | 6.36 | 6.52 | 2412/79/14 | 7.313 | 2.352 | 2.192 | 16.026 | ---- | 4.387 | |
| 123 | 0.20 | 24 | TUNNEL-4 | 17010 | 1 | 9.00 | 9.20 | 2412/79/15 | 6.925 | 2.453 | 2.294 | 15.885 | 97.391 | ---- | |
| 124 | 0.12 | 40 | TUNNEL-4 | 17010 | 1 | 15.08 | 15.20 | 2412/79/16 | 0.097 | 2.619 | 2.617 | 0.254 | ---- | 14.083 | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

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| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 125 | 0.22 | 75 | TUNNEL-4 | 17010 | 1 | 19.32 | 19.54 | 2412/79/17 | 0.412 | 2.860 | 2.849 | 1.173 | 262.514 | ---- | |
| 126 | 0.18 | 95 | TUNNEL-4 | 17010 | 1 | 22.52 | 22.70 | 2412/79/18 | 0.712 | 2.749 | 2.729 | 1.944 | 316.539 | ---- | |
| 127 | 0.20 | 103 | TUNNEL-4 | 17010 | 1 | 24.00 | 24.20 | 2412/79/19 | 0.548 | 2.645 | 2.630 | 1.443 | 234.768 | ---- | |
| 128 | 0.190 | 97 | TUNNEL-4 | 17550 | 2 | 25.00 | 25.19 | 2404/21/22 | 3.795 | 2.743 | 2.643 | 10.030 | 30.503 | ----- | |
| 129 | 0.130 | 113 | TUNNEL-4 | 17550 | 2 | 27.66 | 27.79 | 2404/21/23 | 0.955 | 2.811 | 2.784 | 2.658 | 78.547 | ----- | |
| 130 | 0.180 | 120 | TUNNEL-4 | 17550 | 2 | 28.48 | 28.66 | 2404/21/24 | 1.878 | 2.828 | 2.775 | 5.212 | 76.132 | ----- | |
| 131 | 0.320 | 123 | TUNNEL-4 | 17550 | 2 | 29.34 | 29.66 | 2404/21/25 | 4.541 | 2.603 | 2.490 | 11.306 | 53.531 | ----- | |
| 132 | 0.180 | 128 | TUNNEL-4 | 17550 | 2 | 30.32 | 30.50 | 2404/21/26 | 0.852 | 2.740 | 2.717 | 2.316 | 57.073 | ----- | |
| 133 | 0.170 | 134 | TUNNEL-4 | 17550 | 2 | 32.48 | 32.65 | 2404/21/27 | 3.818 | 2.807 | 2.704 | 10.322 | 15.060 | ----- | |
| 134 | 0.240 | 147 | TUNNEL-4 | 17550 | 2 | 33.53 | 33.77 | 2404/21/28 | 2.122 | 2.844 | 2.784 | 5.909 | 102.716 | ----- | |
| 135 | 0.190 | 153 | TUNNEL-4 | 17550 | 2 | 35.14 | 35.33 | 2404/21/29 | 1.040 | 2.912 | 2.882 | 2.996 | 102.626 | ----- | |
| 136 | 0.220 | 158 | TUNNEL-4 | 17550 | 2 | 36.33 | 36.55 | 2404/21/30 | 3.703 | 2.634 | 2.540 | 9.405 | 21.854 | ----- | |
| 137 | 0.160 | 169 | TUNNEL-4 | 17550 | 2 | 38.29 | 38.45 | 2404/21/31 | 6.458 | 2.415 | 2.269 | 14.652 | 16.539 | ----- | |
| 138 | 0.170 | 174 | TUNNEL-4 | 17550 | 2 | 39.42 | 39.59 | 2404/21/32 | 0.863 | 2.851 | 2.826 | 2.440 | 105.668 | ----- | |
| 139 | 0.20 | 20 | TUNNEL-5 | 18690.0 | 1 | 11.80 | 12.00 | 2301/02/47 | 8.738 | 2.396 | 2.203 | 19.250 | ----- | 0.872 | |
| 140 | 0.15 | 69 | TUNNEL-5 | 18690.0 | 1 | 21.60 | 21.75 | 2301/02/48 | 0.493 | 2.828 | 2.814 | 1.390 | ----- | 3.314 | |
| 141 | 0.25 | 117 | TUNNEL-5 | 18690.0 | 1 | 31.60 | 31.85 | 2301/02/49 | 0.418 | 2.935 | 2.923 | 1.220 | 84.429 | ----- | |
| 142 | 0.20 | 136 | TUNNEL-5 | 18690.0 | 1 | 36.50 | 36.70 | 2301/02/50 | 0.642 | 2.913 | 2.895 | 1.860 | 95.379 | ----- | |
| 143 | 0.30 | 149 | TUNNEL-5 | 18690.0 | 1 | 39.40 | 39.70 | 2301/02/51 | 0.648 | 2.409 | 2.393 | 1.550 | 89.520 | ----- | |
| 144 | 0.40 | 159 | TUNNEL-5 | 18690.0 | 1 | 41.00 | 41.40 | 2301/02/52 | 2.438 | 2.734 | 2.669 | 6.510 | 105.195 | ----- | |
| 145 | 0.230 | 84 | TUNNEL-5A | 19880 | 1 | 24.00 | 24.23 | 2404/21/01 | 0.570 | 2.839 | 2.823 | 1.610 | 33.131 | ----- | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

