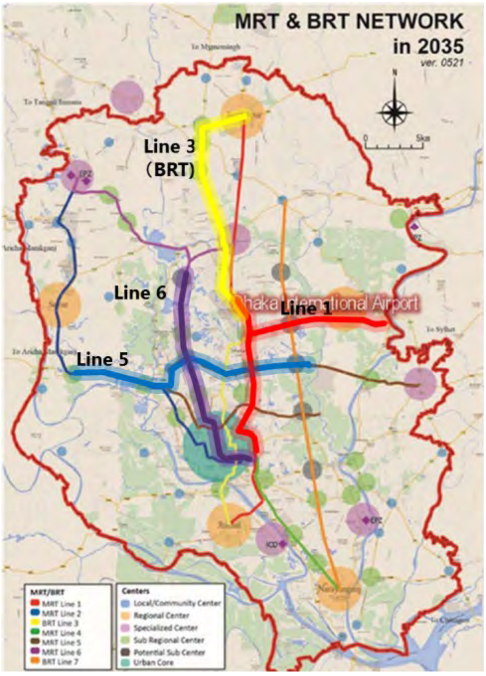
Table 3.3.2 List of Prioritized Route / Section

Route	Section	Length (km)
MRT Line 1	Kamalapur – Bashundhara (Main Line) Future Park - Purbachal Terminal (Purbachal Line)	28.2
MRT Line 5	Hemayetpur- Vatara	22.4
MRT Line 6	Kamalapur – Uttara	20.4
BRT Line 3	Airport – Joydepur	20.4

Source : JICA Study Team
Note: The length is based on RSTP.



Source: JICA Study Team

Figure 3.3.9 Prioritized Route / Section

2) LOS and Fare Setting of Mass Transit

LOS and fare setting assumed in this demand forecast model is shown in Table 3.3.3.

Table 3.3.3 List and Fare Setting of Mass Transit

Mode		2025/2028	2035
MRT	Headway (min)	3.5	
	Capacity (000 pax/day/ direction)	200	
	Speed (km/h)	35	
	Fare (Tk)	22.6+2.8 /km	30.6+3.8 /km
BRT	Headway (min)	3.0	
	Capacity (000 pax/day/ direction)	64	
	Speed (km/h)	23	
	Fare (Tk)	9.9+4.5/km	13.4+6.1 /km
BR	Headway (min)	60	
	Capacity (000 pax/day/ direction)	64	
	Speed (km/h)	15	
	Fare (Tk)	0.7 / km	1.0 / km

Source: JICA Study Team

3.3.4 Daily Passenger Demand Result

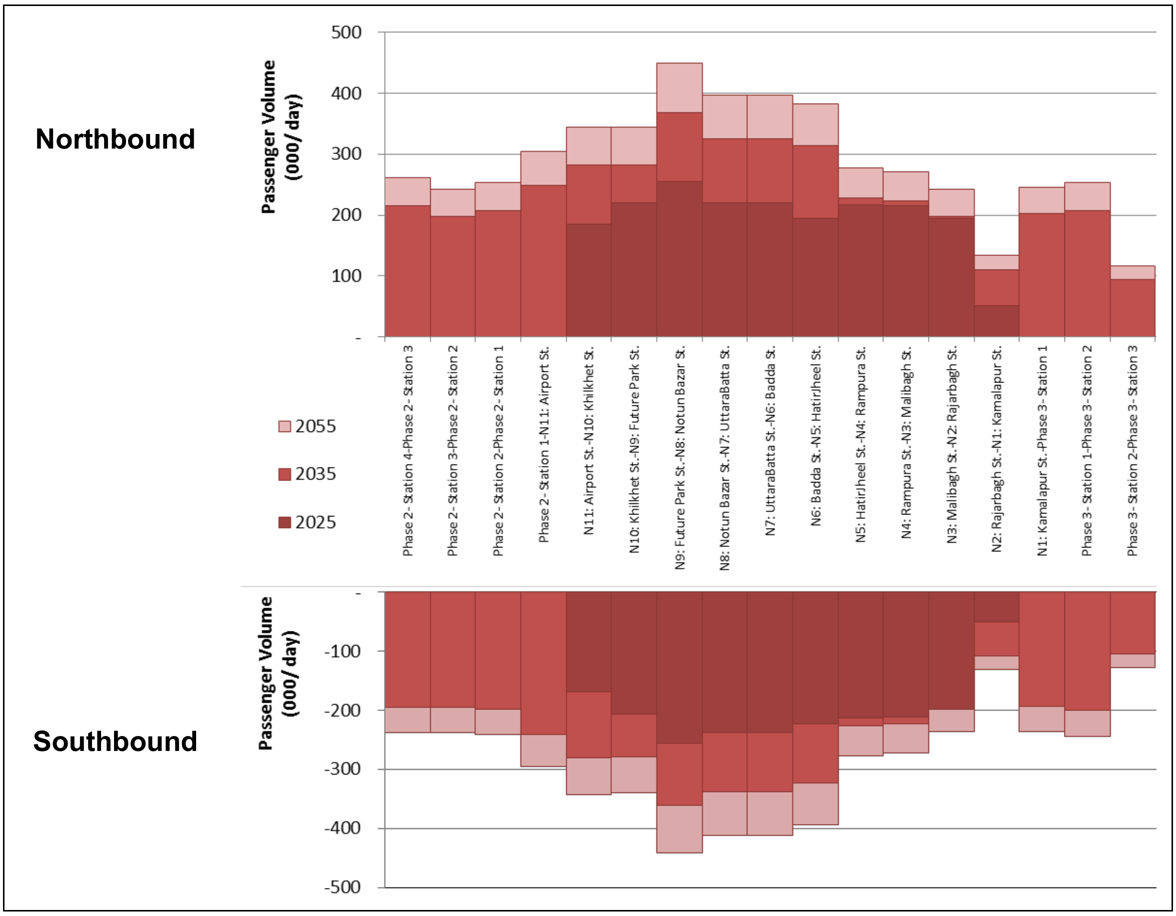
Table 3.3.4 shows the estimated railway performance indicators of MRT Line 1. PPHPD (Passenger Per Hour Per Direction) will be 26,500 pax in 2025[1], 48,000 in 2035 and 58,500 in 2055. This demand can only be handled by Mass Transit.

Table 3.3.4 Estimated Performance Indicators of MRT Line 1

	Route Length (km)	Ridership (000)	PPHPD 1)	Pax-Kms (000)	Pax/km (000)	Pax-kms /km (000)
2025	28.2	1,105	26,500	9,975	39,379	354
2035	52.7	1,812	47,970	21,117	34,377	400
2055	52.7	2,541	58,500	25,786	48,179	489

1) Peak Hour Rate is assumed to be 10 % in 2025 and 13 % in 2035 & 2055.
Source: JICA Study Team

Traffic demand by section of the main line is indicated in Figure 3.3.10 and Table 3.3.5. The most congested section is Notun Bazar to Future Park, which will carry 500,000 pax /day in 2025. For phase 2 sections, the northern part shows high demand and suggests the possibility of further extension.



Source: JICA Study Team

Figure 3.3.10 Line Volume by Section of MRT Line 1 (Main Line)

[1] Although MRT Line 1 has been planned starting the operation in 2026, the traffic demand was considered for 2025, 2035 and 2055. Therefore, the operation planning at chapter 4 is based on the traffic demand.

Table 3.3.5 Line Volume by Section of MRT Line 1 (Main Line) : 000/day

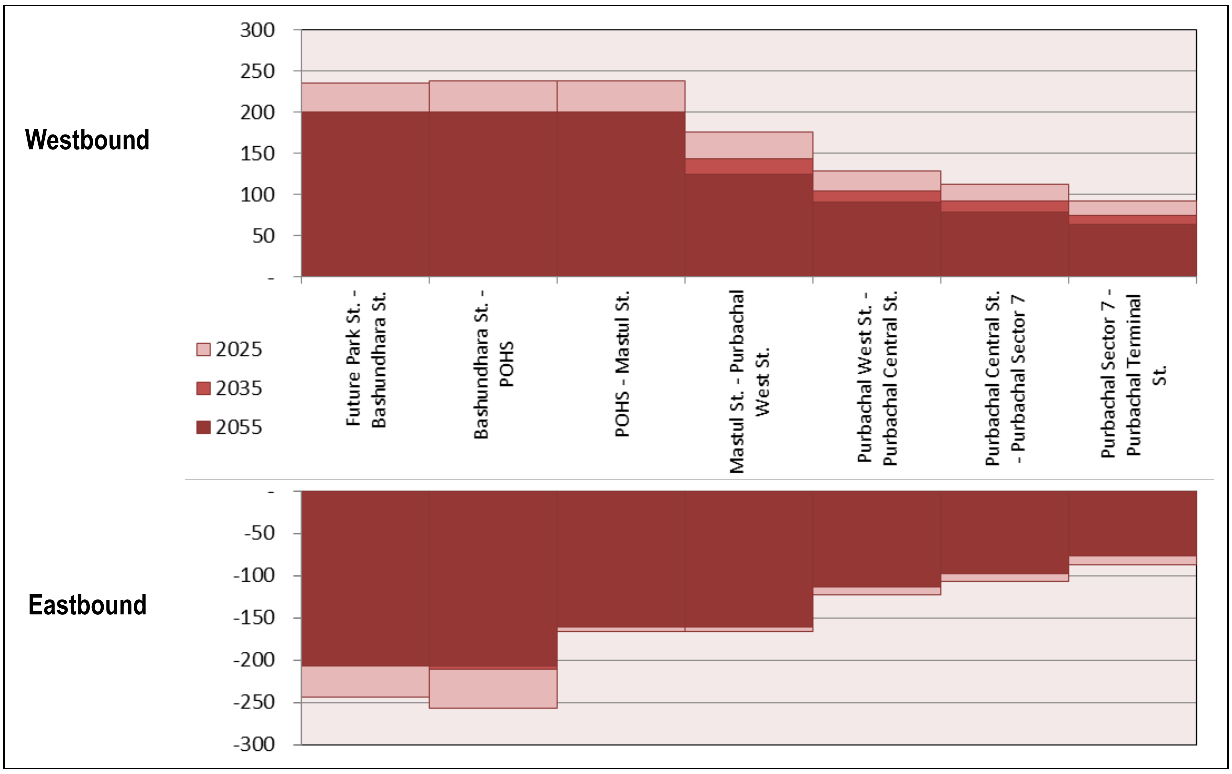
Station	2025		2035		2055	
	Line Volume		Line Volume		Line Volume	
	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
Phase 2- Station 4						
			215	195	262	238
Phase 2- Station 3						
			198	195	242	238
Phase 2- Station 2						
			207	198	253	242
Phase 2- Station 1						
			249	242	304	295
Airport St.						
	184	203	282	281	344	343
Khilkhet St.						
	211	231	282	279	344	340
Future Park St.						
	204	208	369	362	450	442
Notun Bazar St.						
	265	206	325	338	397	412
Uttara Badda St.						
	265	206	325	338	397	412
Badda St.						
	261	204	314	323	383	394
HatirJheel St.						
	236	237	228	227	278	277
Rampura St.						
	232	235	223	223	272	272
Malibagh St.						
	198	198	198	194	242	237
Rajarbagh St.						
	61	49	111	108	135	132
Kamalapur St.						
			202	194	246	237
Phase 3- Station 1						
			207	200	253	244
Phase 3- Station 2						
			95	105	116	128

Phase 3- Station 3						

Source: JICA Study Team

Traffic demand by section of Purbachal line is indicated in Source: JICA Study Team

Figure 3.3.11 and Table 3.3.6. The line volume is comparable with main line and the most congested section is Bashundhara to Mastul which will carry more than 400,000 pax /day in 2025. On the other hand, the demand in eastern part is less than 200,000 pax/day in 2035. On the east of Purbachal, there is no specific development is proposed, and the passenger demand can't be expected.



Source: JICA Study Team

Figure 3.3.11 Line Volume by Section of MRT Line 1 (Purbachal Line)

Table 3.3.6 Line Volume by Section of MRT Line 1 (Purbachal Line): 000/day

Station	2025		2035		2055	
	Line Volume		Line Volume		Line Volume	
	North bound	South bound	North bound	South bound	North bound	South bound
Future Park St.						
	200	207	193	200	235	244
Bashundhara St.						
	200	207	195	210	238	256
POHS						
	200	160	195	136	238	166
Mastul St.						
	125	160	144	136	176	166
Purbachal West St.						
	91	113	105	100	129	122
Purbachal Central St.						
	79	97	92	87	113	107
Purbachal East						
	64	76	75	71	92	87
Purbachal Terminal St.						

