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VOLUME-2

TUNNEL-9 TO TUNNEL-14 (Ch: 34+140-57+990)m DESIGN DOCUMENT

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1 Regional Geology of Tunnels :

1.1 TUNNEL- 9:

S. No	Feature	Chainage (Km)	Length of tunnel(m)
1	Portal-1 and adjoining area	34+140	1470
2	Portal-2 and adjoining area	35+610	

The proposed alignment of Tunnel T9 between Km 34+140 and Km 35+610 is passing through rocks belonging to Deccan Trap of Upper Cretaceous to Paleocene. Mainly Basaltic Lava Flow (Deccan Trap) is reported all along the tunnel length.

The general trend of rock mass exposed along the entire tunnel alignment in the area is varying from N70-80°E – S70-80°W & N80°W – S80°E with dip varying from 10-15° towards North.

Portal P1 and adjoining area:

The proposed Portal 1 of T9 is located at flat ground conditions towards portal and covered with less cover slope wash cum slope debris material & dense vegetation/forest.

Bedrock is not exposed in the vicinity of portal area and along the hill slope, but it may be encounter at shallow depth. Overburden materials i.e., slope wash cum slope debris materials is recorded near portal 1 location.

The proposed tunnel portal 1 has adequate vertical & lateral overburden & suitable for portal location. Seepage is also not observed near the proposed tunnel portal.



Figure 1 Portal 1 area is located at flat top along with forest cover & hill slope debris materials.



Figure 2 Portal 1 area is located at flat top along with forest cover & hill slope debris materials & big size of boulders.



Figure 3 Proposed portal P1 at flat topped & area is covered with forest & debris materials.



Figure 4 Near proposed portal P1 area is covered with dense forest & hill slope debris materials.



Figure 5 Near proposed portal P1 area is covered with dense forest & hill slope debris materials & big size of boulders.

The upslope area has also occupied by forest cover/vegetation and having flat slope towards portal. The portal slope area of proposed portal is covered with less slope debris cum hill slope wash material (overburden materials) represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt and other rock fragment mixed with soil matrix.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal location. The bedrock is not recorded at portal location, but it may be encounter at shallow depth.

Section Between Portal P1/T9 and Portal P2/ T9:

The area between Portal 1 to Portal 2 of proposed T9 tunnel alignment passes through hill with flat to gentle slope and area covered with slope wash cum slope debris material & vegetation/ forest cover. Maximum part of the corridor is covered with less/thin overburden material which is unconsolidated to semi consolidated in nature and the visually estimated ratio between the coarse: fine fraction is 40:60 respectively. Seepage is not observed between proposed tunnel

portal 1 & portal 2. The bedrock Basalt is not recorded/present in between Portal P1/T9 and Portal P2/T9, but it may be encounter at shallow depth (2-3m).



Figure 6 Flat topped & area is covered with forest & debris materials between P1 & P2 of Tunnel 9.



Figure 7 Flat topped & area is covered with forest & debris materials between P1 & P2 of Tunnel 9.



Figure 8 Flat topped & area is covered with forest & debris materials between P1 & P2 of Tunnel 9.



Figure 9 Flat topped & area is covered with forest & debris materials between P1 & P2 of Tunnel 9.



Figure 10 Flat topped & area is covered with forest & debris materials between P1 & P2 of Tunnel 9.



Figure 11 Flat topped & area is covered with forest & debris materials between P1 & P2 of Tunnel 9.

Portal P2 and adjoining area:

The proposed Portal 2 of T9 is located at steep to very steep hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, dense vegetation/dense forest cover. Rock exposures are not noticed in the vicinity of portal 2

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal location. Overburden materials i.e., slope wash cum slope debris materials are recorded near portal 2 location. The bedrock is slightly to moderately weathered nature near portal location.



Figure 12 Proposed portal P2 area is covered with dense forest, hill slope debris materials & big size boulders of Basalt



Figure 13 Proposed portal P2 is located at steep slope area and covered with dense forest, thick overburden materials.



Figure 14 Proposed portal P2 is located at steep slope and covered with dense forest, thick overburden materials & big size of boulders



Figure 15 Proposed portal P2 is located at steep slope and covered with dense forest, thick overburden materials & big size of boulders.



Figure 16 Proposed portal P2 is located at steep slope and covered with dense forest, thick overburden materials & big size of boulders.



Figure 17 Proposed portal P2 is located at steep slope and covered with dense forest, thick overburden materials & big size of boulders.

The upslope area has also occupied by thick forest cover/vegetation and having moderate to steep slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt and other rock fragment mixed with soil matrix.