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| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 146 | 0.170 | 93 | TUNNEL-5A | 19880 | 1 | 25.40 | 25.57 | 2404/21/02 | 5.814 | 2.432 | 2.298 | 13.362 | 18.610 | ----- | |
| 147 | 0.300 | 95 | TUNNEL-5A | 19880 | 1 | 26.00 | 26.30 | 2404/21/03 | 5.828 | 2.420 | 2.287 | 13.327 | 18.733 | ----- | |
| 148 | 0.210 | 101 | TUNNEL-5A | 19880 | 1 | 27.32 | 27.53 | 2404/21/04 | 4.033 | 2.167 | 2.083 | 8.399 | 16.539 | ----- | |
| 149 | 0.200 | 107 | TUNNEL-5A | 19880 | 1 | 28.69 | 28.89 | 2404/21/05 | 8.496 | 2.086 | 1.923 | 16.337 | 15.577 | ----- | |
| 150 | 0.150 | 114 | TUNNEL-5A | 19880 | 1 | 30.30 | 30.45 | 2404/21/06 | 1.831 | 2.816 | 2.766 | 5.064 | 103.532 | ----- | |
| 151 | 0.180 | 124 | TUNNEL-5A | 19880 | 1 | 31.79 | 31.97 | 2404/21/07 | 0.538 | 2.830 | 2.815 | 1.515 | 45.467 | ----- | |
| 152 | 0.180 | 131 | TUNNEL-5A | 19880 | 1 | 32.59 | 32.77 | 2404/21/08 | 8.043 | 2.287 | 2.117 | 17.023 | 25.868 | ----- | |
| 153 | 0.170 | 148 | TUNNEL-5A | 19880 | 1 | 35.42 | 35.59 | 2404/21/09 | 8.158 | 2.432 | 2.248 | 18.340 | 17.699 | ----- | |
| 154 | 0.150 | 156 | TUNNEL-5A | 19880 | 1 | 36.65 | 36.80 | 2404/21/10 | 4.829 | 2.512 | 2.397 | 11.573 | 20.411 | ----- | |
| 155 | 0.200 | 163 | TUNNEL-5A | 19880 | 1 | 37.57 | 37.77 | 2404/21/11 | 3.243 | 2.782 | 2.695 | 8.739 | 52.010 | ----- | |
| 156 | 0.120 | 173 | TUNNEL-5A | 19880 | 1 | 39.31 | 39.43 | 2404/21/12 | 3.592 | 2.676 | 2.583 | 9.279 | 19.751 | ----- | |
| 157 | 0.110 | 87 | TUNNEL-5A | 20040 | 2 | 22.98 | 23.09 | 2404/21/33 | 1.894 | 2.829 | 2.776 | 5.259 | ----- | 1.750 | |
| 158 | 0.280 | 92 | TUNNEL-5A | 20040 | 2 | 24.23 | 24.51 | 2404/21/34 | 1.413 | 2.743 | 2.705 | 3.821 | 16.055 | ----- | |
| 159 | 0.170 | 97 | TUNNEL-5A | 20040 | 2 | 25.50 | 25.67 | 2404/21/35 | 4.740 | 2.655 | 2.535 | 12.014 | 28.593 | ----- | |
| 160 | 0.220 | 105 | TUNNEL-5A | 20040 | 2 | 27.30 | 27.52 | 2404/21/36 | 4.926 | 2.698 | 2.571 | 12.666 | 19.082 | ----- | |
| 161 | 0.170 | 112 | TUNNEL-5A | 20040 | 2 | 28.92 | 29.09 | 2404/21/37 | 2.422 | 2.828 | 2.762 | 6.687 | 86.348 | ----- | |
| 162 | 0.200 | 118 | TUNNEL-5A | 20040 | 2 | 30.45 | 30.65 | 2404/21/38 | 4.561 | 2.663 | 2.547 | 11.618 | 21.039 | ----- | |
| 163 | 0.220 | 124 | TUNNEL-5A | 20040 | 2 | 32.24 | 32.46 | 2404/21/39 | 2.414 | 2.493 | 2.434 | 5.876 | 15.816 | ----- | |
| 164 | 0.250 | 129 | TUNNEL-5A | 20040 | 2 | 33.90 | 34.15 | 2404/21/40 | 8.251 | 2.488 | 2.299 | 18.965 | 15.292 | ----- | |
| 165 | 0.260 | 51 | TUNNEL-6 | 21150 | 1 | 25.90 | 26.16 | 2404/21/13 | 1.562 | 2.819 | 2.775 | 4.334 | 60.582 | ----- | |
| 166 | 0.220 | 55 | TUNNEL-6 | 21150 | 1 | 27.21 | 27.43 | 2404/21/14 | 1.356 | 2.814 | 2.777 | 3.765 | 108.979 | ----- | |
| 167 | 0.210 | 64 | TUNNEL-6 | 21150 | 1 | 29.30 | 29.51 | 2404/21/15 | 4.754 | 2.659 | 2.538 | 12.067 | 91.079 | ----- | |
| 168 | 0.180 | 77 | TUNNEL-6 | 21150 | 1 | 31.76 | 31.94 | 2404/21/16 | 5.026 | 2.265 | 2.157 | 10.839 | 22.395 | ----- | |
| 169 | 0.210 | 84 | TUNNEL-6 | 21150 | 1 | 33.18 | 33.39 | 2404/21/17 | 1.563 | 2.730 | 2.688 | 4.202 | 28.235 | ----- | |
| 170 | 0.180 | 91 | TUNNEL-6 | 21150 | 1 | 35.42 | 35.60 | 2404/21/18 | 3.236 | 2.811 | 2.723 | 8.811 | 19.780 | ----- | |
| 171 | 0.230 | 94 | TUNNEL-6 | 21150 | 1 | 36.27 | 36.50 | 2404/21/19 | 8.197 | 2.359 | 2.181 | 17.873 | 24.161 | ----- | |
| 172 | 0.230 | 101 | TUNNEL-6 | 21150 | 1 | 37.98 | 38.21 | 2404/21/20 | 1.238 | 2.756 | 2.723 | 3.371 | 103.321 | ----- | |
| 173 | 0.120 | 108 | TUNNEL-6 | 21150 | 1 | 39.53 | 39.65 | 2404/21/21 | 0.971 | 2.593 | 2.568 | 2.495 | 91.457 | ----- | |
| 174 | 0.190 | 45 | TUNNEL-6 | 21450 | 2 | 24.05 | 24.24 | 2405/41/01 | 9.486 | 2.298 | 2.099 | 19.914 | 40.418 | ----- | |
| 175 | 0.180 | 53 | TUNNEL-6 | 21450 | 2 | 27.00 | 27.18 | 2405/41/02 | 8.621 | 2.380 | 2.191 | 18.890 | 12.846 | ----- | |
| 176 | 0.140 | 66 | TUNNEL-6 | 21450 | 2 | 30.45 | 30.59 | 2405/41/03 | 7.789 | 2.492 | 2.312 | 18.009 | 40.953 | ----- | |
| 177 | 0.170 | 70 | TUNNEL-6 | 21450 | 2 | 31.69 | 31.86 | 2405/41/04 | 0.498 | 2.969 | 2.954 | 1.472 | 215.136 | ----- | |
| 178 | 0.190 | 74 | TUNNEL-6 | 21450 | 2 | 33.00 | 33.19 | 2405/41/05 | 0.427 | 2.860 | 2.848 | 1.217 | 205.835 | ----- | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

