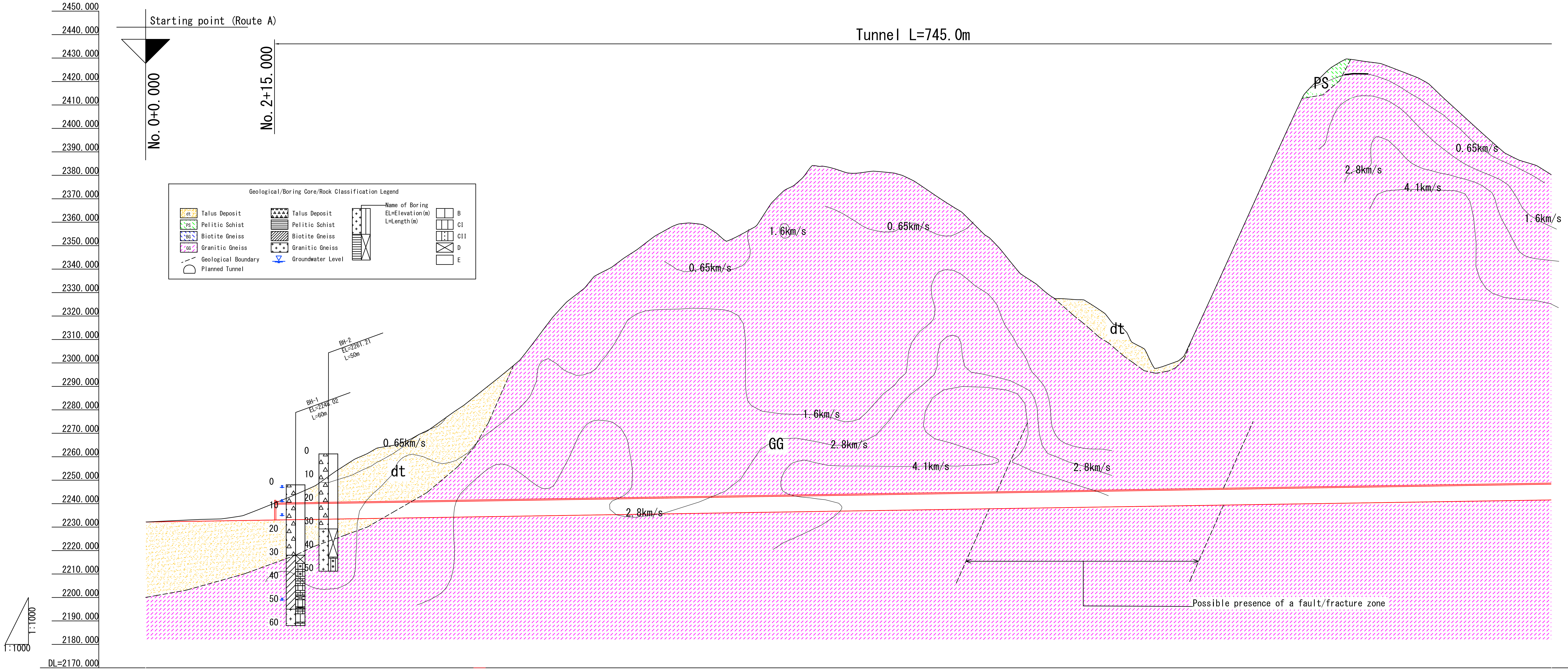
Appendix 7

地山等級分類図

Ground Classification

Route A Geological Longitudinal Profile and Design (1)

V=1:1000
H=1:1000



Inclination	2232.170															
Planned Height	2232.170	2232.484	2232.783 2232.798	2233.112	2233.426	2233.740	2234.054	2234.368	2234.682	2234.996	2235.310	2235.624	2235.938	2236.252	2236.566	
Surface Height	2232.171	2233.121	2234.536 2234.610	2242.237	2253.023	2263.943	2270.837	2285.260	2301.591	2326.236	2341.609	2355.597	2357.690	2357.988	2378.575	
Survey Point	BP	NO.1	BC 1-0 NO.2	NO.3	NO.4	NO.5	NO.6	NO.7	NO.8	NO.9	NO.10	NO.11	NO.12	NO.13	NO.14	

Inclination	i=1.570% L=828.815																
Planned Height	2236.880	2237.194	2237.508	2237.822	2238.136	2238.450	2238.764	2239.078	2239.392	2239.706	2239.860	2240.020	2240.334	2240.648	2240.962	2241.276	2241.590
Surface Height	2380.977	2380.811	2369.458	2353.458	2333.707	2326.924	2310.356	2300.606	2339.584	2383.663	2401.622	2420.362	2428.595	2422.763	2407.411	2389.539	2380.193
Survey Point	NO.15	NO.16	NO.17	NO.18	NO.19	NO.20	NO.21	NO.22	NO.23	NO.24	EC 1-0	NO.25	NO.26	NO.27	NO.28	NO.29	NO.30

<table>
<tr><td rowspan="3">Design</td><td>Tunnel support pattern</td><td></td><td colspan="3">DIII</td><td colspan="2">DI</td><td colspan="4">CI</td><td colspan="2">CII</td><td colspan="2">CI</td></tr>
<tr><td>Auxiliary methods</td><td></td><td colspan="3">70m (AGF)</td><td colspan="2">–</td><td colspan="4">–</td><td colspan="2">100m (PUIF)</td><td colspan="2">–</td></tr>
<tr><td>Section length</td><td></td><td colspan="3">70m</td><td colspan="2">20m</td><td colspan="4">215m</td><td colspan="2">100m</td><td colspan="2">300m</td></tr>
<tr><td rowspan="6">Geological profile</td><td>Geology</td><td colspan="3">Talus Deposit</td><td colspan="2">Highly Weathered Granitic Gneiss</td><td colspan="9">Higher Structural Level Greater Himalayan Zone Granitic Gneiss</td></tr>
<tr><td>Rock type</td><td></td><td colspan="2">E</td><td>DII</td><td>DI</td><td colspan="5">CI</td><td colspan="2">CII</td><td colspan="2">CI</td></tr>
<tr><td>Elastic wave velocity (km/s)</td><td></td><td>≧0.65km/s
＜1.6km/s</td><td colspan="3">≧1.6km/s
＜2.8km/s</td><td colspan="2">≧2.8km/s
＜4.1km/s</td><td>≧1.6km/s
＜2.8km/s</td><td>≧2.8km/s
＜4.1km/s</td><td colspan="2">≧4.1km/s</td><td colspan="2">No Data</td><td>≧4.1km/s</td></tr>
<tr><td>Rock strength (Competence factor)</td><td colspan="14"></td></tr>
<tr><td>Seepage</td><td colspan="3">-Stream is observed in the talus deposit
-Level of confined ground water is estimated to be situated low according to the ground monitoring of BH-8 (14m below surface)</td><td colspan="11"></td></tr>
<tr><td>Remarks</td><td colspan="10">-Countermeasures for slope stability are necessary. Talus deposit is considerably thick so auxiliary works to support the crown during the portal construction will be needed</td><td colspan="2">Possible presence of a fault/fracture zone</td><td colspan="2"></td></tr>
</table>

KOKUSAI KOGYO CO., LTD.
EARTH SYSTEM SCIENCE CO., LTD.

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
OYO INTERNATIONAL CORPORATION

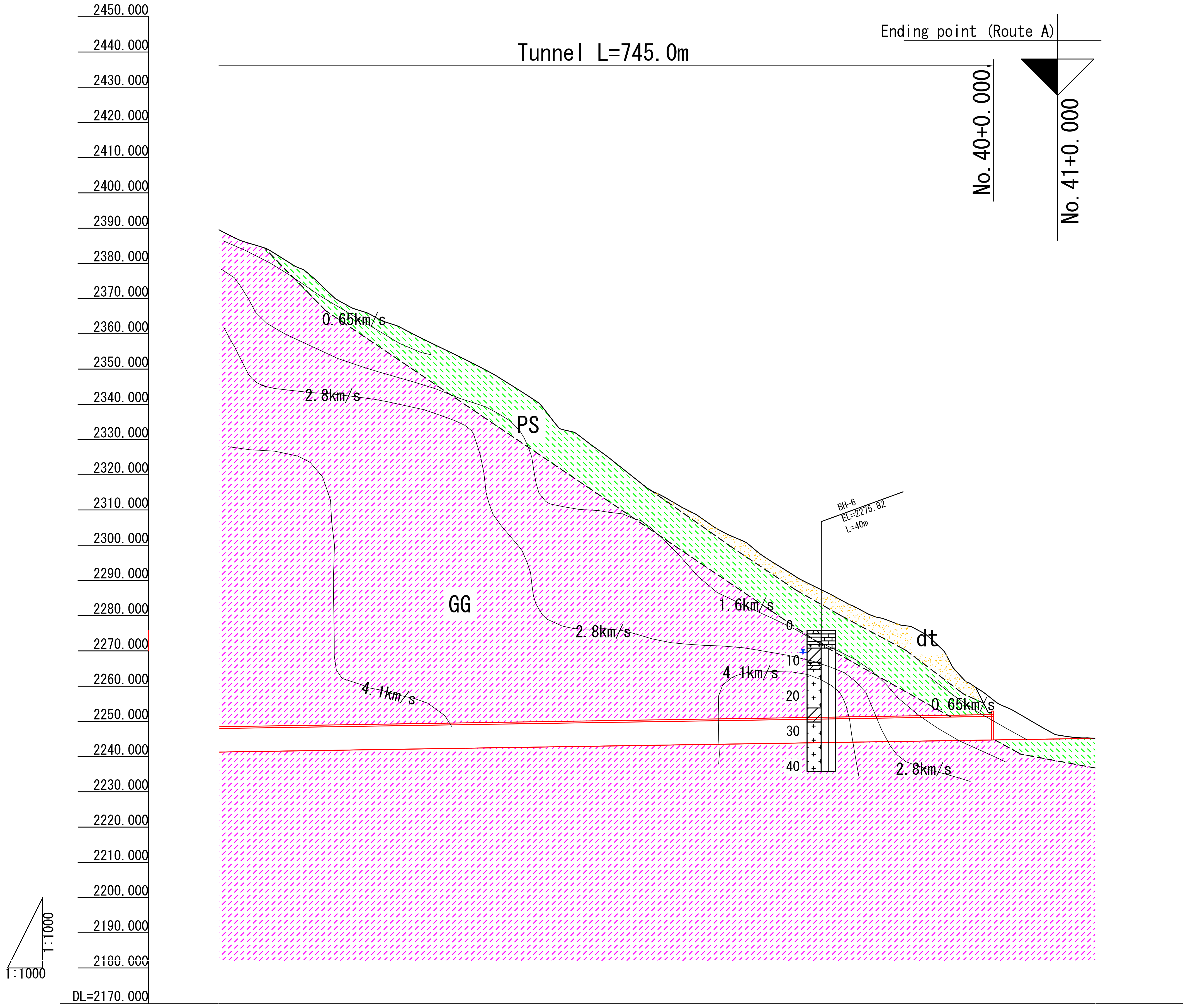
PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

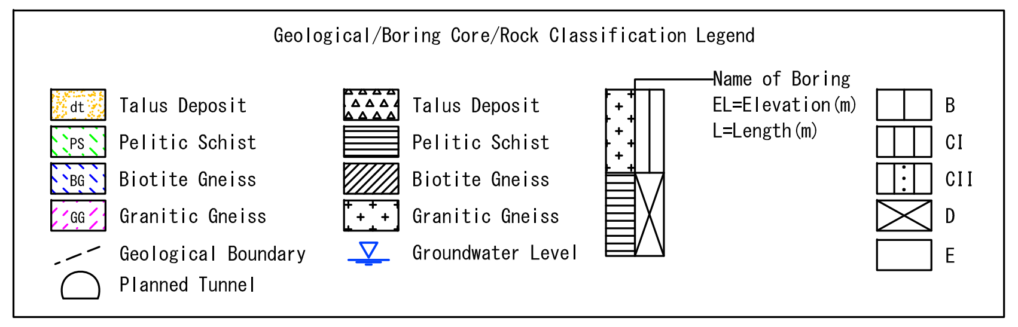
TITLE
ROUTE A GEOLOGICAL LONGITUDINAL PROFILE AND DESIGN (1)

DRAWING No.
SCALE 1:1000 —(A1)

Route A Geological Longitudinal Profile and Design (2)

V=1:1000
H=1:1000





Inclination: i=1.570% L=828.815 — 2245.182

Survey Point	Planned Height	Surface Height
NO.29	2241.276	2389.539
NO.30	2241.590	2380.193
NO.31	2241.904	2366.610
NO.32	2242.218	2357.571
NO.33	2242.532	2347.309
NO.34	2242.846	2332.283
BC 2-0	2243.009	2324.578
NO.35	2243.160	2317.481
NO.36	2243.474	2305.591
NO.37	2243.788	2293.497
NO.38	2244.102	2282.808
NO.39	2244.416	2275.070
NO.40	2244.730	2255.976
EC 2-0	2244.863	2251.684
NO.41	2245.044	2245.821
+8.815	2245.182	2245.201
NO.42	2245.358	

Design	Tunnel support pattern	CI	DI	DIII	
	Auxiliary methods	–	–	20m (PUIF)	
	Section length	300m	20m	20m	
Geological profile	Geology	Higher Structural Level Greater Himalayan Zone Granitic Gneiss	Highly Weathered Granitic Gneiss/Pelitic Schist		
	Rock type	CI	DI	DII	
	Elastic wave velocity [km/s]	≧4.1km/s ≧2.8km/s <4.1km/s ≧4.1km/s	≧2.8km/s <4.1km/s ≧1.6km/s <2.8km/s	≧0.65km/s <1.6km/s	<0.65km/s
	Rock strength [Competence factor]	Gn = 21 (δ = 12MPa) γ = 2.627 g/cm3			
	Seepage	-Unconfined underground water observed 5-6m below the surface at BH-6 -Joints are not so developed. Seepage in the tunnel is estimated to be small			
	Remarks				

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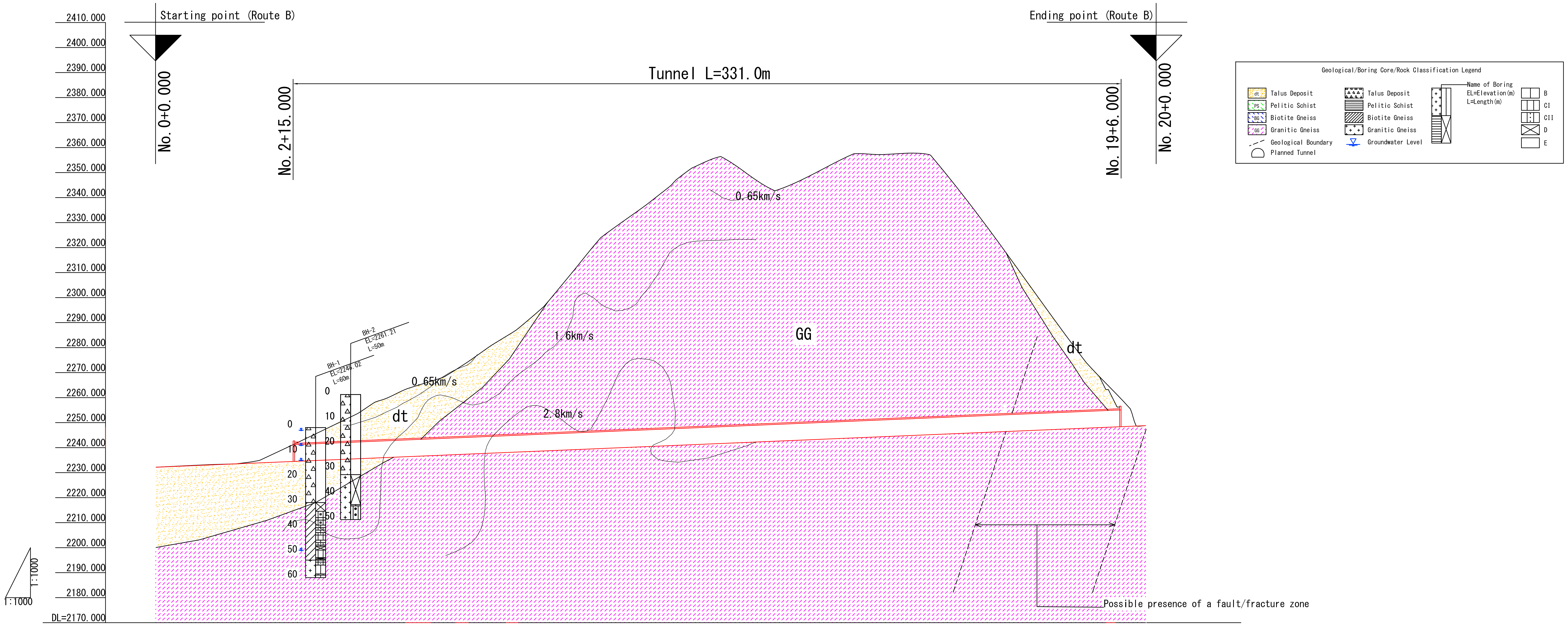
TITLE
ROUTE A GEOLOGICAL LONGITUDINAL PROFILE AND DESIGN (2)

DRAWING No. ---
SCALE 1:1000 —(A1)

Route B Geological Longitudinal Profile and Design (1)

V=1:1000
H=1:1000



2232.170

i=4.200%
L=396.000

2248.802

2232.170	2233.010	2233.809 2233.850	2234.690	2235.530	2236.370	2237.169 2237.210	2238.050	2238.890	2239.730	2240.570	2241.410	2242.250	2243.090	2243.930	2244.770	2245.610	2246.450	2247.290	2247.669	2248.130 2248.179	2248.802 2248.907
2232.171	2233.121	2234.515 2234.587	2243.574	2253.238	2263.339	2270.767 2271.150	2284.400	2302.091	2325.489	2340.055	2354.383	2347.040	2347.912	2357.567	2357.728	2344.492	2317.956	2290.220	2279.144	2265.658 2264.431	
BP	NO.1	BC 1-0 NO.2	NO.3	NO.4	NO.5	EBC 1-1 NO.6	NO.7	NO.8	NO.9	NO.10	NO.11	NO.12	NO.13	NO.14	NO.15	NO.16	NO.17	NO.18	EC 1-0	NO.19 BC 2-0	+16.000 +18.488

<table>
<tr><td rowspan="3">Design</td><td>Tunnel support pattern</td><td></td><td colspan="3">DIII</td><td colspan="2">DI</td><td colspan="3">CI</td><td>DI</td><td colspan="2">DIII</td><td></td></tr>
<tr><td>Auxiliary methods</td><td></td><td colspan="3">70m (AGF)</td><td colspan="2">–</td><td colspan="3">–</td><td>26m
(PUIF)</td><td colspan="2">20m
(PUIF)</td><td></td></tr>
<tr><td>Section length</td><td></td><td colspan="3">70m</td><td colspan="2">20m</td><td colspan="3">195m</td><td>26m</td><td colspan="2">20m</td><td></td></tr>
<tr><td rowspan="6">Geological profile</td><td>Geology</td><td colspan="3">Talus Deposit</td><td colspan="2">Highly Weathered Granitic Gneiss</td><td colspan="8">Higher Structural Level Greater Himalayan Zone Granitic Gneiss</td></tr>
<tr><td>Rock type</td><td></td><td colspan="2">E</td><td>DII</td><td>DI</td><td colspan="4">CI</td><td colspan="2">CII</td><td colspan="2">DII</td></tr>
<tr><td>Elastic wave velocity [km/s]</td><td></td><td>≧0.65km/s
＜1.6km/s</td><td colspan="3">≧1.6km/s
＜2.8km/s</td><td colspan="2">≧2.8km/s
＜4.1km/s</td><td>≧1.6km/s
＜2.8km/s</td><td colspan="5">No Data</td></tr>
<tr><td>Rock strength [Competence factor]</td><td colspan="13"></td></tr>
<tr><td>Seepage</td><td colspan="13">-Stream is observed in the talus deposit
-Level of confined ground water is estimated to be situated low according to the ground monitoring of BH-8 (14m below surface)
-A small amount of seepage is expected around the portal area because some ground water was observed on reconnaissance in the slopes along the current road</td></tr>
<tr><td>Remarks</td><td colspan="9">-Countermeasures for slope stability are necessary. Talus deposit is considerably thick so auxiliary works to support the crown during the portal construction will be needed</td><td colspan="4">Possible presence of a fault/fracture zone</td></tr>
</table>

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ROUTE B GEOLOGICAL LONGITUDINAL PROFILE AND DESIGN (1)

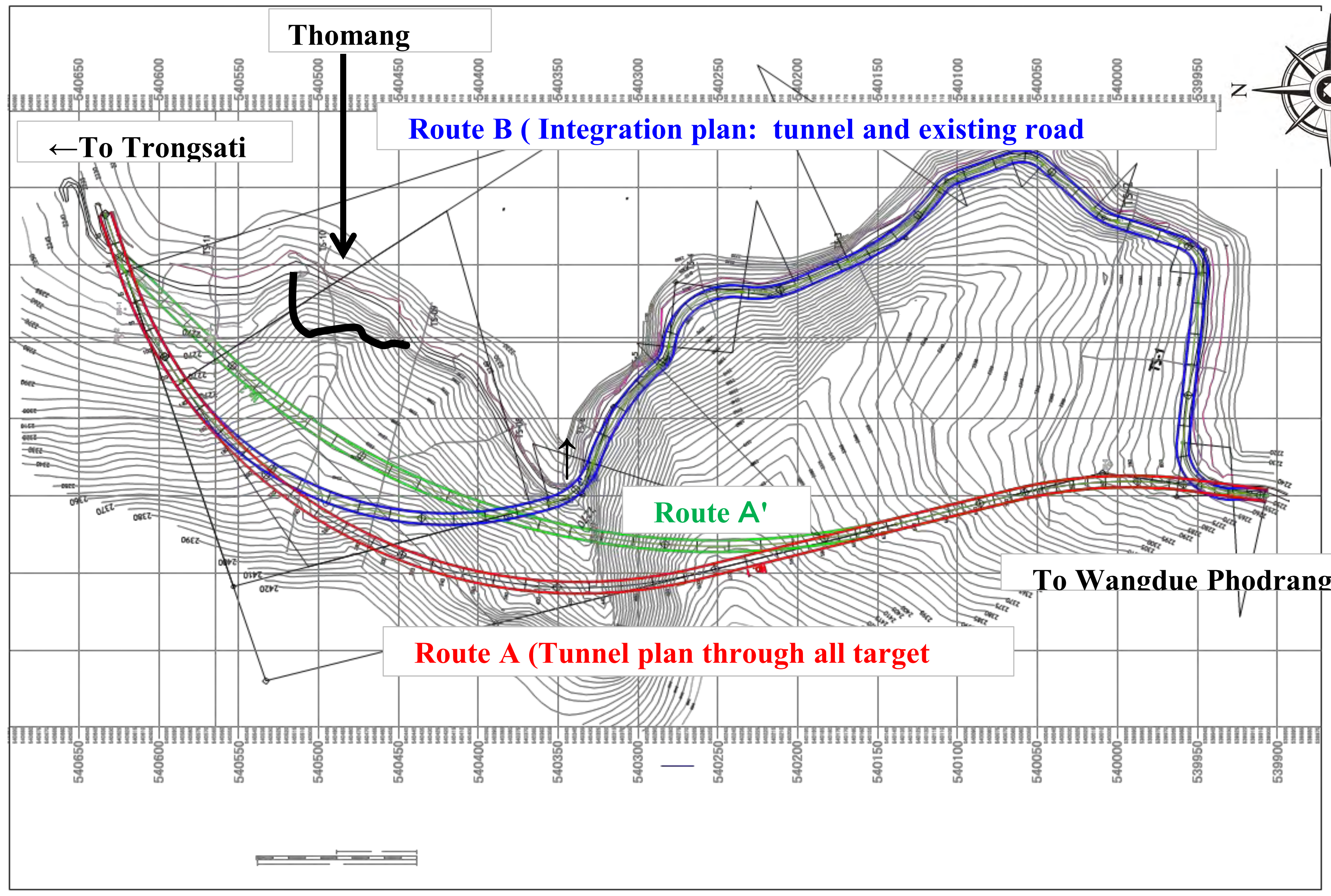
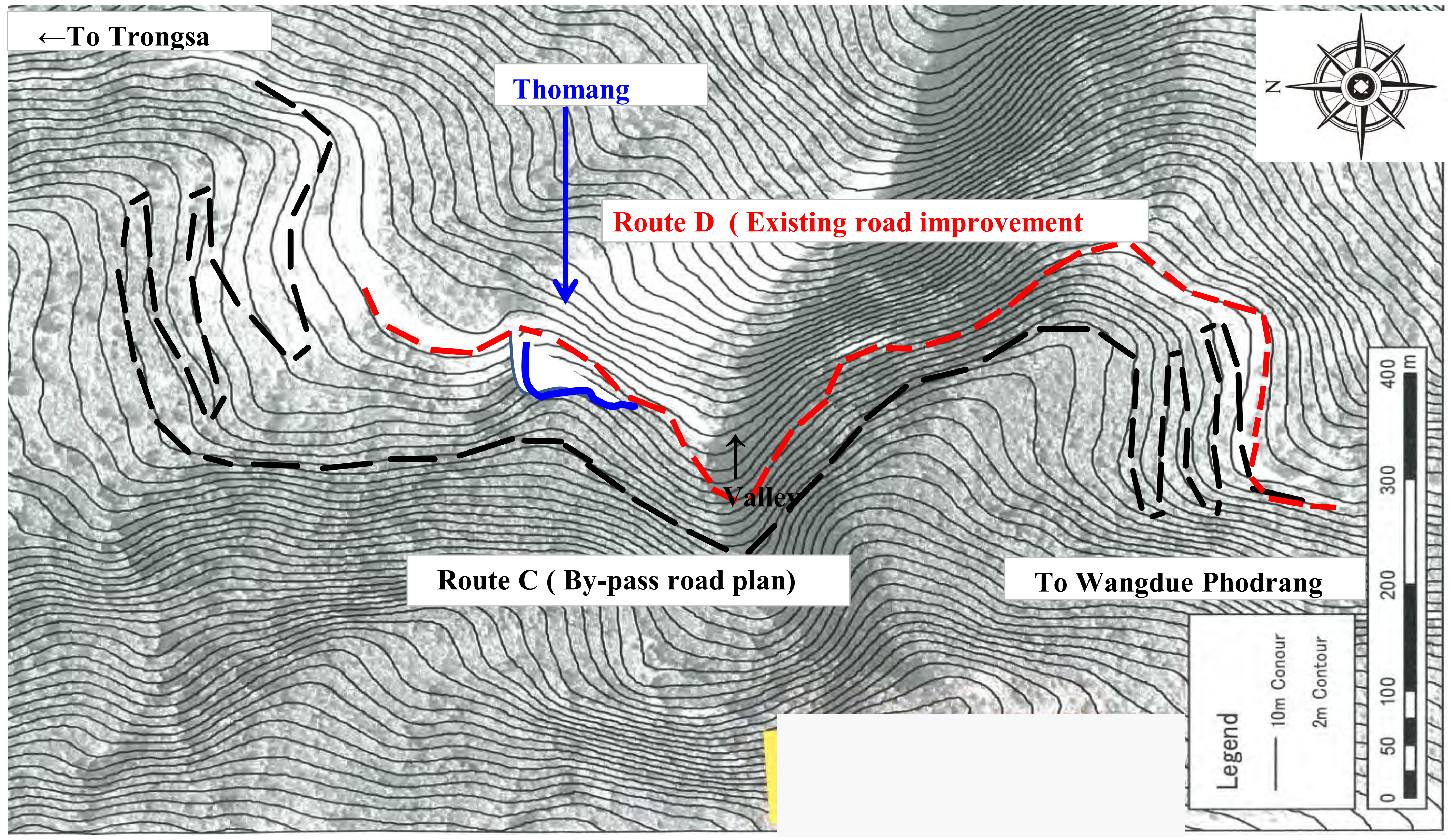
DRAWING No. ---
SCALE 1:1000 —(A1)

Appendix 8

トンネル・斜面対策工等設計図面類

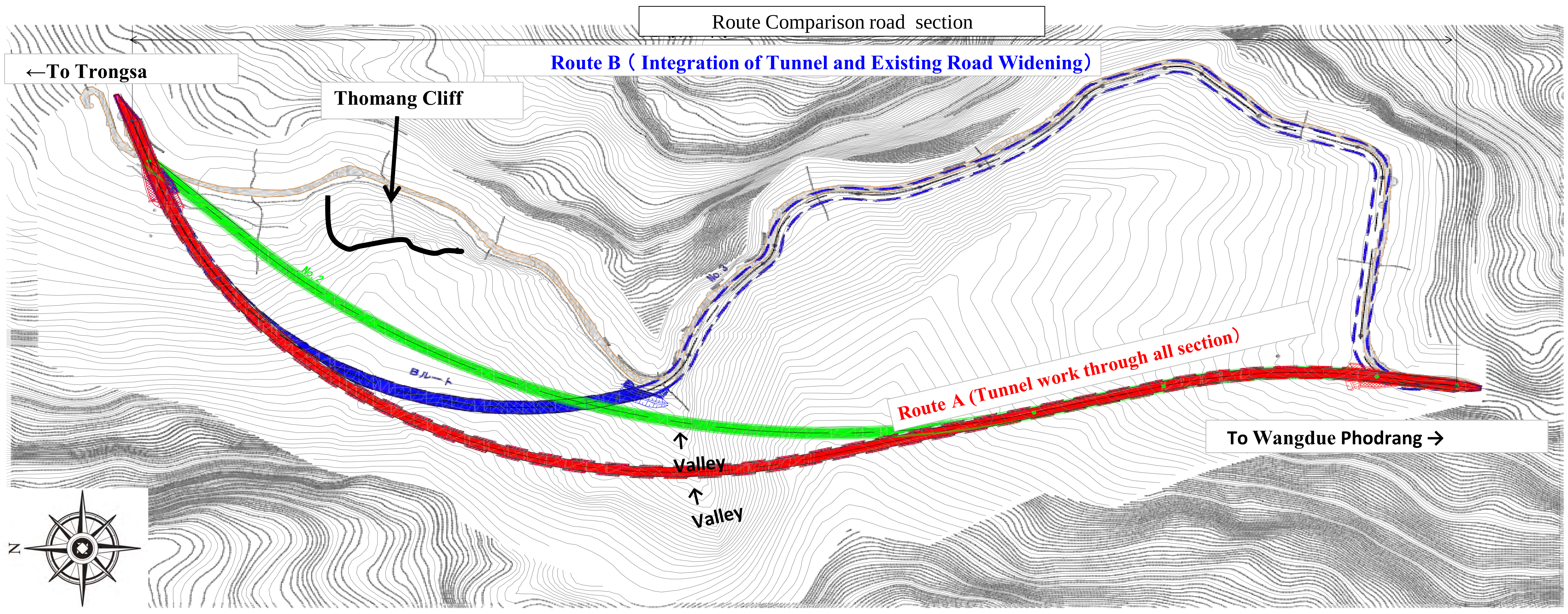
Outcome of Design Activities

BASIC PLAN (DRAFT) ROUTE COMPARISON（FIRST SELECTION: Based on the result of the field survey）