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not exposed near the portal location, but in-situ rock may be encountered at shallow depth.

1.2 TUNNEL- 10:

S. No	Feature	Chainage (Km)	Length of tunnel(m)
1	Portal-1 and adjoining area	36+820	400
2	Portal-2 and adjoining area	37+220	

The proposed alignment of Tunnel T10 between Km 36+820 and Km 37+220 is passing through rocks belonging to Deccan Trap of Upper Cretaceous to Paleocene. Mainly Basaltic Lava Flow (Deccan Trap) is reported all along the tunnel length.

The general trend of rock mass exposed along the entire tunnel alignment in the area is varying from N70-80°E – S70-80°W & N80°W – S80°E with dip varying from 10-15° towards North.

Portal P1 and adjoining area:

The proposed Portal 1 of T10 is located at steep hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, thick vegetation/dense forest cover and no rock exposures is recorded.

Bedrock is not exposed at vicinity of portal area and along the hill slope, but it may be encounter at shallow depth. Overburden materials i.e., slope wash cum slope debris materials is recorded near portal 1 location.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal location. Seepage is also not observed near proposed tunnel portal.



Figure 18 Proposed portal P1 area is covered with dense forest, slope debris materials & big size of boulders of Basalt



Figure 19 Prosed portal P1 area is covered with dense forest, slope debris materials & big size of boulders of Basalt.



Figure 20 Prosed portal P1 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 21 Proposed portal P1 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 22 Proposed portal P1 area is covered with dense forest cover along the hill slope.



Figure 23 Big size of boulders of Basalt are present at top of portal area.

The upslope area has also occupied by thick forest cover/vegetation and having moderate to steep slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt rock fragment mixed with soil matrix. The visually estimated ratio of the coarse: fine material is 80:20 respectively.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not exposed near the portal location, but in-situ rock may be encountered at shallow depth.

Section Between Portal P1/T10 and Portal P2/T10:

The area between Portal 1 to Portal 2 of proposed T10 tunnel alignment passes through hill with flat to gentle slope and area covered with slope wash cum slope debris material & vegetation/ forest cover. Maximum part of the corridor is covered with less/thin overburden material which is unconsolidated to semi consolidated in nature and the visually estimated ratio between the coarse: fine fraction is 40:60 respectively. Seepage is not observed between

proposed tunnel portal 1 & portal 2. The bedrock Basalt is not recorded/present in between Portal P1/T10 and Portal P2/T10, but it may be encounter at shallow depth (2-3m).



Figure 24 Flat topped & area is covered with forest & debris materials between P1 & P2 of Tunnel 10.



Figure 25 Flat topped & area is covered with forest & debris materials between P1 & P2 of Tunnel 10.



Figure 26 Flat topped & area is covered with forest, debris materials & big size of boulders between P1 & P2 of Tunnel 10



Figure 27 Flat topped & area is covered with forest, debris materials & big size of boulders between P1 & P2 of Tunnel 10



Figure 28 Flat topped & area is covered with forest & debris materials.



Figure 29 Flat topped & area is covered with forest, debris materials & big size of boulders between P1 & P2 of Tunnel 10.



Figure 30 Flat topped & area is covered with forest & debris materials.

Portal P2 and adjoining area:

The proposed Portal 2 of T10 is located at steep hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, thick vegetation/dense forest cover and no rock exposures is recorded (Photo-174 - 178).

Bedrock is not exposed at vicinity of portal area and along the hill slope, but it may be encounter at shallow depth. Overburden materials i.e., slope wash cum slope debris materials is recorded near portal 1 location.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal location. Seepage is not observed near proposed tunnel portal but one seasonal nala is passing just below the portal area.



Figure 31 Proposed portal P2 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 32 Proposed portal P2 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 33 Portal P2 area is covered with forest cover, slope debris materials & big size of boulders of Basalt.



Figure 34 Portal P2 area is covered with forest cover, slope debris materials & big size of boulders of Basalt.

The upslope area has also occupied by thick forest cover/vegetation and having steep slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt rock fragment mixed with soil matrix. The visually estimated ratio of the coarse: fine material is 80:20 respectively.

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not exposed near the portal location, but in-situ rock may be encountered at shallow depth.

1.3 TUNNEL- 11:

S. No	Feature	Chainage (Km)	Length of tunnel(m)
1	Portal-1 and adjoining area	37+380	810
2	Portal-2 and adjoining area	38+190	

The proposed alignment of Tunnel T11 between Km 37+380 and Km 38+190 is passing through rocks belonging to Deccan Trap of Upper Cretaceous to Paleocene. Mainly Basaltic Lava Flow (Deccan Trap) is reported all along the tunnel length.