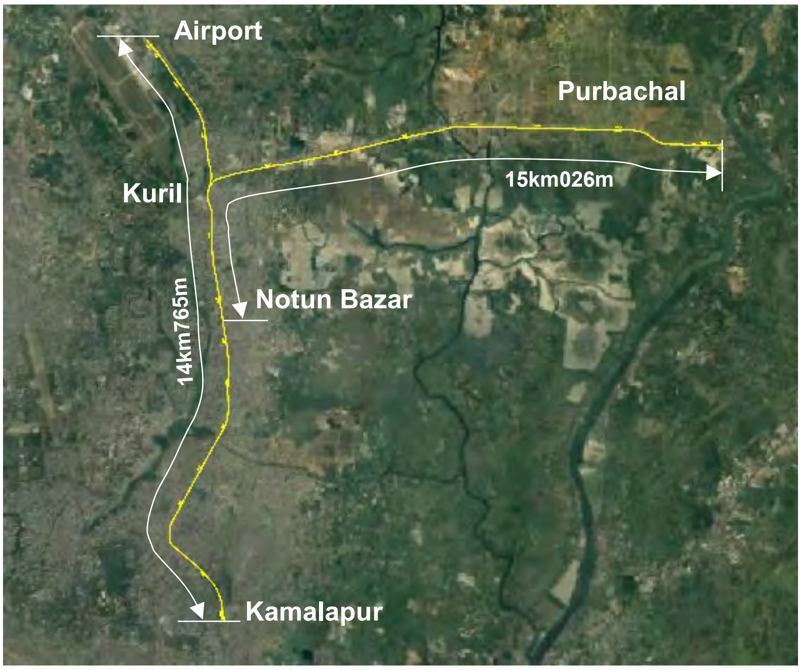
Source: JICA Study Team

4 Project Implementation Plan for Line 1

4.1 Alignment Planning

MRT Line 1 consists of two lines: one route connects Kamalapur in central Dhaka with the Dhaka International Airport (hereafter the "Airport Line"), and the other route branches off from the Airport Line at Notun Bazar Station to the Purbachal area (hereafter the "Purbachal Line") where large-scale urban development is currently under way. The Line 1 route is shown in Figure 4.1.1. Future extension concepts include a northbound line from the airport to Gazipur, and a southbound line from Kamalapur to the Jhimil residential area in Keraniganj.

The Airport Line will run entirely through an underground tunnel, and the Purbachal Line will run through an underground tunnel from Notun Bazar to Kuril, after which it will emerge above ground to become an elevated structure to its destination at Purbachal.



Source: JICA Study Team

Note: Distance indicated is "Distance between Platform Centers of Kamalapur station and Airport Station, Notun Bazar Station and Purbachal Terminal Station) With regarding Construction Length we will discuss in Chapter 4, 6) of 4.2.2.

Figure 4.1.1 Route of Line 1

4.1.1 Basic Policies of the Alignment Planning

The specifications required for alignment planning are shown in Table 4.1.1 below.

Table 4.1.1 Specifications Required for Alignment Planning

Item		Description
Track gauge		1435mm
Maximum design speed		110km/h
Maximum operating speed		100km/h
Minimum radius	Main line	400m
	If absolutely necessary	160m
	Platform sections	400m or greater
Maximum gradient		25/1000 (recommended), 35/1000 (upper limit)
	Station	0 (recommended), 5/1000 (upper limit)
	Stabling track	0
Minimum gradient	Underground sections	2/1000
Vertical curve radius		3000m
		4000m (where R=600 or smaller)
Car length		20m
Track centre intervals	Tangent sections	4.0m
Platform length	8-car trains in the future	170m
Platform width	Island type	11m
	Separate type	3m

Source: JICA Study Team

4.2 Design Standards and Basic Policies of the Alignment Planning

4.2.1 Design standards

Design standards conform to the "Bangladesh MRT Engineering Standards" (2014.12 DTCA, JICA), appending some sentences as may be necessary. Especially safety of passengers and workers are fundamental issues. These subjects we will discuss 4.5 (4) (page 81).

4.2.2 Basic Policies of the Alignment Planning

1) Route Overview

Airport Line

The Airport Line, which runs through an underground tunnel, starts at the Kamalapur Station of Bangladesh National Rail (BR), travels westward under the Outer Circular Road, northward under the Rampura DIT Road and Pragati Sharani Road, crosses the Kuril flyover, and proceeds under the New Airport Road to its destination at Dhaka International Airport.

The underground tunnel will consist of shielded tunnels for single tracks. Typically, tunnels running directly underneath roads will be arranged horizontally in two rows side by side. However, if there are any underground obstacles, the tunnels will be built in a two-tier configuration, or by separating the two lines for trains to overtake and pass. In this project, a typical arrangement will need to be made at the fly-over between Rajarbagh and Malibagh, the Rampura Bridge, and the Kuril fly-over.

Purbachal Line

The Airport Line will branch off to the Purbachal Line at Notun Bazar instead of Future Park according to site availability. The station box which contains two platforms and four tracks, requires of area about 36m in width and 250m in length for station box. As shown in Figure 3.2.2, the same width of land will be required for an extent of 200m north of the station. However, it is difficult to construct a structure with this width in the road in front of Future Park station. Therefore, the JICA Study Team (JST) selected Notun Bazar station as the junction for the Airport Line and Purubachal Line. As shown in Figure 3.2.2, Prangati Sharani Road, where Notun Bazar station is planned to be constructed, has a width of 39.15m. The four tunnels laid out horizontally leading up to Future Park will be of an upper and lower tier configuration, the upper for the Purbachal Line and the lower for the Airport Line. Both of these lines will circumvent the pile foundations at the Kuril fly-over and the Dhaka Elevated Expressway (DEE) that is currently under construction, and run to the north and east, respectively.

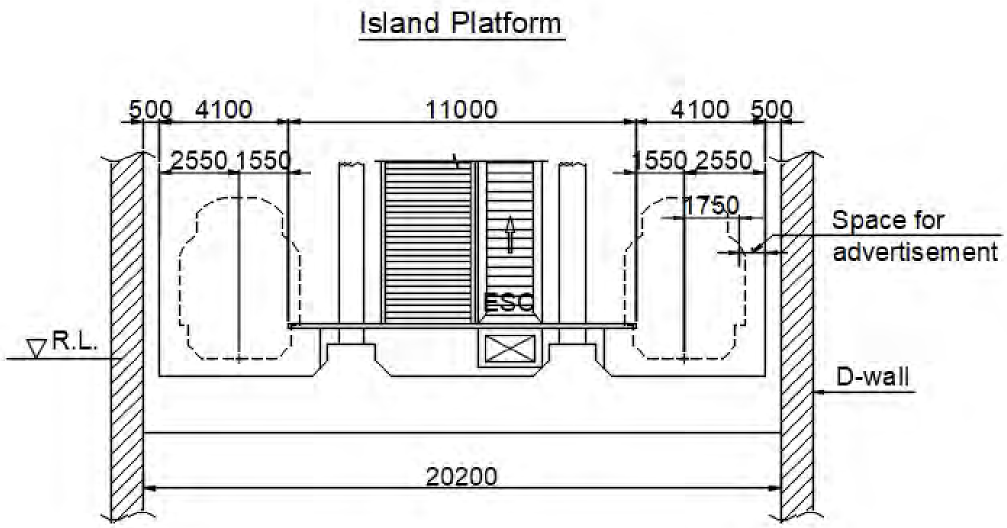
The elevated section of the Purbachal Line begins at the above ground exit/entrance built on the east side of the Kuril fly-over, and will proceed eastward directly above the median strip of the Purbachal Highway to the Purbachal Terminal station. However, on curved sections of the road, the line will run over service roads. The highway crosses six river bridges 70-80m long, and the line will run directly over these bridges.

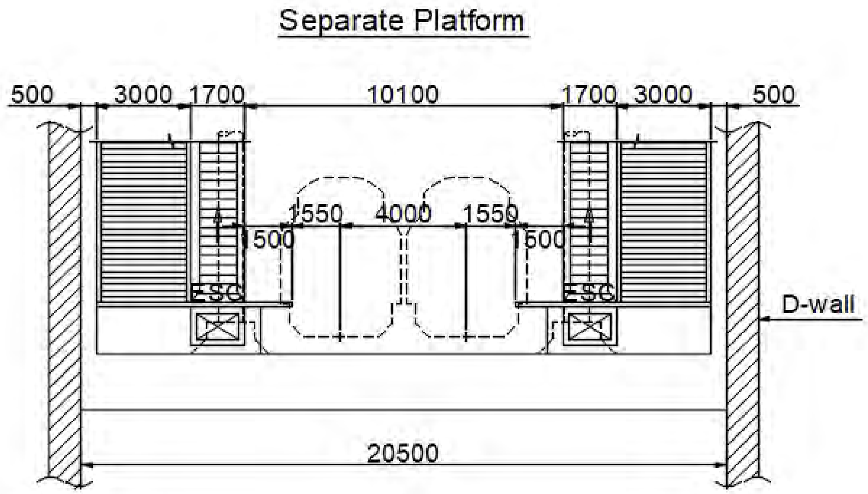
2) Station Location

Taking into account the railway station catchment area, stations will be generally located roughly 1km apart, and 1.5km apart in the suburbs. Their locations will be determined by considering the locations of major facilities, connections to other traffic lines, and the locations of fly-overs.

3) Island Platform and Lateral Platform

Two types of platform are shown below.





Source: JICA Study Team

Figure 4.2.1 Island Platform and Separate Platform

For elevated stations, side (lateral) type platforms will be provided while underground stations contain an island platform.

Side platforms have some advantages for elevated stations, while having disadvantages in the underground stations as shown below.

(Advantage of Side Platform)

Provided track alignment is straight tangent or large radius.

Station area land acquisition is limited

(Disadvantage of Side Platform)

1. Number of station facilities such as escalators and elevators are twice that for Island platforms; and

2. Number of station staff is also twice that for island platforms.
   ① Station Box of lateral type of platform requires wider space than island type.
3. In front of station box, a sharp S-curve is inevitable, because the distance between two tracks is 14m in the TBM section while it is 4m in a station box.

4) Track Layout Planning

The alignment planning will be considered based on the track layout planning below.

(a) Track Layout in Station Yards

As a general rule, underground stations will have one island type platform for two tracks. Exceptions are the Malibagh Station with two layers each with one platform for one track, the Notun Bazar Station with two platforms for four tracks, and the Future Park station with two layers each with one platform for two tracks.

Elevated stations will generally have two separate platforms (Lateral Platform) for two tracks, except the Purbachal Terminal station, which will have two platforms for three tracks.

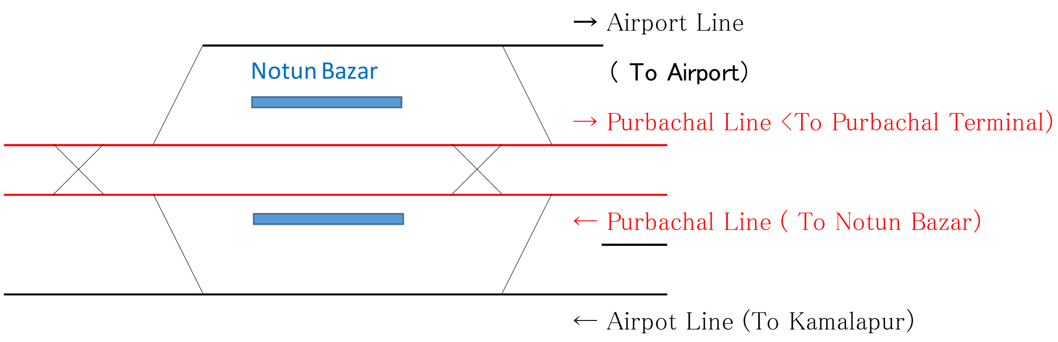
(b) Branch Layout at the Notun Bazar Station

The Airport Line, which enters the Notun Bazar station from the Kamalapur direction, will branch off from the two tracks to four before it reaches the platform. The four tracks leaving the station will run on two tiers to the Future Park station, the upper tier being the Purbachal Line, and the lower being the Airport Line.

Furthermore, at initial stage of MRT Line 1 commercial operation, since development of Purbachal Project may be still on the way, among 13 trains per hour from Purbachal 10 trains shall be returned at Notun Bazal station, remaining 3 trains shall go ahead to Komulapur Terminal. As a result Purbachal Line shall use inner two tracks of Notun Bazar Station while the Airport Line shall use outer two tracks.

(c) Notun Bazar Track Layout

① Track Layout of Notun Bazar Station

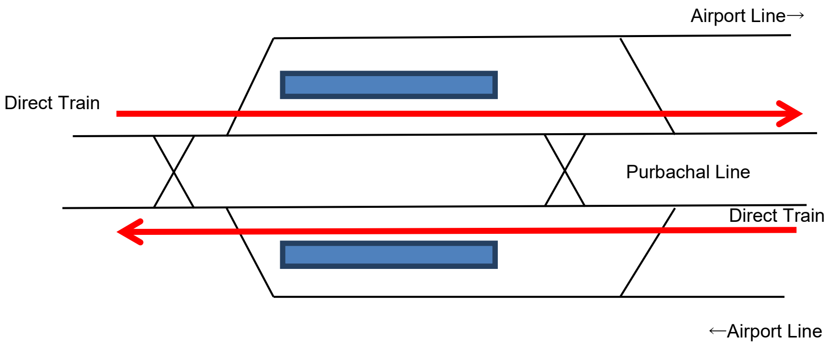


② Track Layout Plan

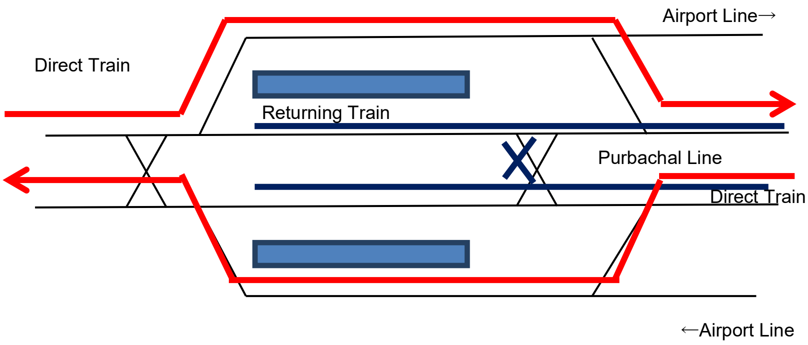
To turn back a part of the train to the Purbachal Line at Notun Bazar Station, the track for the Airport Line shall run outside and the Purbachal Line inside at the station. Also, to prevent obstruction at the platform section due to conflict with the following direct train for Kamalapur Station (or the direct train from Kamalapur Station to the

Purbachal Line) when the shuttle train is present at the platform section, a cross between the Purbachal Line and the Airport Line was established on the Future Parks Station side of the Notun Bazar Station.