Item ＼ Route	Route A (Tunnel plan through entire target section)		Route B (Integration plan: tunnel and existing road widening)		Route C (By-pass road plan)		Route D (Existing road improvement plan)	
Basic concept of the route selection	・To avoid the loose area of Thomang Cliff and the valley at the south of Thomang Cliff through tunnel		・To avoid the loose area of Thomang Cliff through tunnel and to utilize the current road route to minimize the tunnel construction length		・To avoid the loose area of Thomang Cliff by making a new by-pass road at the upper side of the Cliff		・To utilize the current road route and improve the roads	
Length of road work	Total Length L= 0.8 km (Current road - 0.4 km) Length of roads excluding a tunnel 0.1 km Length of a tunnel 0.7 km		Total Length L= 1.1 km (Current road - 0.1 km) Length of roads excluding tunnel = 0.8 km Length of tunnel = 0.3 km		Total Length L= 3.4 km (Current road +2.2km) Length of roads = 2.0 km Road Gradient i = 7 % 1.4 km i = less than 7 %		Total Length L= 1.2 km (Current road route) Length of roads = 1.2 km (Road widening work)	
〈Design Specification〉 ○ Road Standard：Standard of the Primary National Highway ○ Design Speed ：V=30km/h ○ Road Width：W=7.5m of 2 lanes Schematic map ◎ : Very good ○ : Good △ : Conditionally applicable x : Not recommended								
Geological and geographical features from the result of the reconnaissance	The North side of tunnel portal (Trongsa side) is located in natural slopes and entirely covered with trees and shrubs. The slopes are rather gentle compared to the surrounding slopes, which are about 30 to 40 degrees. ・The bedrocks of the area are composed of hard Granite Gneiss rocks and most of the slope is covered with talus deposits including boulders 1 to 3 m in diameter. ・On the slopes of the south wellhead side, the depths of the talus deposits are rather thin and the bedrock underneath are composed of hard Granite Gneiss rocks as well as the north side.		・The north side of the tunnel portal of Route B is the same location as Route A. ・The south side is located in the north-side slope of a valley where the stream water flows constantly. The bedrocks of the slopes around the south side are composed of hard Granite Gneiss rocks. ・The lower side slopes of the current road are very steep at 50 to 80 degrees, and it is difficult to widen the road toward the lower slope side. ・The upper slopes of the road show both gentle slopes at 25 to 30 degrees, and steep slopes with more than 70 degrees alternatively.		・The range of the loose area of the Thomang Cliff is assumed to extend up the slope to an elevation of 2,320 m. ・The south-side slope of the Thomang Cliff is extremely steep and has only shallow surface soil. Also the slope is unstable. ・A steep slope with 60-70 degrees is extended by the more than a 100 m width to the valley south of the cliff.		・An opening crack 2 m in length, 4 m in depth and 25 cm in width is observed at the shoulder of the current road in the Thomang Cliff. The area is significantly unstable. ・Open cracks and other earth-movement phenomena are observed in the slope from the bottom to the 40 m height of the Thomang cliff at the road side. The slope seems loose and in unstable condition. ・Conditions of the area near the valley of the South of the cliff are described in the column of the Route C. ・It is extremely difficult to widen the road toward the lower side of the road because the lower side slope is very steep at 60 to 80 degrees.	
Drivability of the road alignment	・The smoothest road alignment can be achieved among four route selections.	◎	・At the south side of the tunnel portal site, a loose curve of the tunnel is connected to a sharp curve of the road outside the tunnel.Therefore, it is an undesirable combination as the road alignment.	△	・The road is required to be a winding road to climb up by 80 m in height within a short distance. Accordingly, many sharp curves of the minimum radius (R-30 m) continue. Also, the road is required to take the maximum gradient of 7% for almost all sections of the winding road. It will be particularly difficult for heavy vehicles to be driven on the road.	△	・The same drivability can be maintained as the current road.	○
Workability and safety for the construction	・Route A' is a plan to take a closer route toward the current road in order to shorten the length of the tunnel construction by 20 m. However, the route is assumed to get into the influential ranges of the loose area of the Thomang Cliff and so the idea of the route was discarded. ・ The construction of the tunnel work is normally started from the lower position of the elevation, which is the north tunnel portal side. The terrain of the north side is relatively gentle and a construction yard can be made near the area. ・There are hillsides with unconsolidated geological structure near the north tunnel portal area. Accordingly, auxiliary construction methods to stabilize the hillsides will be required during the construction period. ・ Hillsides near the south tunnel portal seem geologically consolidated and have better conditions for the construction work compared to the north tunnel portal side.	○	・The north side of the tunnel portal is has the same location and construction conditions as Route A. ・The south side has similar construction conditions to Route A. ・It is extremely difficult to widen the road toward the lower side from the current road. ・It will be required to cut the hillside beyond the ridge if the road is widened toward the upper side of the road, even if a concrete structure is constructed to reduce the volume of the cutting work. ・Speed control will be required for vehicles coming and running from north to south on the road.	△	・Regarding the cutting work to widen the current road in the South-side slope of the valley south of the Thomang Cliff, the cutting height would be 180 m with a cutting slope gradient of 1:0.3, which its implementation is not realistic. Even if constructing a vertical concrete retaining wall is considered, the height would be 35 m which its implementation is not realistic. Accordingly, designning the road construction is extremely difficult. ・Road construction at route C, if implemented, will be operated in a slope 80 m higher from the current road site. In case of the construction of the concrete structure, it will be also higher. Accordingly, designning the road construction without maintaining the current road traffic will be extremely difficult. It will be required to consider enough temporal support work such as rockfalls protection and other protection methods.	×	・It is difficult to avoid the loose area of Thomang Cliff. Accordingly, the safety of roads and slopes along the road cannot be fundamentally maintained.	×
Environment and landscape	・Noise and exhaust gasses are concentrated in the tunnel. ・ The tunnel passes through the underground and road traffic and the above noise and gasses are assumed not to disturb the natural environment and landscape.	○	・The volume of the cutting work is assumed to be on a large scale. Accordingly, it is required to consider how to deal with the excavated soil from the cutting work. ・Vegetation work and cover work at the cut faces is to be considered to maintain the natural environment and landscape.	△	Cutting work should be operated for a long distance along the road except at the section of the winding road. Accordingly, it is required to consider how to deal with the excavated soil from the cutting work. ・Vegetation work and cover work at the cut faces need to be considered to maintain the natural environment and landscape.	△	Cutting work is required to operate for a long distance along the road. Accordingly, it is required to consider how to deal with the excavated soil from the cutting work. ・Vegetation work and cover work at the cut faces are necessary to be considered to maintain the natural environment and landscape.	△
Evaluation from the first selection	This is applying the tunnel construction suitable for severe terrain features and Route A is adopted in the First Selection.	○	This plan route can avoid the range of the loose area of the Thomang Cliff although many issues are to be resolved. Route B is adopted in the First Selection.	△	It is difficult to design the road while securing the safety at the section of the valley south of the Thomang Cliff. Accordingly, this route cannot be adopted in the First Selection.	×	It is difficult to avoid the loose areas of Thomang Cliff by taking this route. Accordingly, the route is regarded as dangerous and cannot be adopted in the First Selection.	×

ROUTE COMPARISON (SECOND SELECTION)

<table>
<tr><th>Item ＼ Route</th><th colspan="2">Route A (Tunnel work through all section）</th><th colspan="2">Route B（ Integration of Tunnel and Existing Road Widening）</th></tr>
<tr><td>Basic Concept of the route selection</td><td colspan="2">・A route to avoid the loose area of Thomang Cliff and a valley south of Thomang Cliff by tunnel structure.
・At the north side, the tunnel begins from a smooth connection from the direction of the current road under widening construction to the masonry retaining wall at the valley side of the road. From there, it takes a curve with a curvature of 300 m to avoid Thomang Cliff and reaches a valley south of the cliff. The tunnel will have 50 m (5D) depth from the surface for securing sufficient overburden for the tunnel. From there, the tunnel goes straight for 200 m and then takes a curve to the west side with a curvature of 300 m to connect to the current road under widening construction at the exit on the south side of the tunnel.</td><td colspan="2">・ A route to avoid the loose area of Thomang Cliff by tunnel and to minimize the tunnel length.
・ At the north side, the tunnel begins from a smooth connection from the direction of the current road under widening construction to the masonry retaining wall at the valley side of the road. From there, it takes a curve with a curvature of 200 m to avoid Thomang Cliff and reaches a valley south of the cliff. The tunnel comes to the exit there and connects with the current road and then takes a route along the road alignment of the current road.</td></tr>
<tr><td>Length of road work</td><td colspan="2">Total length L= 840m (No.0+0～No.42+0)
Length of Road excluding a tunnel L= 95m (11.3 %)
Length of a tunnel L=745 m (88.7 %)</td><td colspan="2">Total length L= 1,090 m (No.0+0～No.54+10)
Length of road excluding a tunnel L= 759 m(69.6%)
Length of a tunnel L=331 m(30.4%)</td></tr>
<tr><td>〈Design Specification〉
○ Road Standard：Standard of the Primary National Highway
○ Design Speed：V=30km/h
○ Road Width：W=7.5m of 2 lanes

Schematic map</td><td colspan="4">
</td></tr>
<tr><td>Present conditions</td><td colspan="4"><table><tr><th>Road length (m)</th><th>Road width (m)</th><th>Route conditions</th><th>Maximum road gradient (%)</th><th>Mini. radius of curvature (m)</th><th>Traffic volume (cars/day)</th></tr><tr><td>1,210 m</td><td>4.0 m</td><td>Steep terrain</td><td>i=8.7% at 2 locations</td><td>R=12 m at 1 location</td><td>400 cars/day (in 2014)</td></tr></table></td></tr>
<tr><td>Road alignment condition</td><td colspan="2">Minimum radius of curvature (m): R = 300 m
Maximum road gradients and its length i＝1.57%, L= 829 m</td><td colspan="2">Minimum Radius of curvature (m) R=20 m (in the widening section)
Maximum road gradients and its length i＝4.20 %, L= 396 m</td></tr>
<tr><td rowspan="2">Geological and geographical features from the results of:
･Site Reconnaissance
･Boring Survey
･Elastic wave exploration</td><td colspan="4">(Terrain situation) The target area is located on a mountain slope between the peak of the mountain at an elevation of 2,900 m and the river bed at l, 870 m. The target road is the Primary National Highway that crosses almost at the middle of the mountain slope at an altitude of 2,250 m. Large and small valleys are developed to the East direction from a ridgeline stretching between the the North and South direction, and the Highway crosses those valleys.
(Geology) Granitic Gneisses are distributed in the vicinity of the target section. Biotite Gneisses are partly interstratified though it is mostly uniform rock types. As expected in the results of topographic interpretation by maps, it was confirmed in the field that geological structures of schistosity and bedding are observed at the strike of approximately N60 - 80 ° W and 30 ° inclination to the south.</td></tr>
<tr><td colspan="2">A section of the tunnel is located on the mountain side from the current road and crosses two ridges and a valley. The maximum thickness of the expected overburdens is about 190 m at the southern ridge point and about 55 m at the valley site. Regarding the geological conditions, Granite Gneisses are mainly distributed in the area. On the south side, pelitic schists containing garnets are distributed, which is in contact through uncomformity over the Granite Gneisses. Since it was observed on the ground that hard vein-like pegmatites were distributed in the Granite Gneisses, there is a possibility to encounter the hard pegmatites in some places of the tunnel drilling route.
・ The Northern tunnel portal side (Trongsa side) is located in a natural slope and it is rather gentle, at about 30 to 40 degrees, compared to the surrounding slopes.
・ The bedrocks of the area are composed of hard Granite Gneiss rocks and most of the slopes are covered with talus deposits including boulders 1 to 3 m in diameter and trees and shrubs cover the entire area.
・ In slopes of the South tunnel portal side, the depths of the talus deposits are rather thin and the bedrocks underneath are composed of hard Granite Gneiss rocks as well as the North side.</td><td colspan="2">・ The North side of the tunnel portal is the same location as Route A and the South side is at the valley. The maximum thickness of overburden is about 115 m at the ridge point. Regarding the geology, Granite Gneisses are mainly distributed the same as Route A.
・ The North side of the tunnel of Route B is the same location as Route A.
・ The South portal site is located in the North-side slope of a valley where water flows constantly. The bedrocks of the slope are composed of hard Granite Gneisses rocks.
・ The slopes on the lower side of the current roads are very steep, at 50 to 80 degrees, and it is difficult to widen the road toward the lower slope side.
・ Slopes on the upper side are rather gentle at 25 to 30 degrees at the southern part of the taget section and steep slopes of more than 70 degrees continue at the Northern part.</td></tr>
<tr><td>Drivability of the road alignment</td><td>･At the connecting sections between the tunnel, tunnel portals and current roads, road alignments and concrete structures can be designed to connect smoothly.
･A longitudinal slope in the tunnel can be designed with a satisfactory gradient at 1.57 %. (i=1.57%). Desirable gradients in a tunnel for ventilation purposes is 3 % and less.
・ The radius of curvature of the road in the tunnel is 300 m (R=300 m) and it is a satisfactory road alignment which meets a design speed of 80 km/h. (Required design speed is 30 km/h).
･The design speed of the road alignment in the tunnel section is much higher than the road alignments of the current roads connecting at the tunnel portal parts. Accordingly, speed control measures shall be required at the tunnel section and the connecting sections. (The route has a shortening effect, reducing the length from the current road by 370 m, which is shorter by 30% of the rate of the original road length.</td><td>○</td><td>･At the South tunnel portal side, a loose curve in the tunnel (R=200 m) is expected to connect with a sharp curve (R=40 m) of the road outside the tunnel. It is an undesirable combination of road alignment. It is difficult to drive vehicles from the tunnel side to the outside.
･The longitudinal road gradient in the tunnel is 4.2 % (i = 4.2%), which is unfavorable for ventilation. The desirable gradients for ventilation are 3% and less.
･In the Sothern part of the target section, basic consideration was given to widen the current roads while introducing structure measures. However, it did not satisfy the design standards of the national highway which the design speed is 30km/h; the minimum radius is 30 m (R=30m); the minimum curve length is 50 m; and the minimum transition curve length is 25 m (L = 25 m). It was accordingly concluded to adopt a large scale of cutting work for widening the roads toward the upper side in case this route plan is applied. It was therefore expected that the construction costs will increase significantly.</td><td>△</td></tr>
<tr><td>Workability and safety for the construction</td><td>・ The construction of the tunnel work is normally started from the lower elevation side, which is the North side of the tunnel. The terrain of the North portal side is relatively loose and a construction yard can be made near the area.
･There are hillside slopes with unconsolidated geological structure near the North tunnel portal site. Accordingly, auxiliary construction methods to stabilize the slopes will be required during the construction period.
・ Hillsides near the South side of the tunnel portal seem geologically consolidated and have better conditions for the construction work compared to the North side.
・ A construction period can be expected to last roughly two years.
･From considerations about the tunnel length and current traffic volumes, ventilation facilities are not required to be equipped. However, it may be necessary to confirm the necessity of the facilities based on the estimatation of future traffic volumes.
･Emergency equipment for tunnel Grade C, which include emergency telephones, push-button reporting devices and emergency alarm devices, shall be equipped since the tunnel of this plan is regarded as C grade. In Japan, the information system of the emergency equipment has the mechanism to notify the police, fire departments and road administrators, etc.
・ Although there are few pedestrians passing through, it is necessary to consider safety measures to maintain and protect passages of cow herders and light weight vehicles. (This is related with the consideration of emergency facilities.)</td><td>○</td><td>・The North tunnel portal side has the same location and construction conditions as Route A.
・The South portal side has similar construction conditions to Route A.
・Regarding the ventilation system, it has the same situation as Route A.
・Emergency facilities are not particularly required as this tunnel is classified as D Grade.
・It seems extremely difficult to widen the road toward the lower side (valley side). It is also assumed to be difficult to operate road widening work with structures like rock-shed methods at the upper slope side of the road. Maintaining the current traffic is also difficult during the construction periods. In case of cutting method, it will be required to cut the hillside beyond the ridge behind the slopes at a maximum height of 200 m.
・Temporal operational roads for cutting work are required to construct from the North side at the South-faced slope, which is rather gentle, in order to take out excavated soil. The volume of the soil is expected to be 1,120,000 m3 (earth soil) and it accordingly will require a much longer period for construction operation compared with Route A.
・Speed control will be required for vehicles coming from the North and running to the South because of the non-uniformity of road alignments between the tunnel section and current road widening section.
・It is necessary to consider some safety and protection measures if emergency facilities are not equipped.</td><td>△</td></tr>
<tr><td>Environment and landscape</td><td>・Tunnels have little negative impact on the landscape and environment though noises and exhaust gases are concentrated at the tunnel portal sites. It is required to conduct Environment Impact Assessment at each stage of Survey and Planning, Designing, Constructions and Maintenance.
・Waste soil treatment (60,000 m3, Earth soil) from the tunnel construction shall be considered.
・Maintenance costs for lights and emergency facilities is required to be considered.
・The road will be paved with concrete and have a longer operation period compared with</td><td>○</td><td>・The volume of the cutting work will be on a large scale. Accordingly it is required to consider how to deal with the surplus soil from the cutting work.
・Periodical checking and maintenance and management shall be considered for the surface of the long slope of the cutting work.
・Safety measures will be required as there is no plan to equip emergency facilities.</td><td>△</td></tr>
<tr><td>Economic efficiency</td><td>・Rough estimation of total construction cost : 3,262 million Japanese Yen
(3,880 mil. Japanese Yen / km)
・Cost for construction : 2,871
・Cost for designing/construction management : 237
・Cost for reservation : 155</td><td>○</td><td>・Rough estimation of total construction cost : 5,255 million Japanese Yen
(4,824 mil. Japanese Yen / km)
・Cost for the construction : 4,824 (1.6 times of the Route A)
・Cost for designing/ construction management : 181
・Cost for reservation : 250</td><td>△</td></tr>
<tr><td>Remark</td><td colspan="4">・It is necessary to consider a plan of effective usage for the waste soil from the construction (e.g. effective use for land development)
・Tangsibji power generation is being constructed near the North entrance side of the tunnel (by HCC). It will therefore be required to adjust the area and road to enter the generation construction site.
・The road widening construction work of the National Highway No.1 is currently being carried out, excluding this target road section. The designed road width of the work is 7.5 m (W=7.5m), the same as this target work design. The construction work is expected to be completed in December, 2017. It will be required to include the construction completion of the road in the tunnel construction plan.</td></tr>
<tr><td>Comprehensive evaluation</td><td colspan="4">Route A is better in All evaluation items</td></tr>
</table>

Outline Project Cost for the Route A Construction

Item	Classification	Price Unit: 1000JPY	Remarks
［1］Construction Expense		2,870,823	
（1）	Civil Construction Cost	2,734,118	
	1）Construction Cost	2,523,156	
	① Direct Construction Cost	1,914,727	Tunnel section + earthwork section
	② Common Temporary Work	108,492	Kr＝ A×P ①× 5.67 ％ b
	③Field Expense (Ratio)	499,937	（①+②）×24.71％
	④Field Expense (Build-up)	113,869	Detailed statement of field expense (Build-up)
	2）General and Administrative Expense	210,962	（①+②+③+④）×8％
（2）	Environmental Expense	136,706	5% of Civil construction cost (DOR's adjustment)
［2］Design and Construction Management		231,969	
（1）	Detailed Design	71,409	Detailed statement of detailed design
（2）	Construction Management	138,578	Detailed statement of construction management
（3）	Soft Component	21,982	Detailed statement of soft component
Preliminary expenses		155,395	（［1］+［2］）×5％
Operation Cost		3,263,292	
		3,260,000	Rounded to the nearest ten million

Outline Project Cost for the Route B Construction

Item	Classification	Price (Unit:1000JPY)	Remarks
［1］Construction Expense		4,824,218	
（1）	Civil Construction Cost	4,594,494	
	1）Construction Cost	4,248,552	
	①Direct Construction Cost	3,250,341	Tunnel section+ Earthwork section
	②Common Temporary Work	156,405	①× 4.81 ％ Kr＝A×Pb
	③Field Expense (Ratio)	841,807	（①+②）×24.71％
	④Field Expense (Build-up)	75,717	Detailed statement of Field Expense (Build-up)
	2）General and Administrative Expenses	345,942	（①e②+③+④）×8％
（2）	Environmental Expense	229,725	5% of Civil construction cost (DoR’s adjustment)
［2］Design and Construction Management		180,461	
（1）	Detailed Design	66,409	Detailed statement of Detailed Design t
（2）	Construction Management	92,070	Detailed statement of construction management
（3）	Soft Component	21,982	Detailed statement of soft component t
Preliminary expenses		250,234	（［1］+［2］）×5％
Operation Cost		5,254,913	Rounded to the nearest ten million
		5,250,000	

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OYO INTERNATIONAL CORPORATION

PROJECT NAME

THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE

DRAWING No.

SCALE 1:2500 —(A1)
1:5000 —(A3)

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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE

DRAWING No.

SCALE 1:1000 —(A1)
1:2000 —(A3)

KOKUSAI KOGYO CO., LTD.
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PROJECT NAME

THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

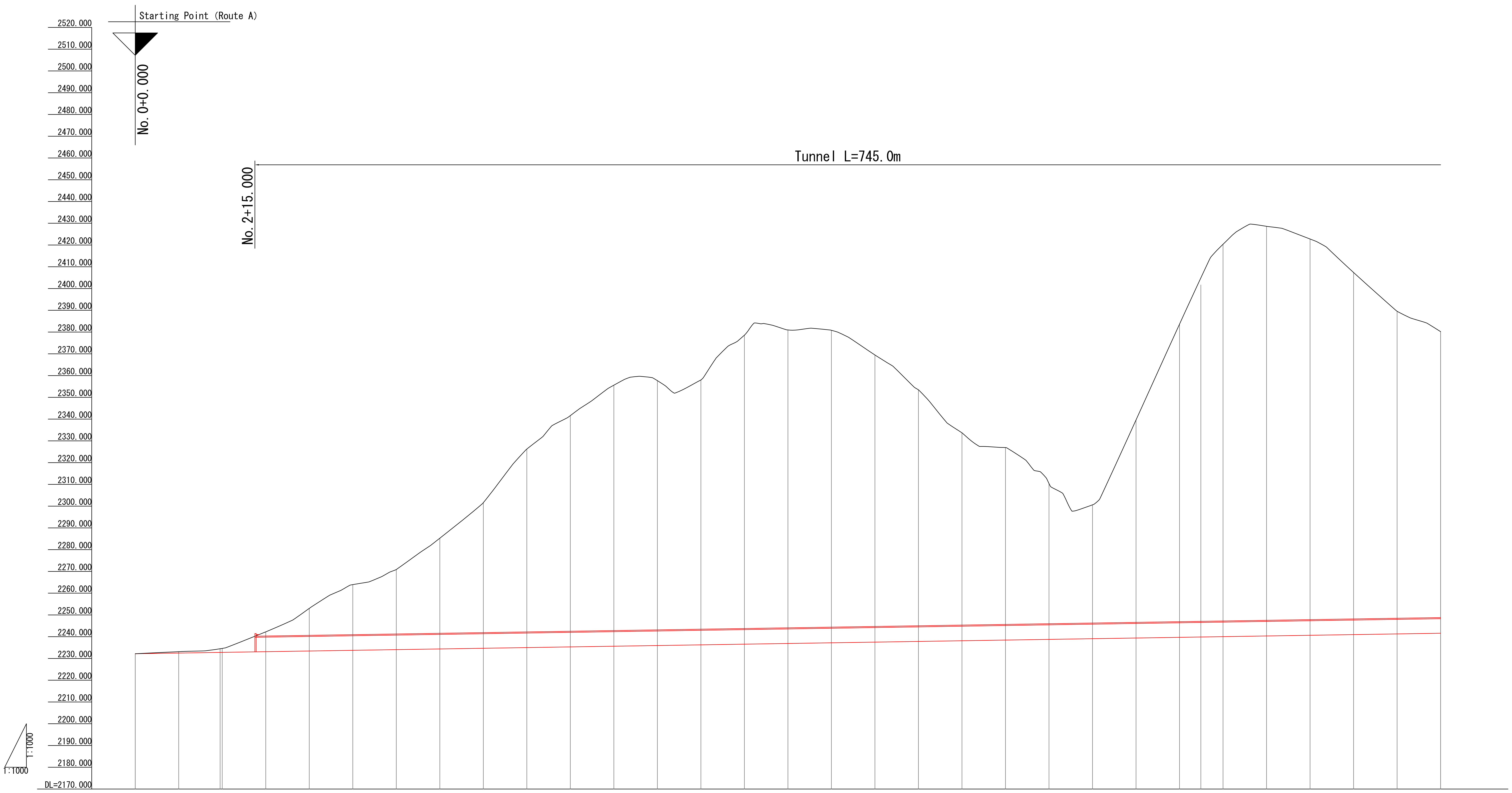
TITLE

DRAWING No.

SCALE 1:1000 —(A1)
1:2000 —(A3)

Route A Longitudinal Profile (1)

V=1:1000
H=1:1000



Inclination: 2232.170 i=1.570% L=828.815

Survey Point	Planned Height	Surface Height
BP	2232.170	2232.171
NO.1	2232.484	2233.121
BC 1-0	2232.783	2234.536
NO.2	2232.798	2234.610
NO.3	2233.112	2242.237
NO.4	2233.426	2253.023
NO.5	2233.740	2263.943
NO.6	2234.054	2270.837
NO.7	2234.368	2285.260
NO.8	2234.682	2301.591
NO.9	2234.996	2326.236
NO.10	2235.310	2341.609
NO.11	2235.624	2355.597
NO.12	2235.938	2357.690
NO.13	2236.252	2357.988
NO.14	2236.566	2378.575
NO.15	2236.880	2380.977
NO.16	2237.194	2380.811
NO.17	2237.508	2369.458
NO.18	2237.822	2353.458
NO.19	2238.136	2333.707
NO.20	2238.450	2326.924
NO.21	2238.764	2310.356
NO.22	2239.078	2300.606
NO.23	2239.392	2339.584
NO.24	2239.706	2383.663
EC 1-0	2239.860	2401.622
NO.25	2240.020	2420.362
NO.26	2240.334	2428.595
NO.27	2240.648	2422.763
NO.28	2240.962	2407.411
NO.29	2241.276	2389.539
NO.30	2241.590	2380.193

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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

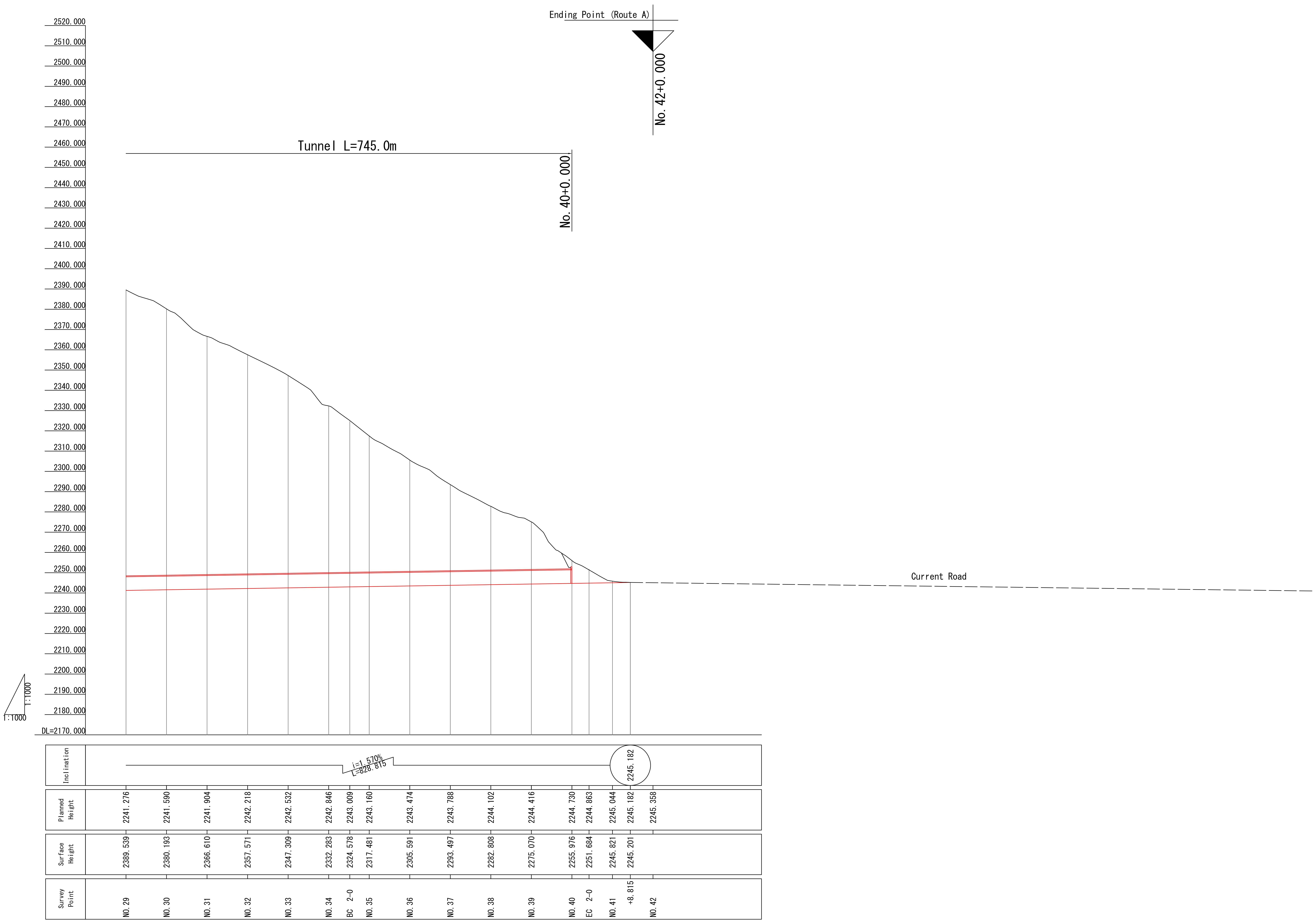
TITLE

DRAWING No.

SCALE 1:1000 —(A1)
1:2000 —(A3)

Route A Longitudinal Profile (2)

V=1:1000
H=1:1000



Survey Point	Planned Height	Surface Height
NO. 29	2241.276	2389.539
NO. 30	2241.590	2380.193
NO. 31	2241.904	2366.610
NO. 32	2242.218	2357.571
NO. 33	2242.532	2347.309
NO. 34	2242.846	2332.283
BC 2-0	2243.009	2324.578
NO. 35	2243.160	2317.481
NO. 36	2243.474	2305.591
NO. 37	2243.788	2293.497
NO. 38	2244.102	2282.808
NO. 39	2244.416	2275.070
NO. 40	2244.730	2255.976
EC 2-0	2244.863	2251.684
NO. 41	2245.044	2245.821
+8.815	2245.182	2245.201
NO. 42	2245.358	

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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

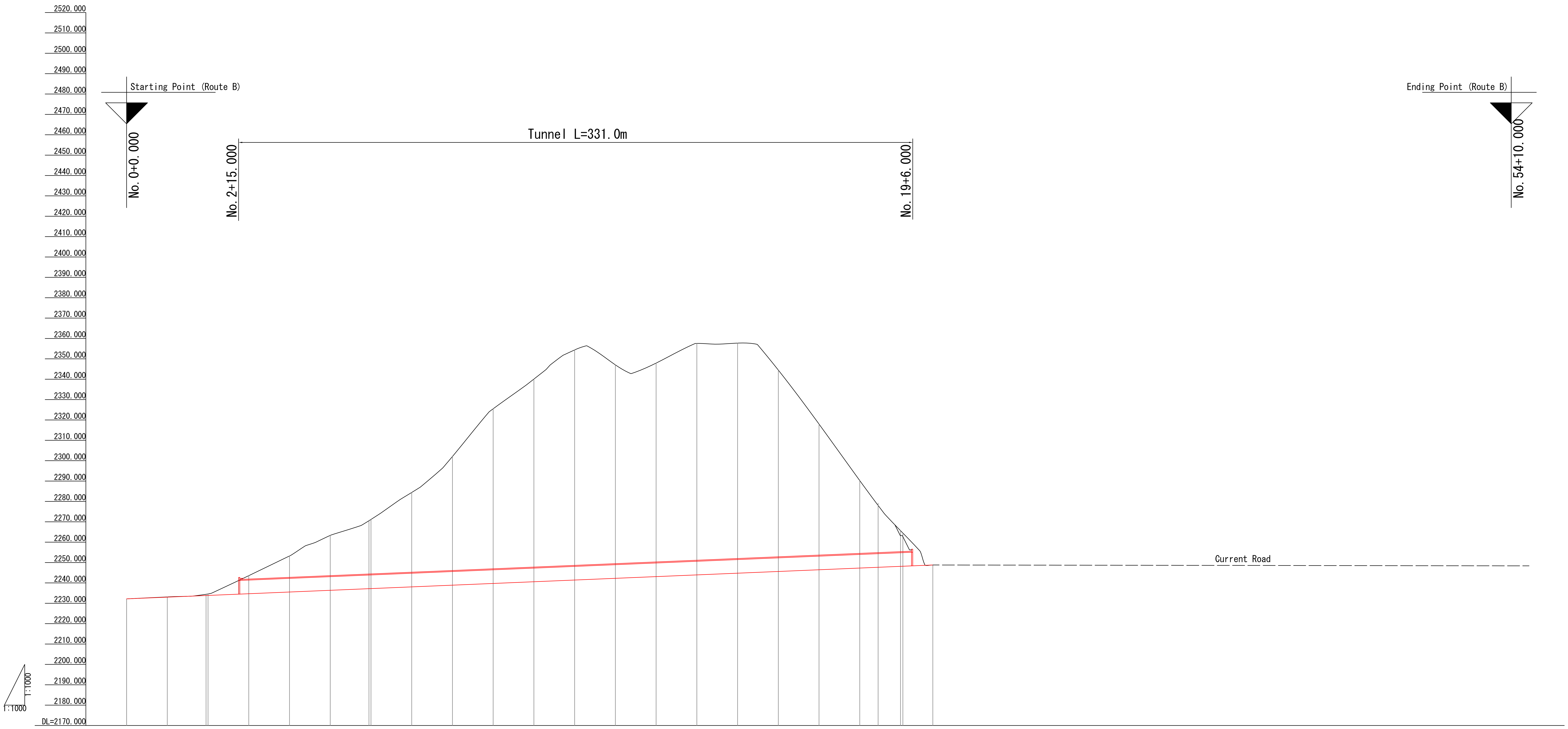
TITLE

DRAWING No.