Basaltic Lava Flow (Basalt) is generally fresh to slightly weathered at places moderately weathered, moderately jointed to massive, thickly spaced, strong to very strong, fine to medium grained, grey to black colour in nature. Normally joint J1 (Primary joint) is horizontal to sub horizontal. Four plus random joints are reported/present in the study area. All the joint sets are almost vertical dipping except J1.

The general trend of rock mass exposed along the entire tunnel alignment in the area is varying from N70-80°E – S70-80°W & N80°W – S80°E with dip varying from 15-20° towards North. These rock units are traversed by four numbers of joint sets where primary/foliation joint is the most prominent one. The joints set in general are close to partly open in nature with medium/moderate to high persistence.

Portal P1 and adjoining area:

The proposed Portal 1 of T11 is located at steep to very steep hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, thick vegetation/dense forest cover.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not reported in the vicinity of portal location. No seepage is observed near proposed tunnel portal but one seasonal nala is passing just below the portal area.



Figure 35 Proposed portal P2 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 36 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 37 Just above the Portal P1 area is located at flat topped & agricultural land.



Figure 38 Just above the Portal P1 area is located at flat topped & agricultural land.

The upslope area has also occupied by thick forest cover/vegetation and having moderate to steep slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt rock fragment mixed with soil matrix. The visually estimated ratio of the coarse: fine material is 80:20 respectively.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not exposed near the portal location, but in-situ rock may be encountered at shallow depth.

Section Between Portal P1/T11 and Portal P2/T11:

The area between Portal 1 to Portal 2 of proposed T11 tunnel alignment passes through hill with gentle to moderate slope and area partly covered with slope wash cum slope debris material & thick vegetation/ dense forest followed by hard, compact, massive, medium strong to strong, thickly spaced, grey to black colored, fine to

medium grained, fresh to slightly weathered, at places moderately weathered Basalt. Maximum part of the corridor is covered with less/thin overburden material which is unconsolidated to semi consolidated in nature and the visually estimated ratio between the coarse: fine fraction is 80:20 respectively.



Figure 39 Fresh to slightly weathered Basalt is exposed inside the well.



Figure 40 Exposure of slightly weathered Basalt along the hill slope



Figure 41 Exposure of slightly weathered Basalt is just above the village road



Figure 42 Exposure of slightly weathered Basalt is just above the village road



Figure 43 Slope debris materials deposited along hill slope & scanty forest



Figure 44 Slope debris materials deposited along hill slope & scanty forest



Figure 45 Exposure of slightly weathered Basalt along the hill slope.



Figure 46 Area is covered with forest cover & slope debris materials (Overburden).



Figure 47 Area is covered with forest cover & slope debris materials (Overburden).



Figure 48 Area is covered with forest cover & slope debris materials (Overburden).



Figure 49 Area is covered with forest cover & slope debris materials (Overburden).



Figure 50 , Area is covered with forest cover, slope debris materials & big size of boulders of Basalt.



Figure 51 Area is covered with forest, slope debris materials & big size of boulders of Basalt.

The general trend of rock mass exposed along the entire tunnel alignment in the area is varying from N70-80°E – S70-80°W & N80°W – S80°E with dip varying from 10-15° towards North. These rock units are traversed by 4 no. of joint sets where foliation joint is considered as most prominent joint set. The joint sets in general are close/tight to partly open in nature with high persistence.

The various joints recorded in this section/above locations on L/s and R/s between Portal P1/ T11 and Portal P2/ T11 are tabulated below.

Joint set	Strike & Dip	Spacing (cm)	Continuity	Persistence (m)	Remarks
J1	N80°E – S80°W /10-15° Northerly	100 - 200	Continuous	High	Rg-Un, tight to open, most prominent.
J2	N40-50°W – S40-50°E/85-88° South Westerly	100 - 200	Continuous	High	Rg-Un, partly open, clean to stained.
J3	N30°W – S30°E/85° North Easterly	50 - 100	Continuous	Medium	Rg-Un, close to partly open, clean to stained.
J4	N70°E – S70°W/85° South Easterly	20 - 100	Continuous	Medium	Rg-Un, close to partly open, clean to stained.

Portal P2 and adjoining area:

The proposed Portal 2 of T11 is located at steep to very steep hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, thick vegetation/dense forest cover.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not reported in the vicinity of portal location. No seepage is observed near proposed tunnel portal but one seasonal nala is passing just below the portal area.