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| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 179 | 0.120 | 81 | TUNNEL-6 | 21450 | 2 | 34.80 | 34.92 | 2405/41/06 | 4.999 | 2.707 | 2.578 | 12.885 | ----- | 3.666 | |
| 180 | 0.10 | 30 | TUNNEL-7 | 22580 | 1 | 9.26 | 9.36 | 2412/79/09 | 0.620 | 2.720 | 2.703 | 1.677 | ---- | 9.374 | |
| 181 | 0.13 | 42 | TUNNEL-7 | 22580 | 1 | 15.26 | 15.39 | 2412/79/10 | 1.162 | 2.664 | 2.633 | 3.060 | ---- | 15.905 | |
| 182 | 0.24 | 59 | TUNNEL-7 | 22580 | 1 | 18.34 | 18.58 | 2412/79/11 | 6.325 | 2.557 | 2.405 | 15.212 | 32.879 | ---- | |
| 183 | 0.20 | 64 | TUNNEL-7 | 22580 | 1 | 19.56 | 19.76 | 2412/79/12 | 1.167 | 2.669 | 2.638 | 3.080 | ---- | 1.064 | |
| 184 | 0.24 | 95 | TUNNEL-7 | 22580 | 1 | 24.36 | 24.60 | 2412/79/13 | 0.509 | 2.791 | 2.777 | 1.413 | 40.520 | ---- | |
| 185 | 0.22 | 13 | TUNNEL-7 | 22800 | 2 | 12.69 | 12.91 | 2304/12/30 | 2.083 | 2.717 | 2.662 | 5.554 | 56.374 | ----- | |
| 186 | 0.42 | 42 | TUNNEL-7 | 22800 | 2 | 19.72 | 20.14 | 2304/12/31 | 5.614 | 2.356 | 2.231 | 12.520 | ----- | 1.221 | |
| 187 | 0.21 | 74 | TUNNEL-7 | 22800 | 2 | 27.70 | 27.91 | 2304/12/32 | 0.766 | 2.650 | 2.630 | 2.010 | 68.080 | ----- | |
| 188 | 0.33 | 106 | TUNNEL-7 | 22800 | 2 | 34.17 | 34.50 | 2304/12/33 | 0.844 | 2.646 | 2.624 | 2.210 | ----- | 2.959 | |
| 189 | 0.28 | 127 | TUNNEL-7 | 22800 | 2 | 39.45 | 39.73 | 2304/12/34 | 0.275 | 2.853 | 2.845 | 0.780 | ----- | 5.381 | |
| 190 | 0.30 | 3 | TUNNEL-8 | 27530 | 1 | 6.00 | 6.30 | 2304/12/38 | 1.523 | 2.567 | 2.529 | 3.850 | 65.302 | ----- | |
| 191 | 0.17 | 56 | TUNNEL-8 | 27530 | 1 | 18.21 | 18.38 | 2304/12/39 | 1.364 | 2.622 | 2.587 | 3.530 | 69.384 | ----- | |
| 192 | 0.37 | 119 | TUNNEL-8 | 27530 | 1 | 22.50 | 22.87 | 2304/12/40 | 3.409 | 2.732 | 2.642 | 9.010 | ----- | 3.690 | |
| 193 | 0.44 | 4 | TUNNEL-8 | 27790 | 2 | 7.50 | 7.94 | 2304/12/35 | 7.296 | 2.366 | 2.205 | 16.090 | ----- | 0.701 | |
| 194 | 0.16 | 65 | TUNNEL-8 | 27790 | 2 | 19.08 | 19.24 | 2304/12/36 | 5.828 | 2.489 | 2.352 | 13.700 | ----- | 4.258 | |
| 195 | 0.25 | 105 | TUNNEL-8 | 27790 | 2 | 27.00 | 27.25 | 2304/12/37 | 2.978 | 2.583 | 2.508 | 7.470 | 15.197 | ----- | |
| 196 | 0.09 | 13 | TUNNEL-8A | 31640 | 1 | 3.46 | 3.55 | 2412/79/01 | 0.483 | 2.691 | 2.678 | 1.293 | 150.641 | ---- | |
| 197 | 0.31 | 37 | TUNNEL-8A | 31640 | 1 | 8.69 | 9.00 | 2412/79/02 | 1.180 | 2.720 | 2.688 | 3.172 | 358.590 | ---- | |
| 198 | 0.19 | 51 | TUNNEL-8A | 31640 | 1 | 12.56 | 12.75 | 2412/79/03 | 0.536 | 2.834 | 2.819 | 1.511 | 366.635 | ---- | |
| 199 | 0.34 | 58 | TUNNEL-8A | 31640 | 1 | 14.66 | 15.00 | 2412/79/04 | 0.484 | 2.872 | 2.858 | 1.382 | 365.928 | ---- | |
| 200 | 0.17 | 70 | TUNNEL-8A | 31640 | 1 | 20.30 | 20.47 | 2412/79/05 | 3.308 | 2.541 | 2.460 | 8.135 | 55.176 | ---- | |
| 201 | 0.24 | 78 | TUNNEL-8A | 31640 | 1 | 22.50 | 22.74 | 2412/79/06 | 3.654 | 2.455 | 2.369 | 8.656 | 109.158 | ---- | |
| 202 | 0.46 | 86 | TUNNEL-8A | 31640 | 1 | 26.54 | 27.00 | 2412/79/07 | 4.262 | 2.476 | 2.375 | 10.120 | 141.262 | ---- | |
| 203 | 0.40 | 94 | TUNNEL-8A | 31640 | 1 | 29.60 | 30.00 | 2412/79/08 | 3.641 | 2.423 | 2.338 | 8.513 | 85.291 | ---- | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