SCALE 1:1000 —(A1)
1:2000 —(A3)

Route B Longitudinal Profile

V=1:1000
H=1:1000



Inclination	2232.170									i=4.200% L=396.000												2248.802
Planned Height	2232.170	2233.010	2233.809 2233.850	2234.690	2235.530	2236.370	2237.169 2237.210	2238.050	2238.890	2239.730	2240.570	2241.410	2242.250	2243.090	2243.930	2244.770	2245.610	2246.450	2247.290	2247.669	2248.130 2248.179	2248.802 2248.907
Surface Height	2232.171	2233.121	2234.515 2234.587	2243.574	2253.238	2263.339	2270.767 2271.150	2284.400	2302.091	2325.489	2340.055	2354.383	2347.040	2347.912	2357.567	2357.728	2344.492	2317.956	2290.220	2279.144	2265.658 2264.431	
Survey Point	BP	NO.1	BC 1−0 NO.2	NO.3	NO.4	NO.5	EBC 1−1 NO.6	NO.7	NO.8	NO.9	NO.10	NO.11	NO.12	NO.13	NO.14	NO.15	NO.16	NO.17	NO.18	EC 1−0	NO.19 BC 2−0	+16.000 +18.488

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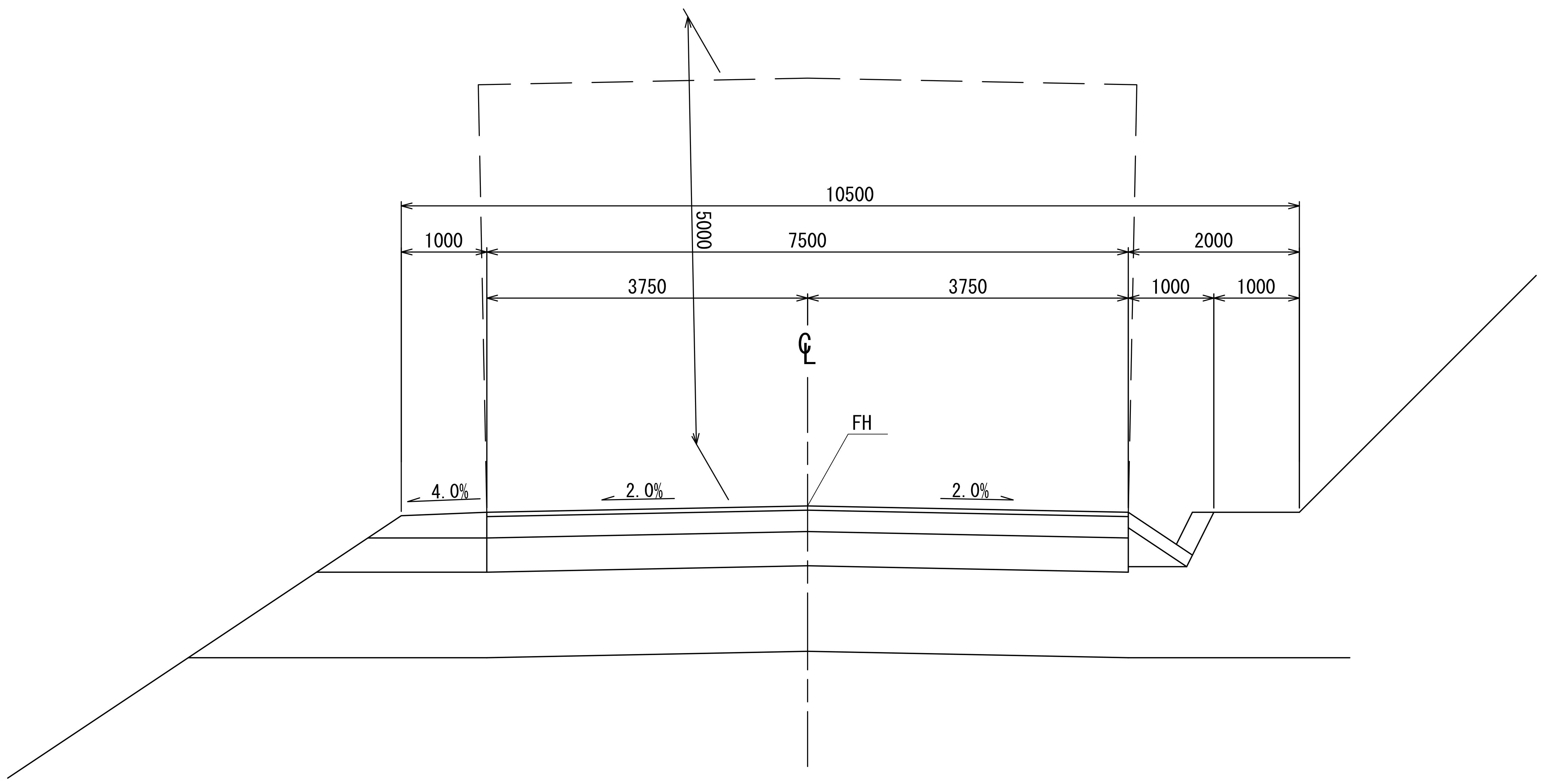
TITLE

DRAWING No.

SCALE 1:1000 —(A1)
1:2000 —(A3)

Standard Transverse Profile Scale 1:50

Design Speed V＝３０ｋｍ/ｈ



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PROJECT NAME

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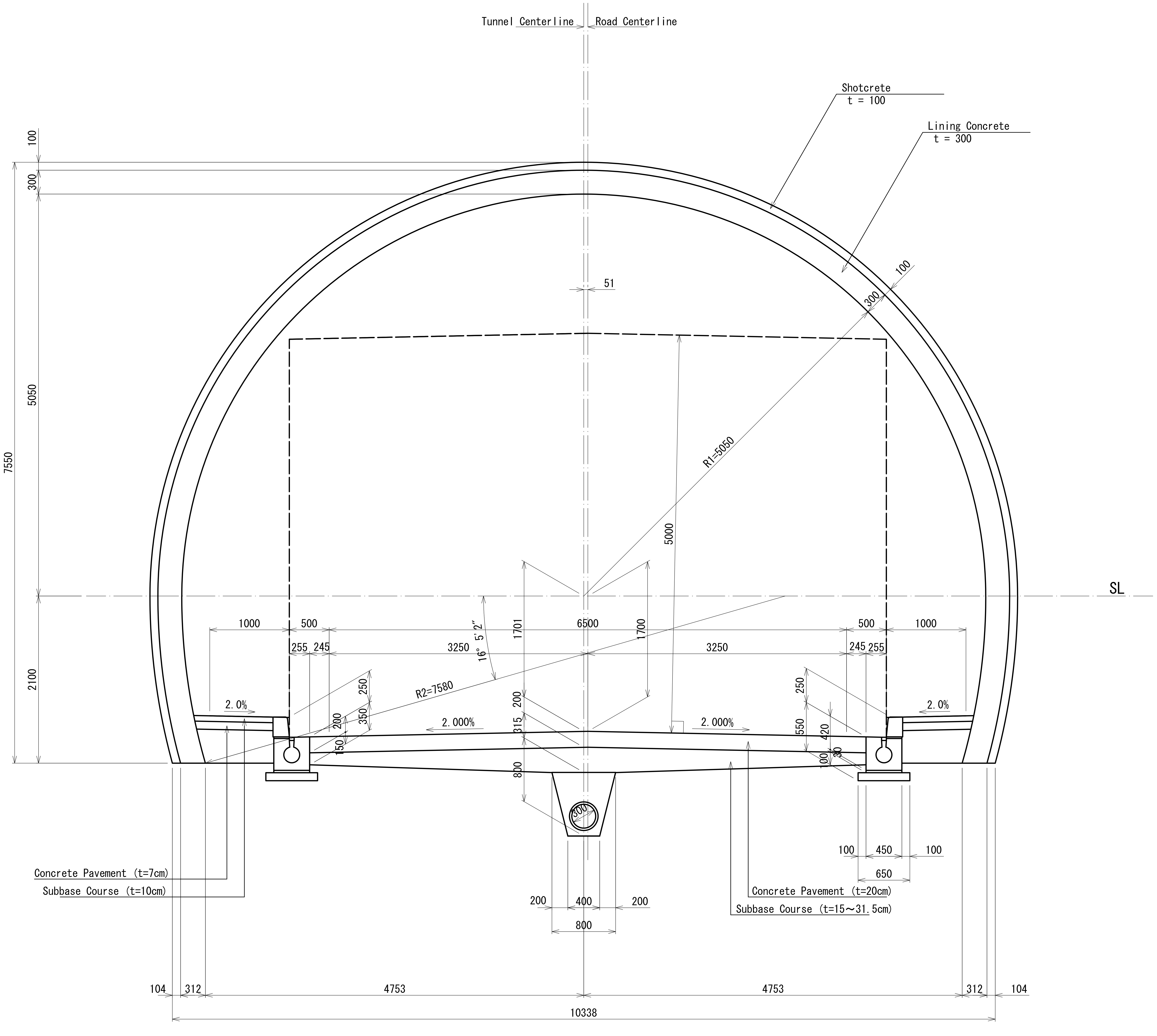
TITLE

DRAWING No.

SCALE 1:50 —(A1)
1:100 —(A3)

Standard Cross Section (1) S=1:30

Cross Section CI, CII



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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

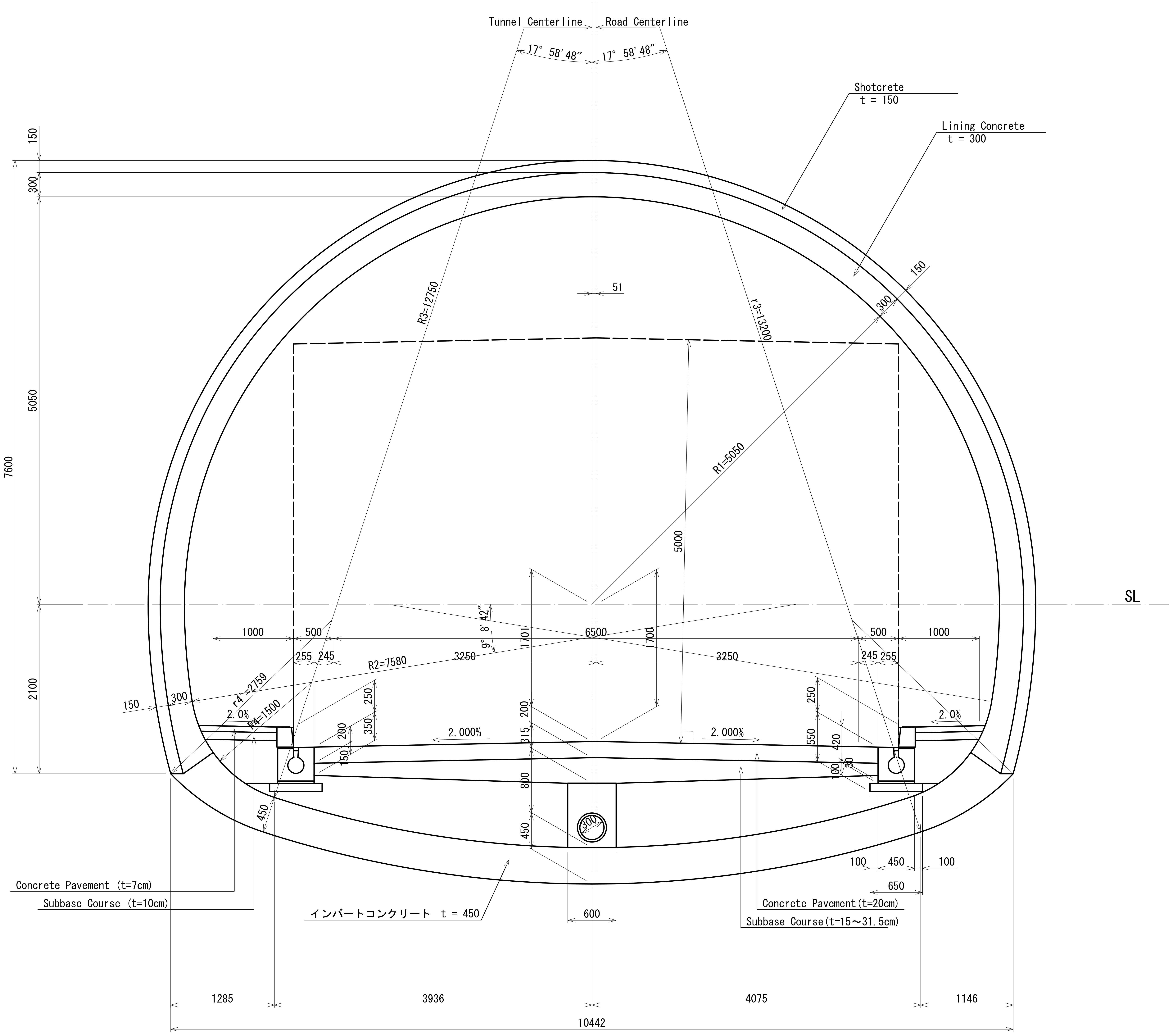
TITLE

DRAWING No.

SCALE 1:30 —(A1)
1:60 —(A3)

Standard Cross Section (2) S=1:30

Cross Section DI



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PROJECT NAME
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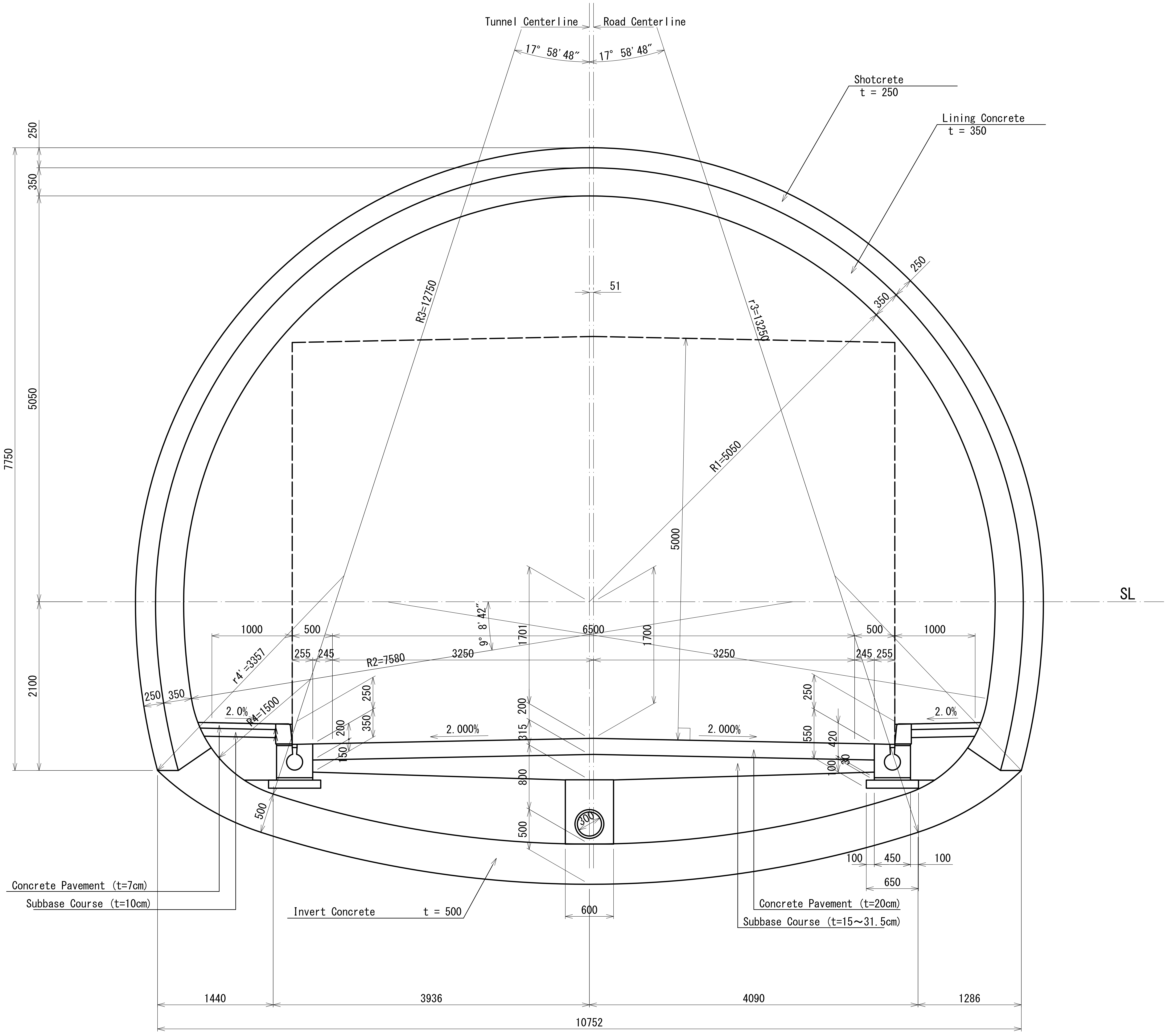
TITLE

DRAWING No.

SCALE 1:30 —(A1)
1:60 —(A3)

Standard Cross Section (3)   S=1:30

Cross Section DⅢ-1, DⅢ-2



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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE

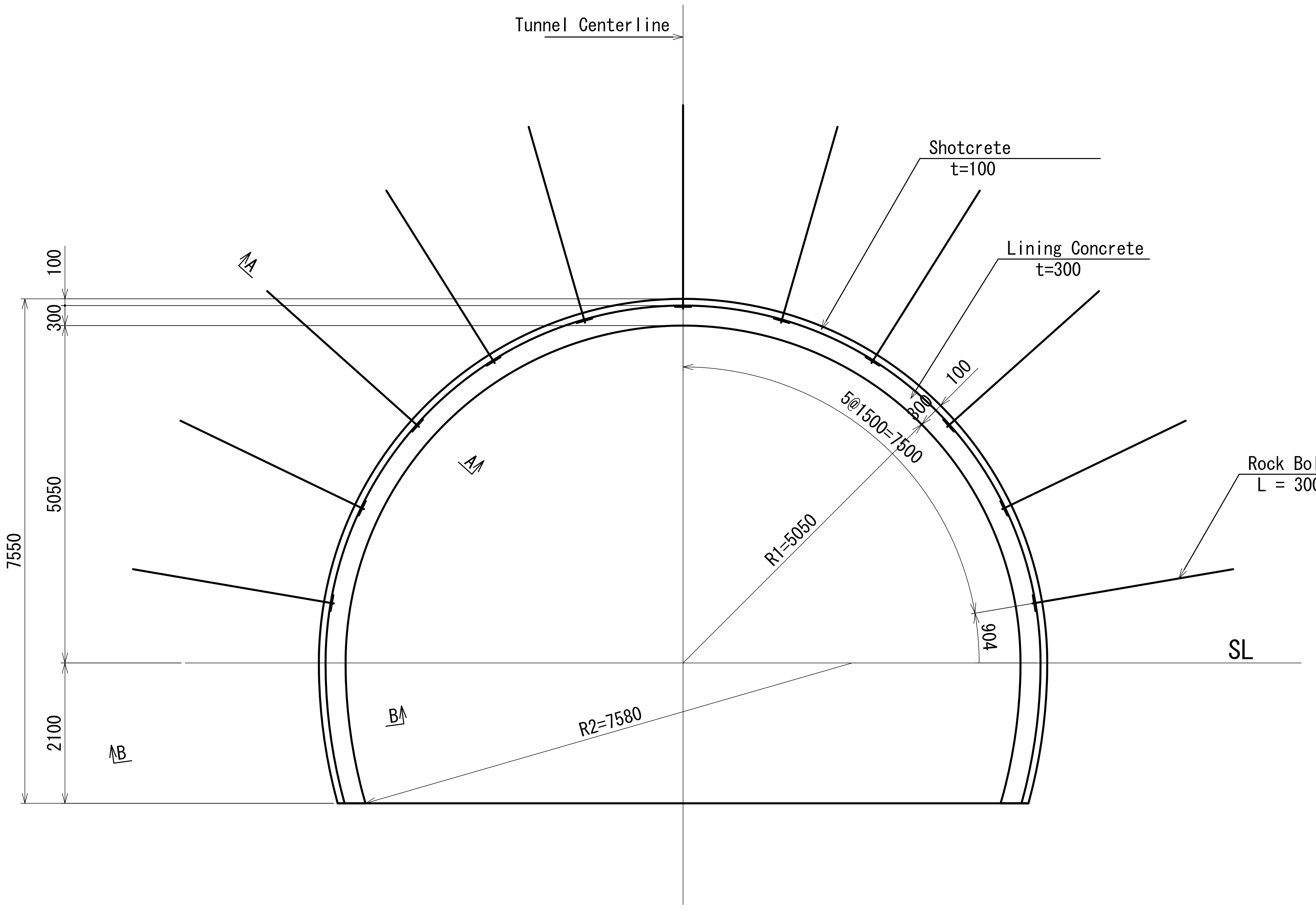
DRAWING No.

SCALE 1:30 —(A1)
1:60 —(A3)

Support Pattern (1) S=1:60

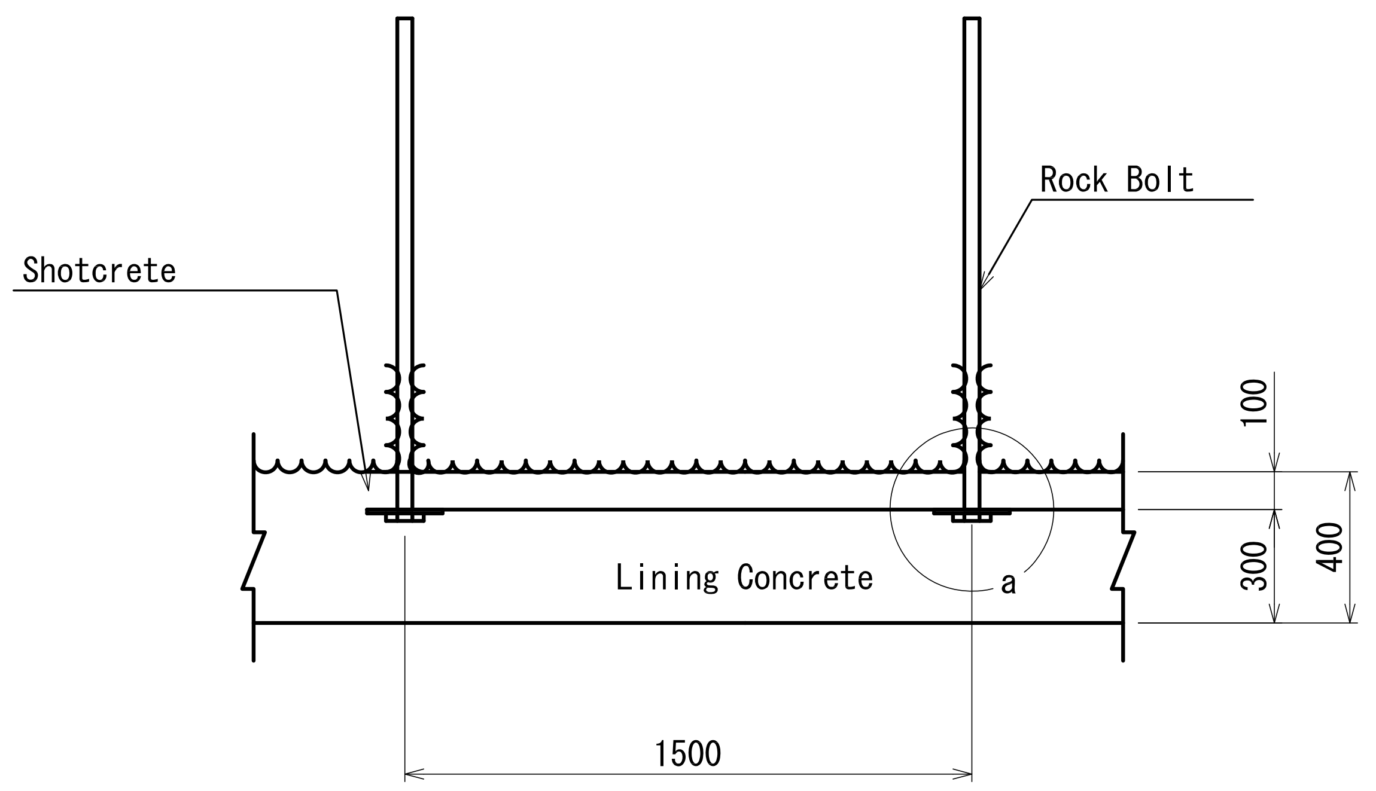
(Cross Section CI)

Shotcrete & Rock Bolt

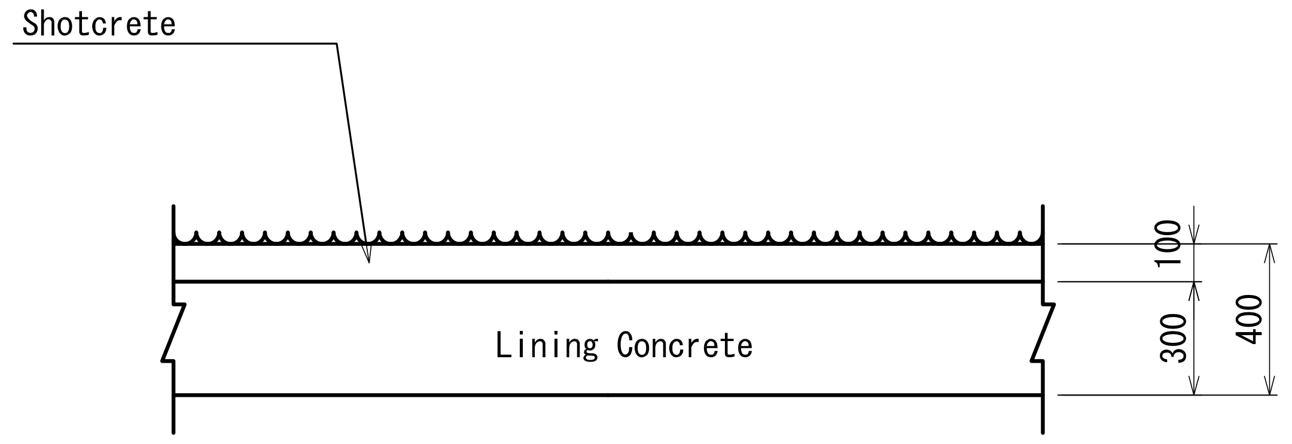


Cross Section Details S=1:20

Cross Section A-A

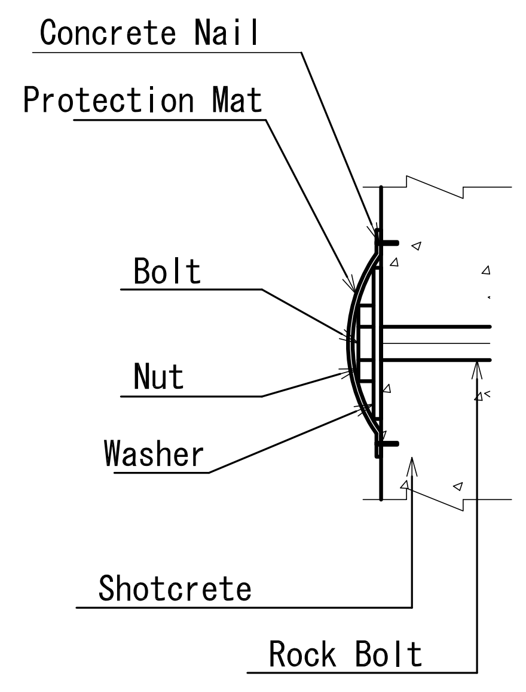


Cross Section B-B



a Parts Details S=1:10

Rock Bolt Head Finishing



Specifications

Rock Bolt			Steel Arch Support		Shotcrete	Lining Thickness (cm)		Wire Net	Deformation Margin(cm)		
Length (m)	Circumferential Direction (m)	Extention Direction (m)	Upper Half	Lower Half	Thickness (cm)	Arch	Invert		Upper Half	Lower Half	Invert
3.0	1.5	1.5	-	-	10	30	-	-	0	0	0

Shotcrete & Rock Bolt Materials

(P= around 1.500m)

Name	Geometries	Standard	Unit	Quantity	Application
Rock Bolt	L=3000	Yield Strength over 176.5kN(18t)	no.	11	Full Face Cementing Mortar
Washer	150×150×9	SS400	no.	11	
Nut		M24	no.	11	
Shotcrete	t=100	Design Standard Strength $\sigma ck=18N/mm^2$	m^2	31.589	21.059 m^2/m
Protection Mat	300×300×10		no.	11	

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PROJECT NAME
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TITLE

DRAWING No.

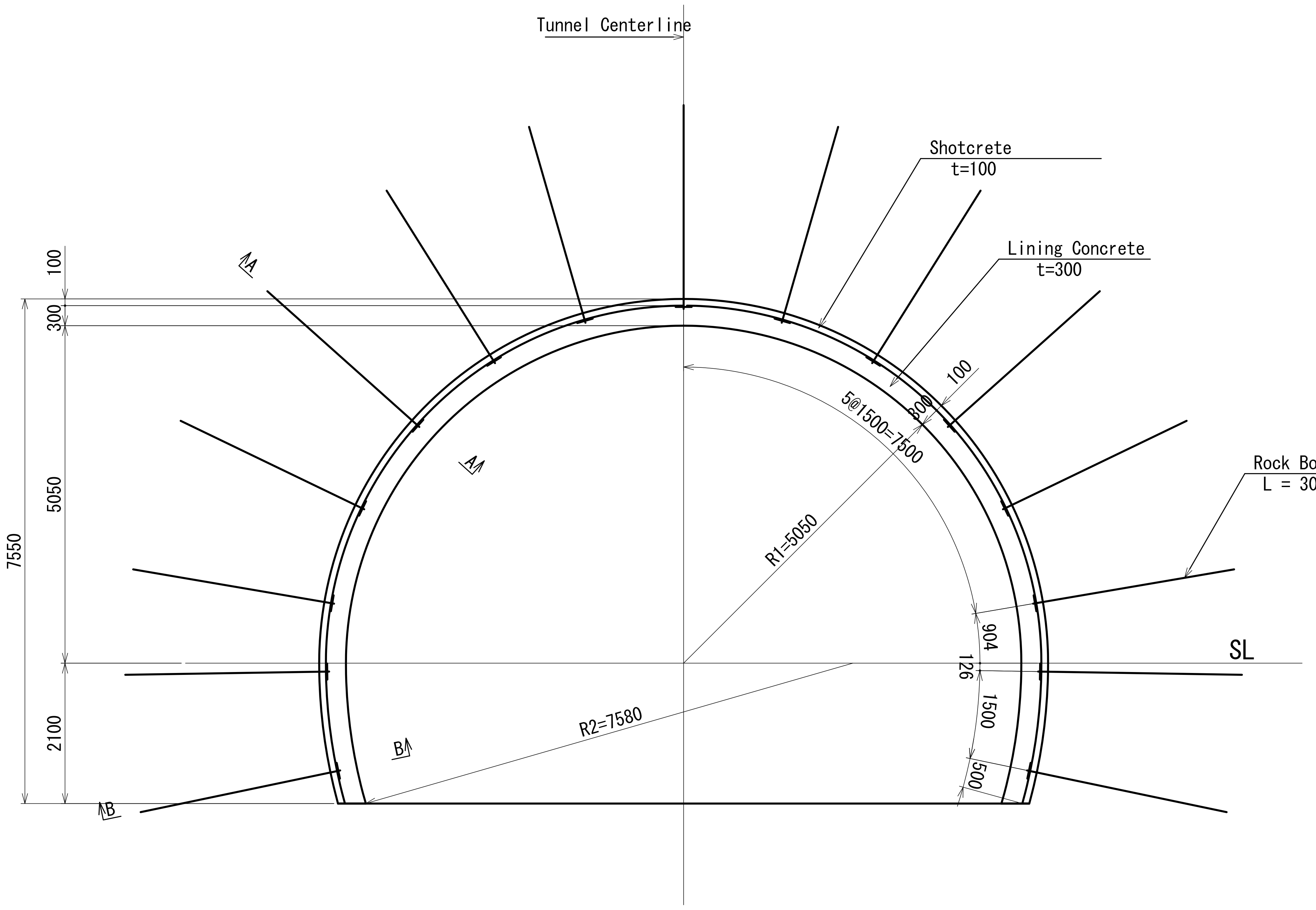
SCALE Illustration —(A1)
Illustration —(A3)

Support Pattern (2)