Figure 52 Portal P2 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt



Figure 53 Portal P2 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 54 Portal P2 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt



Figure 55 Portal P2 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt



Figure 56 Portal P2 area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.

The upslope area has also occupied by thick forest cover/vegetation and having steep slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt rock fragment mixed with soil matrix. The visually estimated ratio of the coarse: fine material is 90:10 respectively.

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not exposed near the portal location, but in-situ rock may be encountered at shallow depth.

1.4 TUNNEL- 12:

S. No	Feature	Chainage (Km)	Length of tunnel(m)
1	Portal-1 and adjoining area	38+510	1280
2	Portal-2 and adjoining area	39+790	

The proposed alignment of Tunnel T12 between Km 38+510 and Km 39+790 is passing through rocks belonging to Deccan Trap of Upper Cretaceous to Paleocene. Mainly Basaltic Lava Flow (Deccan Trap) is reported all along the tunnel length.

Basaltic Lava Flow (Basalt) is generally fresh to slightly weathered at places moderately to highly weathered, moderately jointed to massive, thickly spaced, strong to very strong, fine to medium grained, grey to black colour in nature. Normally joint J1 (Primary joint) is horizontal to sub horizontal. Five plus random joints are reported/present in the study area. All the joint sets are almost vertical dipping except J1.

The general trend of rock mass exposed in between P1 & P2 area is N80°E – S80°W & N80°W – S80°E with dip varying from 15-20° towards North & N80°E – S80°W with dip varying from 15-20° towards South. Sometime Joint J1 is dipping both the side North & South direction due sub horizontal dipping. These rock units are traversed by more than 5 no. of joint sets where foliation joint is the most prominent joint set. The joint sets in general are close/tight to partly open in nature with high to very high persistence.

Portal P1 and adjoining area:

The proposed Portal 1 of T12 is located at steep to very steep hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, thick vegetation/dense forest cover and no rock exposures.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not recorded in the vicinity of portal area. No seepage is observed near proposed tunnel portal but one nala is passing just below the proposed tunnel.



Figure 57 Portal area is located at steep slope, forest cover & slope debris materials & big size of boulders of Basalt associated along hill slope



Figure 58 Portal area is located at steep slope, forest cover & slope debris materials.



Figure 59 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt associated along hill slope.



Figure 60 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt associated along hill slope.

The upslope area has also occupied by thick forest cover/vegetation and having steep to very steep slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt rock fragment mixed with soil matrix. The visually estimated ratio of the coarse: fine material is 90:10 respectively.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not exposed near the portal location, but in-situ rock may be encountered at shallow depth.

Section Between Portal P1/ T12 and Portal P2/ T12:

The area between Portal 1 to Portal 2 of proposed T12 tunnel alignment passes through hill with flat, gentle to moderate slope and area partly covered with slope wash cum slope debris material & thick vegetation/ dense forest followed by hard, compact, massive, medium strong to strong, thickly spaced, grey to black colored, fine to medium grained, fresh to slightly weathered, Basalt. Maximum part of the corridor is covered with less/thin overburden material which is unconsolidated to semi consolidated in nature and the visually estimated ratio between the coarse: fine fraction is 70:30 respectively.



Figure 61 , Flat top, forest cover & slope debris materials.



Figure 62 Flat top, forest cover & slope debris materials.



Figure 63 Flat top, forest cover & slope debris materials.



Figure 64 Exposure of moderately weathered, fine to medium grained, grey to black colored Basalt.



Figure 65 Exposure of moderately weathered, fine to medium grained, grey to black colored Basalt.



Figure 66 , Exposure of fresh to slightly weathered, fine to medium grained, grey to black colored Basalt.



Figure 67 Exposure of fresh to slightly weathered, fine to medium grained, grey to black colored Basalt.



Figure 68 Flat top, forest cover & slope debris materials.

The general trend of rock mass exposed in between P1 & P2 area is N80°E – S80°W & N80°W – S80°E with dip varying from 15-20° towards North & N80°E – S80°W with dip varying from 15-20° towards South. Sometime Joint J1 is dipping both the side North & South direction due sub horizontal dipping. These rock units are traversed by more than 5 no. of joint sets where foliation joint is the most prominent joint set. The joint sets in general are close/tight to partly open in nature with high to very high persistence.

The various joints recorded in this section/above locations on L/s and R/s between Portal P1/T12 and Portal P2/T12 are tabulated below.

