

SECTION-XI

TECHNICAL SPECIFICATIONS FOR SHOTCRETING WORK

11.1. Scope of the work

The Shotcrete work involves following operations. The contractor as to supply material, labour, equipment, tools and tackles transportation etc., require for finishing the work as per this specifications and as directed by Engineer in charge.

- a. Cleaning concrete / masonry / rock surface for guniting / shotcreting by sand blasting method and cleaning by air and water jets after sand blasting as per specifications including cost of all materials, machinery, labour, scaffolding etc., complete with all lead and all lifts.
- b. Providing and fixing 100 x 50 mm 10 gauge(3.8mm) non-galvanized weld mess to concrete / masonry surface including cost of all materials, machinery, labour, fixing weld mesh to exposed reinforcement bars or by driving rafter nails, scaffolding etc., complete with all leads and lifts.
- c. Shotcreting to Excavated rock surface on the downstream of the bucket/ as directed by engineer in charge with steel fiber reinforced shotcrete (SFRS), shotcrete having compressive strength shall be 25 N/mm² and thickness of 75mm and complete as per Drawing and Technical Specifications.

This technical specification covers the shotcreting in terms of materials used, placing, equipment required and pre constructional testing of shotcrete.

11.2. Applicable Publications

Shotcreting and its constituents, methods and procedures of manufacture shall conform to latest revisions of the following Indian Standard Specifications to the extent applicable and relevant for the work unless otherwise specified.

IS : 9012 - 1978	Recommended practice for shotcreting.
IS:456-1978	Indian standard code of practice for plain and reinforced concrete.
IS:9103 -1999	Specification for Concrete Admixtures.
IS:432-Part1-1982	Specification For Mild Steel And Medium Tensile Steel Bars And Hard-Drawn Steel wire For Concrete Reinforcement.

IS-1566-1982	Hard-drawn steel wire fabric for concrete reinforcement.
IS-1786-2008	High strength deformed steel bars and wires for concrete reinforcement.

11.3. Shotcrete and its Properties

Sprayed Concrete (i.e. Shotcrete or Guniting) is a mixture of cement, aggregate (fine and coarse) and water projected at a high velocity from a nozzle into place against an existing structure or formwork where it is compacted by its own velocity to produce a dense homogeneous mass.

The most commonly used terms are:

(a) Shotcrete, where the maximum size of aggregate is beyond 10 mm and less than 1/3 of the buildup thickness.

(b) Guniting (or shotcrete, as the case may be), where the maximum size of aggregate is 10mm or less and produces a high quality material.

The Shotcrete / Guniting shall have the following desirable properties:

- The shotcrete material applied should have Superior bonding ability properly applied. Shotcrete should be structurally sound and durable construction material which exhibits excellent bonding characteristics to existing excavated rock surface.
- Low water-cement ratio, resulting in high strength and low permeability.
 - The water cement ratio for shotcrete in place normally falls within the range of 0.35 to 0.50 by mass which is somewhat lower than for most conventional concrete mixes. However the contractor has to do preconstruction testing of the shotcrete mix design and arrive at necessary water cement ratio and slump required for proper spraying of the mix against excavated rock surface so that loss of the mix due to rebound is minimize.
 - The grade of concrete i.e. the characteristic compressive strength of 15 cm cube at 28 days should be specified. Shotcrete compressive strength shall be minimum 25 N/mm² as specified in drawings. The thickness of the shotcreting shall be minimum of 75mm.
- Pneumatically projected Shotcrete at high velocity onto a backing surface generates the force of spraying action that leads to compaction of the concrete or mortar which then forms layers of concrete to the required thickness. This mechanism reduces the rebound waste that occurs through the shotcreting process.
- The shotcreting work should be in such a quality that it should withstand resistance to weathering and many other types of chemical attack and should be good abrasion resistance.
- Good refractory properties/withstand high temperatures of the weather by using proper aggregates.
- Shotcrete lends itself to the production of many shapes and thin sections with a minimum or no formwork at all.