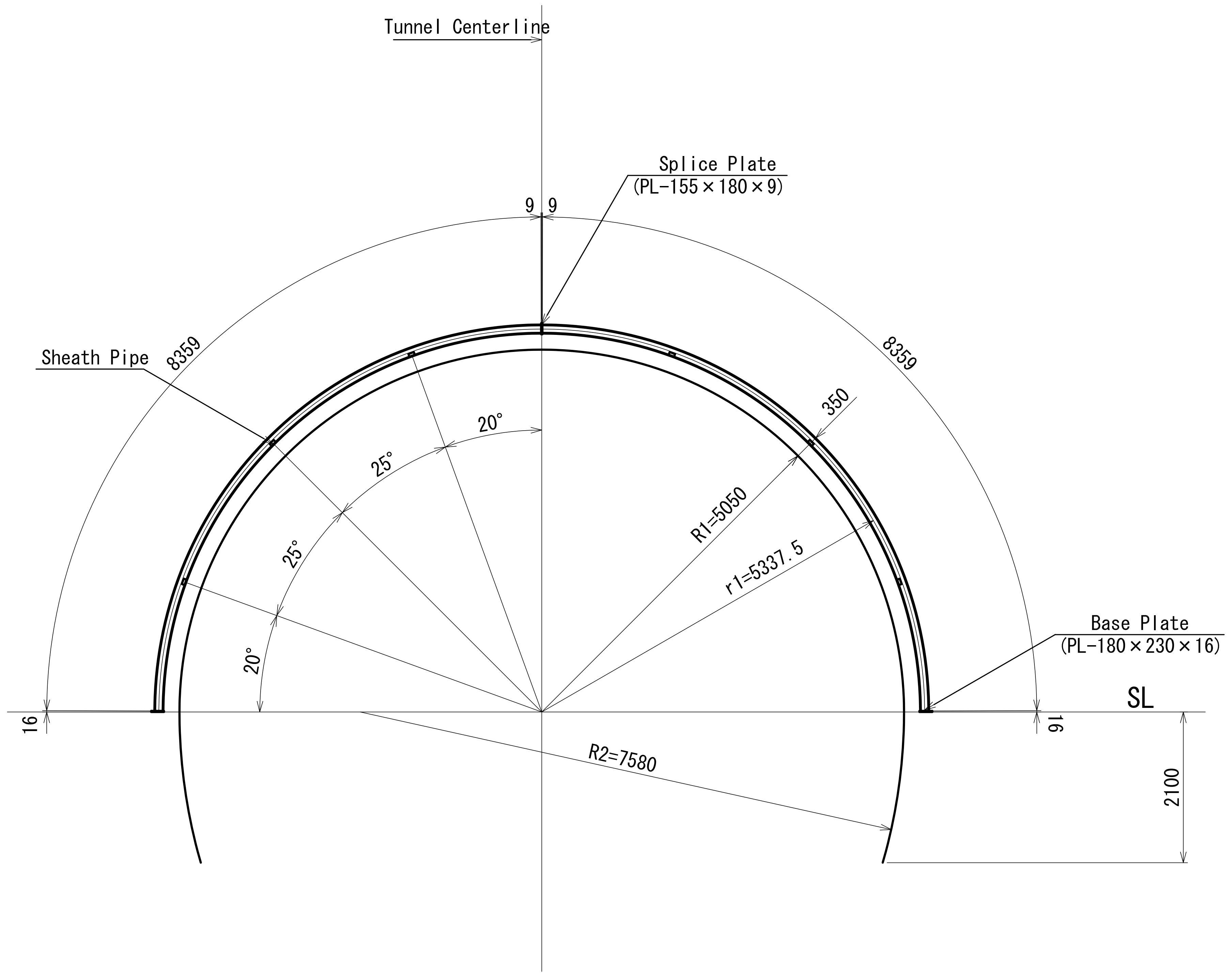
S=1:60

(Cross Section CII)

Shotcrete & Rock Bolt

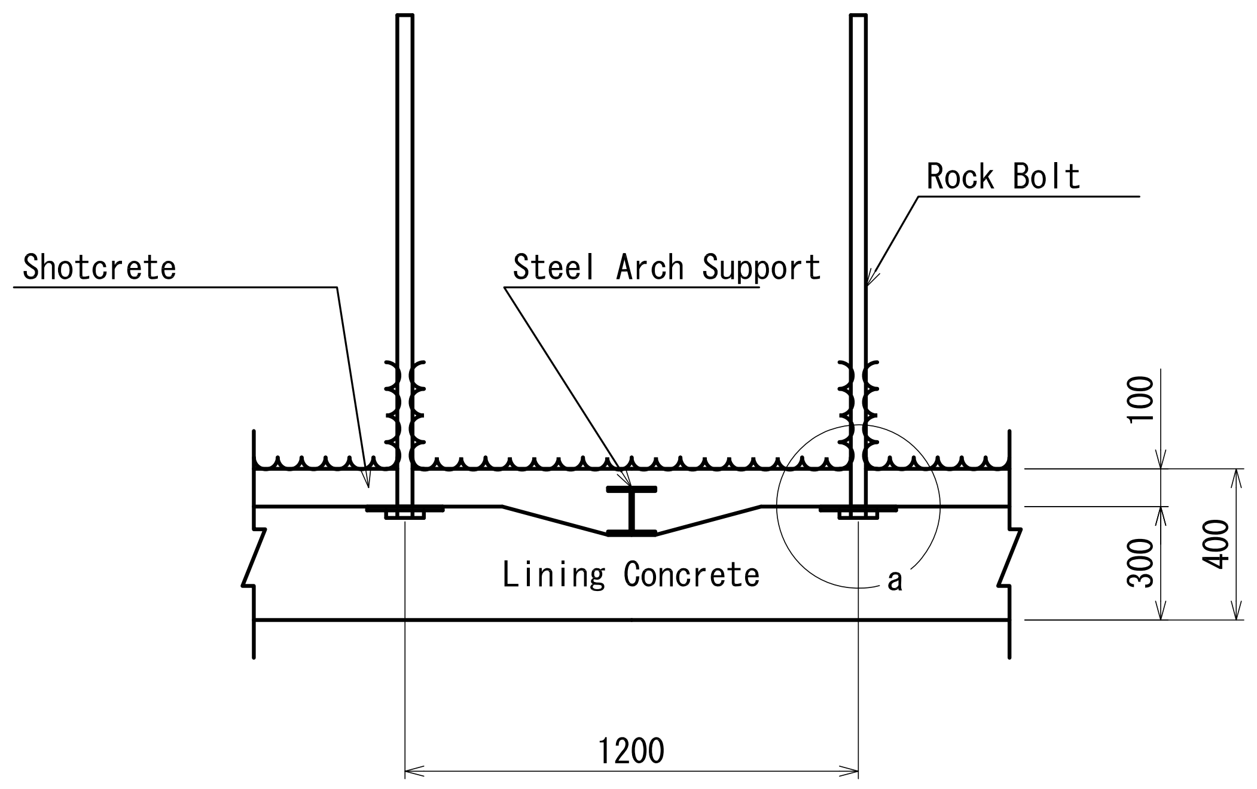


Steel Arch Support

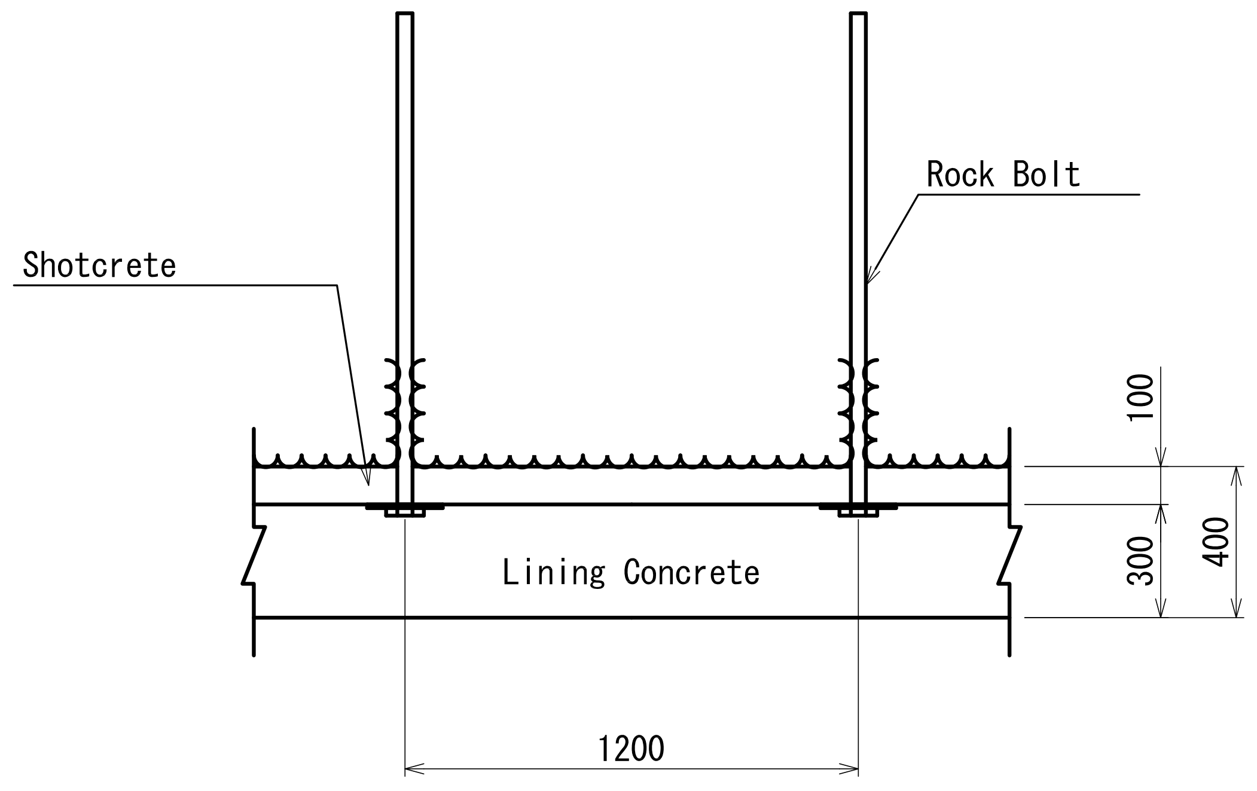


Cross Section Details S=1:20

Cross Section A-A

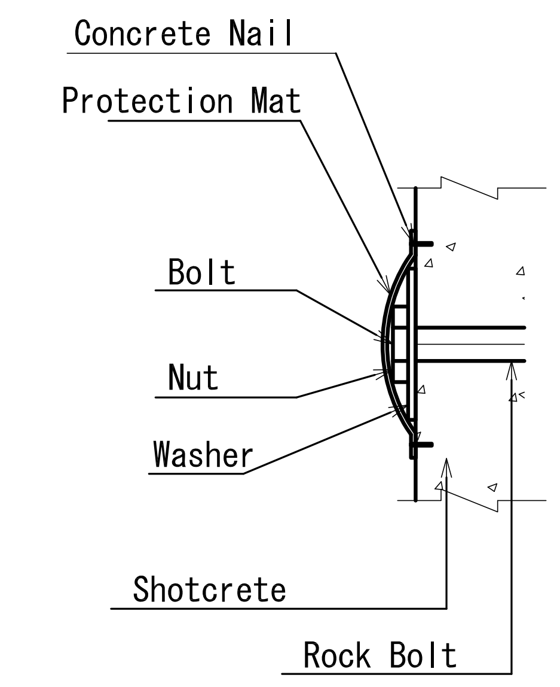


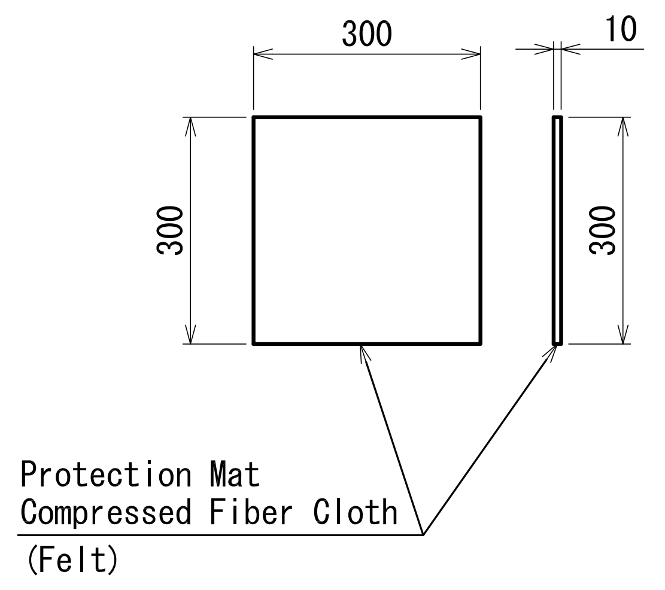
Cross Section B-B



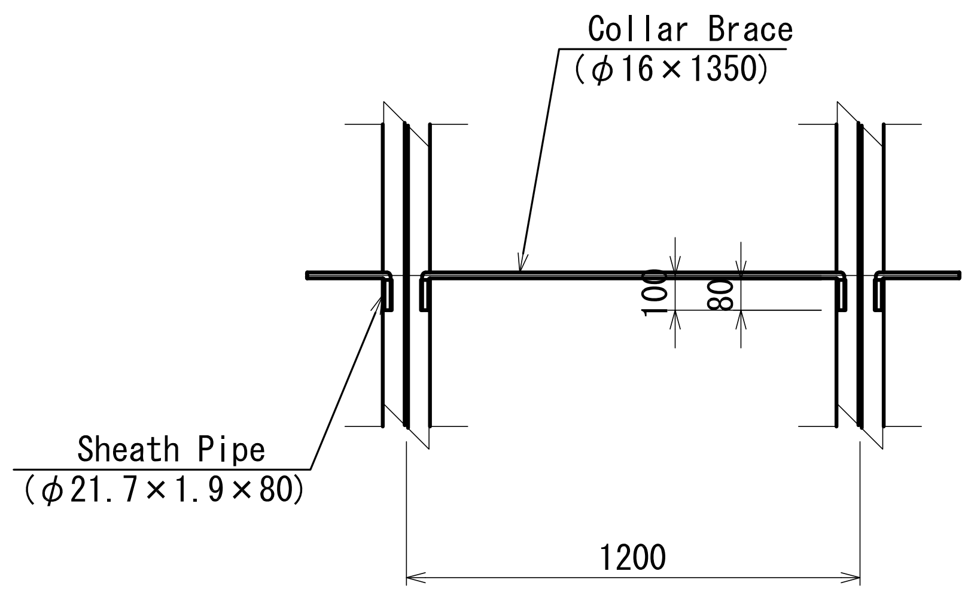
a Parts Details S=1:10

Rock Bolt Head Finishing

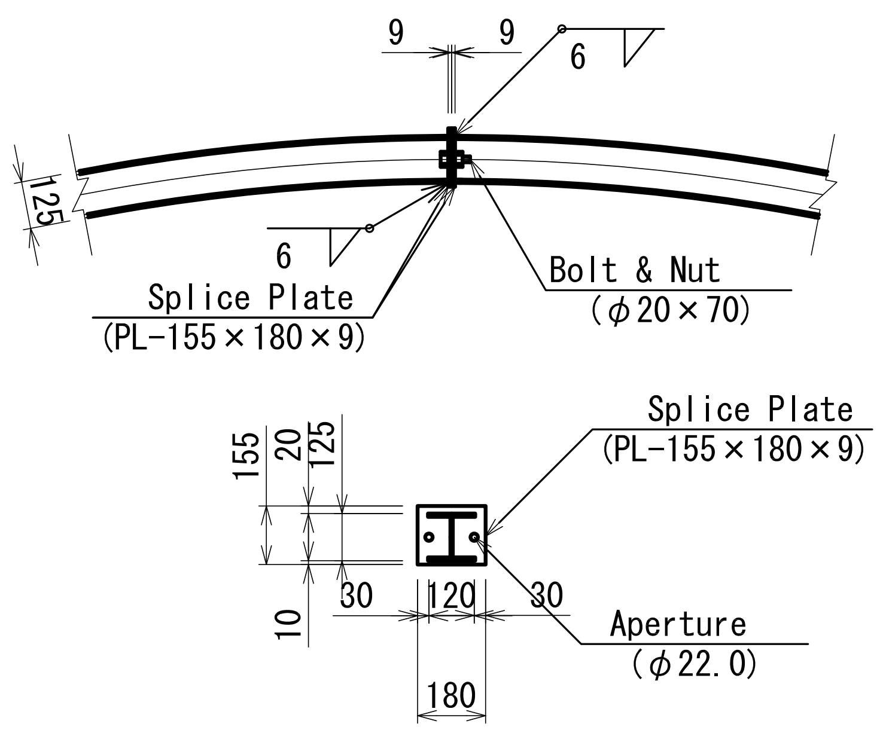




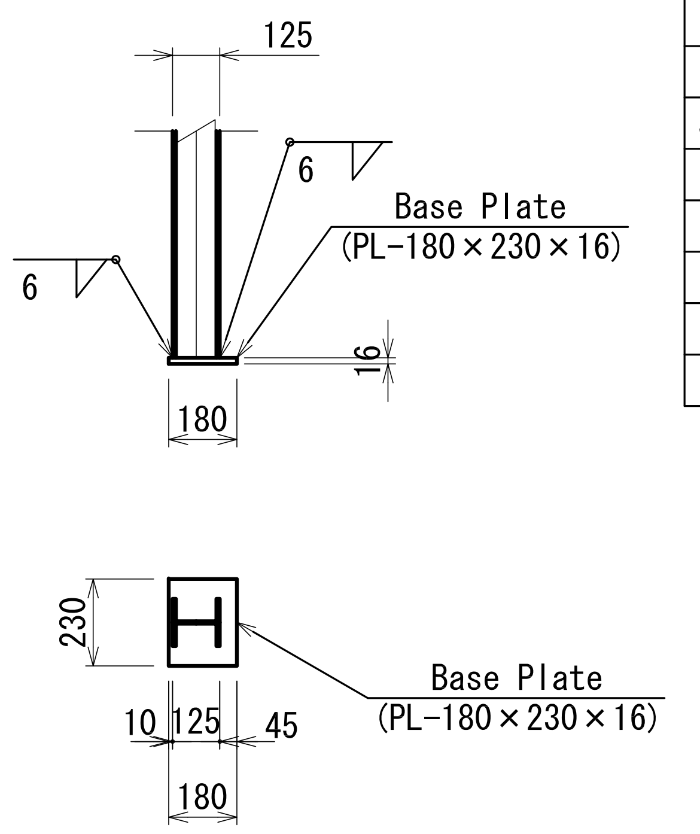
Collar Brace Details S=1:20



Splice Plate Details S=1:20



Base Plate Details S=1:20



Specifications

Rock Bolt			Steel Arch Support		Shotcrete	Lining Thickness (cm)		Wire Net	Deformation Margin(cm)		
Length (m)	Circumferential Direction (m)	Extention Direction (m)	Upper Half	Lower Half	Thickness (cm)	Arch	Invert		Upper Half	Lower Half	Invert
3.0	1.5	1.2	H-125	-	10	30	-	-	0	0	0

Shotcrete & Rock Bolt Materials

(P= around 1.200m)

Name	Geometries	Standard	Unit	Quantity	Application
Rock Bolt	L=3000	Yield Strength over 176.5kN(18t)	no.	15	Full Face Cementing Mortar
Washer	150×150×9	SS400	no.	15	
Nut		M24	no.	15	
Shotcrete	t=100	Design Standard Strength σck=18N/mm^2	m^2	25.271	21.059 m^2/m
Protection Mat	300×300×10		no.	15	

Steel Arch Support Materials

(Per Unit)

Name	Geometries	Unit	Quantity	Unit quantity	Quantity	Application
H Form Steel	H-125×125×6.5×9 L=8359	kg	2	197.272	394.5	23.600 kg/m
Splice Plate	PL-155×180×9	kg	2	1.971	3.9	70.650 kg/m^2
Bolt & Nut	φ20×70	no.	2	-	-	
Base Plate	PL-180×230×16	kg	2	5.200	10.4	125.600 kg/m^2
Sheath Pipe	φ21.7×1.9×80	kg	12	0.074	0.9	0.928 kg/m
Collar Brace	φ16×1350	kg	6	2.133	12.8	1.580 kg/m
Total		442.5 kg				

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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE

DRAWING No.

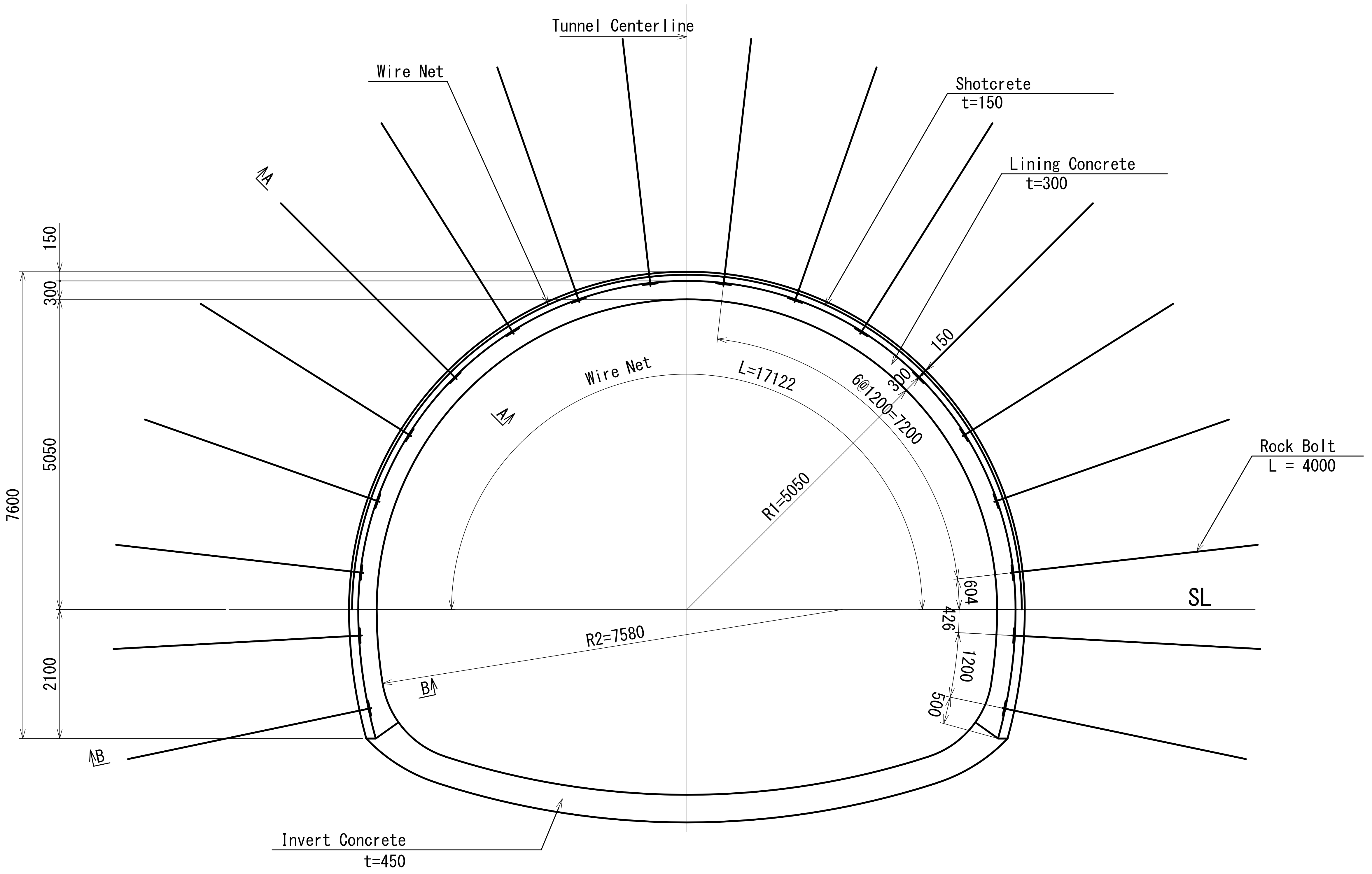
SCALE Illustration —(A1)
Illustration —(A3)

Support Pattern (3)

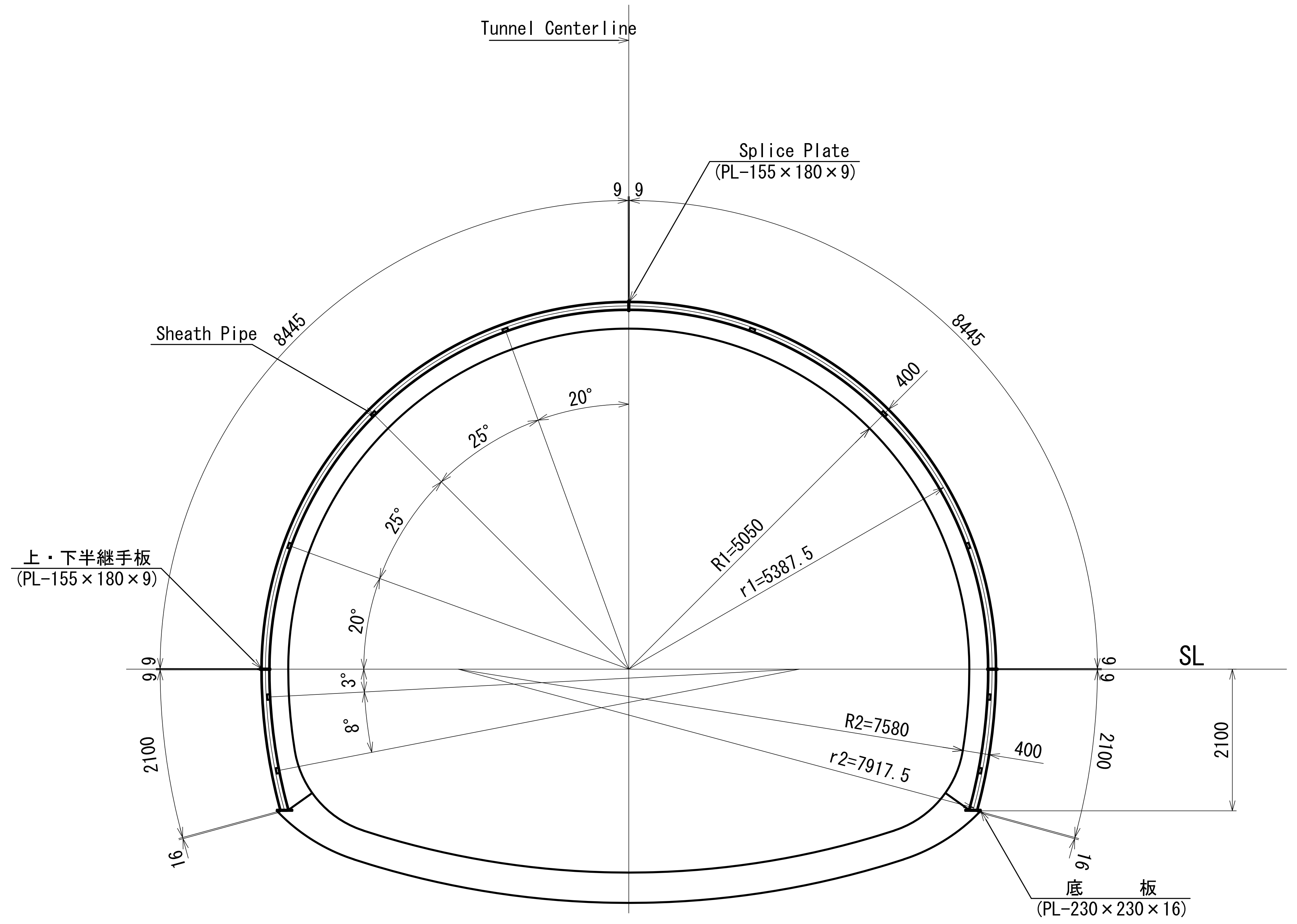
S=1:60

(Cross Section DI)