Joint set	Strike & Dip	Spacing (cm)	Continuity	Persistence (m)	Remarks
J1	N80°W – S80°E /15-20° Northerly & N80°W – S80°E /15-20° Southerly	100 - 200	Continuous	High	Rg-Un, tight to open, most prominent.
J2	N50°W – S50°E/85-88° South Westerly	100 - 200	Continuous	High	Rg-Un, partly open, clean to stained.
J3	N80°E – S80°W/85° Southerly	20 - 100	Continuous	High	Rg-Un, close to partly open, clean to stained.
J4	N35°E – S35°W/85-88° South Easterly	20 - 200	Continuous	High	Rg-Un, tight to open joint.
J5	N50°E – S50°W/80-85° North Westerly	20 - 200	Continuous	Medium	Rg-Un, tight to open joint.
J6	N60°W – S60°E/80-85° North Easterly	20 - 200	Continuous	Medium	Rg-Un, tight to open joint.

In between tunnel T12, there is no major nala which is crossing the proposed tunnel. Therefore, flowing/seepage of water condition may not encounter in proposed tunnel.

Portal P2 and adjoining area:

The proposed Portal 2 of T12 is located at steep hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, dense vegetation/dense forest cover and no rock exposures .

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal location. Thick overburden materials i.e., slope wash cum slope debris materials are recorded near portal 2 location.



Figure 69 P2/T12 area is showing the steep slope, overburden cover & dense forest.



Figure 70 Portal area is located at forest cover, slope debris materials & big size of boulders of Basalt.



Figure 71 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 72 , Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 73 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 74 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.

The upslope area has also occupied by thick forest cover/vegetation and having steep slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt rock fragment mixed with soil matrix. The visually estimated ratio of the coarse: fine material is 90:10 respectively.

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not exposed near the vicinity of portal area, but in-situ rock may be encountered at shallow depth.

1.5 TUNNEL- 13:

S. No	Feature	Chainage (Km)	Length of tunnel(m)
1	Portal-1 and adjoining area	42+800	1600
2	Portal-2 and adjoining area	44+400	

The proposed alignment of Tunnel T13 between Km 42+800 and Km 44+400 is passing through rocks belonging to Deccan Trap of Upper Cretaceous to Paleocene. Mainly Basaltic Lava Flow (Deccan Trap) is reported all along the tunnel length.

Basaltic Lava Flow (Basalt) is generally fresh to slightly weathered at places moderately to highly weathered, moderately jointed to massive, thickly spaced, strong to very strong, fine to medium grained, grey to black colour in nature. Normally joint J1 (Primary joint) is horizontal to sub horizontal. Five plus random joints are reported/present in the study area. All the joint sets are almost vertical dipping except J1.

The general trend of rock mass exposed in between P1 & P2 area is N80°E – S80°W & N80°W – S80°E with dip varying from 15-20° towards North & N80°E – S80°W with dip varying from 15-20° towards South. Sometime Joint J1 is dipping both the side North & South direction due sub horizontal dipping. These rock units are traversed by more than 5 no. of joint sets where foliation joint is the most prominent joint set. The joint sets in general are close/tight to partly open in nature with high to very high persistence.

Portal P1 and adjoining area:

The proposed Portal 1 of T13 is located at steep to vertical hill slope ground conditions towards portal and covered with thin slope wash cum slope debris material, thick vegetation/dense forest cover and rock exposures is also recorded.

The bedrock exposed at near portal area of proposed tunnel is medium strong to weak, grey to blackish grey colour, fine to medium grained, moderately to highly weathered, Basalt.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal. Scanty rock exposure is also recorded near the vicinity of portal area.



Figure 75 Portal area is located at steep slope, forest cover & slope debris materials



Figure 76 Portal area is located at steep slope, forest cover & slope debris materials.



Figure 77 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 78 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt.



Figure 79 Scanty exposure of moderately to highly weathered Basalt.

The upslope area has also occupied by thick forest cover/vegetation and having steep to vertical slope towards portal. The portal slope area of proposed portal is covered with thin slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix and moderately to highly weathered rock exposure of Basalt. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt rock fragment mixed with soil matrix.

The general trend of rock mass exposed in between P1 & P2 area is N80°E – S80°W & N80°W – S80°E with dip varying from 15-20° towards North & N80°E – S80°W with dip varying from 15-20° towards South. Sometime Joint J1 is dipping both the side North & South direction due sub horizontal dipping. These rock units are traversed by more than 5 no. of joint sets where foliation joint is the most prominent joint set. The joint sets in general are close/tight to partly open in nature with high to very high persistence.

The various joints recorded in this section/above locations on L/s and R/s near Portal P1/T13 are tabulated below.