11.4. SHOTCRETE MATERIALS

- a. **Cement**- Ordinary Portland cement of grade 43 or of higher grade relevant IS codes shall be used.
- b. **Aggregates**- Fine and coarse aggregates for shotcrete shall comply with the requirements given in IS: 383-1970 and graded evenly from fine to coarse as per Zone II and Zone I-II grading.
- c. **Water** -Water used for shotcrete shall conform to the requirements of IS: 456-1978.
- d. **Admixture**- Admixture when used, shall meet the requirements of IS: 456-1978 and IS: 9103-1979.
- e. **Reinforcement** - Reinforcing bars if used' shall conforms to IS: 1566-(1962). Hard drawn steel wire fabric bars.

11.5. Shotcreting Process

The two basic shotcreting processes are: a) Dry mix process, and b) Wet mix process.

- a. **Dry Mix Process** - The dry mix process is particularly favoured for repair work because the mix in its dry form can be batched as required and kept in stock at site prior to start of the shooting is unavoidable.

In this system materials like cement, sand or coarse aggregate is batched at site without addition of water. In case it is decided to use powder accelerator, the same shall be mixed with the above prebatched material and to keep at site in dry condition prior going for shooting.

The dry mix process shall consist of

- Thoroughly mixing the dry materials,
 - Feeding of these materials into mechanical feeder or gun,
 - Carrying the materials by compressed air through a hose to a special nozzle,
 - Introducing water at nozzle point and intimately mixing it with other ingredients at the nozzle;
 - Jetting the mixture from the nozzle at high velocity on to the surface to receive the shotcrete.
- b. **Wet Mix Process** - The wet mix process is a technique where a pre-batched mix of cement, aggregate and water is transported to the site and pumped to the nozzle by a concrete pump through flexible hoses (or pipes).

The wet mix process shall consist of

- Thoroughly mixing all the ingredients with the exception of the accelerating admixture, if used;
- Feeding the mixture into the delivery equipment;

- Delivering the mixture by positive displacement or compressed air to the nozzle;
- Jetting the mixture from the nozzle at high velocity on to the surface to receive the shotcrete.

Detailed process of shotcreting shall conform to IS Specification 9012-1979.

11.6. Preconstruction Testing

The mix proportions, grading and quality of aggregate, amount and quality of reinforcing steel mesh, position of the work, design and condition of delivery equipment, and the quality of workmanship all these factors affect the quality of shotcrete placed. Hence a laboratory investigation shall, therefore, be carried out prior to the commencement of the work in order to check the operation of the equipment and the skill of the operating staff, and also to verify that the specified quality of shotcrete materials and the methods to be adopted in the structure before proceeding with the actual field operations. The shotcrete concrete cubes may be casted of required strength at the placement site and tested during the work. The mix design tests at the laboratory prior to placement is most essential for the quality of work expected in the structure. The procedure for preconstruction testing shall be as recommended in IS 9012-1979.

11.7. Equipment

Dry Mix Process

- Batching and Mixing Equipment** - Batching by mass is to be preferred and is strongly recommended.
- Delivery Equipment or Guniting Equipment** - The delivery equipment shall comply with the requirements given in IS 6433-1972.
- Air Supply** - Properly operating air compressor of ample capacity is essential for a satisfactory shotcreting operation.
- Water supply** - The water pressure at the discharge nozzle shall be sufficiently greater than the operating air pressure to ensure that the water is intimately mixed with the other materials.

Wet Mix Process

- Batching and Mixing Equipment** -Batching by mass is to be preferred and is strongly recommended. Aggregates may be batched by volume if periodic checks, are made to ensure that the masses are maintained within a required tolerance. Water may be batched either by mass or by volume.

- b. **Delivery Equipment** -The pneumatic feed type of wet mix delivery equipment is capable of applying high quality, low-slump mortar or concrete with the reliability needed for general construction and repair work.
- c. **Air Supply** -The air compressor shall be capable of keeping up a supply of clean air adequate for maintaining sufficient nozzle velocity for all parts of the work and for simultaneous operation of a blow pipe for clearing away rebound.

Detailed equipment for shotcreting shall conform to IS Specification 9012-1979.