Shotcrete & Rock Bolt

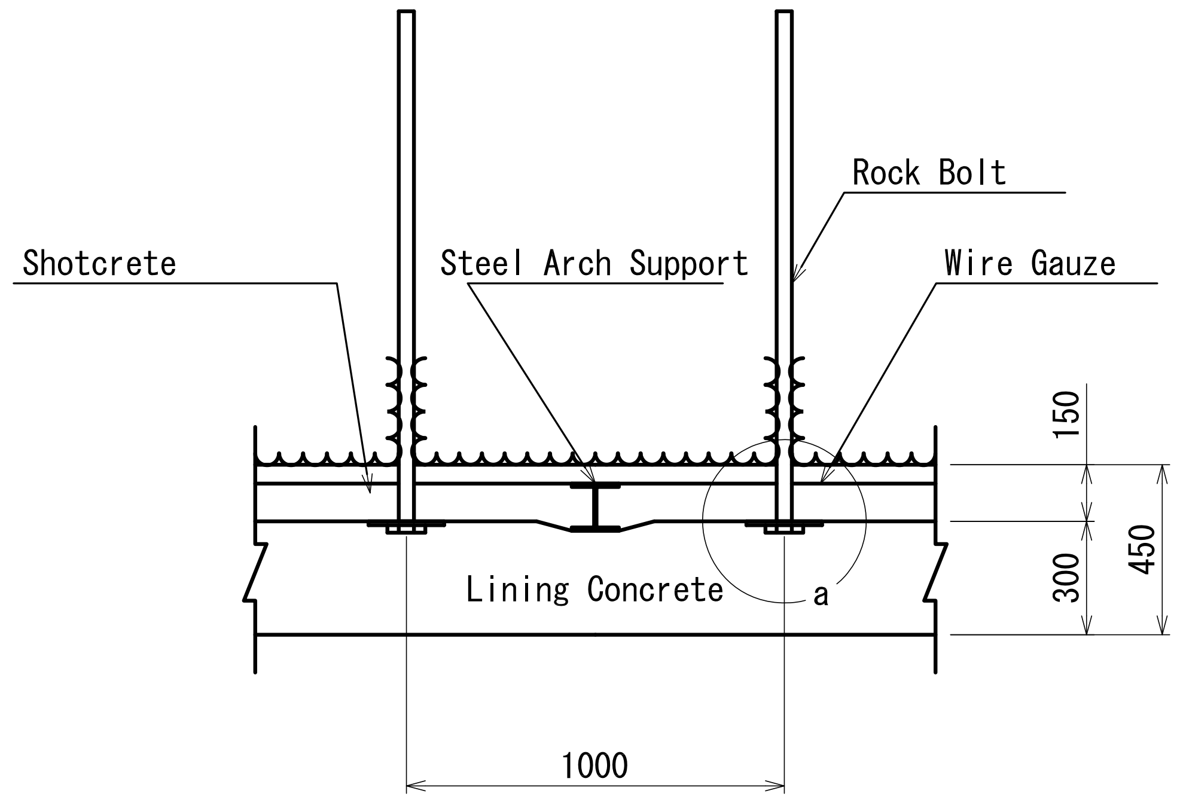


Steel Arch Support

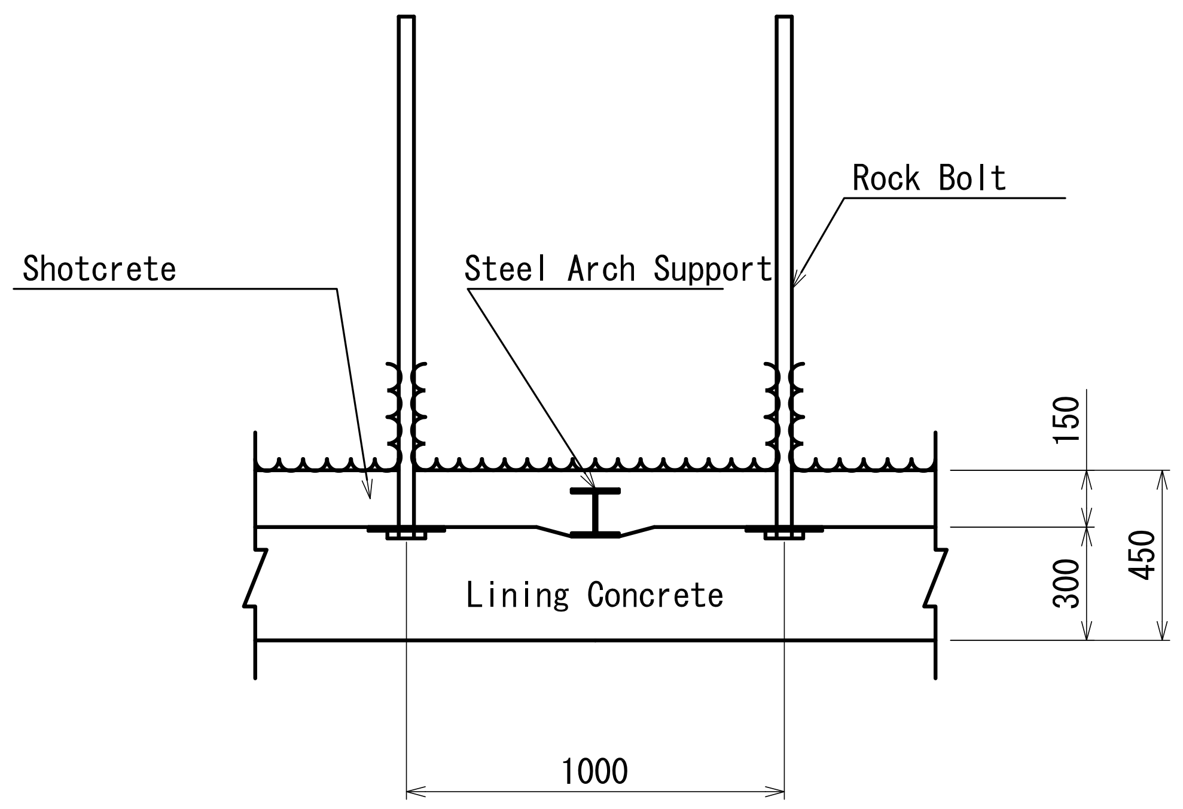


Cross Section Details S=1:20

Cross Section A-A

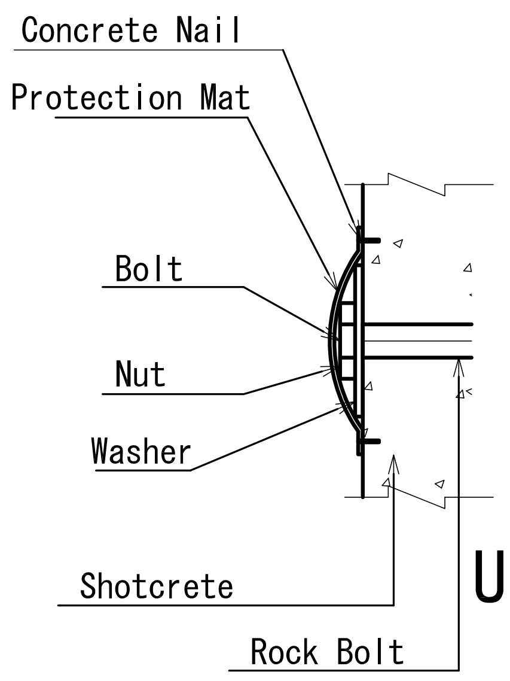


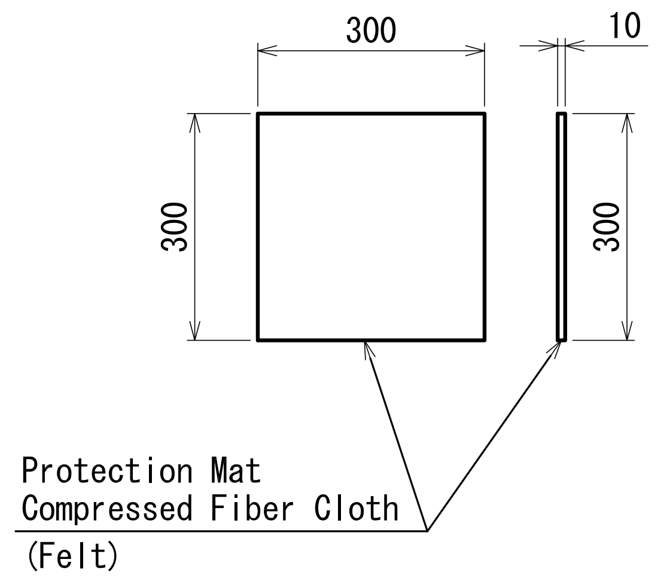
Cross Section B-B



a Parts Details S=1:10

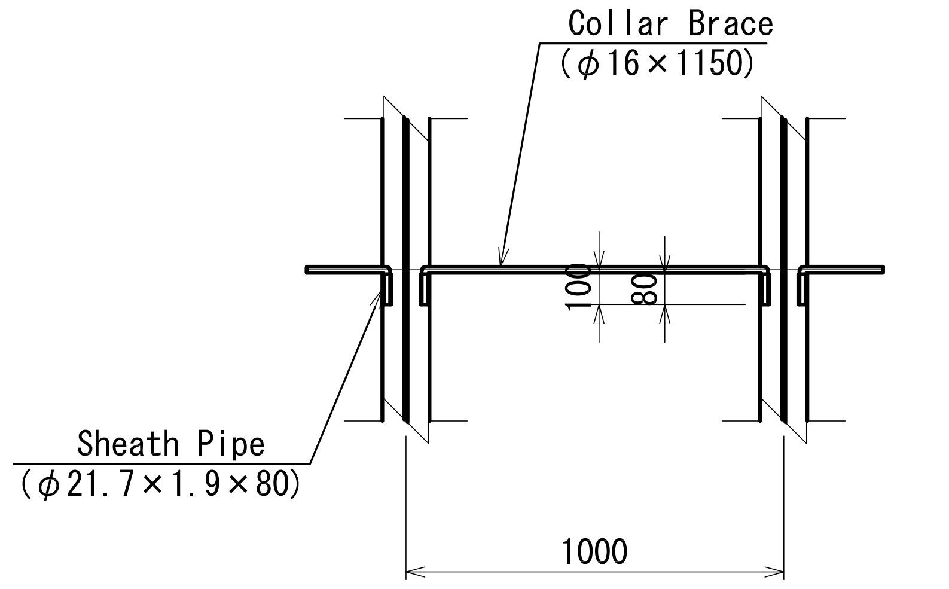
Rock Bolt Head Finishing





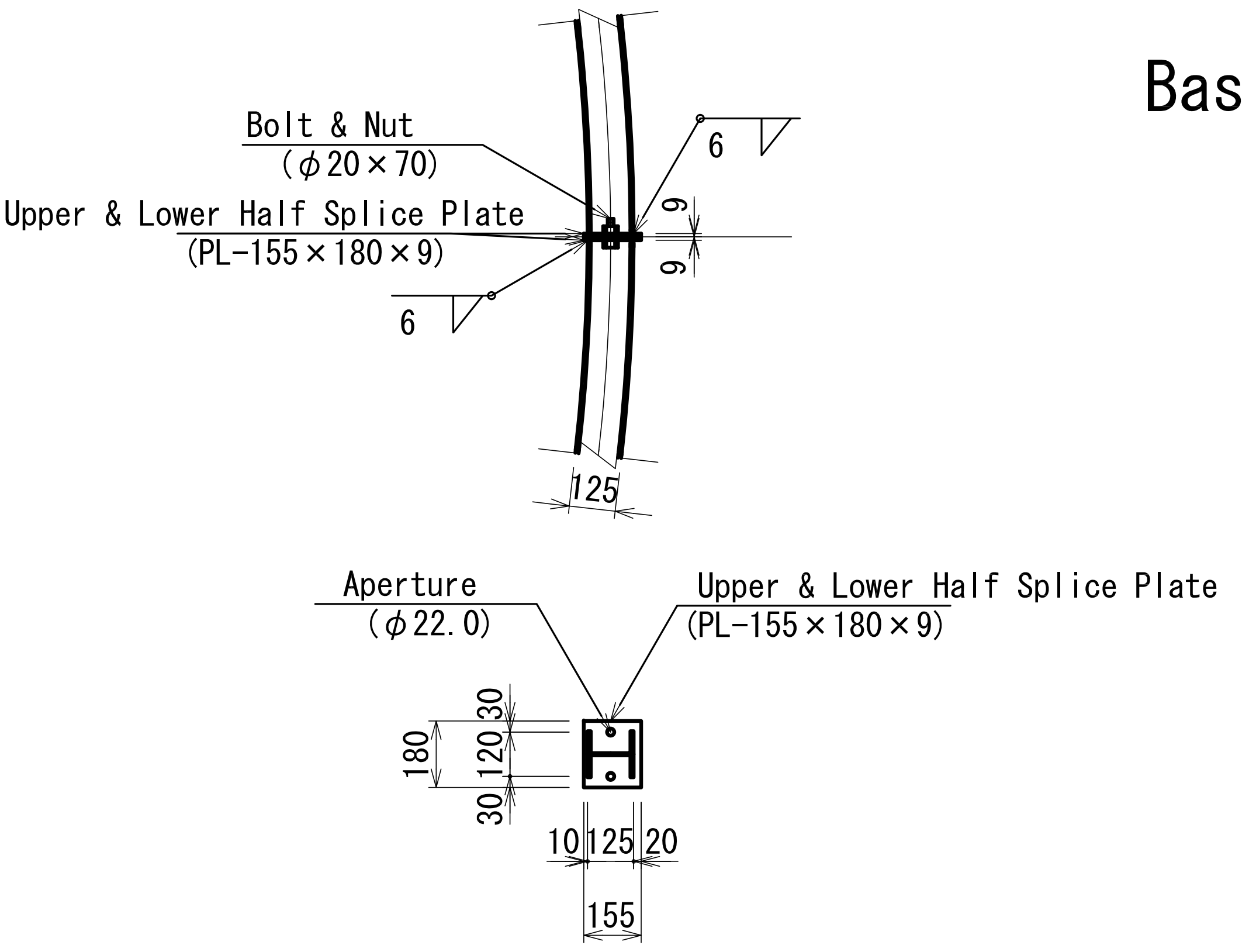
Protection Mat
Compressed Fiber Cloth
(Felt)

Collar Brace Details S=1:20

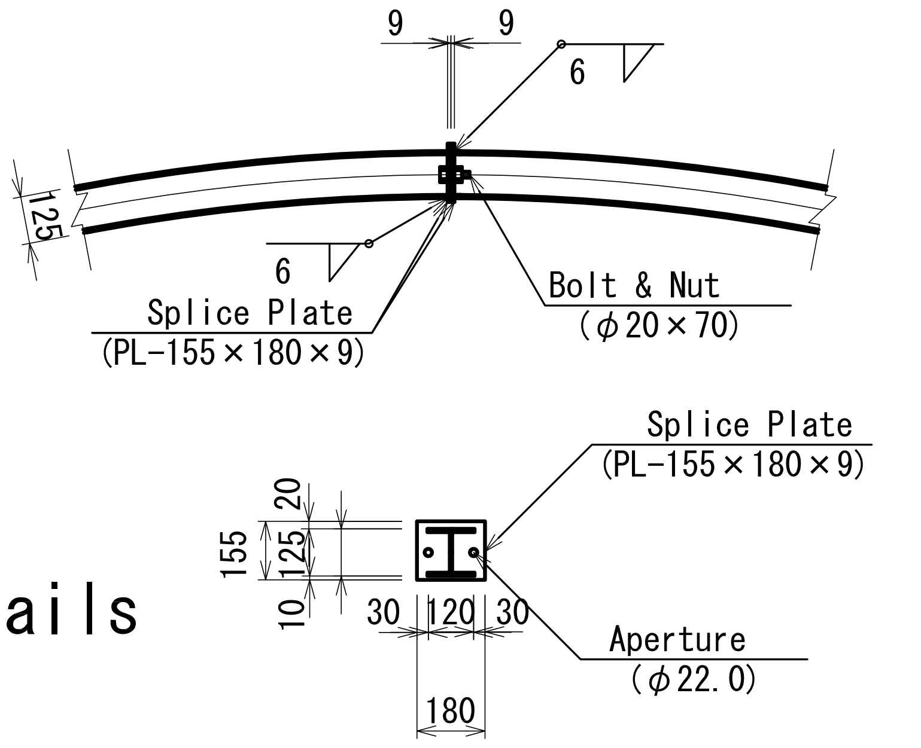


Upper & Lower Half Splice Plate Details

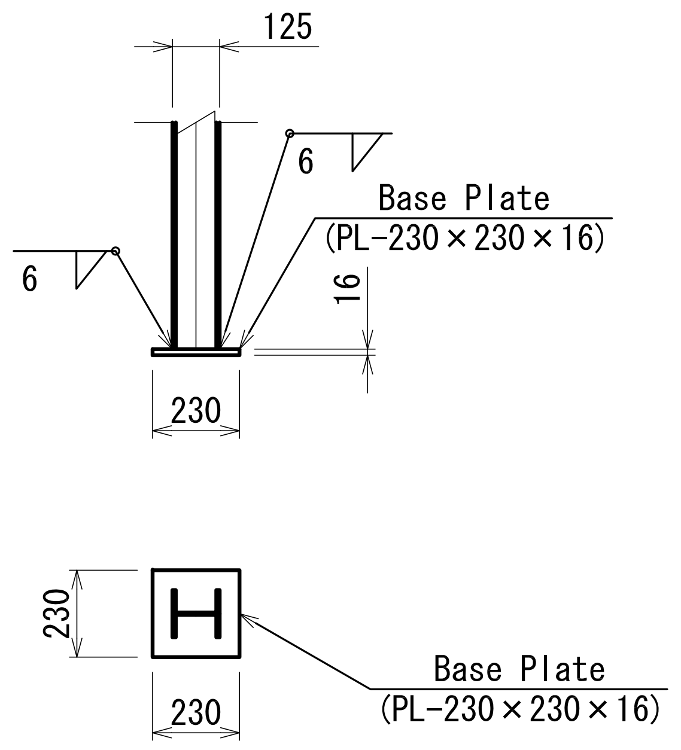
S=1:20



Splice Plate Details S=1:20



Base Plate Details S=1:20



Specifications

Rock Bolt			Steel Arch Support		Shotcrete	Lining Thickness (cm)		Wire Net	Deformation Margin(cm)		
Length (m)	Circumferential Direction (m)	Extention Direction (m)	Upper Half	Lower Half	Thickness (cm)	Arch	Invert		Upper Half	Lower Half	Invert
4.0	1.2	1.0	H-125	H-125	15	30	45	Upper Half	0	0	0

Shotcrete & Rock Bolt Materials

(P= around 1.000m)

Name	Geometries	Standard	Unit	Quantity	Application
Rock Bolt	L=4000	Yield Strength over 176.5kN(18t)	no.	18	Full Face Cementing Mortar
Washer	150×150×9	SS400	no.	18	
Nut		M24	no.	18	
Shotcrete	t=150	Design Standard Strength σck=18N/mm^2	m^2	21.060	
Wire Net	φ5×150×150	JIS G 3551	m^2	17.122	Welded Wire Net for Structural Use
Protection Mat	300×300×10		no.	18	

Steel Arch Support Materials

(Per Unit)

Name	Geometries	Unit	Quantity	Unit quantity	Quantity	Application
H Form Steel	H-125×125×6.5×9 L=8445	kg	2	199.302	398.6	23.600 kg/m
H Form Steel	H-125×125×6.5×9 L=2100	kg	2	49.560	99.1	23.600 kg/m
Splice Plate	PL-155×180×9	kg	2	1.971	3.9	70.650 kg/m^2
Bolt & Nut	φ20×70	no.	2	–	–	
Upper/Lower Half Splice Plate	PL-155×180×9	kg	4	1.971	7.9	70.650 kg/m^2
Bolt & Nut	φ20×70	no.	4	–	–	
Base Plate	PL-230×230×16	kg	2	6.644	13.3	125.600 kg/m^2
Sheath Pipe	φ21.7×1.9×80	kg	20	0.074	1.5	0.928 kg/m
Collar Brace	φ16×1150	kg	10	1.817	18.2	1.580 kg/m
Total		542.5 kg				

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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE

DRAWING No.

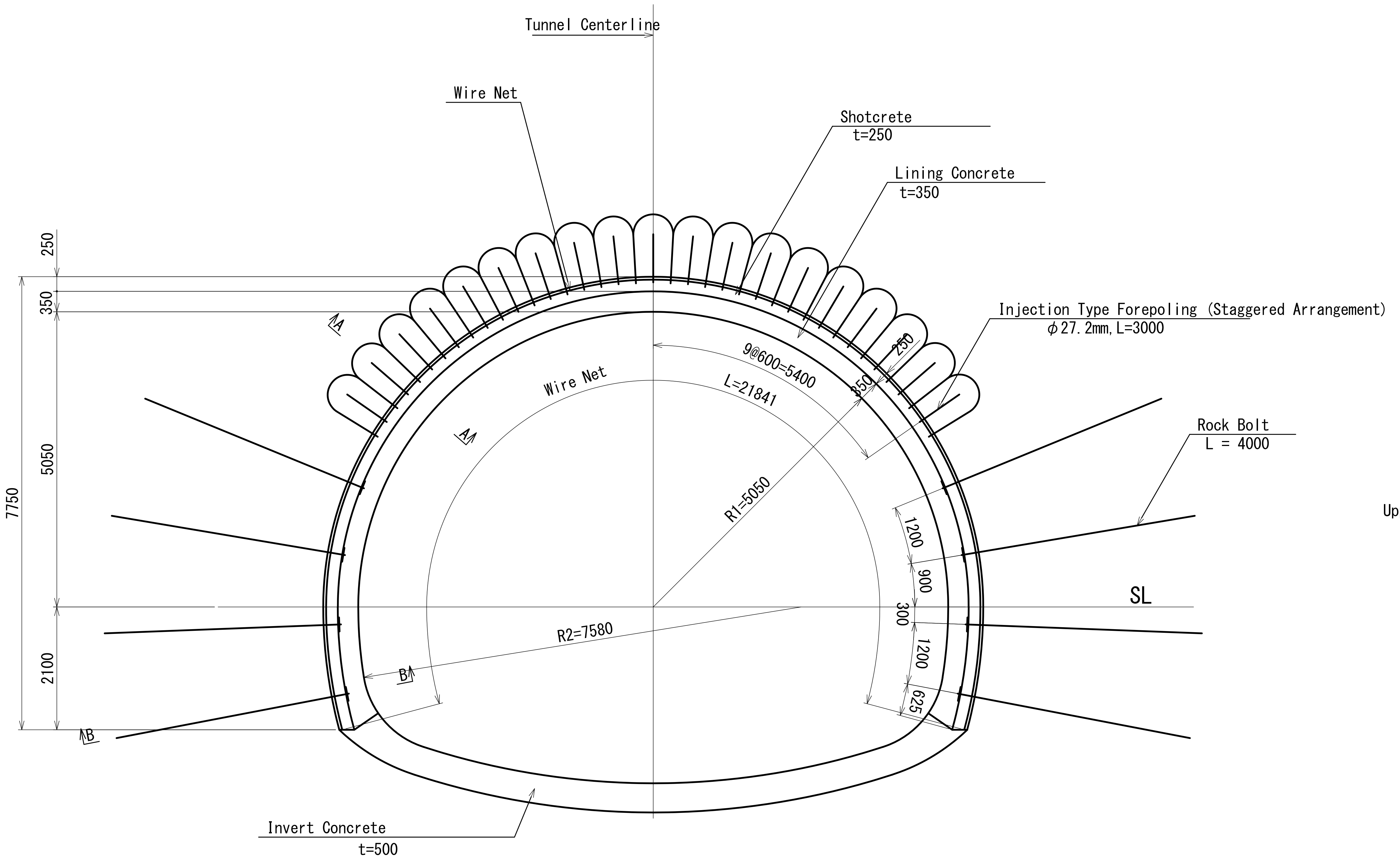
SCALE Illustration —(A1)
Illustration —(A3)

Support Pattern (4)

S=1:60

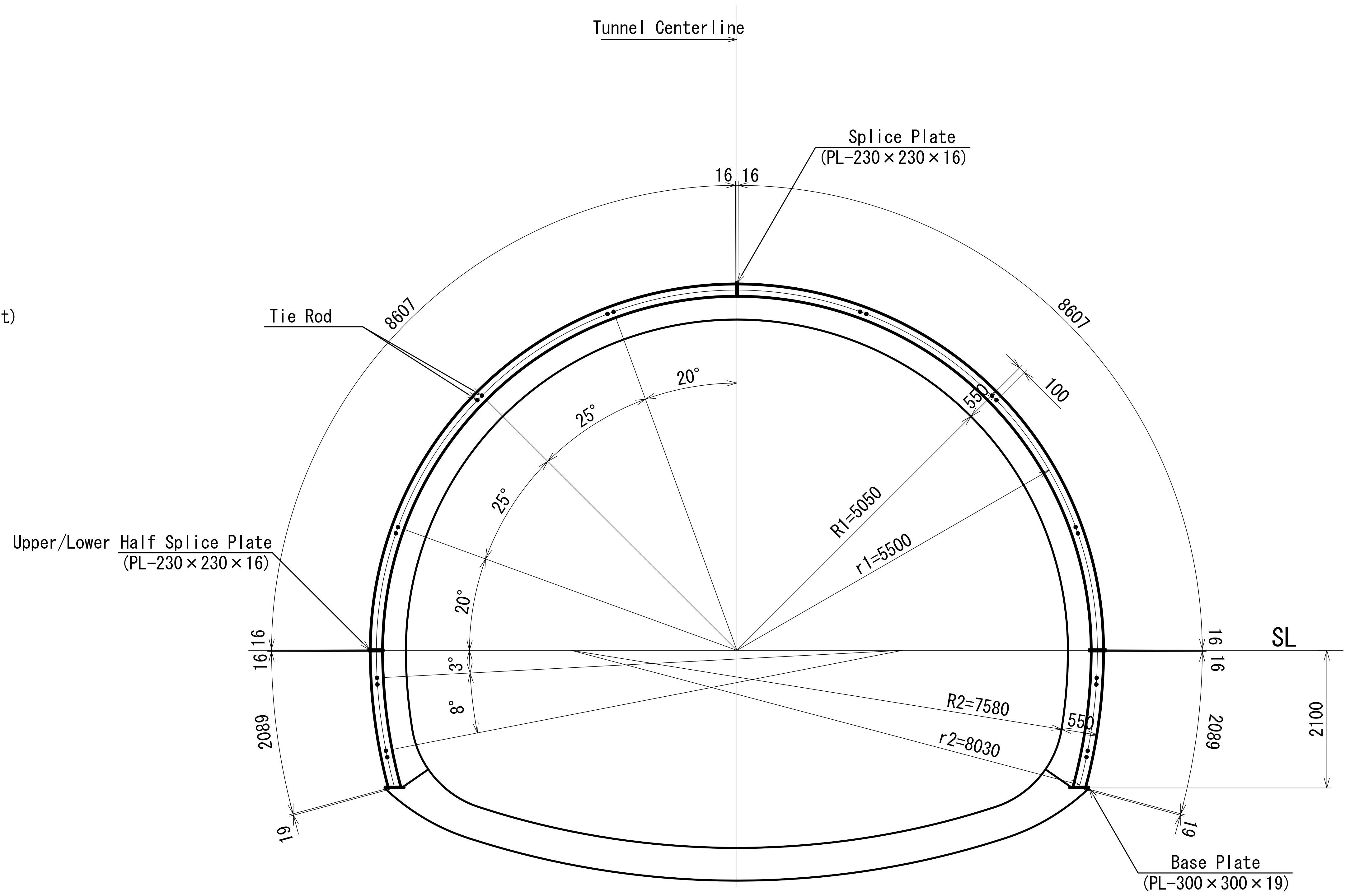
Shotcrete & Rock Bolt

(Cross Section DⅢ-1)



Steel Arch Support

(Cross Section DⅢ-1, DⅢ-2)



Specifications

Rock Bolt			Steel Arch Support		Shotcrete	Lining Thickness (cm)		Wire Net	Deformation Margin(cm)		
Length (m)	Circumferential Direction (m)	Extention Direction (m)	Upper Half	Lower Half	Thickness (cm)	Arch	Invert		Upper Half	Lower Half	Invert
4.0 (3.0)	1.2 (0.6)	1.0 (1.0)	H-200	H-200	25	35	50	Upper & Lower Half	0	0	0

※()refer to Injection Type Forepoling

Shotcrete & Rock Bolt Materials

(P= around 1.000m)

Name	Geometries	Standard	Unit	Quantity	Application
Injection Type Forepoling	L=3000, φ27.2	Driving Hollow Pipe Type	no.	19.5	Silica Resin
Rock Bolt	L=4000	Yield Strength over 176.5KN(18t)	no.	8	Full Face Cementing Mortar
Washer	150×150×9	SS400	no.	8	
Nut		M24	no.	8	
Shotcrete	t=250		m^2	21.215	
Wire Net	φ5×150×150	JIS G 3551	m^2	21.841	Welded Wire Net for Structural Use
Protection Mat	300×300×10		no.	8	

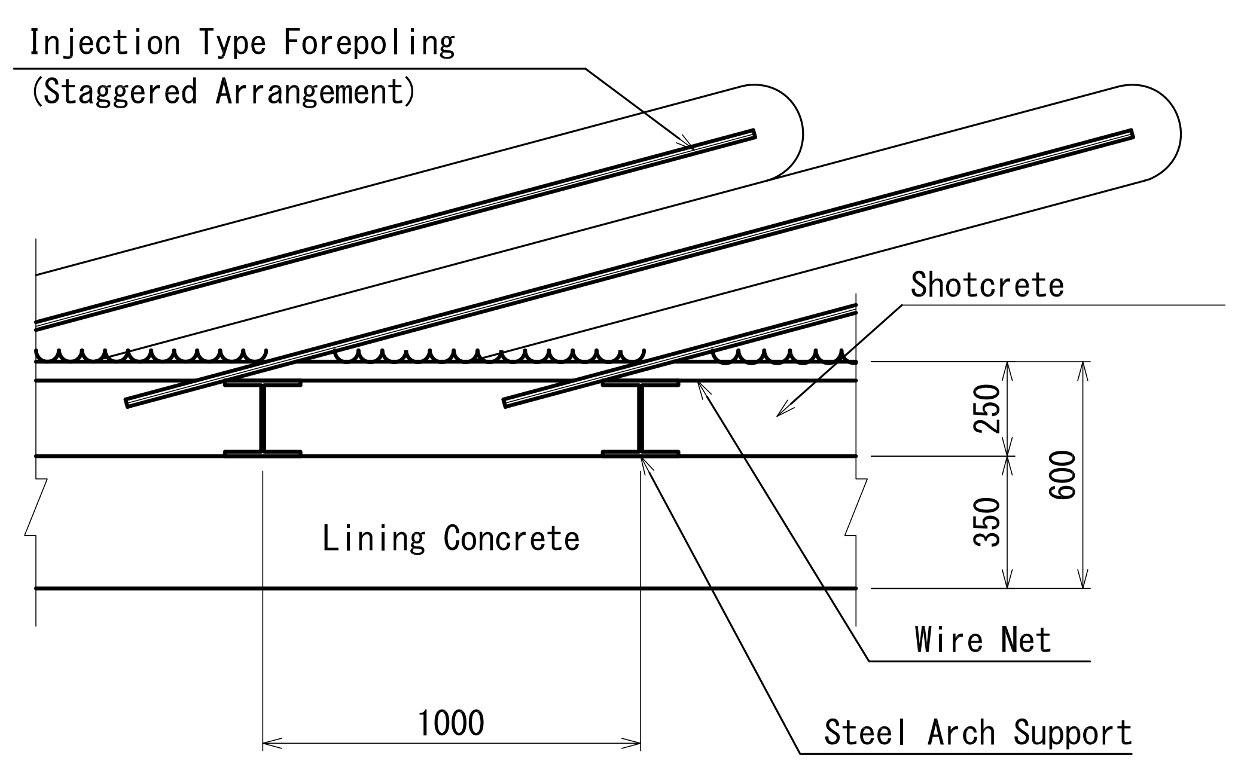
Steel Arch Support Materials

(Cross Section DⅢa, DⅢa-S) (Per Unit)

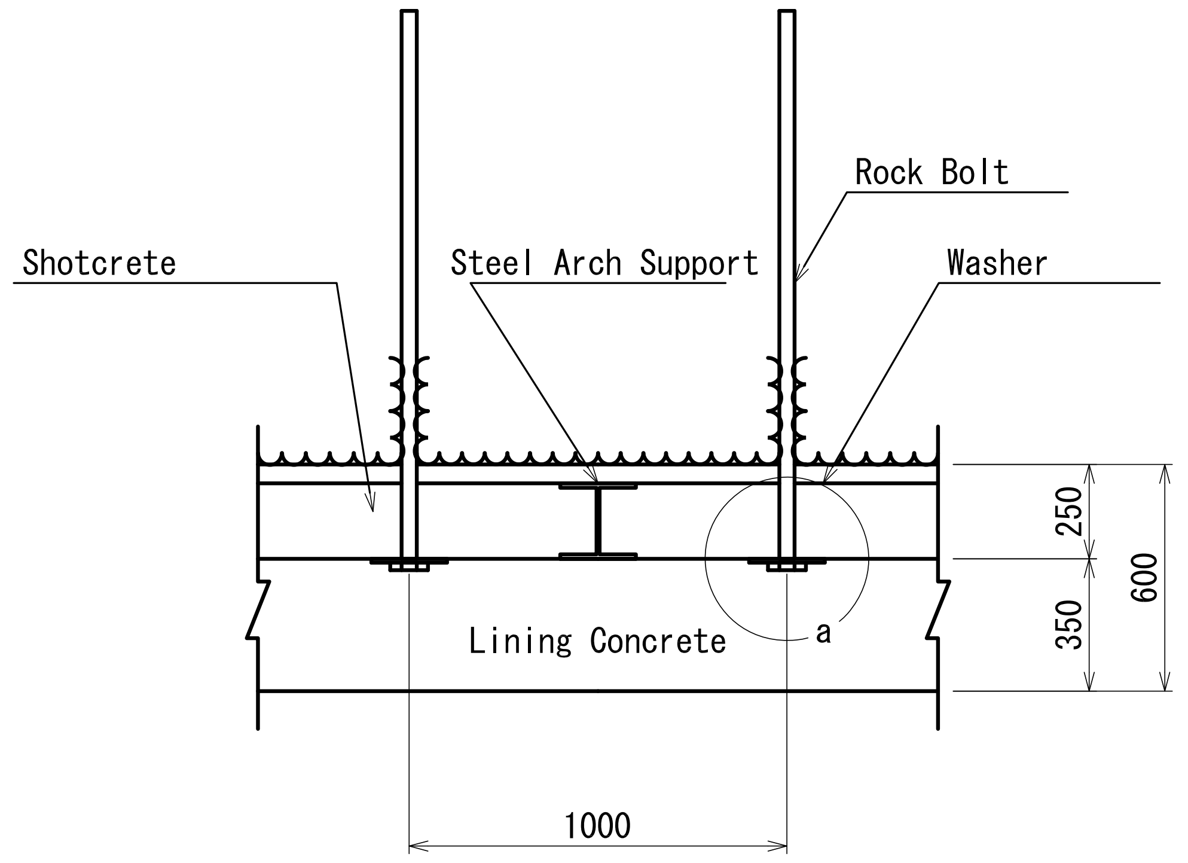
Name	Geometries	Unit	Quantity	Unit quantity	Quantity	Application
H Form Steel	H-200×200×8×12 L=8607	kg	2	429.489	859.0	49.900 kg/m
H Form Steel	H-200×200×8×12 L=2089	kg	2	104.241	208.5	49.900 kg/m
Splice Plate	PL-230×230×16	kg	2	6.644	13.3	125.600 kg/m^2
Bolt & Nut	φ20×70	no.	2	-	-	
Upper/Lower Half Splice Plate	PL-230×230×16	kg	4	6.644	26.6	125.600 kg/m^2
Bolt & Nut	φ20×70	no.	4	-	-	
Base Plate	PL-300×300×19	kg	2	13.424	26.8	149.150 kg/m^2
Tie Rod	φ19×1150	kg	10	2.565	25.7	2.230 kg/m
Nut for Tie Rod		no.	20	-	-	
Steel Pipe	STK φ60.5×2.3×992	kg	10	3.247	32.7	3.300 kg/m
Total		1192.6 kg				