○ In case there are no trains at the platform section

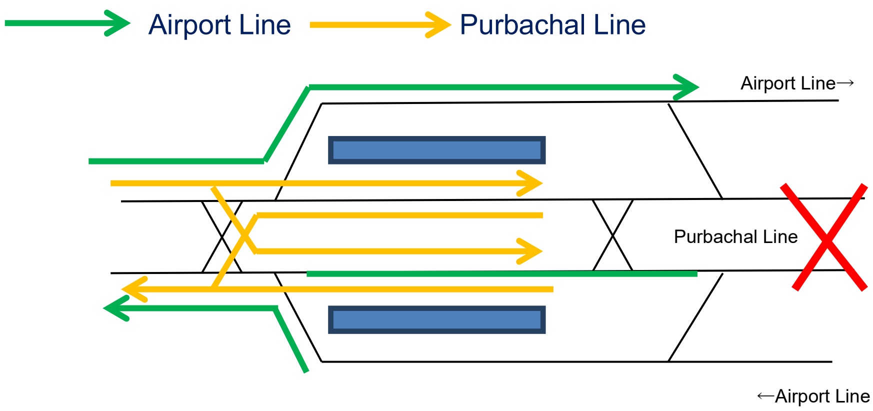


○ In case there is a train turning back



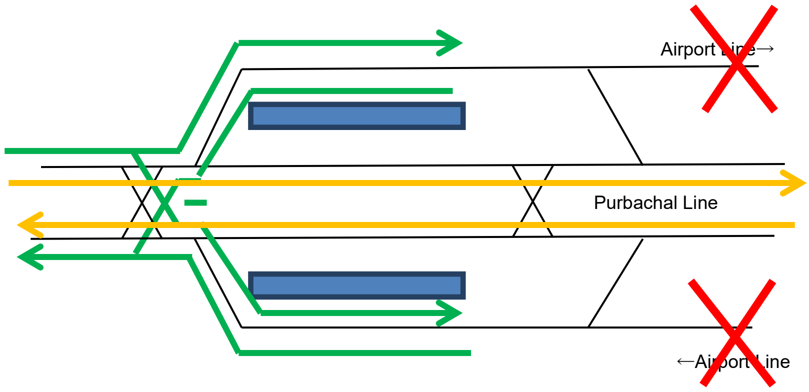
③ In case of emergent shuttle operation

● Purbachal: In case train service is cancelled at Purbachal Terminal side



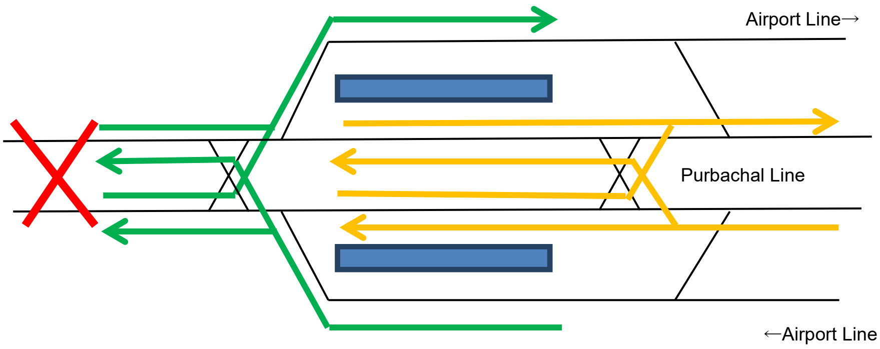
In case a failure occurs at the Future Park side of Notun Bazar, the train coming from the Kamalapur side will turn back. The Airport Line will be able to continue operation.

- In case train service is cancelled at the Airport Line side



In case troubles occur at the Airport Line, the Purbachal Line will continue to operate normally.

- Airport Line: In case train service if cancelled at the Kamalapur side



All trains with troubles at the Kamalapur will turn back at Notun Bazar.

(d) Terminal Station Turn Back Track

Train turn backs at the Kamalapur, Airport, and Purbachal Terminal stations will be achieved by placing a double cross-over at the front of the platform to reduce turn back times.

(e) Stabling Tracks at Station Yards

At the Airport station, two stabling tracks of one train length will be placed at the rear of the platform. At Kamalapur Station, the platform track will be used as the stabling track.

(f) Branch Point Track Layout to the Depot

The approach track to the Depot was studied based on Option 4 regarding the depot site, and the details will be discussed clause 10.2 of this Chapter 4. The proposed depot site is located on the eastern side of the Purbachal Terminal Station. The Station Master of Purbachal Terminal Station shall control leaving/approaching trains from/to the station. The track layout of this station was designed taking into 1) train turn back, 2) approach to depot and 3) future extension of Line 1. The Purbachal Terminal Station contains two scissors-crossings for easy handling in the future. At present, the approach line consists of double tracks near to the station, while near the depot a single track is provided. The proposed depot plan was created based on Google Earth Map, while a topographic survey is inevitable for detailed design, especially crossing between MRT and Road.

JST planned the approach viaduct with a track considering cost saving. In generally, it is commonly early morning to put trains from depot to commercial tracks and returning to depot of the trains are expected after 10 O'clock AM or after service hour. Since train operation on the approach line is so simple that it is possible control depot work with single track. Further Depot approach track shall be provided at the Purbachal Terminal Station which contains two platforms and four tracks. The single depot approach track starts from the eastside of the Purbachal Terminal therefore in/out service trains don't obstruct main line commercial operation. Generally, the train operation plan will have more allowance if the Depot Access Line is a double track. Especially when depots will be established in-between stations, precise operation is necessary between the depot and main track in order to prevent obstructions to the operation of the commercial line. Therefore, the approach line may be double tracks as well.

Source: JICA Study Team

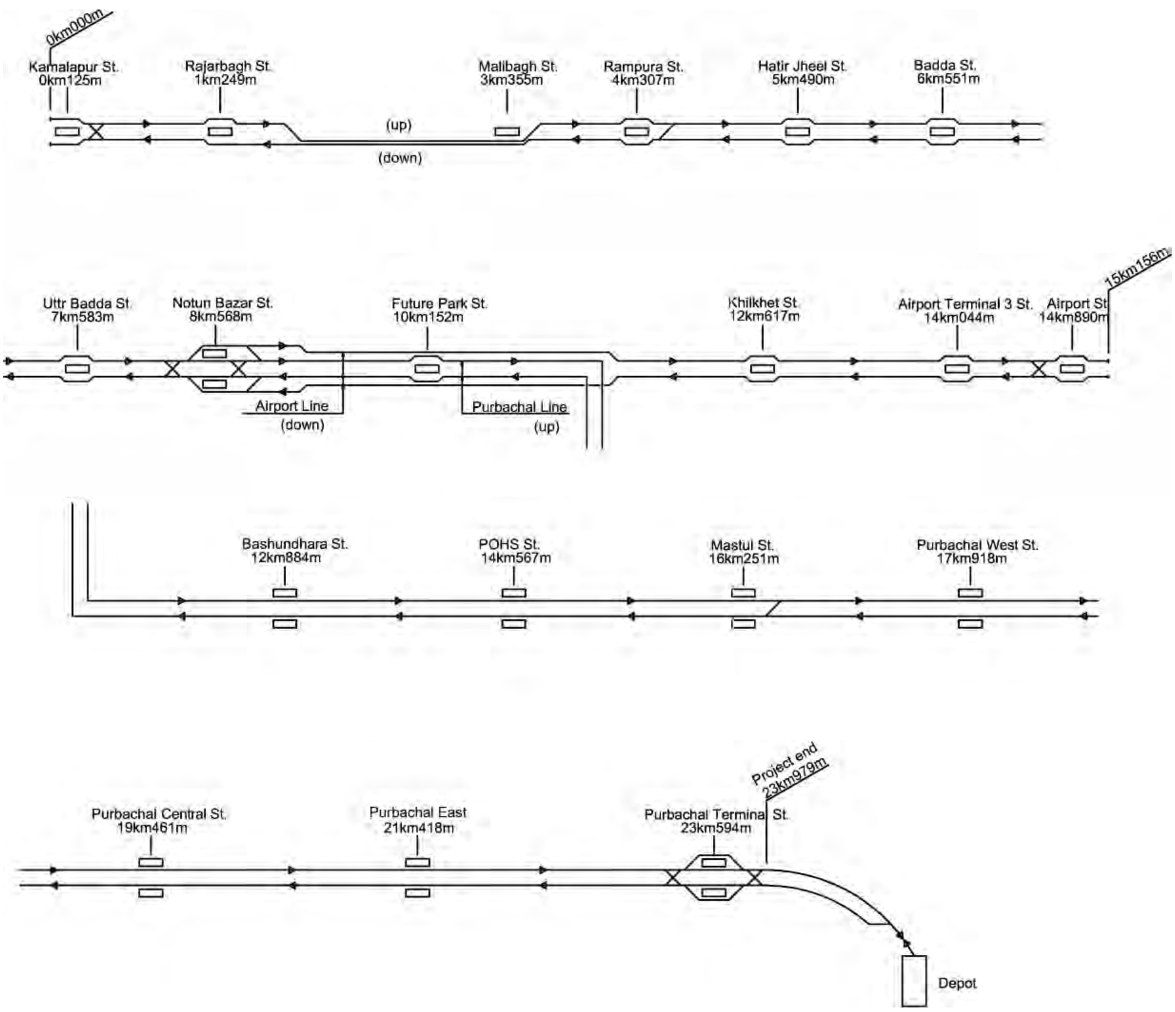
Figure 4.2.2 Approach Track Connected between Terminal and Depot (Option 4)

(g) Emergency Crossovers

Emergency crossovers will be placed at the Rampura, Notun Bazar and Mastul stations to allow for turn back operations in the event of accidents or failures. In order to provide the cross-over as normal practice station box and adjacent structures are constructed by Cut and Cover Method.

(h) Track Layout Diagram

Figure 4.2.3 shows a diagram summarizing the station locations and track layout planning described above.



Source: JICA Study Team

Figure 4.2.3 Track Layout Diagram

5) Defining Rail Levels and Required Clearances

With regard to the overburden thickness of a single track shielded tunnel, the tunnel will have a diameter of at least 7m, and the rail level of underground stations will be at -16.0m from the existing ground surface, or deeper. The rail level at the Notun Bazar station will be restricted to 16m taking into account its intersection with Line 5. At the Malibagh and Future Park stations, both of which will have two-tiered platforms, the rail clearances on the top and bottom tiers will be 7.65m and 8.05m, respectively. Vertical Alignment is presented as Appendix Track Plan and Profile.

The standard clearance between shielded tunnels and that between a shielded tunnel and nearby structures will be equal to or greater than the tunnel diameter. If the clearance must be smaller than this, measures such as reinforcement construction must be considered.

The standard rail level in elevated sections will be +13.0m from the existing ground surface. If it must be lower than this, the rail level must be defined to ensure proper clearance for the roadway below the elevated structure.

6) Construction Length

Airport Line

As 0k000m is the starting point of construction. We established the starting point 600m south from the southern end of Kamalapur Station. This starting point is equivalent to -0k600m. On the other hand, ending point of the Airport Line is set 600m north of Airport Station. Hence, the ending point of the Airport Line is equivalent to 15k615m.

15k615m –(-ok600m)=16k215m

Purbachal Line

The starting point of the Purbachal Line is st at the north end of Notun Bazar Station. Chainage of the starting point is found as follows;

Chainage of Notun Bazar is 8k568m (center of platform/station)

Chainage of the starting point of Purbachal Line is 8k568m + 125m (half of station length 250m) = 8k693m

On the other hand the ending point of the Purbachal Line is set at the end of Purbachal Terminal Station.