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|---|---|
| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 204 | 0.17 | 14 | TUNNEL-8A | 32460 | 2 | 3.47 | 3.64 | 2410/72/13 | 0.332 | 2.841 | 2.832 | 0.940 | 369.901 | ---- | |
| 205 | 0.26 | 20 | TUNNEL-8A | 32460 | 2 | 5.02 | 5.28 | 2410/72/14 | 1.789 | 2.723 | 2.675 | 4.786 | 364.412 | ---- | |
| 206 | 0.12 | 51 | TUNNEL-8A | 32460 | 2 | 13.66 | 13.78 | 2410/72/15 | 0.443 | 2.802 | 2.789 | 1.237 | 89.299 | ---- | |
| 207 | 0.14 | 84 | TUNNEL-8A | 32460 | 2 | 20.01 | 20.15 | 2410/72/16 | 2.359 | 2.662 | 2.601 | 6.135 | ---- | 0.178 | |
| 208 | 0.19 | 97 | TUNNEL-8A | 32460 | 2 | 22.69 | 22.88 | 2410/72/17 | 4.212 | 2.499 | 2.398 | 10.101 | 21.473 | ---- | |
| 209 | 0.20 | 23 | TUNNEL-9 | 35090.0 | 1 | 13.70 | 13.90 | 2301/02/65 | 0.783 | 2.860 | 2.838 | 2.220 | 102.880 | ----- | |
| 210 | 0.20 | 53 | TUNNEL-9 | 35090.0 | 1 | 20.00 | 20.20 | 2301/02/66 | 3.254 | 2.726 | 2.640 | 8.590 | ----- | 3.698 | |
| 211 | 0.25 | 68 | TUNNEL-9 | 35090.0 | 1 | 24.25 | 24.50 | 2301/02/67 | 2.863 | 2.749 | 2.672 | 7.650 | 83.082 | ----- | |
| 212 | 0.35 | 80 | TUNNEL-9 | 35090.0 | 1 | 27.65 | 28.00 | 2301/02/68 | 3.470 | 2.645 | 2.557 | 8.870 | ----- | 0.880 | |
| 213 | 0.20 | 41 | TUNNEL-9 | 35325.0 | 2 | 14.00 | 14.20 | 2301/02/53 | 1.638 | 2.557 | 2.516 | 4.120 | 107.068 | ----- | |
| 214 | 0.20 | 86 | TUNNEL-9 | 35325.0 | 2 | 23.00 | 23.20 | 2301/02/54 | 2.446 | 2.751 | 2.685 | 6.570 | ----- | 4.634 | |
| 215 | 0.20 | 134 | TUNNEL-9 | 35325.0 | 2 | 28.50 | 28.70 | 2301/02/55 | 1.472 | 2.779 | 2.738 | 4.030 | ----- | 6.630 | |
| 216 | 0.30 | 173 | TUNNEL-9 | 35325.0 | 2 | 33.00 | 33.30 | 2301/02/56 | 3.029 | 2.442 | 2.370 | 7.180 | 21.566 | | |
| 217 | 0.20 | 22 | TUNNEL-9 | 35550.0 | 3 | 10.30 | 10.50 | 2301/02/61 | 0.392 | 2.847 | 2.836 | 1.110 | 95.238 | ----- | |
| 218 | 0.30 | 75 | TUNNEL-9 | 35550.0 | 3 | 22.20 | 22.50 | 2301/02/62 | 2.352 | 2.771 | 2.707 | 6.370 | 107.368 | ----- | |
| 219 | 0.30 | 102 | TUNNEL-9 | 35550.0 | 3 | 25.00 | 25.30 | 2301/02/63 | 5.596 | 2.507 | 2.374 | 13.280 | ----- | 3.114 | |
| 220 | 0.20 | 139 | TUNNEL-9 | 35550.0 | 3 | 28.80 | 29.00 | 2301/02/64 | 6.901 | 2.466 | 2.307 | 15.920 | ----- | 1.715 | |
| 221 | 0.15 | 21 | TUNNEL-9A | 36330.0 | 1 | 7.97 | 8.12 | 2302/06/27 | 1.118 | 2.766 | 2.736 | 3.060 | 105.781 | ----- | |
| 222 | 0.20 | 35 | TUNNEL-9A | 36330.0 | 1 | 19.67 | 19.87 | 2302/06/28 | 5.895 | 2.587 | 2.443 | 14.400 | ----- | 4.238 | |
| 223 | 0.25 | 53 | TUNNEL-9A | 36330.0 | 1 | 29.51 | 29.76 | 2302/06/29 | 5.985 | 2.439 | 2.301 | 13.770 | ----- | 3.710 | |
| 224 | 0.28 | 57 | TUNNEL-9A | 36330.0 | 1 | 30.39 | 30.67 | 2302/06/30 | 2.471 | 2.614 | 2.551 | 6.300 | 54.694 | ----- | |
| 225 | 0.25 | 29 | TUNNEL-9A | 36490.0 | 2 | 16.50 | 16.75 | 2301/02/57 | 8.039 | 2.306 | 2.135 | 17.160 | ----- | 0.352 | |
| 226 | 0.22 | 58 | TUNNEL-9A | 36490.0 | 2 | 23.30 | 23.52 | 2301/02/58 | 4.033 | 2.664 | 2.561 | 10.330 | ----- | 2.296 | |
| 227 | 0.30 | 76 | TUNNEL-9A | 36490.0 | 2 | 29.30 | 29.60 | 2301/02/59 | 3.003 | 2.633 | 2.556 | 7.680 | ----- | 1.577 | |
| 228 | 0.30 | 86 | TUNNEL-9A | 36490.0 | 2 | 32.70 | 33.00 | 2301/02/60 | 4.050 | 2.720 | 2.614 | 10.590 | 46.332 | ----- | |
| 229 | 0.24 | 15 | TUNNEL-10 | 36850.0 | 1 | 6.73 | 6.97 | 2302/06/31 | 0.116 | 2.941 | 2.938 | 0.340 | 93.328 | ----- | |
| 230 | 0.25 | 51 | TUNNEL-10 | 36850.0 | 1 | 18.00 | 18.25 | 2302/06/32 | 2.665 | 2.778 | 2.706 | 7.210 | 51.259 | ----- | |
| 231 | 0.23 | 82 | TUNNEL-10 | 36850.0 | 1 | 23.50 | 23.73 | 2302/06/33 | 2.247 | 2.612 | 2.554 | 5.740 | ----- | 0.869 | |
| 232 | 0.16 | 112 | TUNNEL-10 | 36850.0 | 1 | 28.50 | 28.66 | 2302/06/34 | 0.596 | 2.857 | 2.840 | 1.690 | 63.586 | ----- | |
| 233 | 0.19 | 147 | TUNNEL-10 | 36850.0 | 1 | 34.41 | 34.60 | 2302/06/35 | 2.547 | 2.571 | 2.507 | 6.390 | 29.818 | ----- | |
| 234 | 0.20 | 8 | TUNNEL-10 | 37040.0 | 2 | 4.80 | 5.00 | 2209/19/24 | 1.118 | 2.452 | 2.425 | 2.710 | 46.113 | ----- | |
| 235 | 0.15 | 22 | TUNNEL-10 | 37040.0 | 2 | 11.00 | 11.15 | 2209/19/25 | 2.951 | 2.629 | 2.554 | 7.540 | 103.962 | ----- | |
| 236 | 0.15 | 48 | TUNNEL-10 | 37040.0 | 2 | 21.50 | 21.65 | 2209/19/26 | 2.737 | 2.514 | 2.447 | 6.700 | ----- | 9.316 | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