Cross Section Details S=1:20

Cross Section A-A

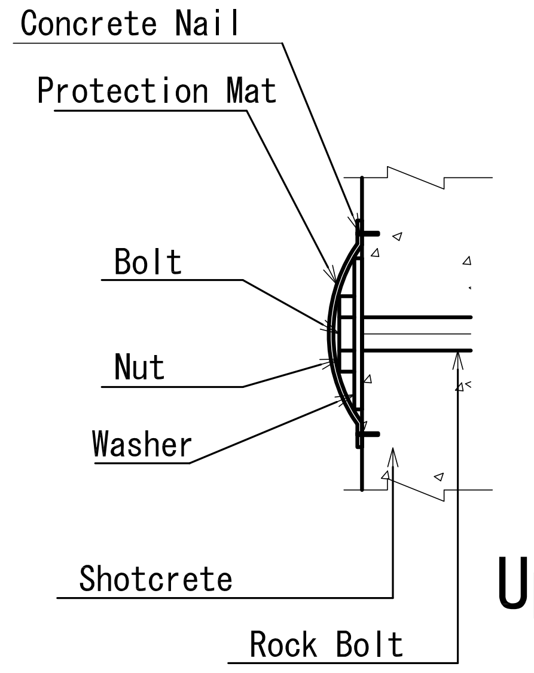


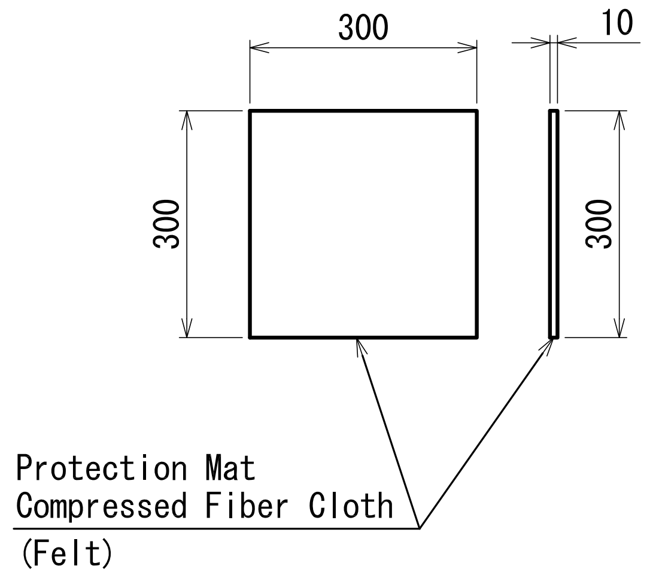
Cross Section B-B



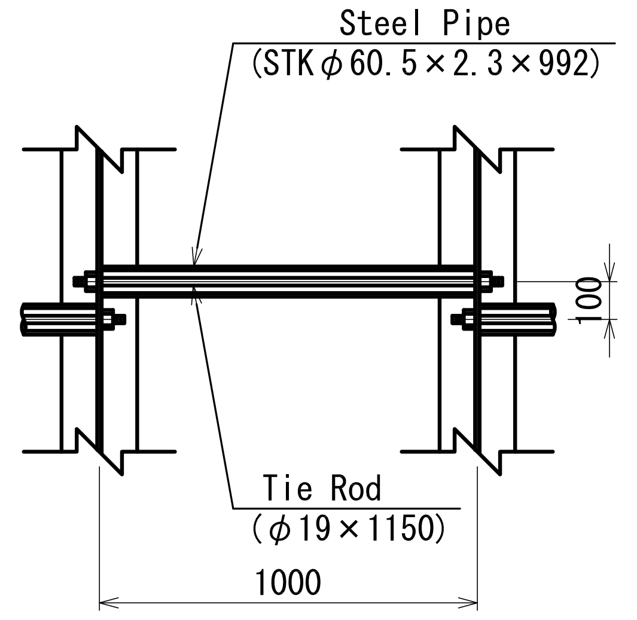
a Parts Details S=1:10

Rock Bolt Head Finishing



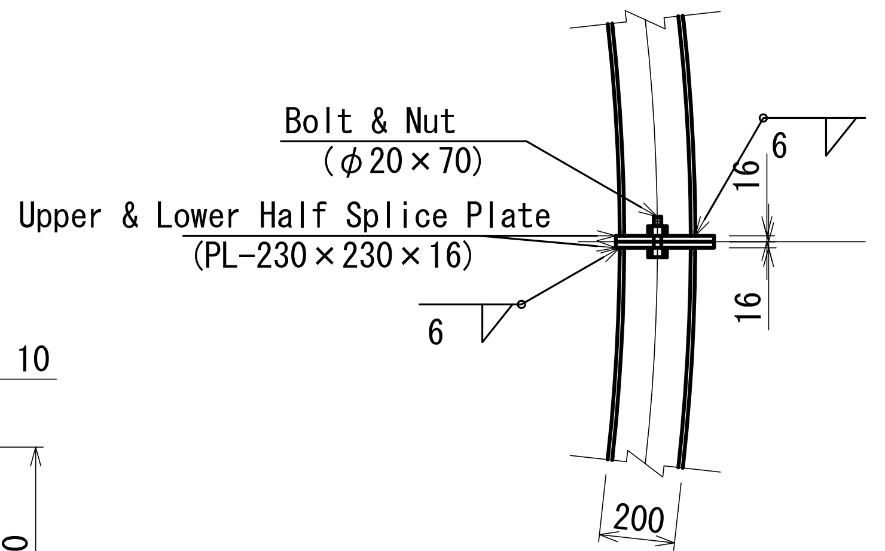


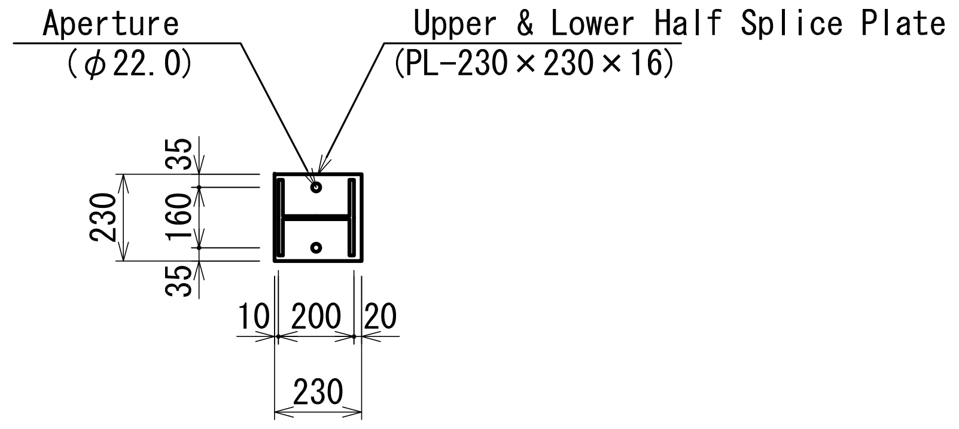
Collar Brace Details S=1:20



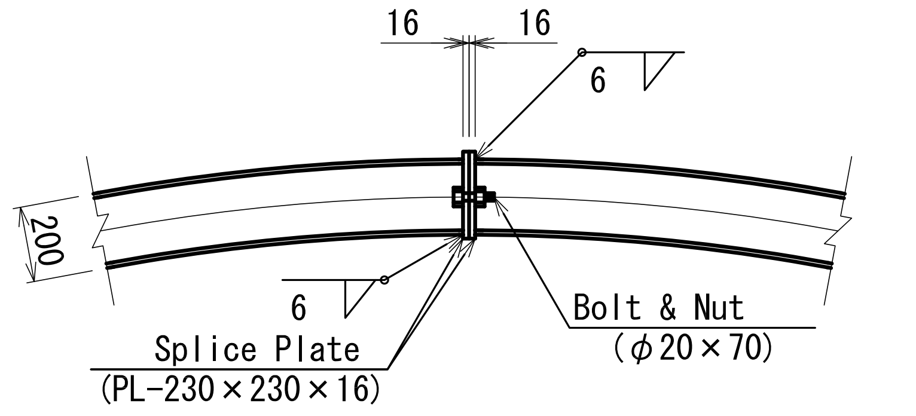
Upper & Lower Half Splice Plate Details

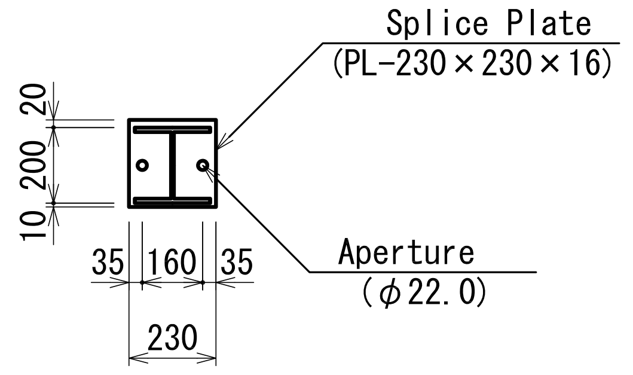
S=1:20



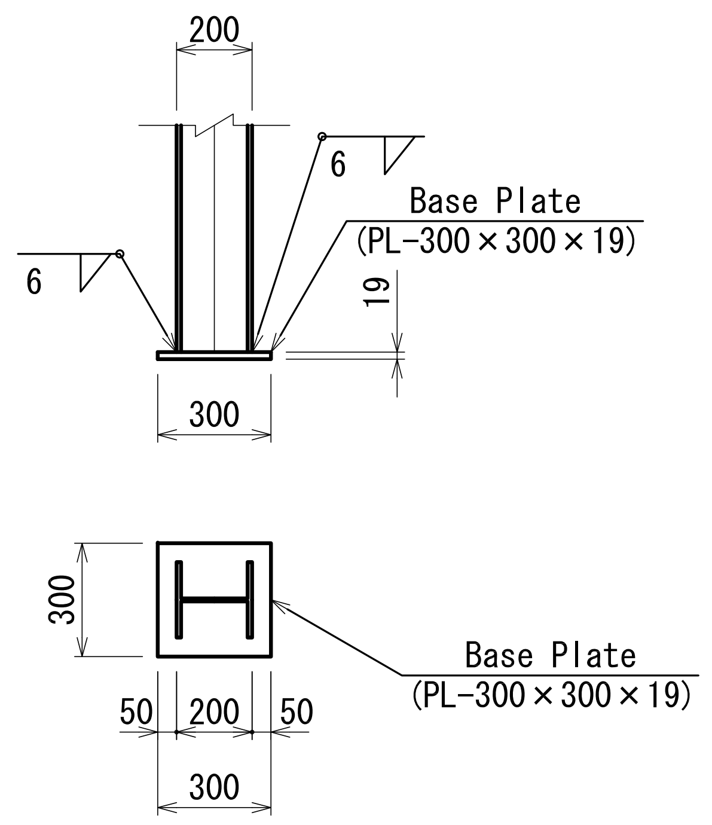


Splice Plate Details S=1:20





Base Plate Details S=1:20



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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY
ON ROAD SLOPE MANAGEMENT IN
BHUTAN, JICA

TITLE

DRAWING No.

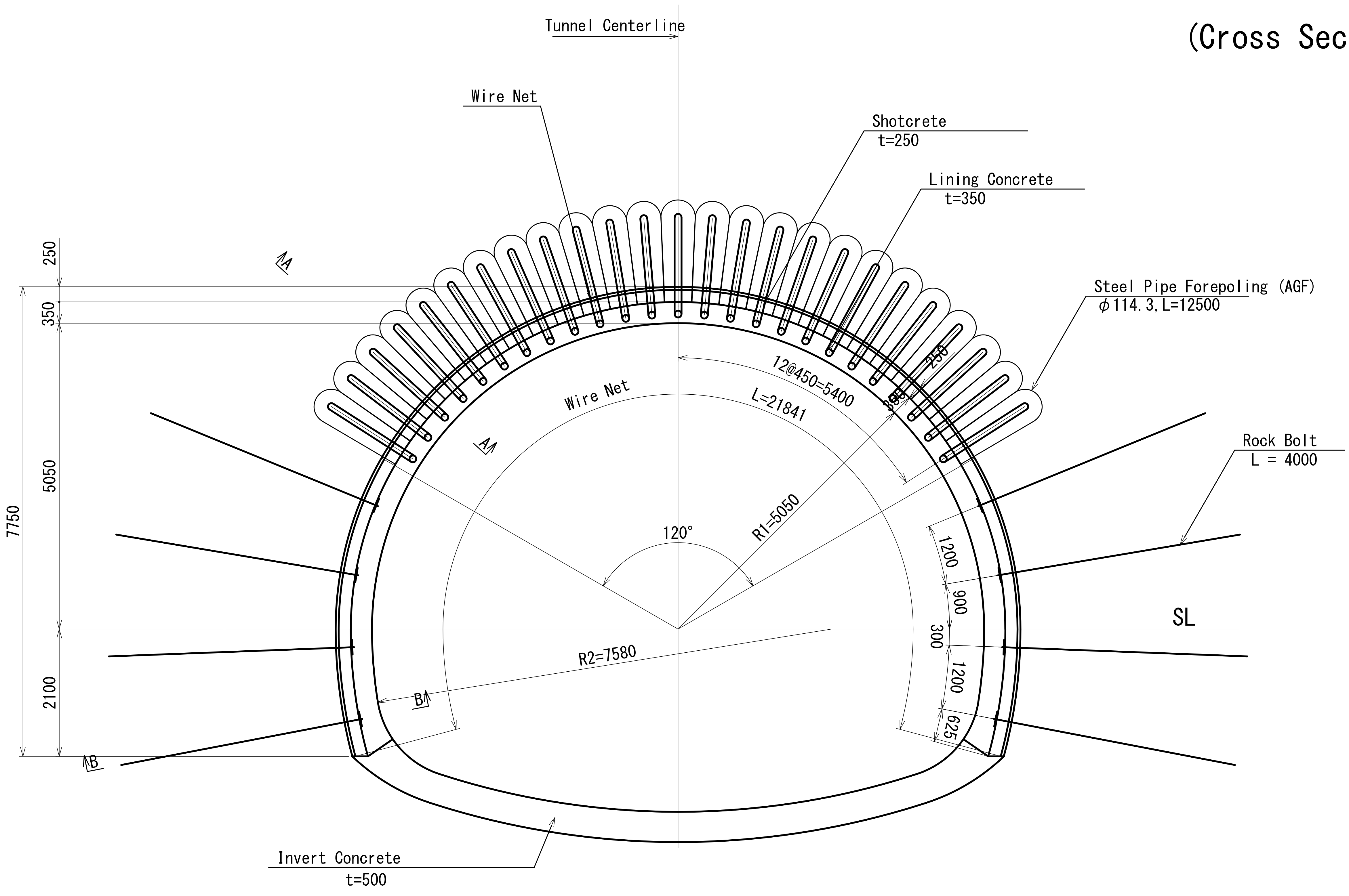
SCALE Illustration —(A1)
Illustration —(A3)

Support Pattern (5)

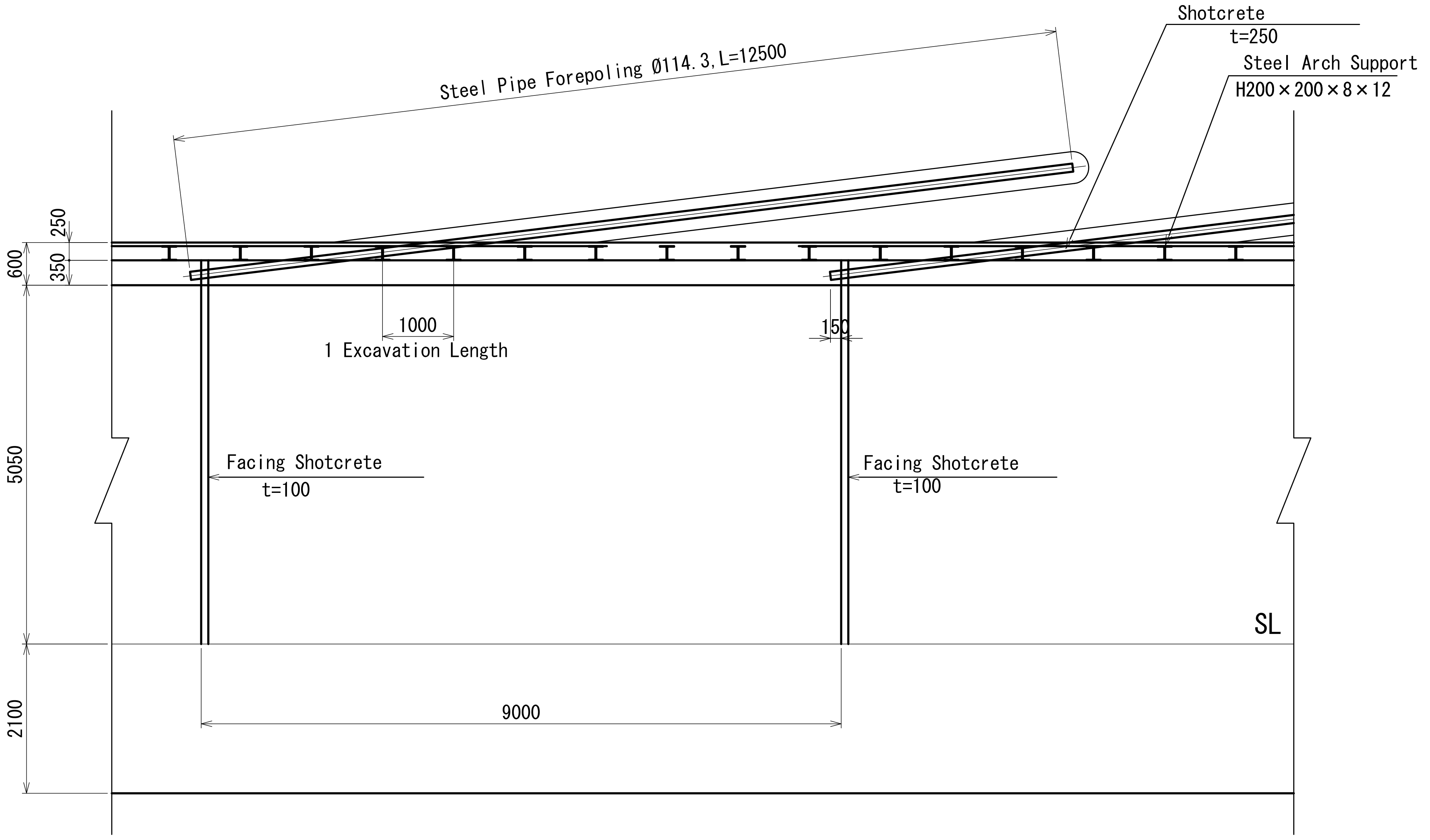
(Cross Section DⅢ-2)

S=1:60

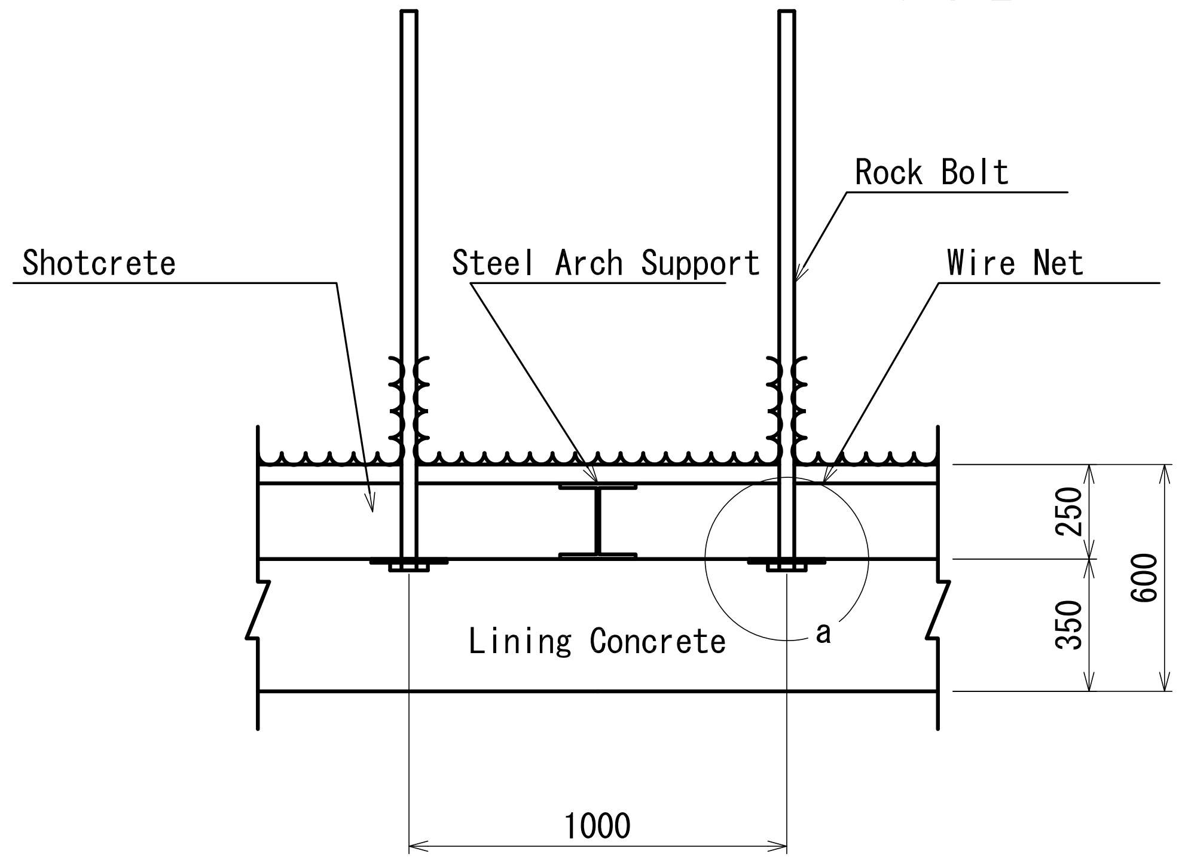
Shotcrete & Rock Bolt



Cross Section A-A

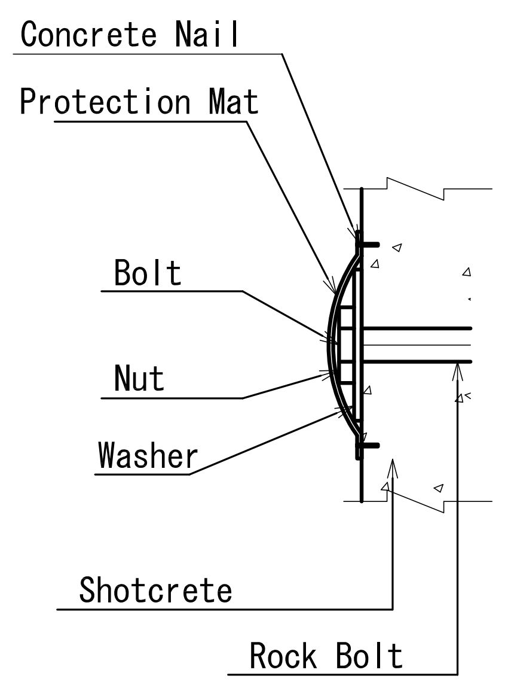


Cross Section B-B S=1:20



a Parts Details S=1:10

Rock Bolt Head Finishing



Specifications

Rock Bolt			Steel Arch Support		Shotcrete	Lining Thickness (cm)		Wire Net	Deformation Margin(cm)		
Length (m)	Circumferential Direction (m)	Extention Direction (m)	Upper Half	Lower Half	Thickness (cm)	Arch	Invert		Upper Half	Lower Half	Invert
4.0 {12.5}	1.2 {0.45}	1.0 {9.0}	H-200	H-200	25	35	50	Upper & Lower Half	—	—	—

※ {} Refer to Steel Pipe Forepoling

Shotcrete & Rock Bolt Materials

(P= around 1.000m)

Name	Geometries	Standard	Unit	Quantity	Application
Rock Bolt	L=4000	Torsion Steel Bar and Equal over(Yield Strength176.5KN)	no.	8	Full Face Cementing Mortar
Washer	150×150×9	SS400	no.	8	
Nut		M24	no.	8	
Shotcrete	t=250	Design Standard Strength σck=18N/mm^2	m^2	18.094	
Wire Net	φ5×150×150	JIS G 3551	m^2	18.720	Welded Wire Net for Structural Use
Protection Mat	300×300×10		no.	8	

Steel Pipe Forepoling & Facing Shotcrete Materials

(P= around 9.000m)

Name	Geometries	Standard	Unit	Quantity	Application
Steel Pipe Forepoling	L=12500	φ114.3	no.	25	Silica Resin Type Injection
Facing Shotcrete	t = 100		m^2	45.804	

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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE

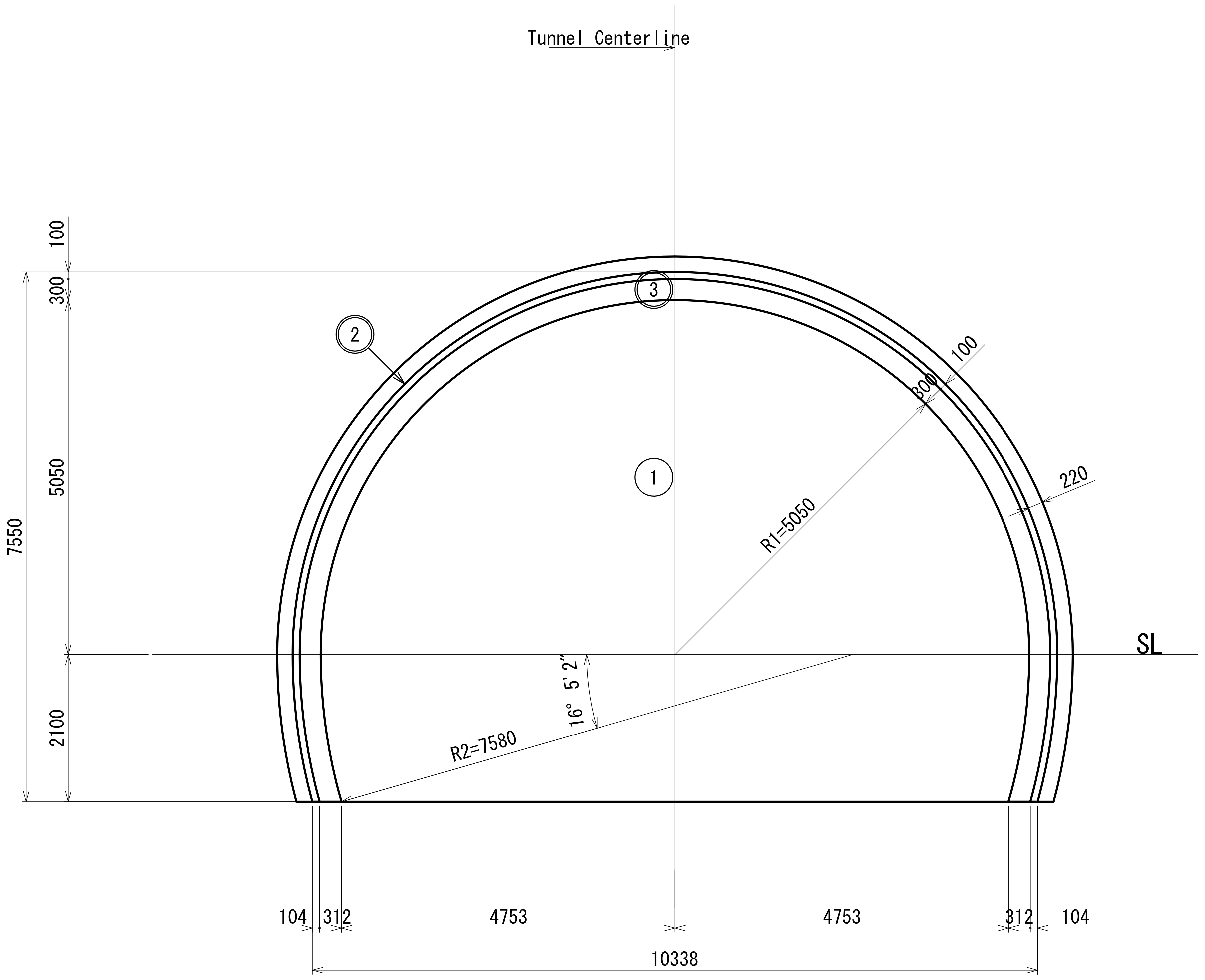
DRAWING No.

SCALE Illustration —(A1)
Illustration —(A3)

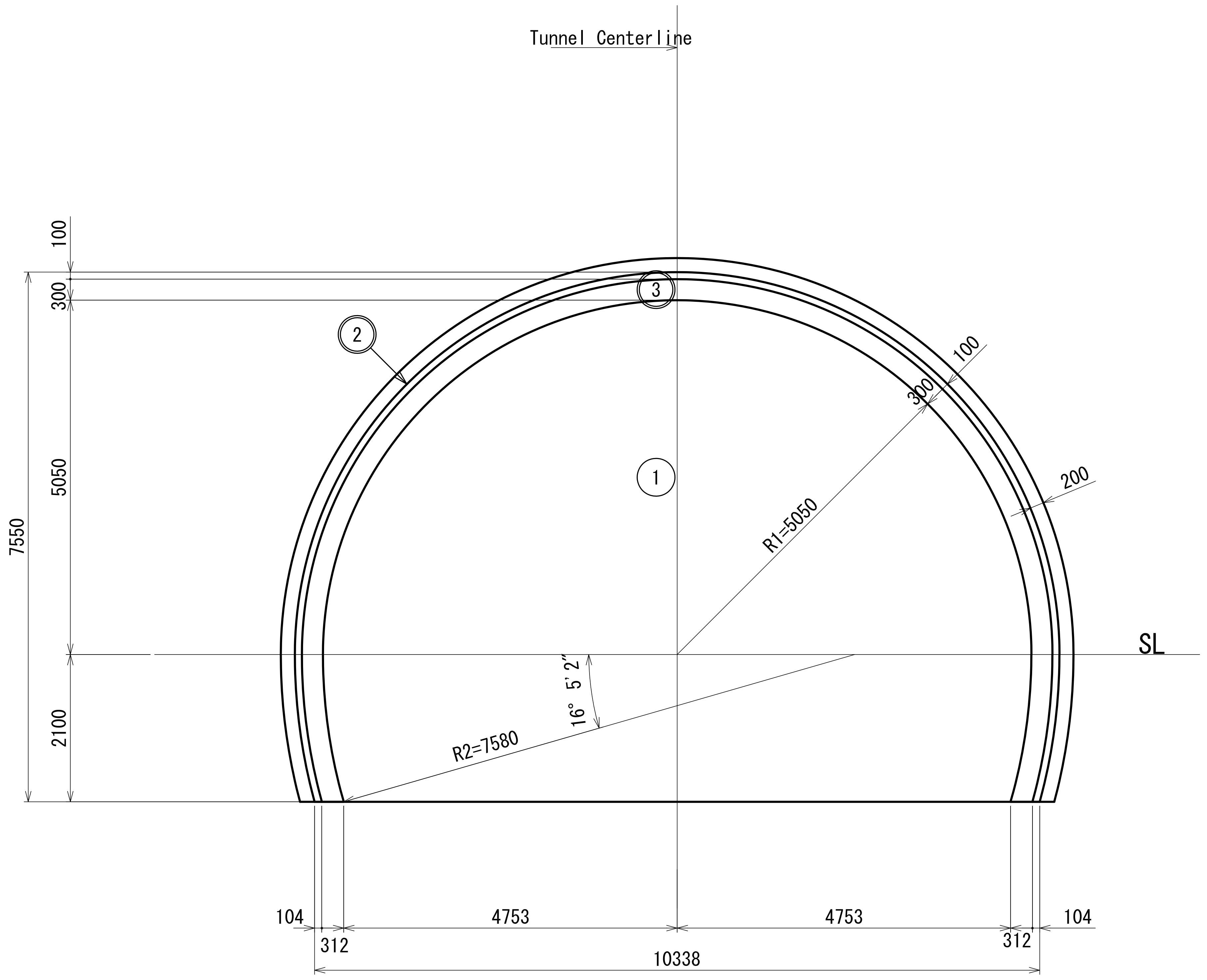
Cross Section of Tunnel Face (1)

S=1:60

Cross Section C I



Cross Section CⅡ



Quantity Table

Name	Excavation (m³/m)		Shotcrete (m²/m)	Concrete (m³/m)	
	Design	Payment		Design	Payment
① Full Face	69.156	73.933			
② Full Face Shotcrete			21.059		
③ Lining Concrete				6.177	9.802
Total	69.156	73.933	21.059	6.177	9.802

Quantity Table

Name	Excavation (m³/m)		Shotcrete (m²/m)	Concrete (m³/m)	
	Design	Payment		Design	Payment
① Full Face	69.156	73.493			
② Full Face Shotcrete			21.059		
③ Lining Concrete				6.177	8.941
Total	69.156	73.493	21.059	6.177	8.941

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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE

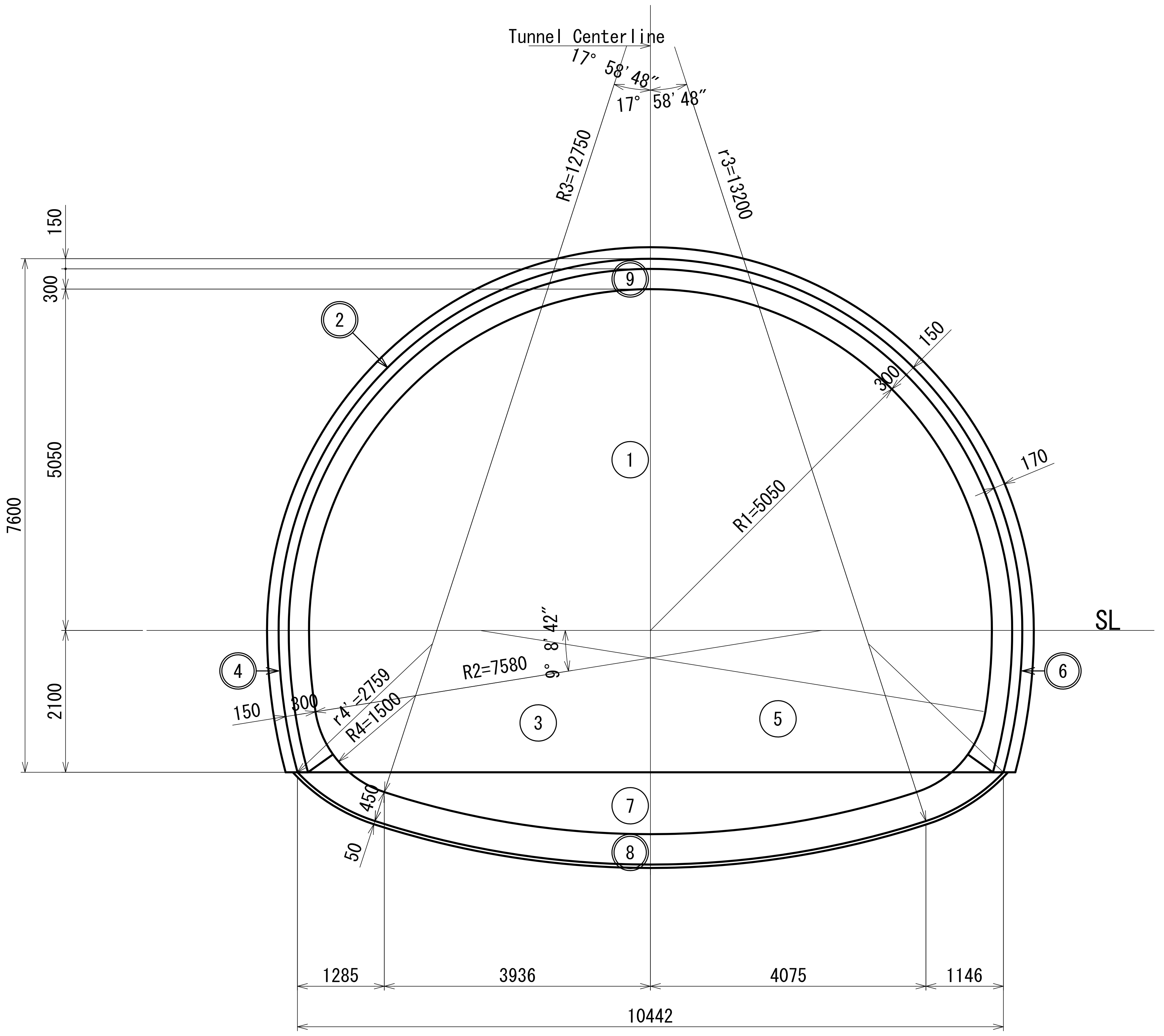
DRAWING No.