Joint set	Strike & Dip	Spacing (cm)	Continuity	Persistence (m)	Remarks
J1	N80°W – S80°E /15-20° Northerly & N80°W – S80°E /15-20° Southerly	100 - 200	Continuous	High	Rg-Un, tight to open, most prominent.
J2	N50°W – S50°E/85-88° South Westerly	100 - 200	Continuous	High	Rg-Un, partly open, clean to stained.
J3	N80°E – S80°W/85° Southerly	20 - 100	Continuous	medium	Rg-Un, close to partly open, clean to stained.
J4	N35°E – S35°W/85-88° South Easterly	20 - 200	Continuous	medium	Rg-Un, tight to open joint.

The proposed tunnel portal 1 is having adequate vertical & lateral overburden & suitable for portal. Scanty rock exposures are noticed near the portal area it indicate that bed rock may be encounter at shallow depth (1-2m)

Section Between Portal P1/ T13 and Portal P2/13:

The area between Portal 1 to Portal 2 of proposed T13 tunnel alignment passes through hill with flat, gentle to moderate slope and area partly covered with slope wash cum slope debris material & thick vegetation/ dense forest followed by hard, compact, massive, medium strong to strong, thickly spaced, grey to black colored, fine to medium grained, fresh to slightly weathered at places moderately weathered, Basalt. Maximum part of the corridor is covered with less/thin overburden material which is unconsolidated to semi consolidated in nature and the visually estimated ratio between the coarse: fine fraction is 70:30 respectively.



Figure 80 Flat to gentle topped, forest cover & slope debris materials



Figure 81 Flat to gentle topped, forest cover & slope debris materials.



Figure 82 Flat to gentle topped, forest cover & slope debris materials.



Figure 83 Dense Forest cover & slope debris materials.



Figure 84 Dense Forest cover & slope debris materials.



Figure 85 Exposure of fresh to slightly weathered, fine to medium grained, grey to black colored Basalt.



Figure 86 Exposure of fresh to slightly weathered, fine to medium grained, grey to black colored Basalt.



Figure 87 Exposure of fresh to slightly weathered, fine to medium grained, grey to black colored fractured Basalt.



Figure 88 Exposure of fresh to slightly weathered, fine to medium grained, grey to black colored fractured Basalt.

The general trend of rock mass exposed in between P1 & P2 area is N80°E – S80°W & N80°W – S80°E with dip varying from 15-20° towards North & N80°E – S80°W with dip varying from 15-20° towards South. Sometime Joint J1 is dipping both the side North & South direction due sub horizontal dipping. These rock units are traversed by more than 5 no. of joint sets where foliation joint is the most prominent joint set. The joint sets in general are close/tight to partly open in nature with high to very high persistence.

The various joints recorded in this section/above locations on L/s and R/s between Portal P1/T13 and Portal P2/T13 are tabulated below.

Joint set	Strike & Dip	Spacing (cm)	Continuity	Persistence (m)	Remarks
J1	N80°W – S80°E /15-20° Northerly & N80°W – S80°E /15-20° Southerly	100 - 200	Continuous	High	Rg-Un, tight to open, most prominent.
J2	N50°W – S50°E/85-88° South Westerly	100 - 200	Continuous	High	Rg-Un, partly open, clean to stained.
J3	N80°E – S80°W/85° Southerly	20 - 100	Continuous	High	Rg-Un, close to partly open, clean to stained.
J4	N35°E – S35°W/85-88° South Easterly	20 - 200	Continuous	High	Rg-Un, tight to open joint.
J5	N50°E – S50°W/80-85° North Westerly	20 - 200	Continuous	Medium	Rg-Un, tight to open joint.
J6	N60°W – S60°E/80-85° North Easterly	20 - 200	Continuous	Medium	Rg-Un, tight to open joint.

In between tunnel T13, there is no major nala which is crossing the proposed tunnel. Therefore, flowing/seepage of water condition may not encounter in proposed tunnel.

Portal P2 and adjoining area:

The proposed Portal 2 of T13 is located at moderate to steep hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, dense vegetation/dense forest cover and no rock exposures.

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal location. Thick overburden materials i.e., slope wash cum slope debris materials is recorded near portal 2 location. Rocks are not present at portal location, but it may be encountered at shallow depth.



Figure 89 Portal and upslope area is covered with dense forest.



Figure 90 Portal area is located at forest cover & slope debris materials.



Figure 91 Portal area is located at forest cover & slope debris materials.



Figure 92 P2/T13 area is covered with overburden materials & dense forest.