Chainage of Purbachal Terminal Station is 23k594m

Chainage of the ending point is 23k594m+125m=23k719m

Length of the Purbachal Line is 23k719m – 8k693m =15k026m

Total Construction length is 16k215m + 15k026m = 31k241m

4.2.3 Control Points

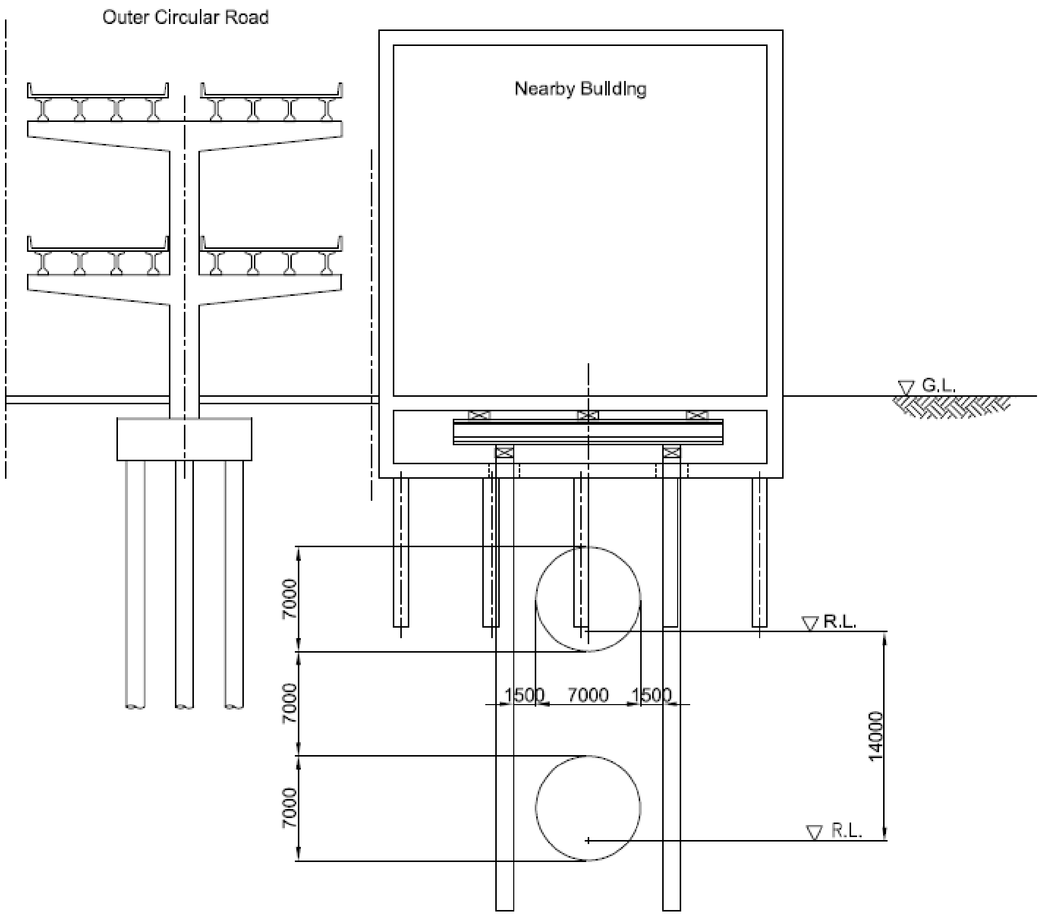
1) Fly-Over between the Rajarbagh and Malibagh Stations, and nearby Buildings

The Control Points where alignment designing is restricted to run, shall be listed up in prior to alignment design. The widths of the Outer Circular Road and Rampura DIT Road between the Rajarbagh and Malibagh stations vary between 30-35m. Construction of a fly-over in these sections is currently under way, and there are buildings, including commercial facilities, along the road near the fly-over. As the clearance between the pile foundations of the fly-over and nearby buildings is expected to be around 14m, an in-depth study of the foundations must be carried out.

Another fly-over from the south will merge at a perpendicular angle with the fly-over above the Outer Circular Road. Since the fly-overs at the merge point will be near each other in a complex fashion, there is believed to be no clearance for the passage of underground tunnels. Therefore, the path of the underground tunnel will be restricted to the south side of the fly-over, and the shielded tunnels will have to have a two-tier configuration.

At the intersection of the Outer Circular Road and Rampura DIT Road, and at the curved road section near the BR railroad crossing, there will be a sharp curve section in the underground tunnel and the tunnel will pass directly under nearby buildings. While the impact on buildings can be minimized by employing a curve radius of 200m, which is close to the minimum radius, the foundations of the underground tunnel and several buildings will interfere with each other. Methods such as underpinning construction are potential options for replacing the loads of these buildings. In light of this, in-depth investigations of the foundations should be conducted as soon as possible. Attached photos show fly-overs at the crossing DIT road and New Circular road, at this point a whole a day heavy congestion is observed.

Figure 4.2.4 shows the JST arrangement of the Existing Fly-over, Existing Building and MRT 1. The Existing Building at the point where the New Circular Road and DIT Road cross shall be supported during TBM construction. JST proposes that the building be supported by additional piles which will be constructed from the basement of the building.



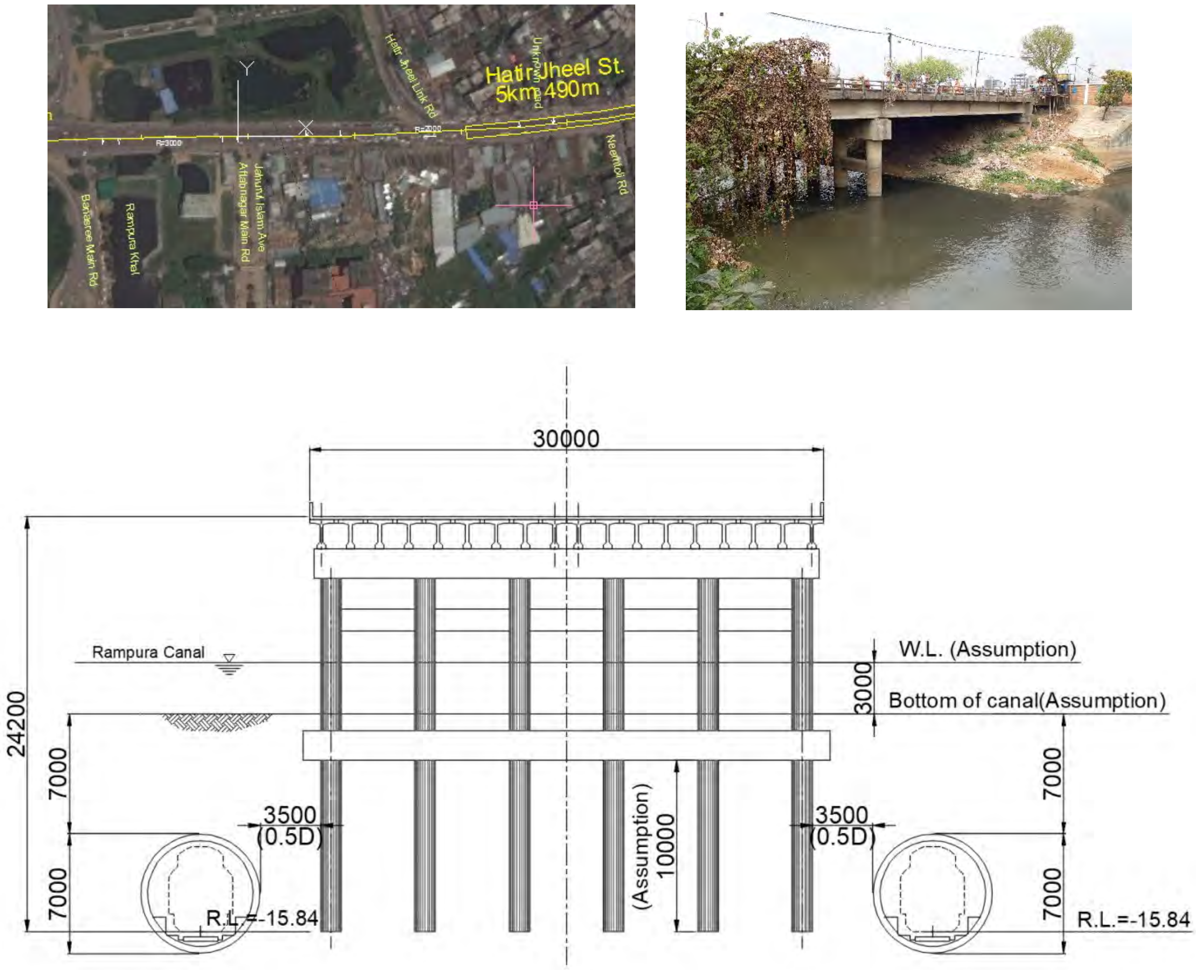
Source: JICA Study Team

Figure 4.2.4 Sharp Curve Section at Malibagh

2) Rampura Bridge

While the plan calls for the rail level at the Hatir Jheel Station to be at the standard level, because the Rampura Bridge that is built on a pile foundation is situated nearby, the underground tunnel must be shifted towards the regulating reservoir and canal. And because the tunnel will be passing directly under the bottom of the water, the rail level must be lowered considerably. In this case, because the gradient between the bridge and station will exceed the maximum gradient, the rail level at the station must be lowered to lessen the gradient. Therefore, in the design stage, a river survey must be performed to determine the water depth.

Prior to establishment of final alignment, detailed data of piles such as length, venue, and type of pile are needed. Figure 4.2.5 shows proposed position of TBM.



Source: JICA Study Team

Figure 4.2.5 The Area near the Rampura Bridge

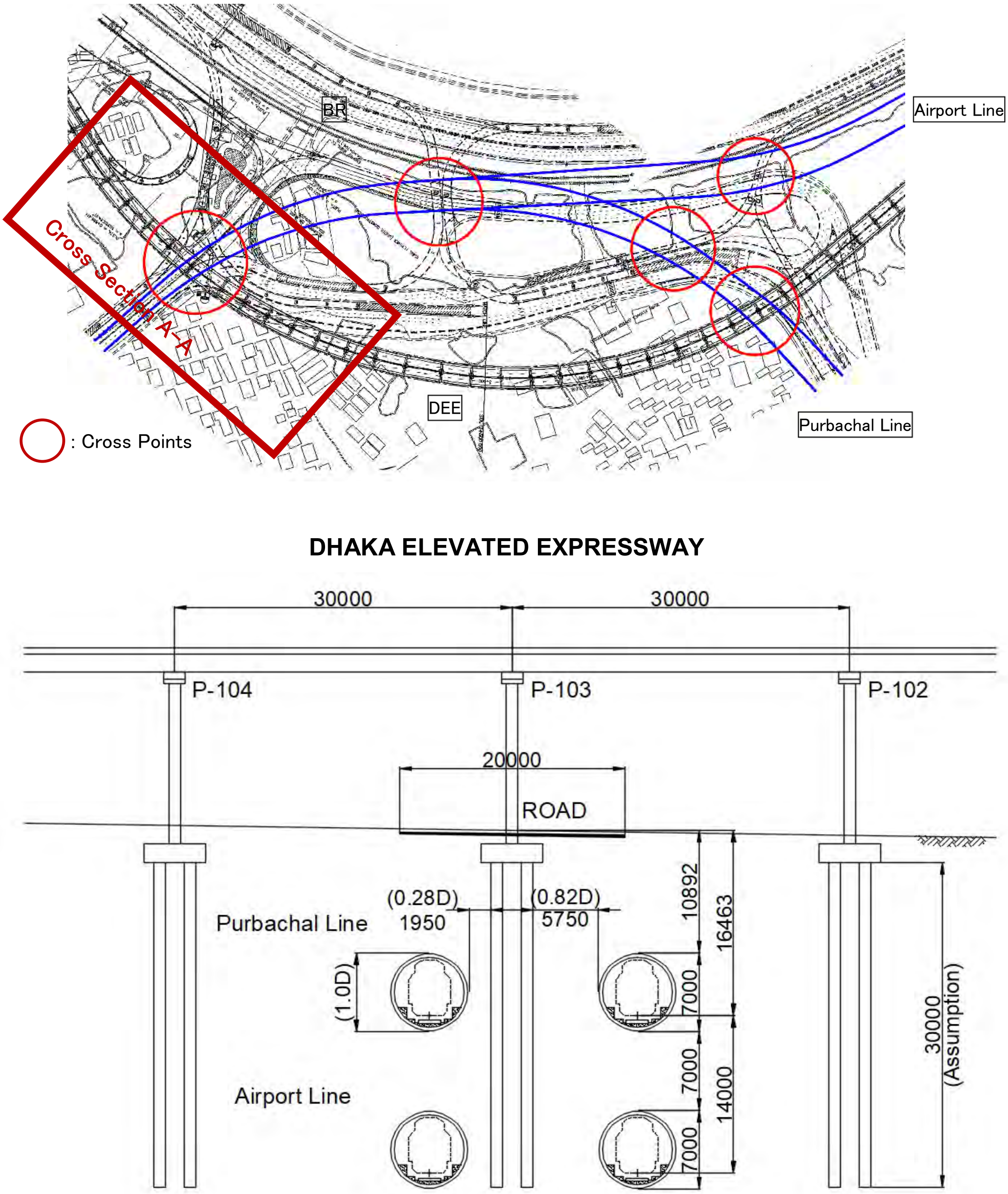
The above photo shows that the Rampura Bridge has piers in the canal and the bridge contains pile foundations. Since the distance between the Hatir Jheel Station and Rampura Bridge is relatively small, a sharp gradient may be applied.

3) Kuril Fly-over

The Kuril fly-over is shaped in a rotary configuration, and therefore, the Airport Line and

Purbachal Line will intersect with the fly-over at five points. Additionally, the DEE currently under construction will intersect at one or two points. Since the length of one span in the fly-overs is approximately 30m, the single track shielded tunnel can pass through the centre of the span. The use of underpinning construction will be considered as needed.

Figure 4.2.6 shows the proposed route of passage.



Source: JICA Study Team

Figure 4.2.6 Proposed Kuril Fly-Over Route of Passage

4) Above Ground Exit and Entrance at Kuril

The exit and entrance from the underground Purbachal Line to above ground is planned to be located at the 10m wide green median between the main line of the Purbachal Highway and its service road near the convention centre. The rail gradient will be 30 /1000, and the distance from the exit/entrance to the elevated section will be approximately 550m.