11.8. Application of shotcrete

- a. **Preparation of Surface** - A good base or foundation is necessary for proper and successful application of shotcrete. Where the shotcrete is to be placed against rock excavation surfaces which are uneven at the dam downstream of the bucket energy dissipating arrangements /at other places as directed by the engineer in charge shall first be thoroughly cleaned by sand blasting, wire brush and wire brooms and using air and water jets. The rock joints shall be trimmed to line and grade.
- b. **Formwork** – wherever the shotcreting surfaces require formwork operations and otherwise for proper spraying of the shotcrete materials, the Contractor has to arrange suitable formwork plywood other suitable scaffoldings materials required for the work. Care shall be taken to avoid sand pockets behind the reinforcement. Adequate and safe scaffolding shall be provided so that the operator can hold the nozzle at the optimum angle and distance from the surface for all parts of the work. Scaffolding shall be constructed to permit uninterrupted applications of the shotcrete wherever possible.
- c. **Reinforcement** – Reinforcement mesh used shall conform to welded wire fabric conforming to IS: 1566–1982 also may be used. Depending on the thickness and nature of the work, reinforcement may consist of welded wire fabric. Where exceptional care shall be taken in encasing the mesh due to uneven rock surfaces with the shotcrete. The soundest shotcrete will be obtained when the reinforcement steel is suitably placed to cause the least interference with placement of shotcrete material. The Contractor has to provide with Steel fiber reinforced micro silica along with the shotcrete mix at the time of spraying to the surface.

- d. **Alignment Control** - Adequate ground nails may be fixed to install the wire mesh to the shotcreting surface in order to get the required thickness of the shotcreting. To establish the required thickness and surface planes of the shotcrete build-up, both horizontal and vertical ground nails shall be embedded/drilled in to the rock at corners and offsets which are not clearly fixed by the formwork. Ground wires shall be tight and true to line, and placed in such a manner that they may be further tightened.
- e. **Placing the Shotcrete** - Each layer of shotcrete is built up by making several passes or loops of the nozzle over the working area. This may be done by moving the nozzle rhythmically in a series of loops from side to side and up and down.
- f. **Rebound** - Rebound is aggregate and cement paste which bounces off the surface during the application of shotcrete due to collision with the hard surface, reinforcement, or with the aggregate particles themselves.
- g. **Preparation for Succeeding Layers** - Where a layer of shotcrete is to be covered by a succeeding layer, it shall first be allowed to take its initial set.
- h. **Finishing** - The natural gun finish is normally preferred from both the structural and durability considerations.
- i. **Suspension of Work** - The application of shotcrete shall be suspended in condition of likely exposure to high winds, freezing or rain.
- j. **Curing** -- Good curing is particularly important for the very thin sections, rough surfaces, and mixes of low workability normally associated with shotcrete. Hence the contractor has to arrange necessary equipment and men and material for curing the shotcrete surface for it is generally recommended that surfaces be kept continuously wet for at least 7 days.
- k. **Quality Control** - Quality control of shotcrete is more difficult than for conventional concrete since it is affected not only by the accuracy of batching but also by the skill and continued care of the crew applying shotcrete.
- l. **Inspection** - The shotcreting operation shall be continuously inspected by a qualified supervisor who shall check materials, forms, reinforcing, ground wires, delivery equipment, and application of material, curing, and protection against high or low temperature.

Detailed application of shotcreting shall conform to IS Specification 9012-1979.

11.9. Skill of operator

The quality of shotcrete depends to a great extent on the skill of the operator in much the same way as the quality of a weld depends on the welder. The foreman, nozzleman, and delivery equipment operator shall be experienced in similar capacities for a sufficient period to be fully qualified to perform his duties as recommended in IS 9012-1979.

The Contractor has to arrange all the necessary equipment and processes involve for the finishing of the work in an engineering manner. The Contractor has to access the requirements for complete finishing of the work and quote his rate suitably.

11.10.Measurement and payment:

Payment as per payment schedule

SECTION XII DRILLING AND GROUTING

12.1. SCOPE

This specification covers the items of,

i) Drilling holes of 45mm to 50mm diameter vertical or inclined up to 10° to vertical in all formations of rock / concrete / masonry/soil by percussion drilling using wagon drill or any other suitable machinery for consolidation/Blanket grouting including flushing and cleaning the hole with air and water at required pressure. Including conducting water loss tests in the holes by suitable double Packers before grouting and after grouting to know the efficacy of grouting work .

ii) Grouting the holes with cement grout at specified pressure for consolidation grouting.

12.2. APPLICABLE PUBLICATIONS

All methods and procedures for drilling, water loss tests and grouting shall conform to the latest revisions of the following Indian Standard Specifications.