SCALE 1:60 —(A1)
1:120 —(A3)

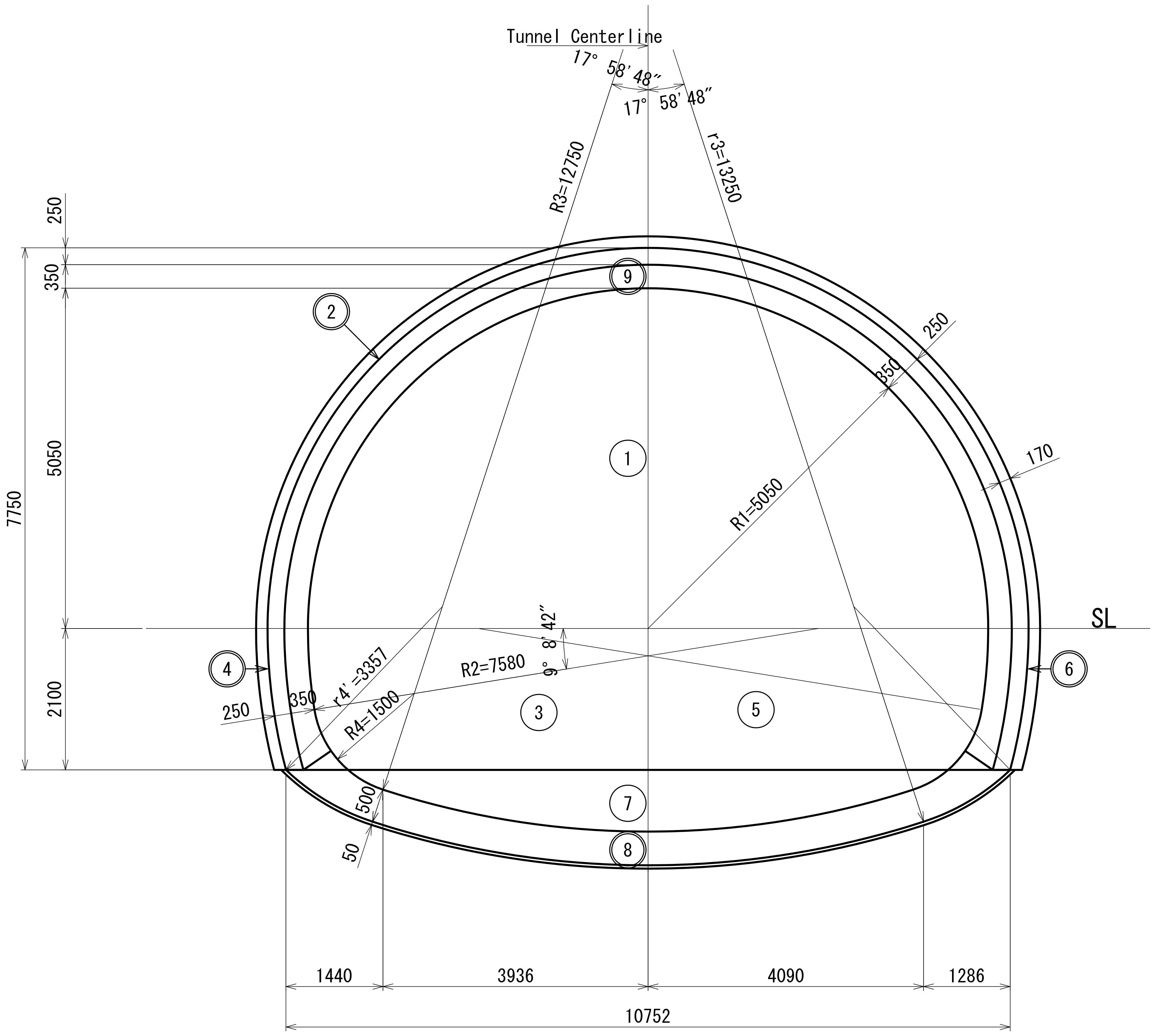
Cross Section of Tunnel Face (2)

S=1:60

Cross Section D I



Cross Section DⅢ-1、DⅢ-2



Quantity Table

Name		Excavation (m^3/m)		Shotcrete (m^2/m)	Concrete (m^3/m)	
		Design	Payment		Design	Payment
①	Upper Half Face	47.517	47.000			
②	Upper Half Shotcrete			16.808		
③	Lower Half Face	11.356	11.717			
④	Lower Half Shotcrete			2.126		
⑤	Lower Half Face	11.356	11.717			
⑥	Lower Half Shotcrete			2.126		
⑦	Lowering of Roadbed	10.375	10.930			
⑧	Invert Concrete				4.764	5.320
⑨	Lining Concrete				6.181	8.303
Total		80.604	84.863	21.060	10.945	13.623

Quantity Table

Name		Excavation (m^3/m)		Shotcrete (m^2/m)	Concrete (m/m)	
		Design	Payment		Design	Payment
①	Upper Half Face	50.144	53.207			
②	Upper Half Shotcrete			16.965		
③	Lower Half Face	11.674	12.035			
④	Lower Half Shotcrete			2.125		
⑤	Lower Half Face	11.674	12.035			
⑥	Lower Half Shotcrete			2.125		
⑦	Lowering of Roadbed	10.992	11.563			
⑧	Invert Concrete				5.406	5.977
⑨	Lining Concrete				7.213	9.350
Total		84.484	88.840	21.215	12.619	15.327

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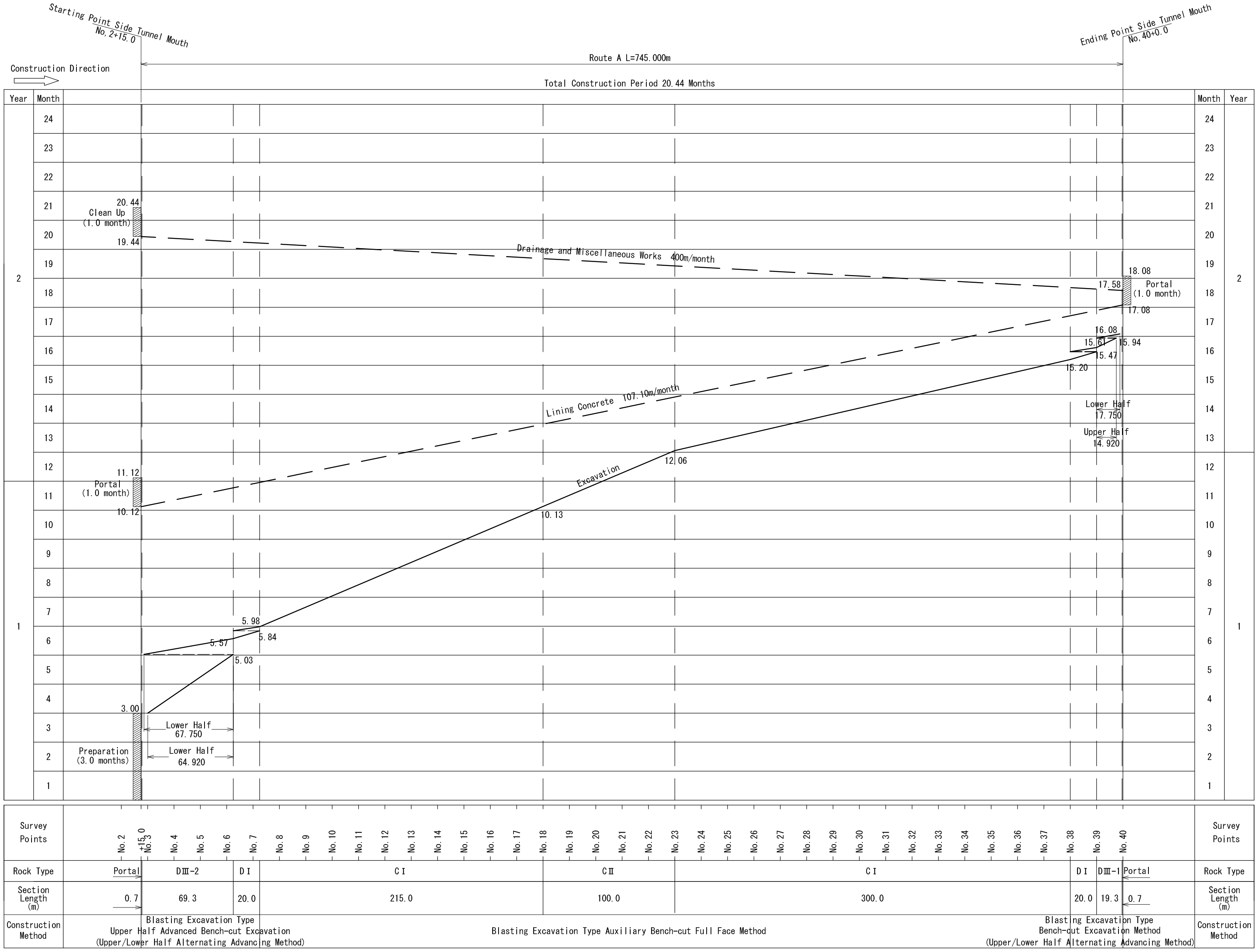
TITLE

DRAWING No.

SCALE 1:60 —(A1)
1:120 —(A3)

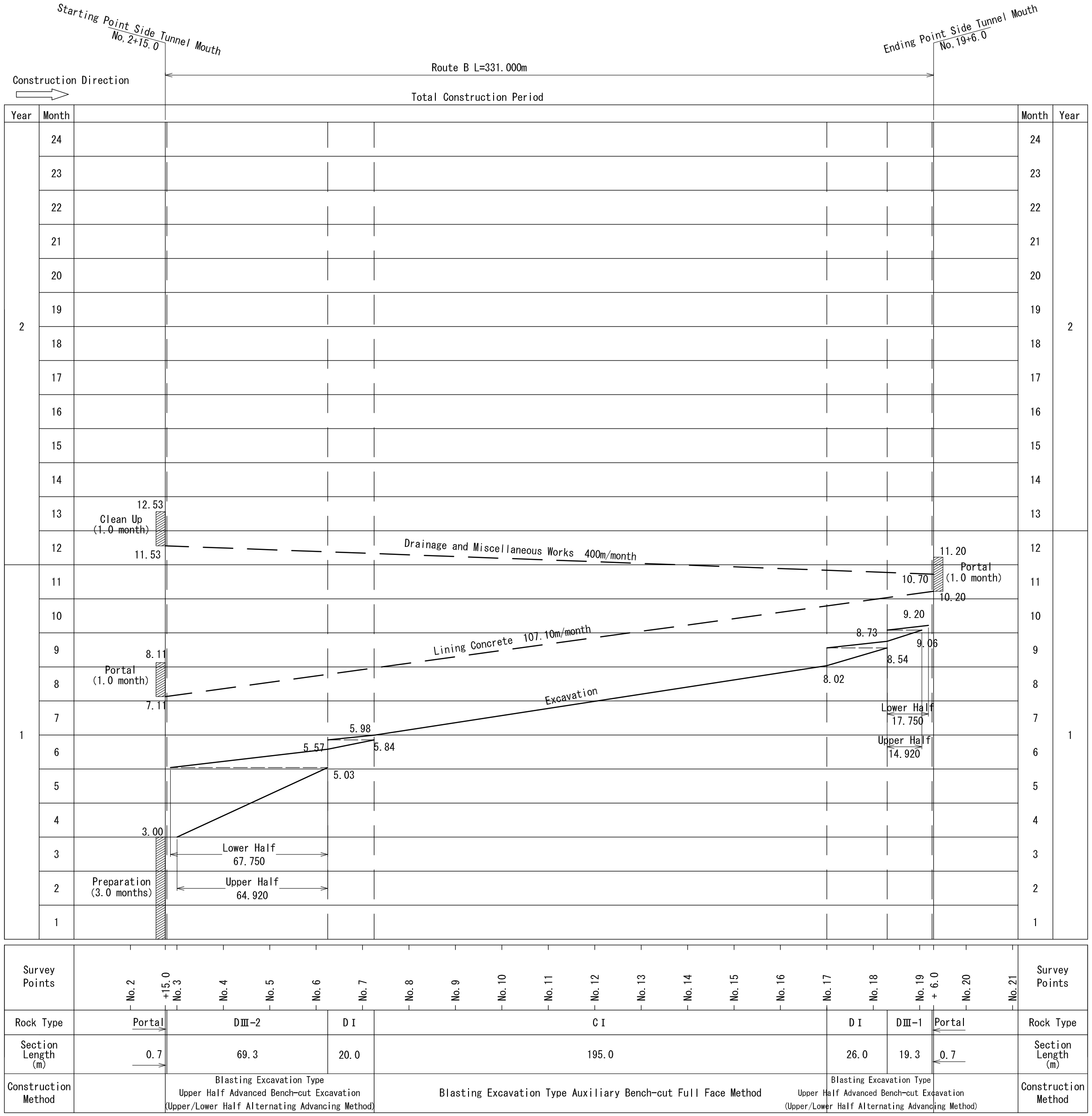
Route A Construction Schedule S=1:1500



・Planned Daily Advance

Type of Construction		Planned Daily Advance
Preparation	Preparation (3 months)	3 months
Excavation, Support, etc.		
CⅠ	Full Face	4.69m/day
CⅡ	Full Face	2.54m/day
DⅠ	Upper Half	3.62m/day
	Lower Half	6.80m/day
DⅢ-1	Upper Half	2.23m/day
	Lower Half	6.13m/day
DⅢ-2	Upper Half	1.57m/day
	Lower Half	6.13m/day
Portal		1 month/unit
Lining Concrete		107.10m/month
Drainage & Miscellaneous Works		400m/month
Construction Site Clean Up		1 month

Route B Construction Schedule S=1:1000



・Planned Daily Advance

Type of Construction		Planned Daily Advance
Preparation	Preparation (3 months)	3 months
Excavation, Support, etc.		
C I	Full Face	4.69m/day
D I	Upper Half	3.62m/day
	Upper Half	※2.46m/day
	Lower Half	6.80m/day
DⅢ-1	Upper Half	2.23m/day
	Lower Half	6.13m/day
DⅢ-2	Upper Half	1.57m/day
	Lower Half	6.13m/day
Portal		1month/unit
Lining Concrete		107.10m/month
Drainage and Miscellaneous Works		400m/month
Construction Site Clean Up		1 month

※Auxiliary Method Section in the Ending Point Side(L=26.0m)

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PROJECT NAME

THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE

PLAN MAP OF EMPANSION OF EXISTING ROAD

DRAWING No.

SCALE1:1000 —(A1)

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OYO INTERNATIONAL CORPORATION

PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE
PLAN MAP OF ACCESS ROAD

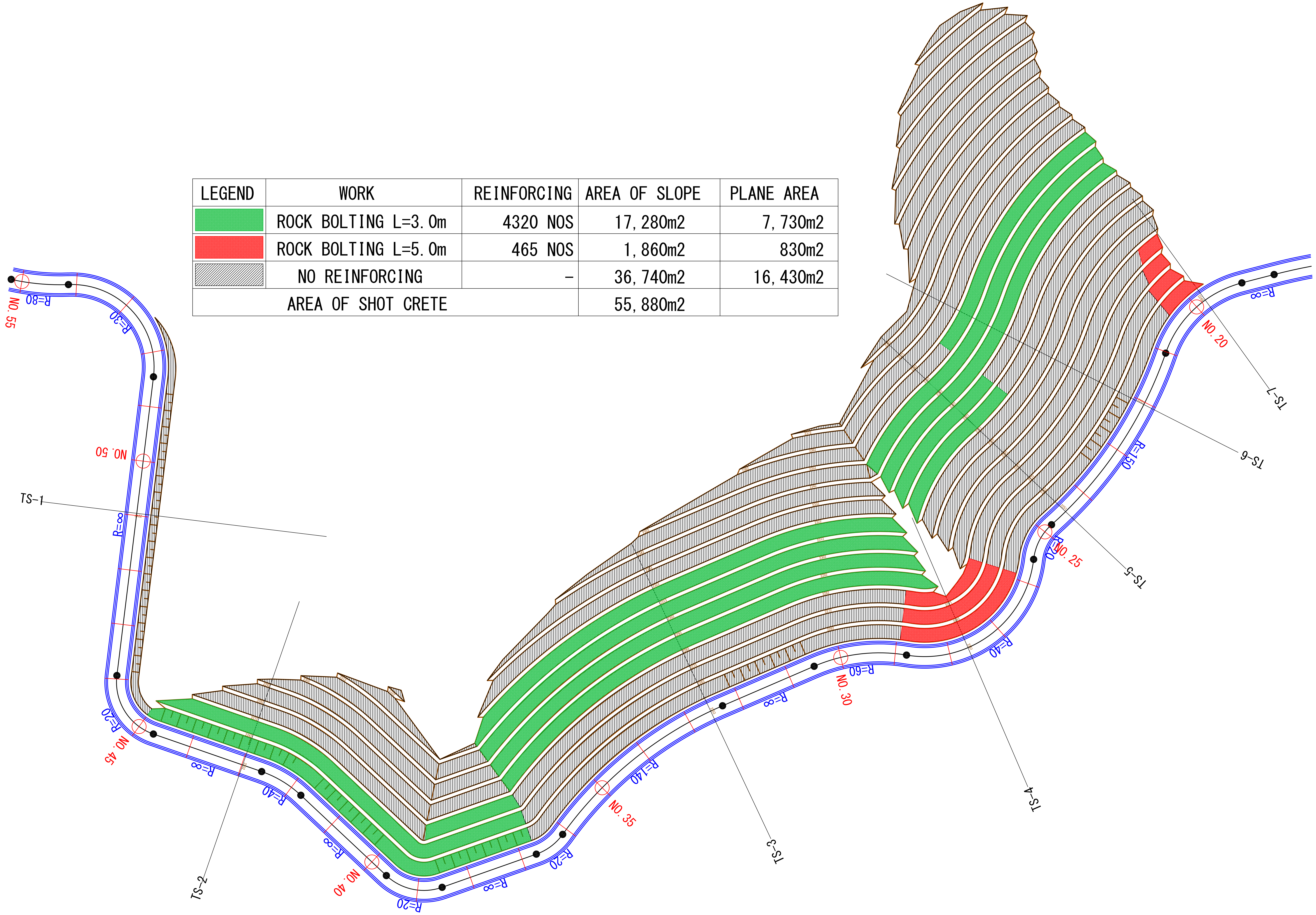
DRAWING No.

SCALE1:1000 —(A1)

AREA ESTIMATION DIAGRAM OF SLOPE PROTECTION WORK

S=1:1500(A3)

LEGEND	WORK	REINFORCING	AREA OF SLOPE	PLANE AREA
🟩	ROCK BOLTING L=3.0m	4320 NOS	17,280m2	7,730m2
🟥	ROCK BOLTING L=5.0m	465 NOS	1,860m2	830m2
▨	NO REINFORCING	–	36,740m2	16,430m2
	AREA OF SHOT CRETE		55,880m2	



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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

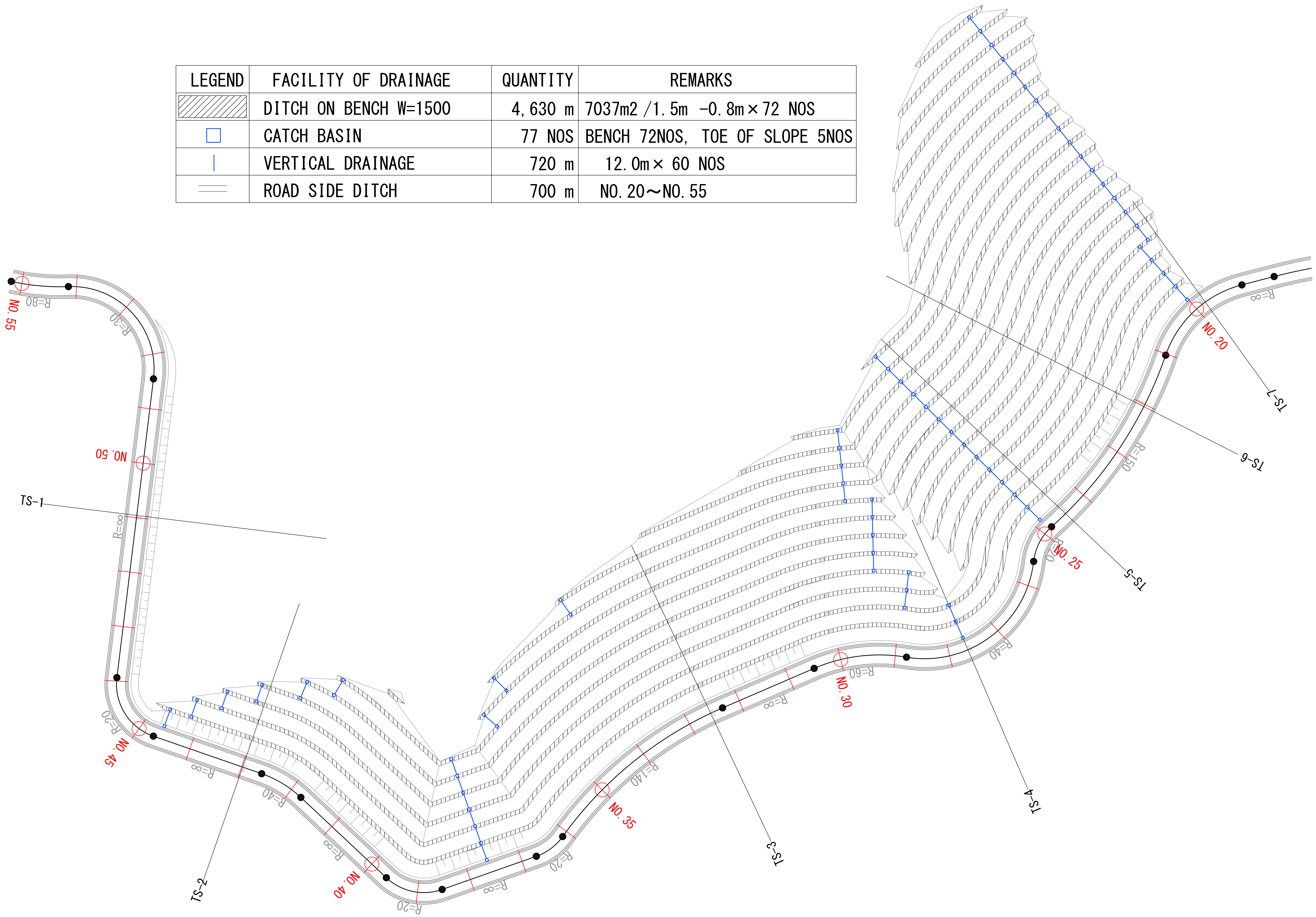
TITLE
AREA ESTIMATION DIAGRAM OF SLOPE PROTECTION WORK

DRAWING No.

SCALE 1:750 —(A1)

# PLAN MAP OF DRAINAGE SYSTEM
S=1:1500(A3)

LEGEND	FACILITY OF DRAINAGE	QUANTITY	REMARKS
▨	DITCH ON BENCH W=1500	4,630 m	7037m2 /1.5m -0.8m×72 NOS
□	CATCH BASIN	77 NOS	BENCH 72NOS, TOE OF SLOPE 5NOS
|	VERTICAL DRAINAGE	720 m	12.0m× 60 NOS
═	ROAD SIDE DITCH	700 m	NO.20～NO.55



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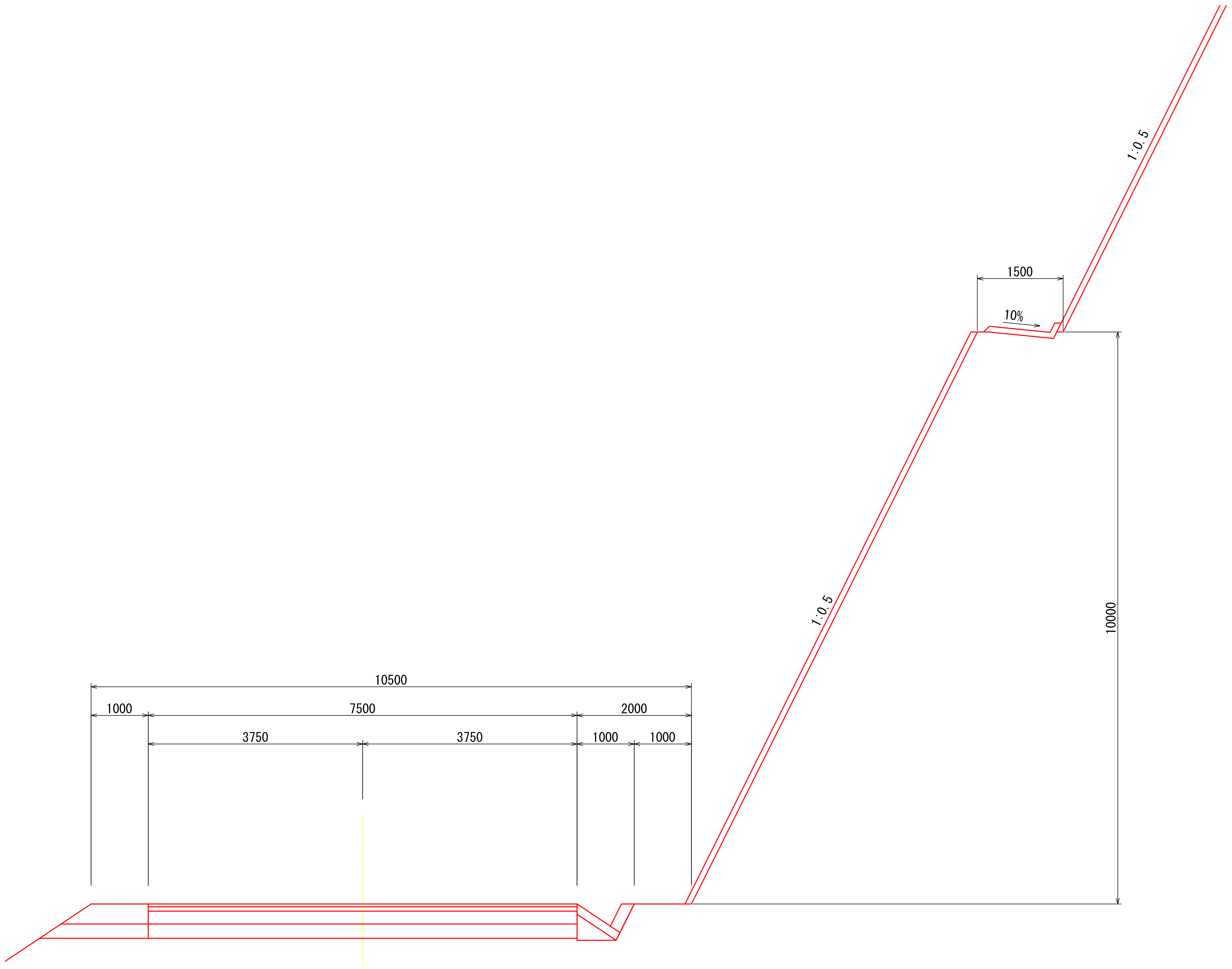
PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE
PLAN MAP OF DRAINAGE SYSTEM

DRAWING No.
SCALE 1:750 －(A1)

STANDARD CROSS SECTION S=1:50



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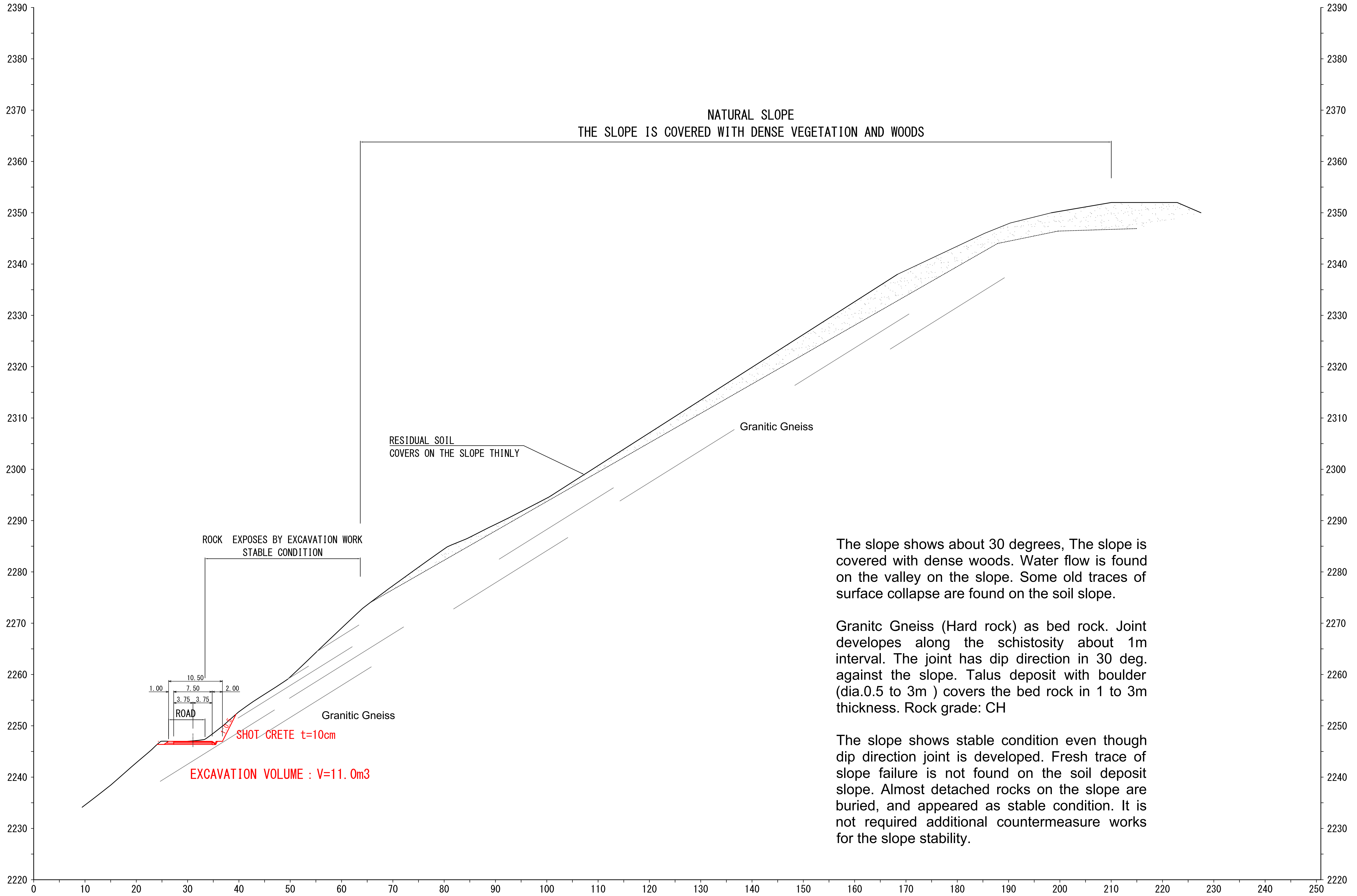
PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE
STANDARD CROSS SECTION FOR ROAD AND CUT SLOPE

DRAWING No.

SCALE 1:50 ―(A1)

THOMANG ROAD SECTION - TS-01



The slope shows about 30 degrees, The slope is covered with dense woods. Water flow is found on the valley on the slope. Some old traces of surface collapse are found on the soil slope.

Granitc Gneiss (Hard rock) as bed rock. Joint developes along the schistosity about 1m interval. The joint has dip direction in 30 deg. against the slope. Talus deposit with boulder (dia.0.5 to 3m) covers the bed rock in 1 to 3m thickness. Rock grade: CH

The slope shows stable condition even though dip direction joint is developed. Fresh trace of slope failure is not found on the soil deposit slope. Almost detached rocks on the slope are buried, and appeared as stable condition. It is not required additional countermeasure works for the slope stability.