Source: JICA Study Team

Figure 4.2.7 Location of the Exit and Entrance

5) Purbachal Highway River Bridges

The Purbachal Highway has six river bridges that come in two different types as shown in Figure 4.2.8. Both of these are PC-bridges with girder lengths of 18m (left) and 45m (right). The bridges are all 70-80m long.

Source: JICA Study Team

Figure 4.2.8 River Bridges

Since the Purbachal Line runs over the centre of the highway, it will pass directly above the river bridges. The exception is at the Balu River bridge shown in the right photo. This section includes a curved section so the line will shift to above the highway service road.

Source: JICA Study Team

Figure 4.2.9 Alignment at River Bridges

6) Plan and Profile Drawings

The plan alignment and profile alignment of the Airport Line and Purbachal Line will be designed based on the basic policies of the track layout planning and the points that need to be kept in mind regarding the control points. The plan and profile alignments are attached at the end of this document.

4.3 Underground Utilities and Soil Conditions

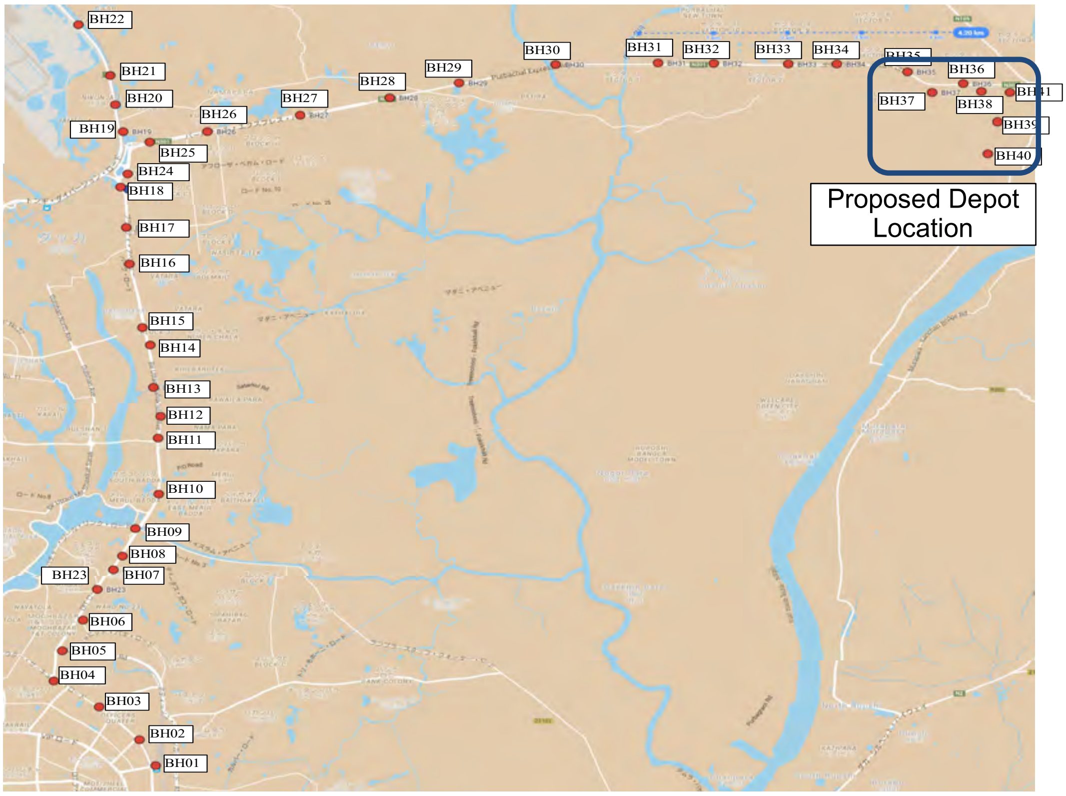
As for utilities along proposed alignment of Airport Line (Kamalapur Station to Airport Station), there are gas line, sewerage line and WASA (Water Supply & Sewerage Authority) line under the ground and electric line and BTCL (Bangladesh Telecommunications Company Limited) line over head at almost all the sections. The other hand there is no utilities along proposed alignment of Purbachal Line (Bashundhara Station to Purbachal Terminal Station.

A geotechnical investigation for the elevated section of Purbachal Line was smoothly conducted without problem, but it took time to get permission to conduct investigation for the underground section. The permission was finally obtained and 1 borings were conducted in total.

4.3.1 The Result of Geotechnical Survey

1) Location of Geotechnical Investigation

Forty-One (41) borings (BH1 to BH41), as shown in Figure 4.3.1.



Source: JICA Study Team

Figure 4.3.1 Boring Location

2) Characteristics of Geological Layers

Several layers as shown in Table 4.3.1 are identified in the section where 41 borings were conducted.

Holocene sediments, "Ac" and "Ap" are observed only between BH26 and BH29. Pleistocene sediments, "Dc" and "Ds", appear in all the boreholes as the same Pliocene sediments, "Pc" and "Ps".

"Dc" layer is called "Madhpur clay" in Bangladesh.

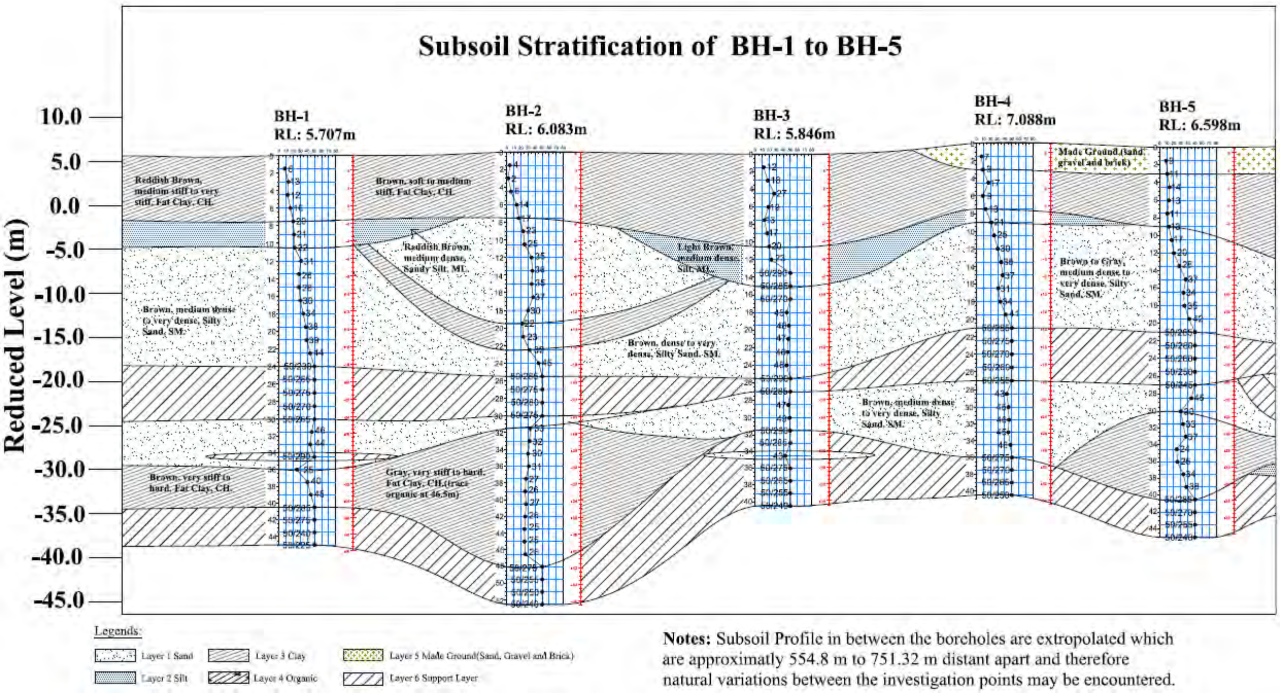
Table 4.3.1 Summary of Soil Layers

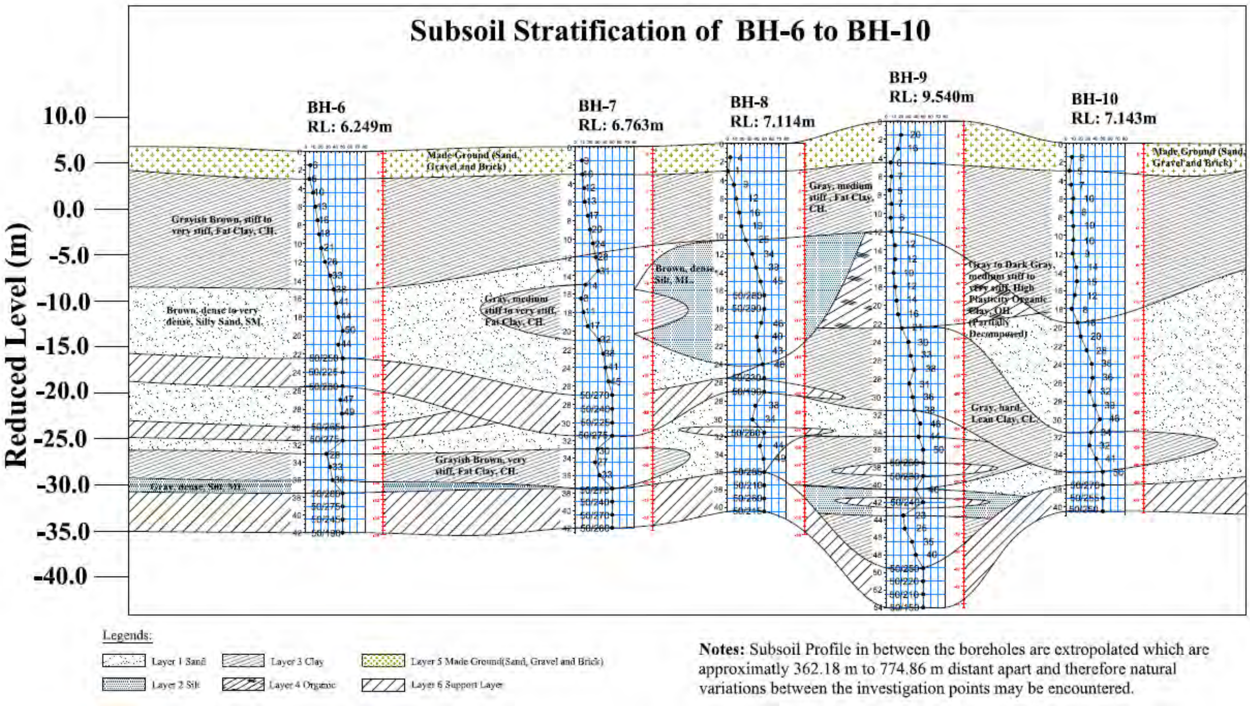
Layer	Average N-Value	Thickness (m)	Description
B	7	6～9m	Road embankment, consisting of loose, poorly graded sand mainly. Appeared from BH25 to BH29. Gray
Ap	4	3～4.5m	Organic clay, soft to medium stiff. Appeared between BH26 and BH27 only. Dark Gray or Dark Brown.
Ac	2	6～13.5m	Soft Clay or silt. Appeared between BH28 and BH29 only. Gray or light Gray.
Dc	17	6～33m	Medium to stiff Clay or Silt. Appeared at all Boreholes except BH29. Observed at surface in the eastern side of BH30.
Ds	22	4.5m～18m	Medium dense to Dense sandy soil. Appeared as lens form in Dc layer. Brown or reddish.
Pc	39	1.5m～7.5m	Very stiff clay or silt with sand. Observed N=50 over at some Boreholes. Appeared as the lens form in Ps. Gray.
Ps	48	5m～	Very stiff sandy soil. Possible bearing layer for large structures. Mostly indicating N=50 and over.

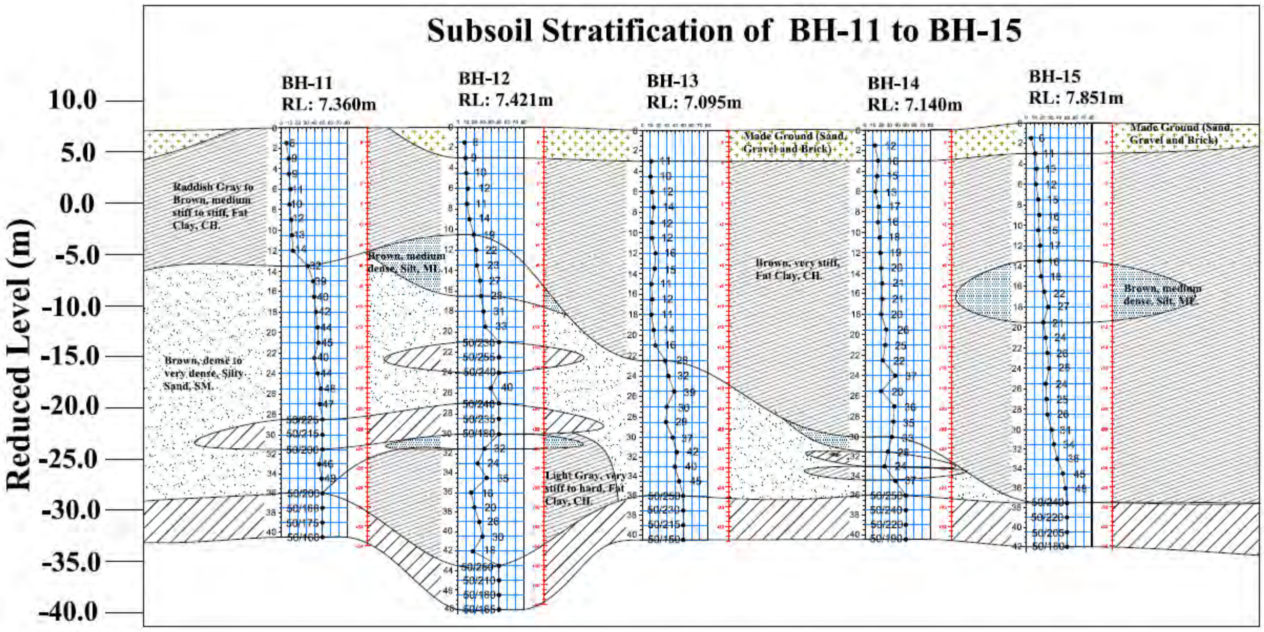
Source: JICA Study Team

3) Geological Cross Section

Geological cross section which is made from the result of conducted borings is shown in Figure 4.3.2.