IS: 1489	Portland pozzolana cement. (Fly ash based)
IS: 5229 (Part 2)	Code of practice for insitu permeability tests in rock bed.
IS: 6066	Recommendations for pressure grouting of rock Foundations in river valley Project
IS: 8112	43 grade ordinary Portland cement.

12.3. PATTERN OF DRILLING FOR GROUTING

The pattern of drilling and grouting shall be as decided by the Engineer. The grouting operation shall always be started from the side towards which the seams dip, so that the trapped air may be more easily forced out. This can be decided on the basis of field conditions assessed by the Engineer whose decision shall be final. Adequate lighting shall be provided and maintained by the Contractor during the night operations, which shall be subject to the approval of the Engineer. Communication facilities between grout plant and location of holes shall be provided by the Contractor where required by the Engineer.

12.4. SELECTION OF HOLES

The actual location, spacing, inclination and depth of grout holes will depend on the nature of the rock, and its dip and strike direction, jointing pattern, height of the water to be retained, loads from the super structure etc and shall be as directed by the Engineer. The order in which the holes are to be drilled and the manner

in which each hole is to be drilled and grouted, the proportions of cement and water to be used in grout, the type and quantity of admixture to be used, the time of grouting, the pressure to be applied for grouting, the depth at which the packers are to be fixed and all other details of the grouting operations shall be as directed by the Engineer. The grout holes shall be water tested and grouted in sections or stages located between depths in the hole best suited to treat the geological defects of the foundation as determined by the Engineer or his authorised representative. All pressure grouting operations shall be performed in the presence of the Engineer. The stage depths for grouting holes shall be generally 3 m. However, the same shall be increased or decreased, if necessary, in accordance with the site and geological conditions encountered or as directed by the Engineer. consolidation grouting /Blanket grouting shall be taken up from open area after The foundation bed area is cleaned and final design excavation level are reached prior to laying of bed concrete . At all locations, the drilling and grouting shall be carried out and completed before placing any reinforcement and concrete, as directed by the Engineer.

The cost of all machinery, labour and materials required for drilling, flushing the grout holes and pressure grouting, conducting water loss tests with packers shall be deemed to be included in the unit rates quoted for the respective items in the 'Bill of Quantities '

Grouting shall be accomplished from the final foundation excavation level. The holes shall be further drilled in rock by approved percussion drilling equipment. The holes shall be drilled vertical or inclined as directed. Percussion drilling shall be by pneumatic type of equipment having both linear impact as well as rotary motion, and shall be capable of producing well-rounded holes. Percussion drills are to be equipped with constant water flushing arrangement at the bottom of the holes being drilled. Adequate supply of water shall be ensured from time to time to wash the holes being drilled. The rate for drilling shall be deemed to be inclusive of cost of each washing. Drilling equipment and techniques shall be such as to minimize chances of holes cave in or become oversize. In case any part of hole caves in after drilling, re-drilling shall be carried out by the Contractor without any extra charges. Water used for drilling shall be clear water. If drilling bit or rod is jammed in any hole at any stage, such hole shall be abandoned. No payment shall be made for drilling, washing and grouting carried out for such holes. The contractor shall have to drill fresh hole adjacent to the abandoned hole and complete it in all respects as directed by the Engineer.

The diameter of grout hole shall not be less than 40mm for consolidation grouting. Unless otherwise directed, grout holes shall be spaced widely and shall be drilled and grouted. Using this procedure, the drilling and grouting of all holes shall be completed with such final spacing of holes as the grouting results shown to be necessary. After holes in a region have been drilled and grouted and as the construction work progresses, the condition of the surrounding foundations or the development of leakage shall be observed and additional holes be drilled and grouted. No allowance above the unit rates tendered for the items in the ` Bill of

Quantities' will be made for drilling such holes or for the expense of moving the equipment to other operations area and returning them to a previously drilled area.