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| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 237 | 0.20 | 72 | TUNNEL-10 | 37040.0 | 2 | 26.80 | 27.00 | 2209/19/27 | 1.545 | 2.846 | 2.802 | 4.330 | ----- | 7.291 | |
| 238 | 0.30 | 85 | TUNNEL-10 | 37040.0 | 2 | 29.50 | 29.80 | 2209/19/28 | 5.96 | 2.546 | 2.402 | 14.320 | ----- | 4.165 | |
| 239 | 0.26 | 5 | TUNNEL-10 | 37170.0 | 3 | 8.54 | 8.80 | 2302/06/36 | 0.334 | 2.782 | 2.773 | 0.930 | 65.602 | ----- | |
| 240 | 0.21 | 32 | TUNNEL-10 | 37170.0 | 3 | 18.77 | 18.98 | 2302/06/37 | 1.715 | 2.661 | 2.616 | 4.490 | 34.740 | ----- | |
| 241 | 0.19 | 72 | TUNNEL-10 | 37170.0 | 3 | 22.31 | 22.50 | 2302/06/38 | 4.246 | 2.580 | 2.475 | 10.510 | ----- | 0.883 | |
| 242 | 0.23 | 123 | TUNNEL-10 | 37170.0 | 3 | 28.92 | 29.15 | 2302/06/39 | 2.536 | 2.704 | 2.637 | 6.690 | ----- | 2.665 | |
| 243 | 0.20 | 150 | TUNNEL-10 | 37170.0 | 3 | 34.30 | 34.50 | 2302/06/40 | 6.761 | 2.414 | 2.261 | 15.290 | ----- | 1.686 | |
| 244 | 0.50 | 22 | TUNNEL-11 | 37410.0 | 1 | 8.50 | 9.00 | 2302/06/41 | 0.657 | 2.831 | 2.812 | 1.850 | 103.270 | ----- | |
| 245 | 0.15 | 52 | TUNNEL-11 | 37410.0 | 1 | 18.00 | 18.15 | 2302/06/42 | 4.501 | 2.433 | 2.329 | 10.480 | ----- | 0.528 | |
| 246 | 0.27 | 86 | TUNNEL-11 | 37410.0 | 1 | 24.00 | 24.27 | 2302/06/43 | 3.254 | 2.565 | 2.484 | 8.080 | ----- | 0.704 | |
| 247 | 0.23 | 109 | TUNNEL-11 | 37410.0 | 1 | 31.27 | 31.50 | 2302/06/44 | 4.052 | 2.685 | 2.581 | 10.460 | ----- | 2.832 | |
| 248 | 0.15 | 17 | TUNNEL-11 | 37600.0 | 2 | 4.35 | 4.50 | 2209/19/29 | 0.868 | 2.82 | 2.796 | 2.430 | 81.266 | 0.000 | |
| 249 | 0.15 | 49 | TUNNEL-11 | 37600.0 | 2 | 12.00 | 12.15 | 2209/19/30 | 0.882 | 2.896 | 2.871 | 2.530 | 102.998 | ----- | |
| 250 | 0.30 | 97 | TUNNEL-11 | 37600.0 | 2 | 21.20 | 21.50 | 2209/19/31 | 3.363 | 2.658 | 2.572 | 8.650 | ----- | 6.475 | |
| 251 | 0.30 | 157 | TUNNEL-11 | 37600.0 | 2 | 34.10 | 34.40 | 2209/19/32 | 3.971 | 2.558 | 2.460 | 9.770 | 18.494 | ----- | |
| 252 | 0.20 | 15 | TUNNEL-11 | 37750.0 | 3 | 5.01 | 5.21 | 2302/06/45 | 2.219 | 2.760 | 2.700 | 5.990 | ----- | 3.856 | |
| 253 | 0.30 | 35 | TUNNEL-11 | 37750.0 | 3 | 9.71 | 10.01 | 2302/06/46 | 2.793 | 2.589 | 2.518 | 7.030 | 23.655 | ----- | |
| 254 | 0.18 | 54 | TUNNEL-11 | 37750.0 | 3 | 15.26 | 15.44 | 2302/06/47 | 0.596 | 2.847 | 2.830 | 1.690 | 112.335 | ----- | |
| 255 | 0.32 | 64 | TUNNEL-11 | 37750.0 | 3 | 19.18 | 19.50 | 2302/06/48 | 0.348 | 2.917 | 2.907 | 1.010 | 91.104 | ----- | |
| 256 | 0.22 | 102 | TUNNEL-11 | 37750.0 | 3 | 27.90 | 28.12 | 2302/06/49 | 2.315 | 2.398 | 2.344 | 5.430 | ----- | 0.712 | |
| 257 | 0.21 | 138 | TUNNEL-11 | 37750.0 | 3 | 38.26 | 38.47 | 2302/06/50 | 3.852 | 2.596 | 2.500 | 9.630 | ----- | 3.458 | |
| 258 | 0.20 | 207 | TUNNEL-11 | 37750.0 | 3 | 51.00 | 51.20 | 2302/06/51 | 3.021 | 2.604 | 2.528 | 7.640 | ----- | 1.954 | |
| 259 | 0.28 | 10 | TUNNEL-11 | 37950 | 4 | 6.70 | 6.98 | 2304/12/17 | 0.770 | 2.891 | 2.869 | 2.210 | 85.470 | ----- | |
| 260 | 0.23 | 44 | TUNNEL-11 | 37950 | 4 | 16.81 | 17.04 | 2304/12/18 | 0.632 | 2.828 | 2.810 | 1.780 | 106.598 | ----- | |
| 261 | 0.19 | 79 | TUNNEL-11 | 37950 | 4 | 22.50 | 22.69 | 2304/12/19 | 1.179 | 2.649 | 2.618 | 3.090 | 99.572 | ----- | |
| 262 | 0.32 | 92 | TUNNEL-11 | 37950 | 4 | 30.00 | 30.32 | 2304/12/20 | 3.089 | 2.516 | 2.440 | 7.540 | ----- | 5.098 | |
| 263 | 0.22 | 135 | TUNNEL-11 | 37950 | 4 | 40.14 | 40.36 | 2304/12/21 | 3.885 | 2.525 | 2.430 | 9.440 | ----- | 3.661 | |
| 264 | 0.29 | 175 | TUNNEL-11 | 37950 | 4 | 49.21 | 49.50 | 2304/12/22 | 2.392 | 2.595 | 2.534 | 6.060 | 61.384 | ----- | |
| 265 | 0.16 | 19 | TUNNEL-11 | 38120 | 5 | 6.17 | 6.33 | 2304/12/13 | 0.436 | 2.755 | 2.743 | 1.200 | 98.180 | ----- | |
| 266 | 0.87 | 31 | TUNNEL-11 | 38120 | 5 | 20.15 | 21.02 | 2304/12/14 | 2.036 | 2.685 | 2.632 | 5.360 | 67.932 | ----- | |
| 267 | 0.22 | 42 | TUNNEL-11 | 38120 | 5 | 22.50 | 22.72 | 2304/12/15 | 1.196 | 2.701 | 2.669 | 3.190 | 77.270 | ----- | |
| 268 | 0.27 | 82 | TUNNEL-11 | 38120 | 5 | 31.50 | 31.77 | 2304/12/16 | 1.053 | 2.889 | 2.859 | 3.010 | 82.108 | ----- | |
| 269 | 0.40 | 5 | TUNNEL-12 | 38550 | 1 | 3.45 | 3.85 | 2304/12/26 | 0.817 | 2.797 | 2.774 | 2.227 | 100.676 | ----- | |