Figure 93 Portal area is located at steep slope, forest cover, slope debris materials & big size of boulders of Basalt



Figure 94 Portal area is located at forest cover, slope debris materials & big size of boulders of Basalt.



Figure 95 Portal area is located at forest cover, slope debris materials & big size of boulders of Basalt.

The upslope area has also occupied by thick forest cover/vegetation and having steep slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt embedded in silty clay matrix. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt rock fragment mixed with soil matrix. The visually estimated ratio of the coarse: fine material is 90:10 respectively.

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal. The bedrock is not exposed near the vicinity of portal area, but in-situ rock may be encountered at shallow depth.

1.6 TUNNEL- 14:

S. No	Feature	Chainage (Km)	Length of tunnel(m)
1	Portal-1 and adjoining area	55+700	2290
2	Portal-2 and adjoining area	57+990	

The proposed alignment of Tunnel T14 between Km 55+700 and Km 57+990 is passing through rocks belonging to Deccan Trap of Upper Cretaceous to Paleocene. Mainly Basaltic Lava Flow (Deccan Trap) is reported all along the tunnel length.

Basaltic Lava Flow (Basalt) is generally fresh to slightly weathered at places moderately to highly weathered, moderately jointed to massive, thickly spaced, strong to very strong, fine to medium grained, grey to black colour in nature. Normally joint J1 (Primary joint) is horizontal to sub horizontal. Four plus random joints are reported/present in the study area. All the joint sets are almost vertical dipping except J1.

The general trend of rock mass exposed in between P1 & P2 area is N80°E – S80°W & N80°W – S80°E with dip varying from 15-20° towards North & N80°E – S80°W with dip varying from 15-20° towards South. Sometime Joint J1 is dipping both the side North & South direction due sub horizontal dipping. These rock units are traversed by more than 4 no. of joint sets where foliation joint is the most prominent joint set. The joint sets in general are close/tight to partly open in nature with high to very high persistence.

Portal P1 and adjoining area:

The proposed Portal 1 of T14 is located at flat and agriculture land ground conditions towards portal and covered with thick slope debris material. Thick vegetation/dense forest cover is also recorded just 60-70m (Towards increasing chainage) ahead of portal area. The bedrock is not exposed at nearby portal area of proposed tunnel.



Figure 96 P1/T14 area is falling on agricultural land.



Figure 97 P1/T14 area is falling on agricultural land & no rock exposure.



Figure 98 Ahead of portal area is falling in forest cover & slope debris materials



Figure 99 Ahead of portal area is falling in forest cover & slope debris materials.

The upslope area has also occupied by agricultural land & thick forest cover/vegetation and having flat slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt and other rock fragment mixed with soil matrix.

Section Between Portal P1/ T14 and Portal P2/ T14:

The area between Portal 1 to Portal 2 of proposed T14 tunnel alignment passes through hill with flat to gentle slope and area mostly covered with slope wash cum slope debris material & thick vegetation/ dense forest. followed by hard, compact, massive, medium strong to strong, thickly spaced, grey to black colored, fine to medium grained, fresh to slightly weathered at places moderately weathered, Basalt. Maximum part of the corridor is covered with less/thin overburden material which is unconsolidated to semi consolidated in nature and the visually estimated ratio between the coarse: fine fraction is 70:30 respectively. Field is indicating that, bedrock Basalt rocks to be encountered at shallow depth (1-2m)



Figure 100 Between P1 & P2 area is located at dense forest cover & slope debris materials.
Maximum part of area is covered with dense forest.



Figure 101 Between P1 & P2 area is located at dense forest cover & slope debris materials



Figure 102 Between P1 & P2 area is located at dense forest cover & slope debris materials.



Figure 103 Rock exposure of Basalt is recorded at just below the culvert/minor bridge.



Figure 104 Rock exposure of slightly weathered Basalt is recorded at just below the culvert/minor bridge.



Figure 105 Rock exposure of Basalt is recorded at near the culvert/minor bridge area.



Figure 106 Between P1 & P2 area is located at dense forest cover & slope debris materials.



Figure 107 Between P1 & P2 area is located at dense forest cover & slope debris materials



Figure 108 Exposure of compact, massive, fresh to slightly weathered Basalt rock exposed along railway cutting section.



Figure 109 Between P1 & P2 area is located at dense forest cover & slope debris materials.