Each grout hole shall be drilled to its full depth or stage depth and grouted in stages up or down. Where necessary, because of the rock joints and / or type of strata encountered during the drilling, the grout hole shall be drilled and grouted in successive operations by stages down from the collar of the hole. The method of grouting, stage up or stage down, shall be as directed by the Engineer. In case of stage up grouting, minimum interval of 6 hours be kept between grouting of successive stages in the same hole. Similarly, 24 hours minimum time shall be allowed between grouting of successive stages in the same hole when stage down method is adopted. Where stage down grouting is directed, redrilling required because of the contractor's failure to clean out a hole before the grout has set shall be by and at the expense of the contractor. No allowance above the unit rates tendered for in the 'Bill of Quantities' for drilling grout holes in stages will be made because of the need for interrupting the drilling of holes to permit grouting, for cleaning out holes before further drilling, or for any amount of movement of equipment that may be necessary due to such successive stage grouting.

When the drilling of each hole or stage of hole has been completed, clean water shall be circulated through the hole until it is flushed free of drill cuttings. The hole shall then be temporarily capped or otherwise suitably protected to prevent the hole from becoming clogged or obstructed until it is grouted. Any hole that becomes obstructed before it is grouted shall be opened by and at the expense of the contractor.

12.5. WASHING OF DRILLED HOLES

Upon completion of drilling the holes as per approved pattern and before water testing or grouting is commenced, each hole shall be thoroughly washed with water and air under required pressure or as directed by the Engineer to remove any accumulated sludge of drilling or cuttings. The time of washing shall be about 20 minutes for each stage and may be varied by the Engineer. After completing the drilling of holes to the required depths, water shall be allowed to run in the holes until returning water at the top of holes is reasonably clear of sludge and mud. If reasonably clear water does not emerge even after 10 to 15 minutes, the drill rod is to be removed and the holes washed with a blow pipe of about 12mm diameter with flattened lower end having two way connection at the upper end so that alternate jets of water and compressed air can be sent for washing each hole and for quickly switching off the flow from one to another so as to produce turbulent action necessary to dislodge the material. It is desirable to bend lower portion of pipe by 90° so as to have the jet directly impinging on the walls of the holes. By raising and lowering the blowpipe and by sending alternate jets of water and compressed air, the seams and cracks in the rock surrounding the holes shall be thoroughly cleaned. The washing shall be continued till the loose material is removed from the seams and crevices and till all the possible interconnections established between adjacent holes are

cleaned. It shall also be continued till the colour of the effluent disappears. The pressure of air and water applied for washing shall be limited to the specified grouting pressure. However, the actual pressure of application for washing of any individual hole shall be determined on the site as revealed from the experience gained on previously completed holes.

Holes taking water freely shall be washed for reasonable length of time, where out flow occurs from adjacent holes. After cleaning the hole it shall be capped. The connected holes shall be blown clear off any muck, which may have been washed and settled below the seams. For any hole, the washing shall usually be done just before grouting. Final washing shall not be completed too far in advance of grouting and shall be done as the last operation preparatory to grouting. Before the grouting of a hole is taken up, the adjoining holes shall be kept clean so that they will be ready for grouting in case they are found connected with a grouted hole.

12.6. WATER LOSS TESTS

3.7.1 Selected stages in grout holes shall be water tested to determine initial grout mix as well as grout pressures to be applied and to ascertain the effectiveness of grouting treatment. If the ground water level in the vicinity of the hole is below the collar level of the hole, the hole, after washing and before conducting the water loss test, shall be saturated by allowing continuous flow of water for not less than 24 hours. After the hole is saturated, the water loss tests shall be carried out by keeping double packers at top of the respective stages being tested. If it is not possible to keep the packer at the top of the respective stage effectively, the test shall be carried out by keeping the packer at the top of the hole. In such an event suitable correction has to be effected while computing the water loss in the particular stage. Alternatively, the inflatable type packer may be used in such cases if directed by the Engineer. The water tests shall be cyclic. The tests shall consist of a series of simple tests performed in succession in accordance with IS: 5229 (Part 2) and IS: 6066. Water loss for specified duration shall be measured in the same stage at varying pressures, usually in the ratio $P/3$, $2P/3$, P , $2P/3$, $P/3$ where 'P' represents the maximum safe pressure for that stage or 1 kg/sqcm, whichever is lower. The water loss max pressure shall be calculated as under;

In simple tests water at the prescribed pressure shall be continuously pumped into the hole until measurements taken at an interval of 10 minutes indicate that the rate of absorption has become constant for a minimum period of 10 minutes. The results of water loss shall be expressed in lugeons, that is, liters per metre, per minute, at a pressure of 10 kg/sqcm in accordance with IS:6066. For homogeneous strata the lugeon coefficient of 1 is approximately equivalent to permeability of 10^{-5} cm/second. When the test pressure is less than the standard pressure of 10 kg/sqcm test results at different pressures may be converted to standard pressure on a linear scale but a specific mention of such conversion shall be made in the records.