# RITES GEOTECHNICAL LABORATORY

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| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) | | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | From | To | | | | | | | | |
| 270 | 0.12 | 35 | TUNNEL-12 | 38550 | 1 | 13.38 | 13.50 | 2304/12/27 | 0.940 | 2.772 | 2.746 | 2.580 | 103.198 | ----- | |
| 271 | 0.16 | 51 | TUNNEL-12 | 38550 | 1 | 22.50 | 22.66 | 2304/12/28 | 1.345 | 2.719 | 2.683 | 3.610 | ----- | 2.628 | |
| 272 | 0.29 | 76 | TUNNEL-12 | 38550 | 1 | 29.71 | 30.00 | 2304/12/29 | 4.498 | 2.520 | 2.411 | 10.840 | ----- | 5.803 | |
| 273 | 0.13 | 8 | TUNNEL-12 | 39810 | 2 | 6.40 | 6.53 | 2410/72/01 | 0.373 | 2.750 | 2.739 | 1.021 | 207.955 | ---- | |
| 274 | 0.13 | 12 | TUNNEL-12 | 39810 | 2 | 10.37 | 10.50 | 2410/72/02 | 0.720 | 2.875 | 2.854 | 2.055 | 71.626 | ---- | |
| 275 | 0.19 | 18 | TUNNEL-12 | 39810 | 2 | 12.30 | 12.49 | 2410/72/03 | 3.506 | 2.678 | 2.587 | 9.071 | 54.827 | ---- | |
| 276 | 0.15 | 21 | TUNNEL-12 | 39810 | 2 | 13.91 | 14.06 | 2410/72/04 | 2.433 | 2.690 | 2.626 | 6.389 | 64.411 | ---- | |
| 277 | 0.24 | 30 | TUNNEL-12 | 39810 | 2 | 19.50 | 19.74 | 2410/72/05 | 2.140 | 2.700 | 2.643 | 5.656 | 126.765 | ---- | |
| 278 | 0.23 | 40 | TUNNEL-12 | 39810 | 2 | 23.77 | 24.00 | 2410/72/06 | 1.800 | 2.700 | 2.652 | 4.775 | 109.022 | ---- | |
| 279 | 0.73 | 56 | TUNNEL-12 | 39810 | 2 | 28.87 | 29.60 | 2410/72/07 | 4.464 | 2.604 | 2.493 | 11.128 | 60.128 | ---- | |
| 280 | 0.20 | 27 | TUNNEL-12A | 40605.0 | 1 | 9.90 | 10.10 | 2212/28/32 | 1.073 | 2.871 | 2.840 | 3.050 | 55.748 | 0.000 | |
| 281 | 0.20 | 46 | TUNNEL-12A | 40605.0 | 1 | 14.05 | 14.25 | 2212/28/33 | 0.952 | 2.876 | 2.849 | 2.710 | 30.717 | ----- | |
| 282 | 0.20 | 83 | TUNNEL-12A | 40605.0 | 1 | 21.50 | 21.70 | 2212/28/34 | 0.977 | 2.807 | 2.780 | 2.720 | 185.844 | ----- | |
| 283 | 0.30 | 100 | TUNNEL-12A | 40605.0 | 1 | 26.00 | 26.30 | 2212/28/35 | 0.27 | 2.915 | 2.907 | 0.780 | 7.220 | ----- | |
| 284 | 0.25 | 113 | TUNNEL-12A | 40605.0 | 1 | 32.10 | 32.35 | 2212/28/36 | 11.51 | 2.677 | 2.401 | 27.640 | ----- | 0.881 | |
| 285 | 0.50 | 128 | TUNNEL-12A | 40605.0 | 1 | 35.50 | 36.00 | 2212/28/37 | 5.591 | 2.347 | 2.223 | 12.430 | ----- | 0.878 | |
| 286 | 0.12 | 7 | TUNNEL-12A | 40670.0 | 2 | 9.05 | 9.17 | 2212/28/26 | 0.495 | 2.636 | 2.623 | 1.300 | ----- | 7.393 | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