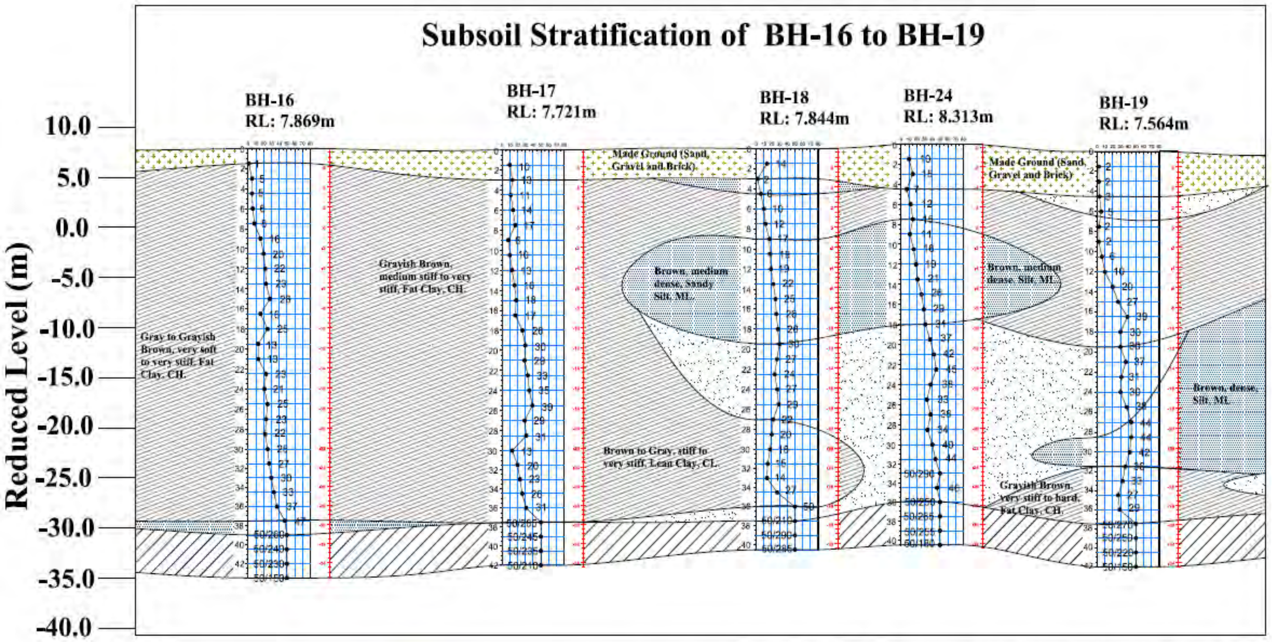




Legends:

Layer 1 Sand, Layer 2 Silt, Layer 3 Clay, Layer 4 Organic, Layer 5 Made Ground(Sand, Gravel and Brick), Layer 6 Support Layer

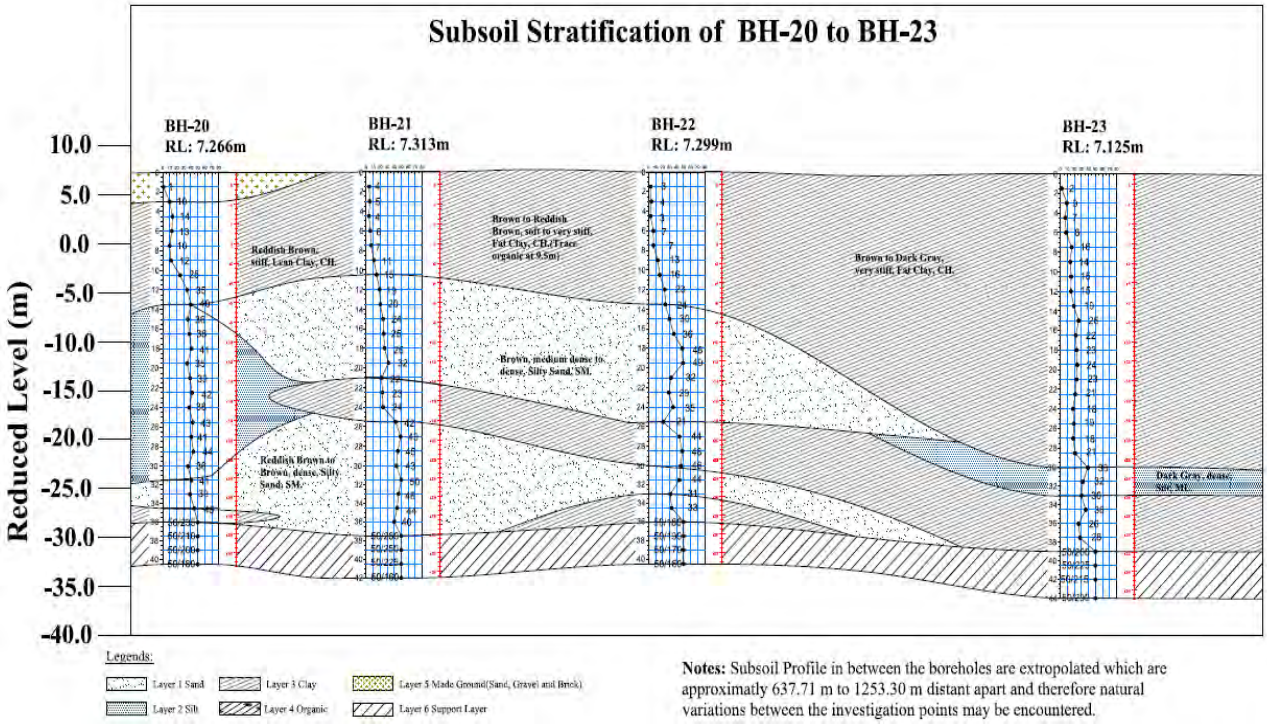
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 423.66 m to 902.61 m distant apart and therefore natural variations between the investigation points may be encountered.

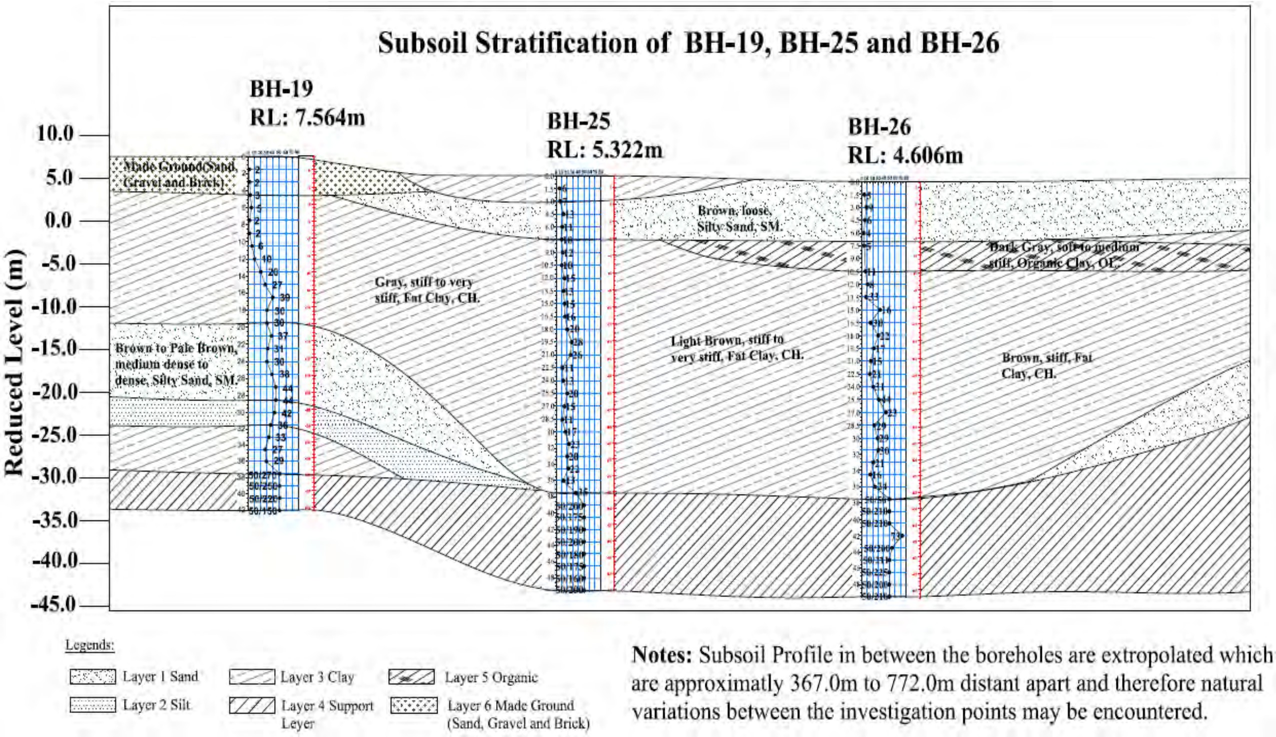


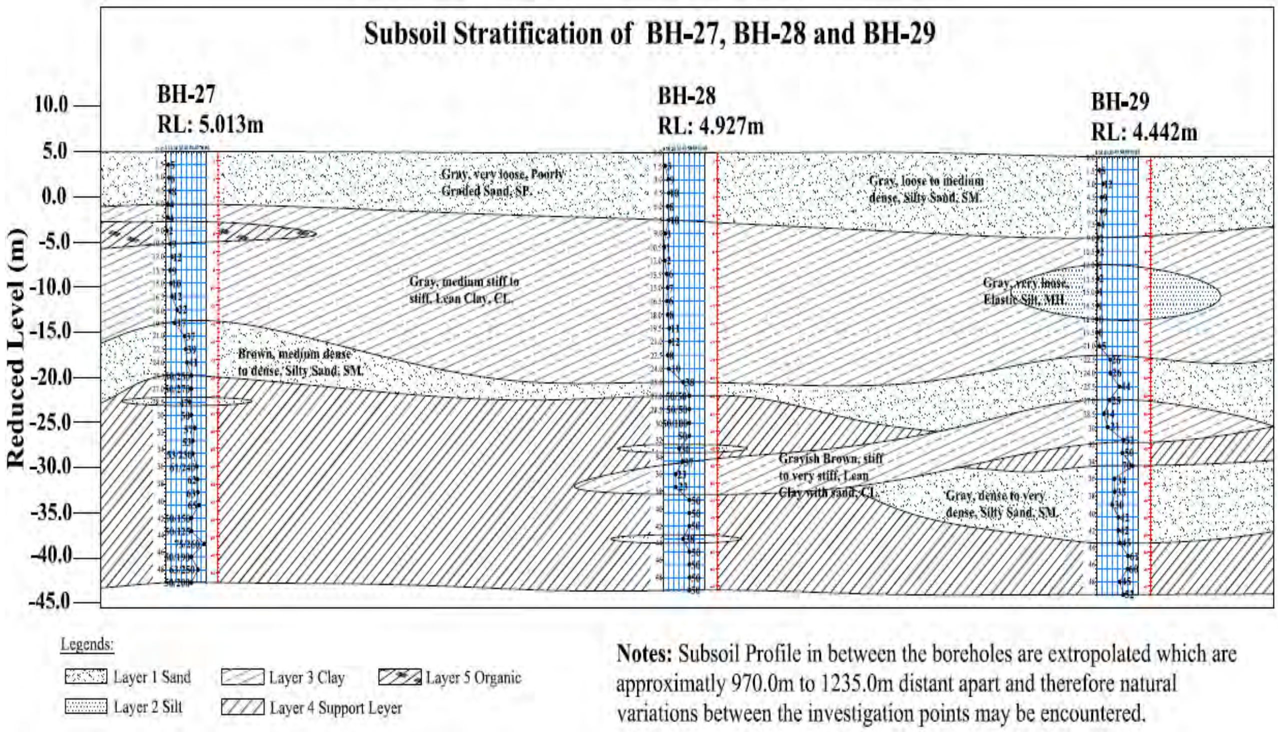
Legends:

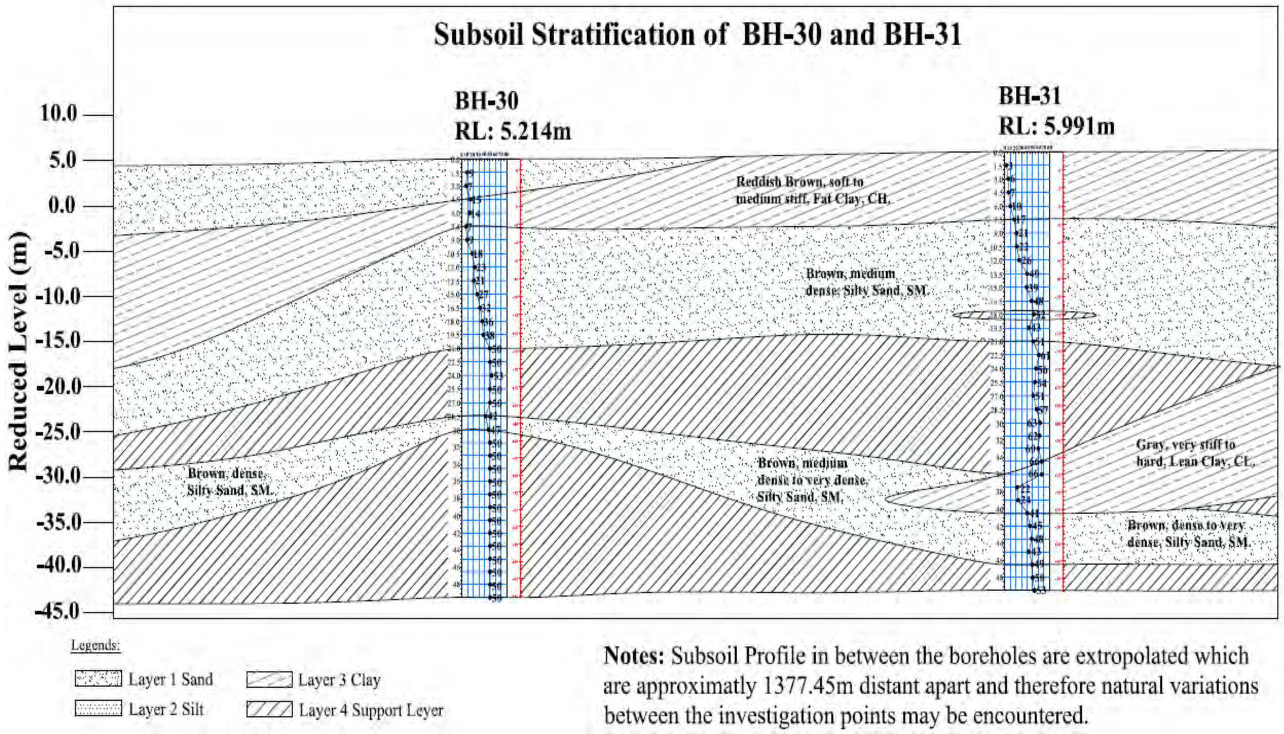
Layer 1 Sand, Layer 2 Silt, Layer 3 Clay, Layer 4 Organic, Layer 5 Made Ground(Sand, Gravel and Brick), Layer 6 Support Layer

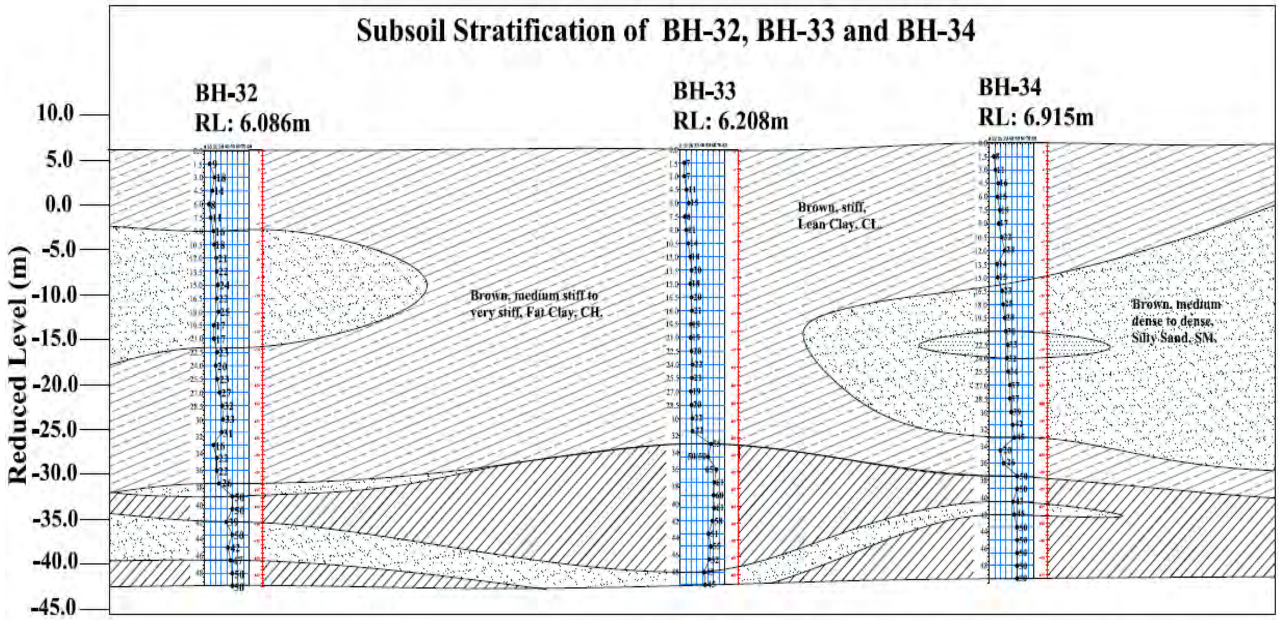
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 120.91 m to 953.30 m distant apart and therefore natural variations between the investigation points may be encountered.


Subsoil Stratification of BH-20 to BH-23
BH-20
RL: 7.266m
BH-21
RL: 7.313m
BH-22
RL: 7.299m
BH-23
RL: 7.125m
Reduced Level (m)
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
Reddish Brown, stiff, Lean Clay, CH.
Brown to Reddish Brown, soft to very stiff, Fat Clay, CH.(Trace organic at 9.5m)
Brown to Dark Gray, very stiff, Fat Clay, CH.
Brown, medium dense to dense, Silty Sand, SM.
Reddish Brown to Brown, dense, Silty Sand, SM.
Dark Gray, dense, Silt, ML
Legends:
Layer 1 Sand
Layer 2 Silt
Layer 3 Clay
Layer 4 Organic
Layer 5 Made Ground(Sand, Gravel and Brick)
Layer 6 Support Layer
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 637.71 m to 1253.30 m distant apart and therefore natural variations between the investigation points may be encountered.


Subsoil Stratification of BH-19, BH-25 and BH-26
BH-19
RL: 7.564m
BH-25
RL: 5.322m
BH-26
RL: 4.606m
Reduced Level (m)
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
Made Ground(Sand, Gravel and Brick).
Brown, loose, Silty Sand, SM.
Dark Gray, soft to medium stiff, Organic Clay, OL.
Gray, stiff to very stiff, Fat Clay, CH.
Light Brown, stiff to very stiff, Fat Clay, CH.
Brown, stiff, Fat Clay, CH.
Brown to Pale Brown, medium dense to dense, Silty Sand, SM.
Legends:
Layer 1 Sand
Layer 2 Silt
Layer 3 Clay
Layer 4 Support Layer
Layer 5 Organic
Layer 6 Made Ground (Sand, Gravel and Brick)
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 367.0m to 772.0m distant apart and therefore natural variations between the investigation points may be encountered.

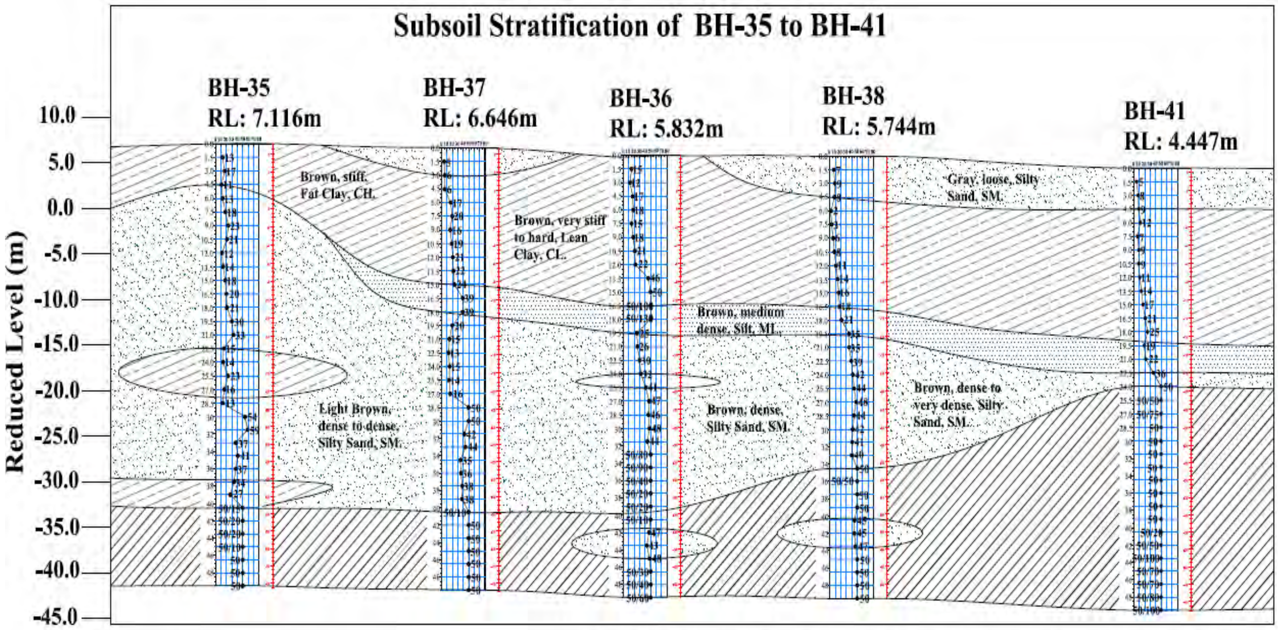

Subsoil Stratification of BH-27, BH-28 and BH-29
BH-27
RL: 5.013m
BH-28
RL: 4.927m
BH-29
RL: 4.442m
Reduced Level (m)
Gray, very loose, Poorly Graded Sand, SP.
Gray, loose to medium dense, Silty Sand, SM.
Gray, medium stiff to stiff, Lean Clay, CL.
Gray, very loose, Elastic Silt, MH.
Brown, medium dense to dense, Silty Sand, SM.
Grayish Brown, stiff to very stiff, Lean Clay with sand, CL.
Gray, dense to very dense, Silty Sand, SM.
Legends:
Layer 1 Sand
Layer 2 Silt
Layer 3 Clay
Layer 4 Support Leyer
Layer 5 Organic
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 970.0m to 1235.0m distant apart and therefore natural variations between the investigation points may be encountered.


Subsoil Stratification of BH-30 and BH-31
BH-30
RL: 5.214m
BH-31
RL: 5.991m
Reduced Level (m)
Reddish Brown, soft to medium stiff, Fat Clay, CH.
Brown, medium dense, Silty Sand, SM.
Brown, dense, Silty Sand, SM.
Brown, medium dense to very dense, Silty Sand, SM.
Gray, very stiff to hard, Lean Clay, CL.
Brown, dense to very dense, Silty Sand, SM.
Legends:
Layer 1 Sand
Layer 2 Silt
Layer 3 Clay
Layer 4 Support Leyer
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 1377.45m distant apart and therefore natural variations between the investigation points may be encountered.



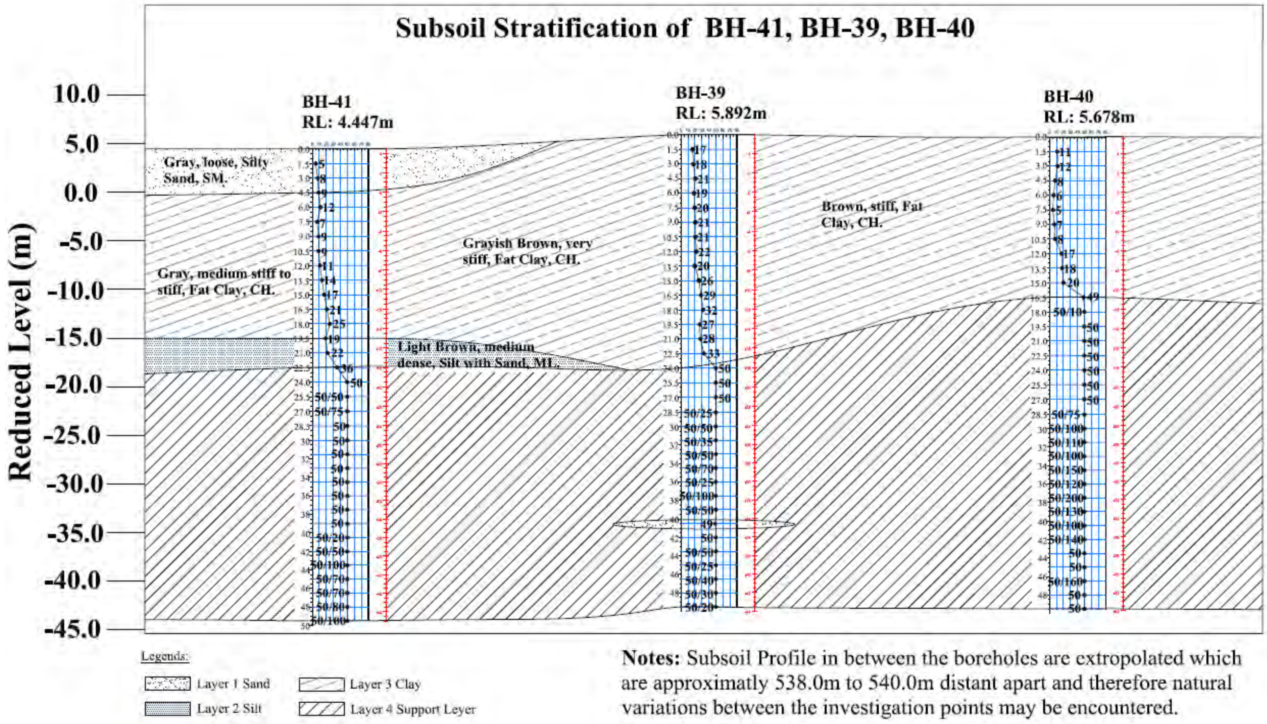
Legends:
Layer 1 Sand
Layer 2 Silt
Layer 3 Clay
Layer 4 Support Leyer

Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 660.85m to 1014.0m distant apart and therefore natural variations between the investigation points may be encountered.