3.7.2 Water loss tests shall be carried out in holes before grouting to assess pre - grouting permeability of the rock and to decide proportion of initial grout mix. Tests carried out in secondary and tertiary holes will indicate post grouting permeability and effectiveness of grouting in primary/secondary holes. Tests carried out in an individual test hole in a grouted zone will indicate the effectiveness of the grouting already carried out in the holes located around it. Test holes drilled for this purpose shall be located midway between the grouted holes or as directed by the Engineer. Water loss tests shall be carried out in any or each stage as directed before grouting to find out whether grouting of that stage can be omitted. It shall provide information about the effectiveness of grouting already done and the necessity or otherwise of further grouting.

3.8 PRESSURE GROUTING

3.8.1 General

The grout mix for pressure grouting shall be composed of mainly cement and water in proportion as specified by the Engineer.

3.8.2 Materials

i) Cement

Cement shall be ordinary Portland cement conforming to IS: 8112. However the Contractor may use 53-grade cement conforming to IS: 12269 at no extra cost to the Employer.

ii) Water

Water shall meet the requirements as indicated in the Technical Specification No. 05.

iii) Additives

The decision to use any commercially available additives, shall be governed by field conditions and approved by the Engineer.

3.8.3 Plant And Equipment

The Contractor shall provide all Plant and Equipment required to mix and pump the grout into the various stages of the grout holes. The apparatus for mixing and pumping grout including circulating line and fittings shall be of a type and size approved by the Engineer and shall be capable of effectively mixing and stirring the grout and forcing it into the grout connections in a continuous flow at any specified pressure up to a maximum of 3 kg/sqcm measured at the collar of the hole. Water supply to the mixer shall be adequate at all times to provide the required pumping rate.

The mixer shall be suitable for properly mixing the cement with the water to remove any air attached to the particles of cement and to ensure thorough wetting. Different impeller shapes be used when sand, rock dust

or other additives have to be incorporated in the cement slurry. In addition to the grout mixer, a holdover mechanical agitator tank similar in volume to the mixer shall be provided. The drain valve from mixer to agitator shall be adequate in size so as to regulate the injection rate. A suitable measuring device shall be equipped to measure the quantity of water, cement and other admixtures, if any, to be mixed. Screens shall be provided to remove from the grout entering either from the mixer or from the return line any hardened grout or foreign materials not passing 150 micron IS sieve in case of cement grout and 1.18 mm IS sieve in case of sand mixed grout is pumped. All grout shall be pumped with a helical screw rotor type pump or a double acting-reciprocating pump. The helical screw rotor type pump shall have a minimum capacity of 100 litres per minute at a pressure of 7 kg/sqcm. The double acting-reciprocating pump shall have a minimum capacity of 30 litres per minute at a pressure of 10 kg/ sqcm. A standby grouting equipment shall be maintained in a satisfactory manner and shall be capable of continuous and efficient performance during grouting operation. Grout holes abandoned due to faulty equipment shall be at the Contractor's expense. The arrangement of the grouting equipment shall be such as to provide a supply line and return line from the grout pump to grout hole. A manifold consisting of a system of valves and a pressure gauge shall be located in the line at the collar of the hole to permit continuous circulation, accurate control of grouting pressure, and regulation of flow into the grout hole. The minimum size of the supply line, return line and manifold, including valves and fittings shall be 25mm inside diameter. When sand, rock dust or other additives are required to be incorporated in cement grout, the diameter of the supply line, return line and manifold including valve and fitting shall be suitably increased so that such grout can be conveniently pumped for grouting of foundation. A pressure gauge shall also be placed in the discharge(supply) line at the grout pump. Pressure gauges shall be equipped with gauge savers when pumping grout and the gauge shall be checked frequently to ensure accuracy.

The grout pump shall be so located above the collar of the hole, where practicable, to prevent pressure head in the line from exceeding the allowable grouting pressure at the collar of the hole.