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| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa — **Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) From | Depth (m) To | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 287 | 0.40 | 45 | TUNNEL-12A | 40670.0 | 2 | 14.60 | 15.00 | 2212/28/27 | 1.377 | 2.806 | 2.767 | 3.810 | 44.615 | ----- | |
| 288 | 0.40 | 69 | TUNNEL-12A | 40670.0 | 2 | 21.00 | 21.40 | 2212/28/28 | 1.261 | 2.788 | 2.753 | 3.470 | 51.028 | ----- | |
| 289 | 0.25 | 86 | TUNNEL-12A | 40670.0 | 2 | 25.25 | 25.50 | 2212/28/29 | 0.614 | 2.751 | 2.734 | 1.680 | 16.135 | ----- | |
| 290 | 0.10 | 97 | TUNNEL-12A | 40670.0 | 2 | 27.50 | 27.60 | 2212/28/30 | 22.41 | 2.0833 | 1.702 | 38.140 | ----- | 3.775 | |
| 291 | 0.43 | 145 | TUNNEL-12A | 40670.0 | 2 | 33.12 | 33.55 | 2212/28/31 | 7.403 | 2.366 | 2.203 | 16.310 | ----- | 0.874 | |
| 292 | 0.19 | 10 | TUNNEL-13 | 42910 | 1 | 6.48 | 6.67 | 2304/12/23 | 0.832 | 2.820 | 2.797 | 2.330 | 76.468 | ----- | |
| 293 | 0.29 | 50 | TUNNEL-13 | 42910 | 1 | 17.71 | 18.00 | 2304/12/24 | 1.227 | 2.628 | 2.596 | 3.190 | 75.888 | ----- | |
| 294 | 0.33 | 68 | TUNNEL-13 | 42910 | 1 | 22.87 | 23.20 | 2304/12/25 | 1.128 | 2.645 | 2.615 | 2.950 | 80.276 | ----- | |
| 295 | 0.12 | 1 | TUNNEL-13 | 44410 | 2 | 6.00 | 6.12 | 2304/12/41 | 0.572 | 2.890 | 2.873 | 1.550 | ----- | 7.908 | |
| 296 | 0.19 | 14 | TUNNEL-13 | 44410 | 2 | 12.29 | 12.48 | 2304/12/42 | 1.654 | 2.678 | 2.634 | 4.360 | 37.478 | | |
| 297 | 0.24 | 34 | TUNNEL-13 | 44410 | 2 | 17.76 | 18.00 | 2304/12/43 | 3.030 | 2.578 | 2.496 | 8.250 | ----- | 4.547 | |
| 298 | 0.24 | 56 | TUNNEL-13 | 44410 | 2 | 22.50 | 22.74 | 2304/12/44 | 0.901 | 2.675 | 2.651 | 2.390 | 96.170 | ----- | |
| 299 | 0.20 | 9 | TUNNEL-14 | 57470.0 | 1 | 8.80 | 9.00 | 2212/28/14 | 4.122 | 2.608 | 2.505 | 10.320 | ----- | 0.882 | |
| 300 | 0.20 | 36 | TUNNEL-14 | 57470.0 | 1 | 13.00 | 13.20 | 2212/28/15 | 2.634 | 2.675 | 2.607 | 6.870 | ----- | 3.733 | |
| 301 | 0.35 | 65 | TUNNEL-14 | 57470.0 | 1 | 18.20 | 18.55 | 2212/28/16 | 1.305 | 2.634 | 2.600 | 3.390 | ----- | 3.741 | |
| 302 | 0.20 | 90 | TUNNEL-14 | 57470.0 | 1 | 24.50 | 24.70 | 2212/28/17 | 0.521 | 2.815 | 2.801 | 1.460 | 19.029 | ----- | |
| 303 | 0.20 | 108 | TUNNEL-14 | 57470.0 | 1 | 29.50 | 29.70 | 2212/28/18 | 0.546 | 2.9 | 2.885 | 1.570 | 71.691 | ----- | |
| 304 | 0.15 | 10 | TUNNEL-14 | 57650.0 | 2 | 6.10 | 6.25 | 2212/28/08 | 10.766 | 2.269 | 2.048 | 22.050 | ----- | 0.880 | |
| 305 | 0.35 | 44 | TUNNEL-14 | 57650.0 | 2 | 16.15 | 16.50 | 2212/28/09 | 1.002 | 2.62 | 2.594 | 2.600 | 26.843 | ----- | |
| 306 | 0.30 | 57 | TUNNEL-14 | 57650.0 | 2 | 19.50 | 19.80 | 2212/28/10 | 5.117 | 2.564 | 2.439 | 12.480 | ----- | 1.969 | |
| 307 | 0.20 | 91 | TUNNEL-14 | 57650.0 | 2 | 27.00 | 27.20 | 2212/28/11 | 7.927 | 2.265 | 2.099 | 16.640 | ----- | 5.350 | |
| 308 | 0.40 | 112 | TUNNEL-14 | 57650.0 | 2 | 31.60 | 32.00 | 2212/28/12 | 1.145 | 2.847 | 2.815 | 3.220 | 57.232 | ----- | |
| 309 | 0.30 | 119 | TUNNEL-14 | 57650.0 | 2 | 33.70 | 34.00 | 2212/28/13 | 1.135 | 2.67 | 2.641 | 3.000 | 42.539 | ----- | |
| 310 | 0.26 | 25 | TUNNEL-14 | 57830.0 | 3 | 8.50 | 8.76 | 2212/28/01 | 2.621 | 2.676 | 2.607 | 6.830 | ----- | 0.889 | |
| 311 | 0.20 | 38 | TUNNEL-14 | 57830.0 | 3 | 12.00 | 12.20 | 2212/28/02 | 9.001 | 2.231 | 2.048 | 18.430 | ----- | 1.250 | |
| 312 | 0.30 | 56A | TUNNEL-14 | 57830.0 | 3 | 16.50 | 16.80 | 2212/28/03 | 3.17 | 2.572 | 2.493 | 7.900 | ----- | 0.883 | |
| 313 | 0.20 | 83 | TUNNEL-14 | 57830.0 | 3 | 23.60 | 23.80 | 2212/28/04 | 1.247 | 2.591 | 2.560 | 3.190 | ----- | 1.228 | |
| 314 | 0.40 | 112 | TUNNEL-14 | 57830.0 | 3 | 30.10 | 30.50 | 2212/28/05 | 0.217 | 2.921 | 2.915 | 0.630 | ----- | 3.714 | |
| 315 | 0.20 | 132 | TUNNEL-14 | 57830.0 | 3 | 34.00 | 34.20 | 2212/28/06 | 0.37 | 2.853 | 2.843 | 1.050 | 22.580 | ----- | |
| 316 | 0.25 | 168 | TUNNEL-14 | 57830.0 | 3 | 41.75 | 42.00 | 2212/28/07 | 0.631 | 2.795 | 2.778 | 1.750 | 61.283 | ----- | |
| 317 | 0.20 | 20 | TUNNEL-14 | 58010.0 | 4 | 8.70 | 8.90 | 2212/28/19 | 6.309 | 2.309 | 2.172 | 13.700 | ----- | 0.889 | |
| 318 | 0.25 | 45 | TUNNEL-14 | 58010.0 | 4 | 13.25 | 13.50 | 2212/28/20 | 9.552 | 2.432 | 2.220 | 21.200 | ----- | 0.884 | |
| 319 | 0.40 | 62 | TUNNEL-14 | 58010.0 | 4 | 18.00 | 18.40 | 2212/28/21 | 2.525 | 2.587 | 2.523 | 6.370 | ----- | 1.231 | |