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PROJECT NAME
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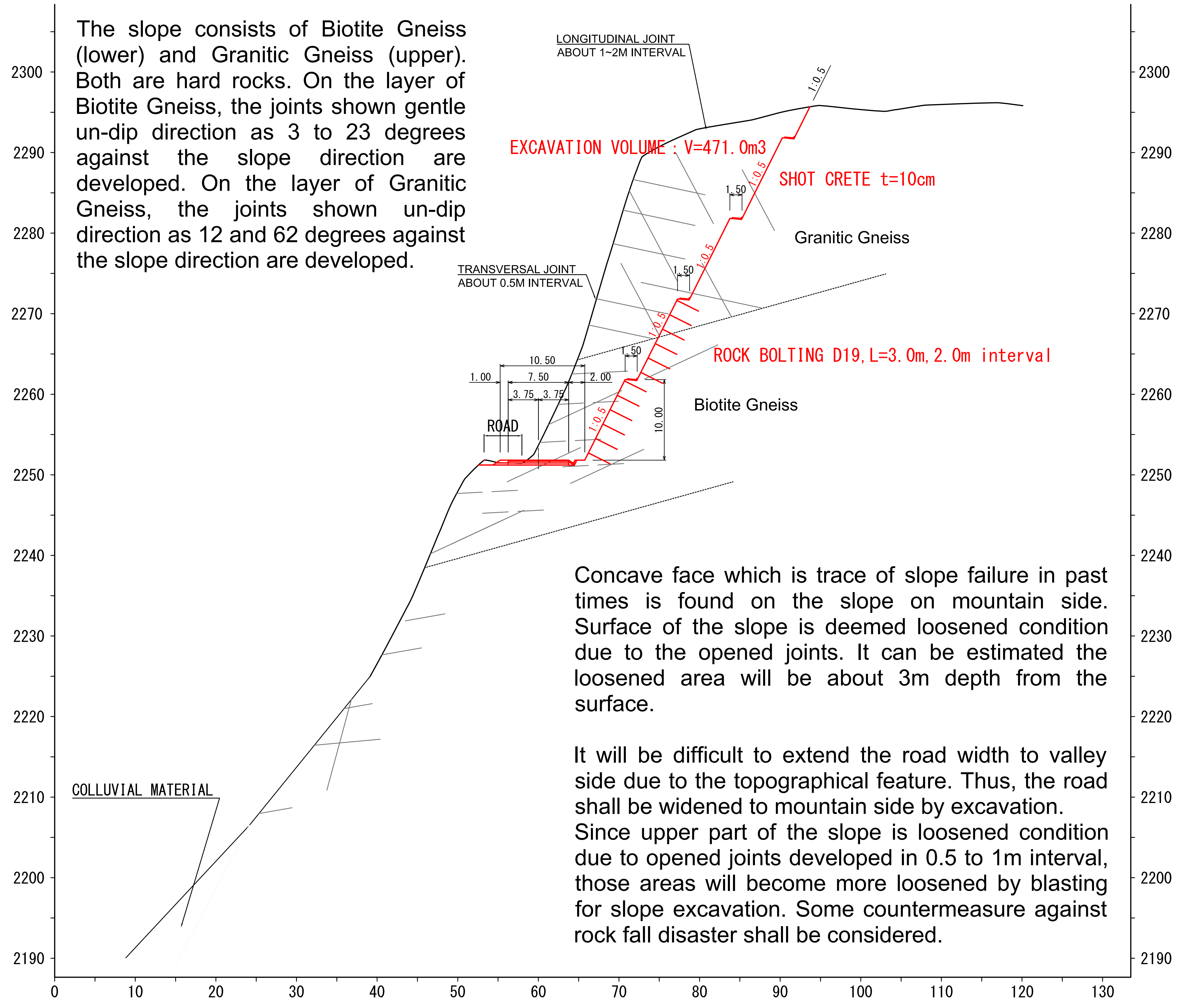
TITLE
CROSS SECTION FOR SLOPE
PROTECTION WORK (TS-01)

DRAWING No.
SCALE 1:400 -(A1)

THOMANG ROAD SECTION - TS-2

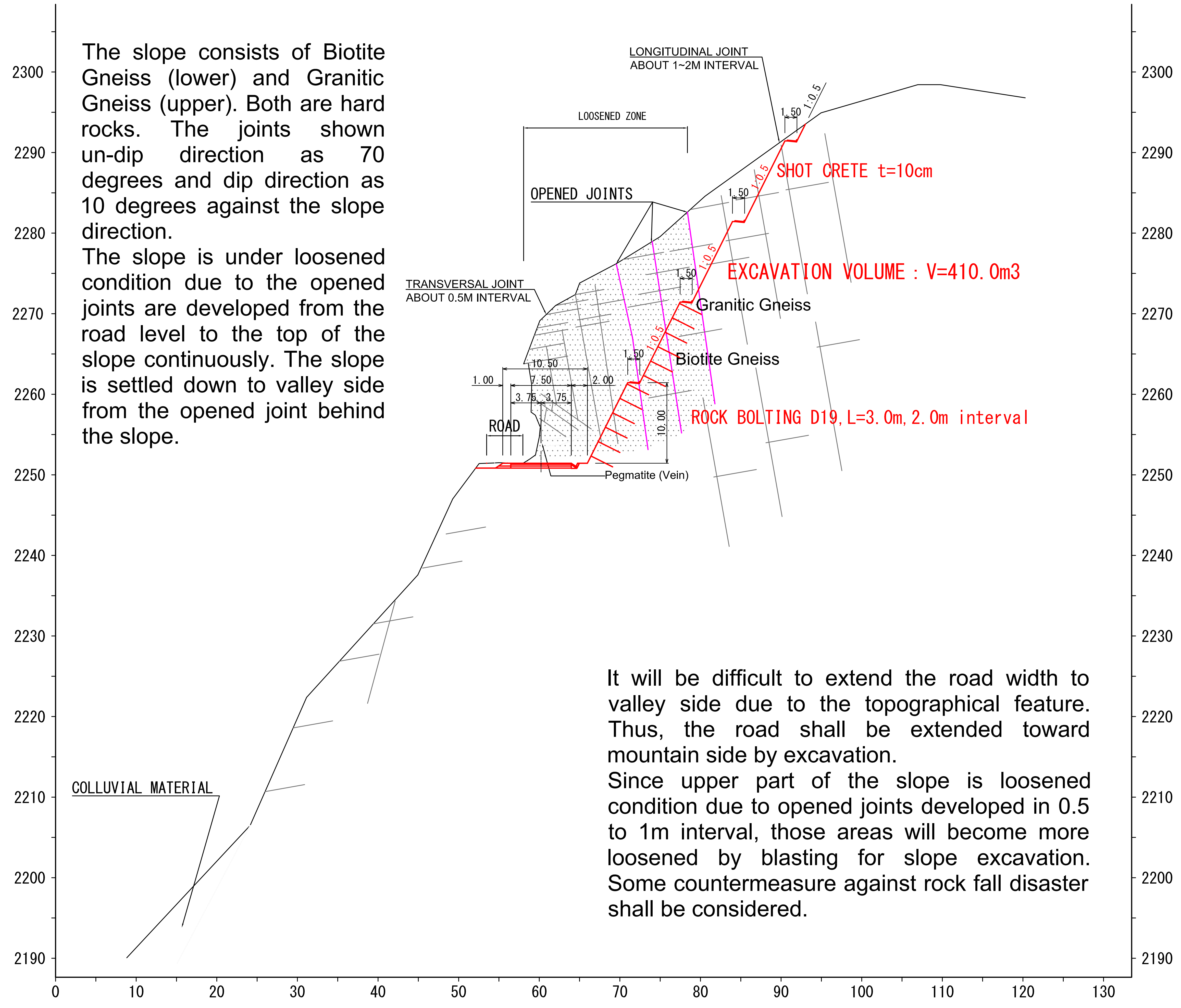


The slope consists of Biotite Gneiss (lower) and Granitic Gneiss (upper). Both are hard rocks. On the layer of Biotite Gneiss, the joints shown gentle un-dip direction as 3 to 23 degrees against the slope direction are developed. On the layer of Granitic Gneiss, the joints shown un-dip direction as 12 and 62 degrees against the slope direction are developed.

Concave face which is trace of slope failure in past times is found on the slope on mountain side. Surface of the slope is deemed loosened condition due to the opened joints. It can be estimated the loosened area will be about 3m depth from the surface.

It will be difficult to extend the road width to valley side due to the topographical feature. Thus, the road shall be widened to mountain side by excavation. Since upper part of the slope is loosened condition due to opened joints developed in 0.5 to 1m interval, those areas will become more loosened by blasting for slope excavation. Some countermeasure against rock fall disaster shall be considered.

THOMANG ROAD SECTION - TS-02-1



The slope consists of Biotite Gneiss (lower) and Granitic Gneiss (upper). Both are hard rocks. The joints shown un-dip direction as 70 degrees and dip direction as 10 degrees against the slope direction.

The slope is under loosened condition due to the opened joints are developed from the road level to the top of the slope continuously. The slope is settled down to valley side from the opened joint behind the slope.

It will be difficult to extend the road width to valley side due to the topographical feature. Thus, the road shall be extended toward mountain side by excavation. Since upper part of the slope is loosened condition due to opened joints developed in 0.5 to 1m interval, those areas will become more loosened by blasting for slope excavation. Some countermeasure against rock fall disaster shall be considered.

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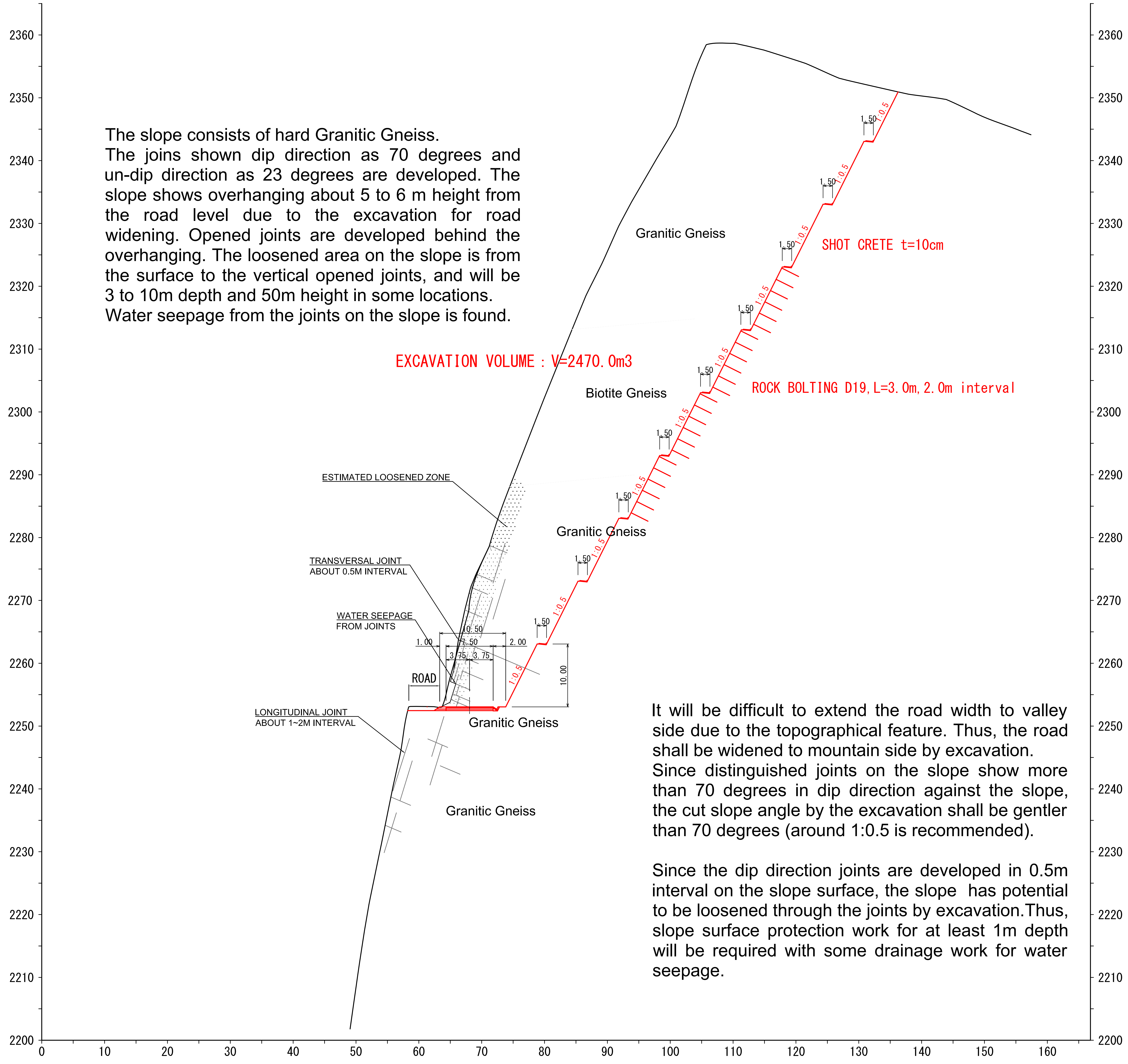
PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE CROSS SECTION FOR SLOPE PROTECTION WORK (TS-02, TS-02-1)
DRAWING No.
SCALE 1:400 -(A1)

THOMANG ROAD SECTION – TS-03



The slope consists of hard Granitic Gneiss.
The joins shown dip direction as 70 degrees and un-dip direction as 23 degrees are developed. The slope shows overhanging about 5 to 6 m height from the road level due to the excavation for road widening. Opened joints are developed behind the overhanging. The loosened area on the slope is from the surface to the vertical opened joints, and will be 3 to 10m depth and 50m height in some locations.
Water seepage from the joints on the slope is found.

EXCAVATION VOLUME : V=2470.0m3

It will be difficult to extend the road width to valley side due to the topographical feature. Thus, the road shall be widened to mountain side by excavation.
Since distinguished joints on the slope show more than 70 degrees in dip direction against the slope, the cut slope angle by the excavation shall be gentler than 70 degrees (around 1:0.5 is recommended).

Since the dip direction joints are developed in 0.5m interval on the slope surface, the slope has potential to be loosened through the joints by excavation.Thus, slope surface protection work for at least 1m depth will be required with some drainage work for water seepage.

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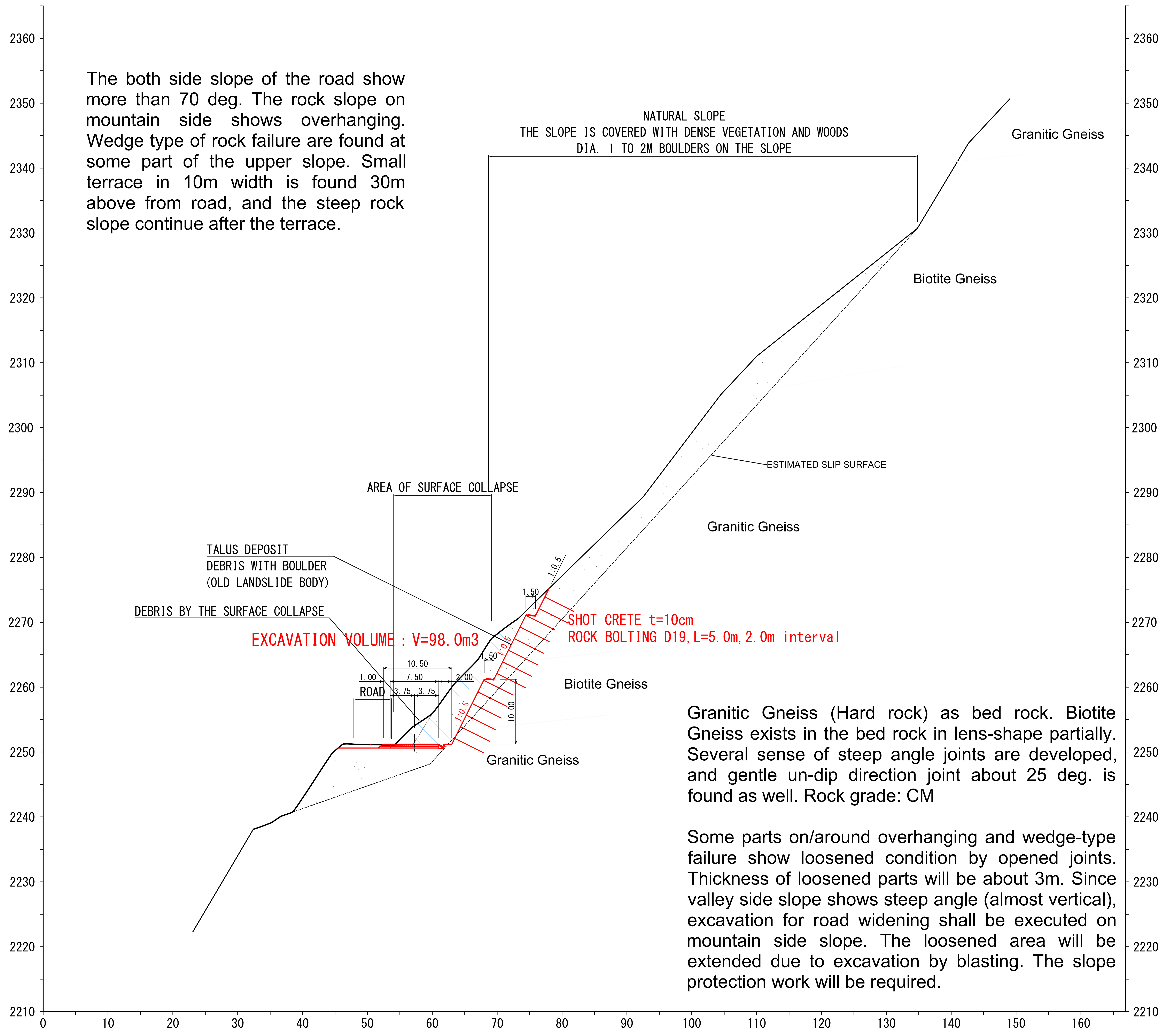
TITLE
CROSS SECTION FOR SLOPE PROTECTION WORK (TS-03)

DRAWING No.
SCALE 1:400 —(A1)

THOMANG ROAD SECTION - TS-04



The both side slope of the road show more than 70 deg. The rock slope on mountain side shows overhanging. Wedge type of rock failure are found at some part of the upper slope. Small terrace in 10m width is found 30m above from road, and the steep rock slope continue after the terrace.

Granitic Gneiss (Hard rock) as bed rock. Biotite Gneiss exists in the bed rock in lens-shape partially. Several sense of steep angle joints are developed, and gentle un-dip direction joint about 25 deg. is found as well. Rock grade: CM

Some parts on/around overhanging and wedge-type failure show loosened condition by opened joints. Thickness of loosened parts will be about 3m. Since valley side slope shows steep angle (almost vertical), excavation for road widening shall be executed on mountain side slope. The loosened area will be extended due to excavation by blasting. The slope protection work will be required.

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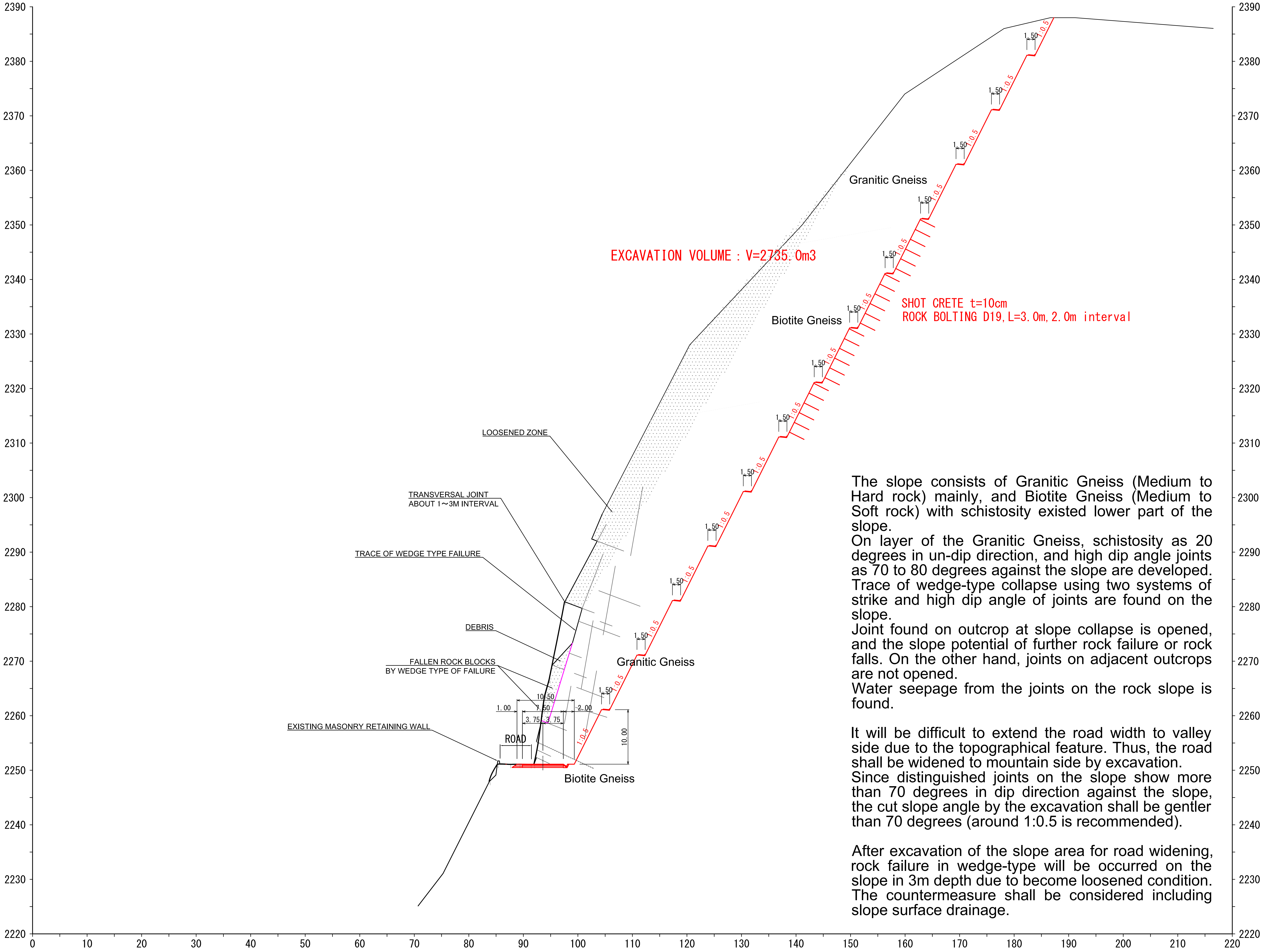
TITLE
CROSS SECTION FOR SLOPE
PROTECTION WORK (TS-04)
DRAWING No.
SCALE 1:400 -(A1)

THOMANG ROAD SECTION – TS-05



The slope consists of Granitic Gneiss (Medium to Hard rock) mainly, and Biotite Gneiss (Medium to Soft rock) with schistosity existed lower part of the slope.
On layer of the Granitic Gneiss, schistosity as 20 degrees in un-dip direction, and high dip angle joints as 70 to 80 degrees against the slope are developed.
Trace of wedge-type collapse using two systems of strike and high dip angle of joints are found on the slope.
Joint found on outcrop at slope collapse is opened, and the slope potential of further rock failure or rock falls. On the other hand, joints on adjacent outcrops are not opened.
Water seepage from the joints on the rock slope is found.

It will be difficult to extend the road width to valley side due to the topographical feature. Thus, the road shall be widened to mountain side by excavation.
Since distinguished joints on the slope show more than 70 degrees in dip direction against the slope, the cut slope angle by the excavation shall be gentler than 70 degrees (around 1:0.5 is recommended).

After excavation of the slope area for road widening, rock failure in wedge-type will be occurred on the slope in 3m depth due to become loosened condition. The countermeasure shall be considered including slope surface drainage.

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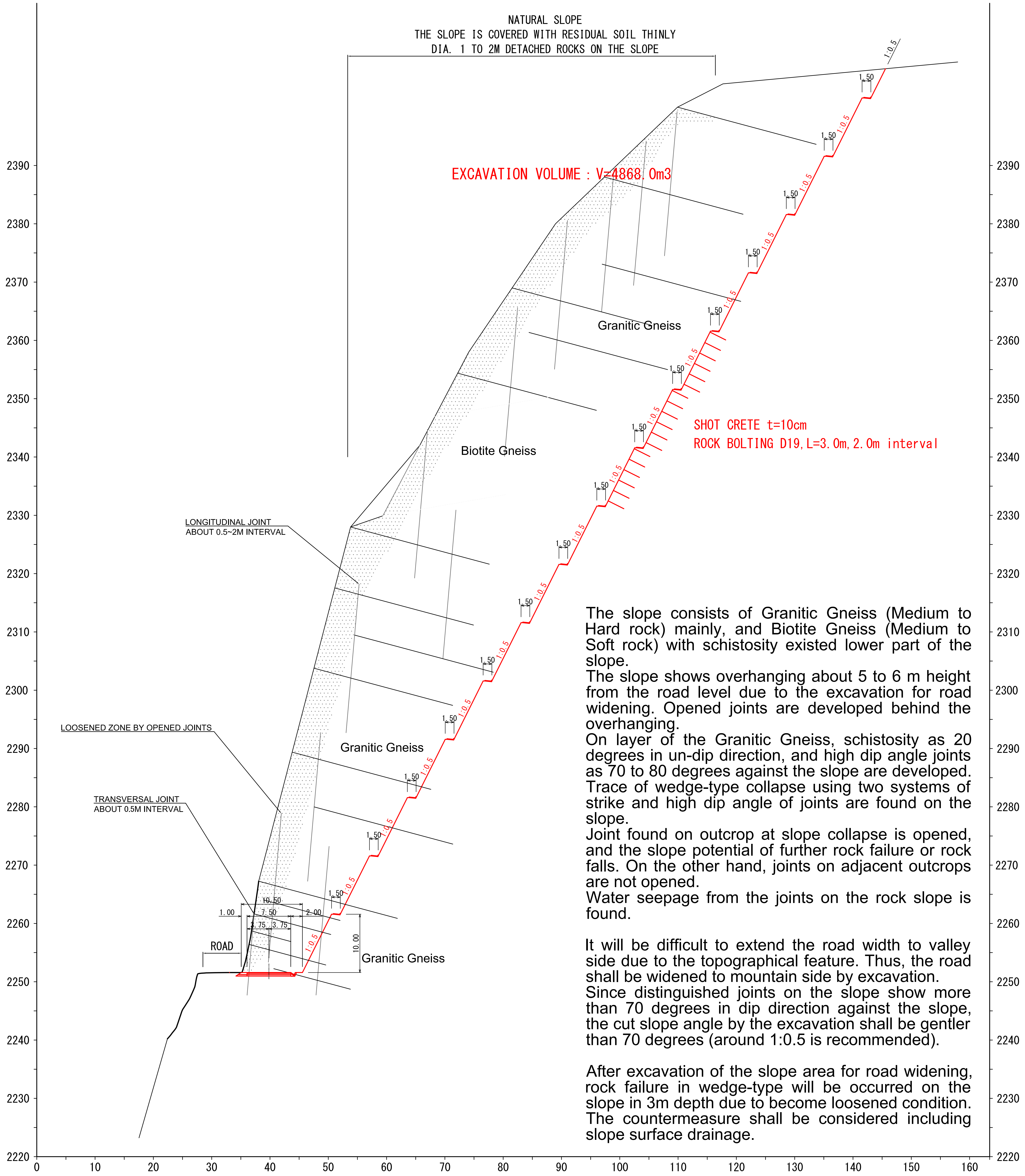
TITLE
CROSS SECTION FOR SLOPE PROTECTION WORK (TS-05)
DRAWING No.
SCALE 1:400 —(A1)

THOMANG ROAD SECTION – TS-06



The slope consists of Granitic Gneiss (Medium to Hard rock) mainly, and Biotite Gneiss (Medium to Soft rock) with schistosity existed lower part of the slope.
The slope shows overhanging about 5 to 6 m height from the road level due to the excavation for road widening. Opened joints are developed behind the overhanging.
On layer of the Granitic Gneiss, schistosity as 20 degrees in un-dip direction, and high dip angle joints as 70 to 80 degrees against the slope are developed. Trace of wedge-type collapse using two systems of strike and high dip angle of joints are found on the slope.
Joint found on outcrop at slope collapse is opened, and the slope potential of further rock failure or rock falls. On the other hand, joints on adjacent outcrops are not opened.
Water seepage from the joints on the rock slope is found.

It will be difficult to extend the road width to valley side due to the topographical feature. Thus, the road shall be widened to mountain side by excavation.
Since distinguished joints on the slope show more than 70 degrees in dip direction against the slope, the cut slope angle by the excavation shall be gentler than 70 degrees (around 1:0.5 is recommended).

After excavation of the slope area for road widening, rock failure in wedge-type will be occurred on the slope in 3m depth due to become loosened condition. The countermeasure shall be considered including slope surface drainage.

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PROJECT NAME
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TITLE
CROSS SECTION FOR SLOPE PROTECTION WORK (TS-06)

DRAWING No.

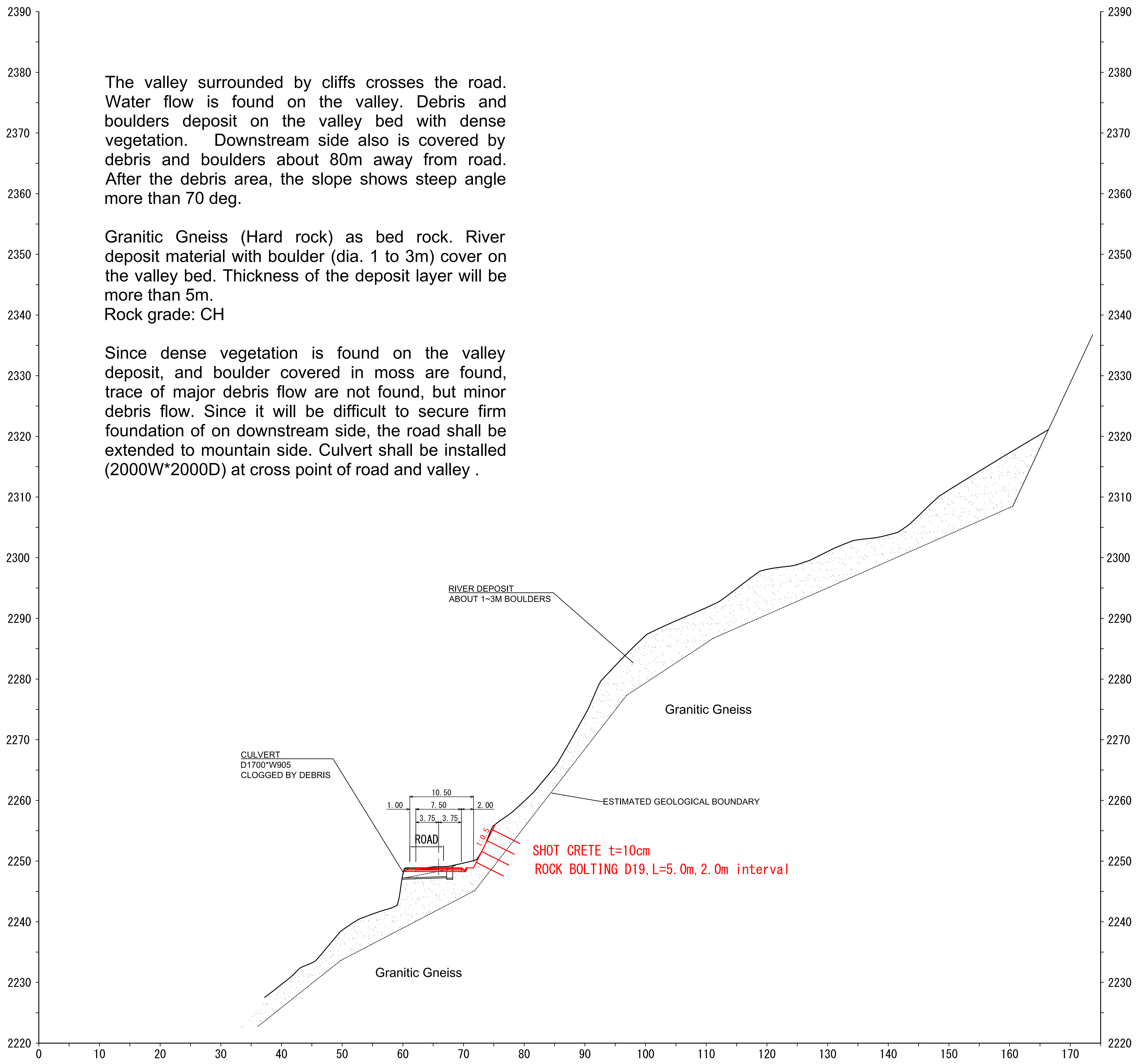
SCALE 1:400 —(A1)

THOMANG ROAD SECTION - TS-07

The valley surrounded by cliffs crosses the road. Water flow is found on the valley. Debris and boulders deposit on the valley bed with dense vegetation. Downstream side also is covered by debris and boulders about 80m away from road. After the debris area, the slope shows steep angle more than 70 deg.

Granitic Gneiss (Hard rock) as bed rock. River deposit material with boulder (dia. 1 to 3m) cover on the valley bed. Thickness of the deposit layer will be more than 5m.
Rock grade: CH

Since dense vegetation is found on the valley deposit, and boulder covered in moss are found, trace of major debris flow are not found, but minor debris flow. Since it will be difficult to secure firm foundation of on downstream side, the road shall be extended to mountain side. Culvert shall be installed (2000W*2000D) at cross point of road and valley .



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PROJECT NAME
THE PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN, JICA

TITLE
CROSS SECTION FOR SLOPE PROTECTION WORK (TS-07)

DRAWING No.
SCALE 1:400 －(A1)