The contractor shall keep in stock at all times, sufficient number and variety of packers to accomplish the grouting. The packers shall consist of pneumatic tubes or expansible rings of rubber, leather or other suitable material attached to the end of the grout supply pipe. The packer shall be so designed that they can be expanded to seal the drill holes, capable of withstanding water pressure equal to maximum grout pressures to be used.

3.8.4 Grouting Procedure

Each grout hole shall be drilled to its full depth/stage depth and shall be grouted in stages of depth not more than 3m up/down. Based on the condition of the strata the stage depth can be reduced or increased as directed by the Engineer. Where necessary because of substantial drill water loss due to rock jointing and /or type of strata encountered during the drilling, the grout hole shall be drilled and grouted in successive operations by stages down from the collar of the hole. The method of grouting stage up or stage down shall be as directed by the Engineer.

Where stage up grouting of a hole is directed by the Engineer, the grouting shall be performed by attaching a packer to the end of the grout supply pipe, lowering the grout supply pipe into the hole to the top of the bottom section that is required to be grouted, grouting at the required pressure, allowing the packer to remain in place until there is no back pressure, withdrawing the grout supply pipe and packer to the top of the next higher section that is required to be grouted, and thus successively grouting the entire hole in stages at the specified grouting pressures. In case of stage up grouting, minimum interval of 6 hour be kept between grouting of successive stages in the same hole.

Wherever stage down grouting is necessary, as determined by the Engineer, the drilling and grouting shall be performed in successive operations, consisting in each case, drilling the hole to the required depth, flushing and grouting that section, cleaning out the grout hole by washing or other suitable means after the grout in the hole attains its initial set but before it attains its final set, drilling the hole to an additional depth, flushing and grouting by fixing packer near the bottom of the previously grouted stage, and thus successively drilling and grouting the hole in stages at various depths until the required depth of hole is completely drilled and grouted. Sufficient time lag shall be kept between the completion of grouting for the previous stage and the commencement of grouting for the next stage as directed by the Engineer. Pressure as high as practicable and as determined by trials, but safe against rock or concrete displacement shall be used in grouting. Different grouting pressure may be required for grouting different sections of the grout holes. 24 hours minimum time shall be allowed between grouting of successive stages in the same hole when stage down method is adopted.

If, during grouting of any hole, grout is found to flow from adjacent grout hole in sufficient quantity to interfere seriously with the grouting operations or to cause appreciable loss of grout, such connections shall be capped with valves to allow intermittent bleeding. When grouting is being done with packers, the pressure of the grout returning from any adjacent hole shall be measured by seating a packer in the adjacent hole immediately above the point where the grout is entering and such pressure shall be kept below the allowable pressure for the stage of that hole. Where seating a packer or capping is not essential, adjacent holes shall be left open to facilitate the escape of air and water as the grout is forced into other holes. Before the grout

has set, the grout pump shall be connected to holes from which grout flow was observed, and grouting of all holes shall be completed at the pressure specified for grouting. If during the grouting of any hole grout is found to flow from points in the foundations or any parts of concrete structures, such flow or leak shall be plugged or caulked by the Contractor as directed by the Engineer. The grouting of any hole shall be carried out to refusal or grout intake less than one litre per minute under permissible grouting pressure. The maximum permissible grouting pressure shall not exceed 3 kg/sqcm under any circumstances. So far as practicable, the full grouting pressure shall be maintained during grout injection. As safeguard against rock or concrete displacement or while grout leaks are being caulked, the Engineer may require the reduction of pumping pressure or the discontinuance of pumping. Where the grout hole or grout connections take a large amount of grout, the Engineer may require that grouting be done intermittently, waiting for a period of 8 hours or more between pumping periods to allow grout in the formation to set. After the grouting of holes or connection is completed, the pressures shall be maintained by means of stopcocks or other suitable valve devices until the grout has set sufficiently so that it will be retained in the holes or connections being grouted. The consistency of the grout mix shall be varied as directed by the Engineer depending on the conditions encountered. The thickening of the mix during grouting operations shall be done in scientific manner on studying the behaviour of the hole and as directed by the Engineer. The contractor shall install upheaval gauges as directed to measure any movement /upheaval of the rock taking place because of excess pressure applied for injecting the grout .

All the completed grout holes shall be filled up to the top of the hole with thick mix of cement mortar in proportion of 1:3 by weight.