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR ROCK )

| | |
|---|---|
| Doc. No. | RGTL/LAB/F.26 |
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |
| Rev. Date | --- |

**Project Name:-** Ratlam - Khandawa

**Rock Sample**

| Sr. No. | Core Length(m) | Core pc. No. | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Depth (m) | | Lab Sample ID | Water Absorption (%) (IS 1124:1974) | Bulk Density (gm/cc) (IS 13030:1991 | Dry Density (gm/cc) (IS 13030:1991 | Porosity (IS 13030:1991 | UCS (MPa) (IS 9143:1974) | Point Load Index (MPa) (IS 8764:1998) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | From | To | | | | | | | | |
| 320 | 0.15 | 78 | TUNNEL-14 | 58010.0 | 4 | 22.35 | 22.50 | 2212/28/22 | 3.612 | 2.688 | 2.594 | 9.370 | ----- | 0.876 | |
| 321 | 0.20 | 98 | TUNNEL-14 | 58010.0 | 4 | 26.00 | 26.20 | 2212/28/23 | 0.125 | 2.872 | 2.868 | 0.360 | ----- | 0.877 | |
| 322 | 0.20 | 147 | TUNNEL-14 | 58010.0 | 4 | 36.15 | 36.35 | 2212/28/24 | 1.069 | 2.685 | 2.656 | 2.840 | ----- | 0.884 | |
| 323 | 0.50 | 154 | TUNNEL-14 | 58010.0 | 4 | 38.50 | 39.00 | 2212/28/25 | 7.872 | 2.496 | 2.312 | 18.210 | ----- | 1.948 | |

**Name:** Priyanka Khandelwal
**Designation:** JGM
**Reviewed By**

**Name:** R.K.Nayar
**Designation:** Manager/GT
**Authorised By**

# RITES GEOTECHNICAL LABORATORY

## LABORATORY TEST REPORT (FOR SOIL )

| Doc. No. | RGTL/LAB/F.26 |
|---|---|
| Issue No. | 1 |
| Issue Date | March,1 2021 |
| Rev. No. | 0 |

| Project Name:- | Ratlam - Khandawa | | Receving date:- 18 10 2024 | | ULR NO: TC 1399024000000072F | | Soil sample |
|---|---|---|---|---|---|---|---|

| Sr. No. | Type of Sample | Bridge/Tunnel No. | Chainage no. | Bore hole no. | Lab Sample ID | Depth (m) | Soil Classification | MECHANICAL ANALYSIS (IS 2720 PART-4:1985) | | | CONSISTENCY LIMIT (IS 2720 PART-5:1985) | | | Silt factor | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Gravel (%) | Sand (%) | Silt + Clay (%) | Liquid Limit (%) | Plastic Limit (%) | Plasticity Index(PI) | | |
| 1 | DS | TUNNEL-5A | 19880 | 1 | 2403/21/87 | 0.50 | ML | 4 | 43 | 53 | ---- | N.P | ---- | | |
| 2 | DS-1 | TUNNEL-6 | 21150 | 1 | 2403/21/88 | 0.50 | ML | 8 | 40 | 52 | ---- | N.P | ---- | | |
| 3 | DS-2 | | | | 2403/21/89 | 1.50 | ML | 4 | 41 | 55 | ---- | N.P | ---- | | |
| 4 | DS | TUNNEL-4 | 17010 | 1 | 2412/79/22 | 0.50 | SM | 5 | 64 | 31 | ---- | N.P. | ---- | 1.554 | |
| 5 | DS | | 17550 | 2 | 2403/21/90 | 0.50 | ML | 5 | 43 | 52 | ---- | N.P | ---- | | |
| 6 | DS | TUNNEL-5A | 20040 | 2 | 2403/21/91 | 0.50 | ML | 3 | 43 | 54 | ---- | N.P | ---- | | |
| 7 | DS | TUNNEL-5 | 19090 | 1 | 2403/21/92 | 0.50 | ML | 3 | 45 | 52 | ---- | N.P | ---- | | |
| 8 | DS | TUNNEL-7 | 22580 | 1 | 2412/79/21 | 0.50 | SM | 32 | 55 | 13 | ---- | N.P. | ---- | 3.034 | |
| 9 | DS -1 | Tunnel No.08A | 31640 | 1 | 2412/79/20 | 0.50 | SM | 8 | 79 | 13 | ---- | N.P. | ---- | 1.877 | |
| 10 | DS -1 | | 32460 | 2 | 2410/72/28 | 0.50 | CL | 9 | 25 | 66 | 31 | 19 | 12 | 1.638 | |
| 11 | DS -1 | Tunnel No. 12. | 39810 | 2 | 2410/72/26 | 0.50 | SM | 8 | 55 | 37 | ---- | N.P. | ---- | 1.789 | |

| Abbreviation | |
|---|---|
| Non Plastic | N.P |

Reviewed By
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Designation: Eng./GT

End of Report

Name: R K Nayar
Designation M/GT