The general trend of rock mass exposed in between P1 & P2 area is N80°E – S80°W & N80°W – S80°E with dip varying from 15-20° towards North & N80°E – S80°W with dip varying from 15-20° towards South. Sometime Joint J1 is dipping both the side North & South direction due sub horizontal dipping. These rock units are traversed by more than 5 no. of joint sets where foliation joint is the most prominent joint set. The joint sets in general are close/tight to partly open in nature with high to very high persistence.

The various joints recorded in this section/above locations on L/s and R/s between Portal P1/T14 and Portal P2/T14 are tabulated below.

Joint set	Strike & Dip	Spacing (cm)	Continuity	Persistence (m)	Remarks
J1	N80°W – S80°E /15-20° Northerly & N80°W – S80°E /15-20° Southerly	100 - 200	Continuous	High	Rg-Un, tight to open, most prominent.
J2	N50°W – S50°E/85-88° South Westerly	100 - 200	Continuous	High	Rg-Un, partly open, clean to stained.
J3	N80°E – S80°W/85° Southerly	20 - 100	Continuous	High	Rg-Un, close to partly open, clean to stained.
J4	N35°E – S35°W/85-88° South Easterly	20 - 200	Continuous	High	Rg-Un, tight to open joint.
J5	N50°E – S50°W/80-85° North Westerly	20 - 200	Continuous	Medium	Rg-Un, tight to open joint.
J6	N60°W – S60°E/80-85° North Easterly	20 - 200	Continuous	Medium	Rg-Un, tight to open joint.

In between tunnel T14, there is no major nala which is crossing the proposed tunnel. But proposed tunnel alignment is passing through at two locations in just below the existing railway line, Therefore, flowing/seepage of water condition may encounter in proposed tunnel.

Portal P2 and adjoining area:

The proposed Portal 2 of T14 is located at moderate hill slope ground conditions towards portal and covered with thick slope wash cum slope debris material, dense vegetation/dense forest cover and lack of rock exposures.

The bedrock exposed at near portal area of proposed tunnel are medium strong to strong, grey to black colour, fine to medium grained, slightly to moderately weathered, Basalt.

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal location. Thick overburden materials i.e., slope wash cum slope debris materials is recorded near portal 2 location. Lack of in-situ rocks are present at portal location, but it may be encountered at shallow depth.



Figure 110 P2/T14 area is covered with dense forest, overburden & lack of rock exposure.



Figure 111 P2/T14 area is covered with dense forest, overburden & lack of rock exposure.



Figure 112 P2/T14 area is covered with dense forest & overburden materials.



Figure 113 Narmada pipeline is crossing just below the portal area (Towards increasing chainage)



Figure 114 Lack of rock exposures are recorded in the vicinity of portal area and also indicating the bedrock Basalt may be encounter at shallow depth.

The upslope area has also occupied by thick forest cover/vegetation and having gentle to moderate hill slope towards portal. The portal slope area of proposed portal is covered with thick slope debris cum hill slope wash material represented by pebbles to boulders of Basalt & followed by minor rock exposure. The overburden material is unconsolidated to semi-consolidated in nature consisting of pebbles, cobbles, boulders of Basalt and other rock fragment mixed with soil matrix.

The general trend of rock mass exposed in between P1 & P2 area is N80°E – S80°W & N80°W – S80°E with dip varying from 15-20° towards North & N80°E – S80°W with dip varying from 15-20° towards South. Sometime Joint J1 is dipping both the side North & South direction due sub horizontal dipping. These rock units are traversed by more than 5 no. of joint sets where foliation joint is the most prominent joint set. The joint sets in general are close/tight to partly open in nature with high to very high persistence.

The various joints recorded in this section/above locations on L/s and R/s at Portal P2/T14 are tabulated below.

Joint set	Strike & Dip	Spacing (cm)	Continuity	Persistence (m)	Remarks
J1	N80°W – S80°E /15-20° Northerly & N80°W – S80°E /15-20° Southerly	100 - 200	Continuous	High	Rg-Un, tight to open, most prominent.
J2	N50°W – S50°E/85-88° South Westerly	100 - 200	Continuous	High	Rg-Un, partly open, clean to stained.
J3	N80°E – S80°W/85° Southerly	20 - 100	Continuous	High	Rg-Un, close to partly open, clean to stained.
J4	N35°E – S35°W/85-88° South Easterly	20 - 200	Continuous	Medium	Rg-Un, tight to open joint.

The proposed tunnel portal 2 is having adequate vertical & lateral overburden & suitable for portal location. The bedrock is slightly to moderately weathered, medium strong to strong, fine to medium grained, Basalt nature at portal location. Entire portal area is covered with dense forest cover, thick overburden materials and lack of exposure but in-situ rock may be encountered at shallow depth.