3.8.5 GROUTING AND WATER TEST RECORDS

Records of drilling, grouting and testing etc shall be maintained by the Contractor neatly, systematically in the manner approved by the Engineer. The exact locations of all holes in relation to proper reference lines and accurate logs of all operations shall be detailed in the records. Records, maps and sections shall indicate all stages, connections of holes grouted. All information regarding the grouting operations, amount of grout intake, effects observed in the surrounding holes or rock etc, observations about the behaviour of the holes under air and water pressure, appearance of wash water, quantity and proportion of grout used, time and pressure of grouting applications shall be noted for each hole. A copy of such records shall be submitted to the Engineer daily during drilling and grouting operation. The cost of this shall be deemed to have been included in the unit rate tendered for drilling and grouting items in 'Bill of Quantities'.

3.8.6 MEASUREMENT AND PAYMENT

3.8.6.1 Drilling Grout Holes

Payment of drilling holes for consolidation grouting will be made for the actual depth of holes drilled into the foundation or concrete as per the direction of the Engineer for foundation grouting. Stage depths of drilling grout holes will be measured from the collar of the holes at the exposed surface of the rock in running meter .

However, Payment for drilling grout holes will be made at the unit rate tendered in the 'Bill of Quantities' which shall include cost of furnishing all labour, materials, tools and equipment required for drilling the holes, maintaining the holes free from obstructions until grouted, and all incidental works connected therewith, in accordance with the specifications. The unit rate shall also include cleaning of all the holes before the grout has set and the drilling for the next stage is taken up for stage grouting. No payment shall be made, for re - drilling if required because of Contractor's failure to clean out a hole before the grout has set. The unit rate shall also include the cost of interruptions in drilling operations due to cleaning out holes before further drilling, to any amount of movement of equipment that may be necessary due to successive stage grouting. The unit rate shall also include mobilisation and de - mobilisation of all men and machinery, cost of dewatering, drainage, desilting, protective works etc., with all leads and lifts. The unit rate for also include the cost of flushing and cleaning of holes before grouting. conducting water loss tests at different stages .

3.8.6.2 Grouting

Payment of grouting will be made on the basis of weight of cement in dry state actually forced into the holes. The unit rate shall include all expenditure on labour, materials, mobilising and de - mobilising equipment required for carrying out satisfactory grouting work. The unit rate shall also be inclusive of cost of clearing of the site before and after the grouting work, plugging of grout holes with cement mortar, treatment of surface leakage and preparation, maintenance and submission of records and all other incidental operations connected therewith in accordance with the specifications. The unit rate shall include the pipes, fittings, and other fixtures, packers, gauges etc., required for grouting. The unit rate shall also include the cost of repeated movement and installation of equipment required for grouting from time to time due to successive stage grouting. The unit rate shall include necessary dewatering, desilting, protective works, drainage with all leads and lifts. The unit rate quoted per tonne of cement for grouting shall include cost of transportation, storing, handling, mixing, adding additives if any. Grout mix with or without additives rejected because of any reasons such as clogging, spilling, improper mixing, improper operation procedure or failure of equipment or negligence of the contractor will not be measured and paid.

The contractor has to make arrangements for transportation, loading and unloading, stacking, storing handling of cement/additives at work site at his own cost.

3.8.6.3 Flushing and Conducting Water Loss Tests

Payment for flushing and conducting water loss test will be made on the basis of running metre. Basis carried out irrespective of depth of holes or the part depth of holes suggested for the test. Payment will be made once only for each flushing and water loss test of a stage of a hole for which water loss testing is directed by the Engineer regardless of the number of times that water under pressure is applied to the hole or re - applied following caulking, surface leaks or because of any other reason which prevents a satisfactory test being completed at the first attempt. Payment for flushing and water loss tests for grout holes will be made at the unit rate tendered therefor in the 'Bill of Quantities'. The unit rate shall include the pipes, fittings, and other fixtures, packers, gauges etc., required for conducting water loss tests. The unit rate shall include the cost of all labour, materials and equipments required to perform the work and all other incidental works including saturation of holes before water loss test connected therewith in accordance with the specifications, including dewatering, desilting, protective works etc., complete with all leads and lifts.

3.8.6.4 Measurement and payment:

Payment as per payment sched