Legends:
Layer 1 Sand
Layer 2 Silt
Layer 3 Clay
Layer 4 Support Leyer

Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 273m to 468.6m distant apart and therefore natural variations between the investigation points may be encountered.



Source: JICA Study Team

Figure 4.3.2 Geological Cross Section

4) Soil Parameters

Soil parameters are shown in Table 4.3.2.

Table 4.3.2 Soil Parameters

Layer	Average N-Value	Unit Weight γt (kN/m³)	Cohesion c (kN/m²)	Angle of Internal Friction Fai (°)	Modulus of Deformation E (kN/m²)
B	7	18	0	25	4,900
Ap	4	20	24	0	2,800
Ac	2	18	30	0	1,400
Dc	17	19	62	0	11,900
Ds	22	19	0	33	15,400
Pc	39	20	230	0	27,300
Ps	48	20	0	42	33,600

Source: JICA Study Team

5) Discussion

As the SPT-N values of the "Ps" layer are mostly over 50, that layer is the first option as a "Bearing Layer for the Viaduct" in the project. On the other hand, the depth of the bearing layer must be determined at each borehole based on the SPT-N because the SP-N value of some parts of the Ps layer is less than 50. If the SPT-N value of "Pc" and "Dc" layers is over 50, the layer is the first option as the bearing layer on the condition that the thickness of the layer is adequate to serve as the bearing layer (more than 5m).

As “Ac” and “Ap” layers are identified as “Unconsolidated Layer” based on the calculations conducted in the section, negative friction must be taken into account while designing the pile foundations for the section between BH26 and BH29.

As for ground settlement in the proposed depot area, the final settlements are 22.2cm and 36.0cm for BH38 and BH41, where the embankment is 5m in height. Therefore, some soil improvement is required for the proposed depot area.

Although no literatures showing the existence of active faults in Dhaka are found, seismic design should be carried out on basic and detailed designs, after acquiring detailed data on earthquakes and active faults from universities such as BUET.

4.4 Hydrological Survey

The flood survey results by the Bangladesh Water Development Board (BWDB) in Bangladesh are summarized in the "Flood Study in and around Dhaka City", April 2017.

According to the survey results, flooding in Bangladesh is categorized into flood of rivers during monsoon, flash flood, rain flood, storm surge and so on. Among those items, the most important point in the project area is the effect of flooding caused by monsoon rains. A total of 75% of annual rainfall occurs from June to September. Dhaka is prone to flooding, and since 1982 Dhaka has had floods several times. Especially large flood damage occurred in 1988 and 1998, and the city was flooded to a depth of 0.3m to 4.5m.

Five Water Level Recording stations are set up around Dhaka City. Based on the records at each point, the elevation of the highest water level so far is 8.35m above MSL.

Source: BWDB HP

Figure 4.4.1 BWDB Water Level Recording Stations around Dhaka City

The name of the river, danger level and respective highest flood level are shown in the table below.

Table 4.4.1 Danger Levels and Respective Highest Flood Level around Dhaka City Area

Station	River	Danger level (m PWD)	HWL (m PWD)	Year corresponding to HWL
Demra	Balu	5.75	7.11	1988
Dhaka	Buriganga	6.00	7.58	1988
Tongi	Tongikhal	6.08	7.84	1988
Mirpur	Turag	5.94	8.35	1988
Narayangonj	ShitaLakhya	5.50	7.00	1988

Source: JICA Study Team

According to the measurement data, it is necessary to assume that the elevation of the highest water level in Dhaka City is 8.35m or more when designing all structures since the elevation of the highest water level in the rainy season is 8.35m.

Countermeasures against rainfall caused floods have been taken such as levee construction, water level adjustment reservoirs, pipe culverts and so on. Looking toward the future, flood countermeasures, drainage planning, flood embankments, reinforced concrete walls, water quantity adjustment structure equipment, etc. are being studied.

Currently, the surveying of the planned site has not yet been carried out, and accurate ground height has not been measured. Since the elevation of the highest water level in the rainy season is 8.35m, the design high water elevation level is set to 8.5 m.

In this connection, the underground station entrances and ventilation towers, etc., shall be planned to be 8.5m above MSL in this plan. The design high water level of 8.5m is used as a virtual design in the Feasibility Study, and when proceeding with the basic design and detailed design, the design high water level should be decided in agreement with the client. After considering the survey results to be implemented in the future, the scale of detailed flood response should be decided.

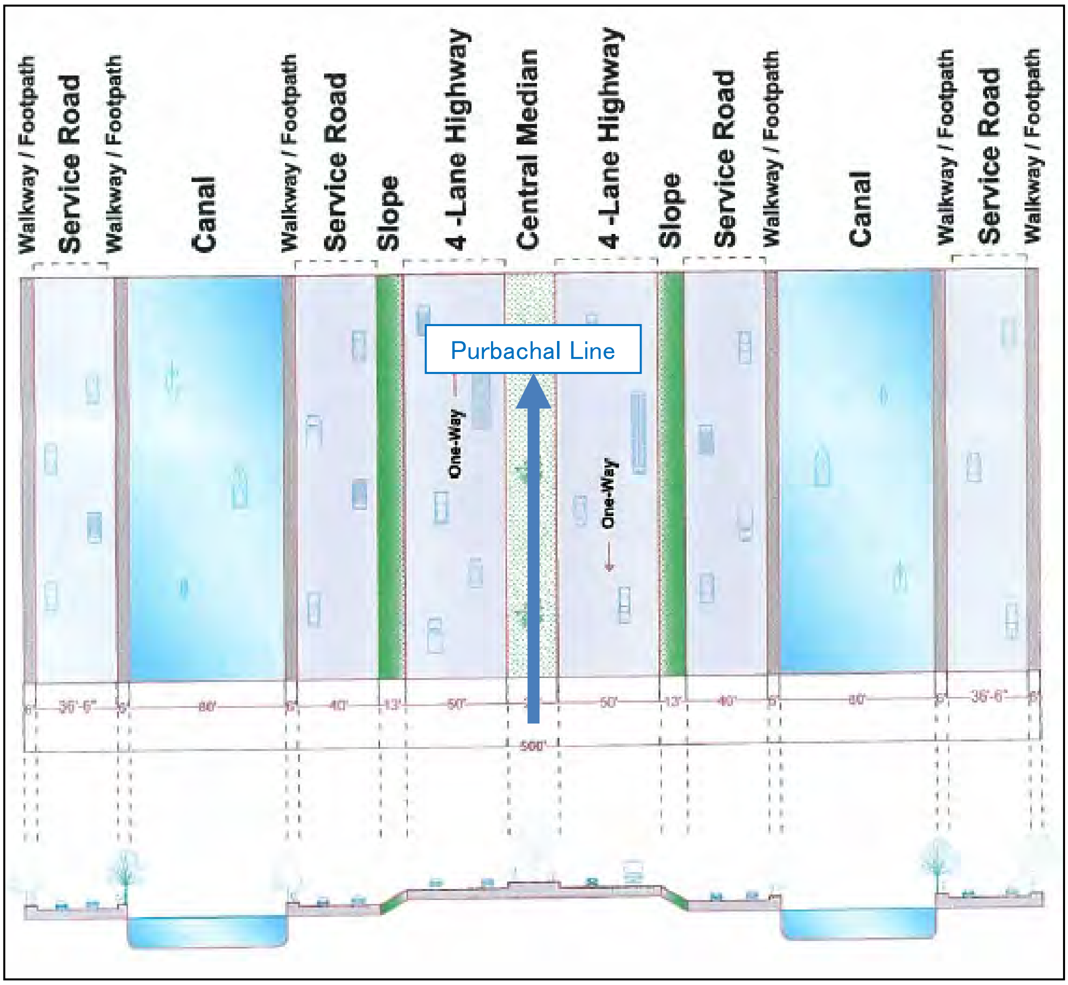
4.5 Civil and Utilities Plan

4.5.1 Elevated Structure

1) Purbachal Road Plan

The Purbachal Road Plan, shown in Figure 4.5.1, is to construct a road whose width in total is 500m and which includes two (2) canals. Currently, although these canals have not been constructed yet, the highway at the centre of the road and the service roads on both sides are under construction. Then, this line will contain six (6) river bridges. There is a big bridge over Balu River, which is a large river of about 100m wide, and the others are relatively small bridges.

Basically, Line 1 will be on the median strip and the stations will also be constructed at the centre of the road. However, Bashundhara Station will not be constructed at the centre but at the north part of the slope because the transition part from the underground to the elevated part will be constructed at the slope on the green. Balu River is planned to be constructed at the northern part of the existing bridge since it is unrealistic to construct a bridge for the metro at the centre of the existing bridge.



Source: DTCA

Figure 4.5.1 Road Plan along the Purbachal Line

The following photos show existing features of Purbachal Road.

General	Bridge
	

Source: JICA Study Team

Figure 4.5.2 Existing Features of Purbachal

2) Selection of Structure for Elevated Track

Table 4.5.1 shows the comparison of structure type for the selection of an adequate structure for Purbachal Road.

Table 4.5.1 Comparison of Structure Types

Item	Elevated Structure	Underground Structure	Banking
Outlook			
Social Environment			
Land Acquisition	If the road shape is smaller than the curve radius, land acquisition for MRT is necessary.	Excluding incidental facilities of station building, ventilation tower, etc. No land acquisition required.	On current routes, the impact of embankment is enormous.
Number of affected households	A lot	Least	Quite a lot
Width of Land	Width of the site at completion is around 2.5mm between stations.	Basically, it is unnecessary in the inter-station area.	Width of the site at completion is about 16m between stations.
Natural Environment			
Protected Area	There are no protected areas along the railroad tracks. There is a river (Balu River) designated as ECA, and it is necessary to prevent further deterioration of the environment.	There are no protected areas along the railroad tracks. Although there is a river (Balu River) designated as ECA, there is no influence due to the underground structure.	There are no protected areas along the railroad tracks. There is a river (Balu River) designated as ECA, and it is necessary to prevent further deterioration of the environment.
Biodiversity	Nature such as vegetation remains in the Purbachal District, but it is presumed that there is no big influence.	Nature such as vegetation remains in the Purbachal District, but due to the underground structure, the influence is estimated to be very small.	Nature such as vegetation remains in the Purbachal District, but it is presumed that there is no big influence. Because of the embankment structure, there is a possibility that the movement of animals may be obstructed.
Risk of flood	No special measures are necessary.	• An emergency drainage system (pump) is placed. • Flood gates required.	• There is a possibility that the embankment will stop the drainage. Additional drains are needed to minimize floods.
Pollution Control			
Noise (Vehicles outside)	Noises are generated along the railroad tracks. However, it can be mitigated by installing soundproof walls.	There is no noise along the railway.	Noises are generated along the railroad tracks. However, it can be mitigated by installing soundproof walls.
Noise (Vehicles inside)	Small	Very big	Small
Air Pollution	There is concern about the impact of exhaust and dust of construction machinery during construction.	The impact of exhaust and dust of the construction machinery at construction is the smallest.	The impact of exhaust gas and dust of the construction machinery during construction gives much cause for concern.
Water pollution	There is a river (Balu River) designated as ECA, and it is necessary to prevent further deterioration of the environment.	There is a possibility that groundwater will be affected during construction. Although there is a river (Balu River) designated as ECA, there is no impact due to the underground structure.	There is a river (Balu River) designated as ECA, and it is necessary to prevent further deterioration of the environment. It is necessary to pay attention to the generation of turbid water from the embankment.
Ground subsidence	No ground subsidence occurs.	There is a possibility of ground level subsidence during tunnel excavation.	There is a possibility of ground subsidence in soft ground.

Item	Elevated Structure	Underground Structure	Banking
Construction Period	Shorter than underground structure	The longest	Can be shortened if ground improvement is not required.
Technical aspect			
Construction Cost	Inexpensive compared to the underground structure	Extremely expensive	Cheaper than the elevated structure
Operation/Maintenance	Easy access and easy maintenance	• High maintenance cost. • Periodic inspections should be conducted, in particular, leakage investigations that cause electrocution.	Easy access
Disaster Prevention	• Relatively safe • Easier countermeasures than underground structure	Fire in the tunnel will be a major disaster.	• Relatively safe • Easier countermeasures than underground structure
Earthquake Resistance	The structure is designed in consideration of the seismic load.	Subsurface structures are difficult to be affected by earthquakes, but underground structures are designed in consideration of the seismic load.	The embankment structure is designed in consideration of the seismic load.
Scenery from the window	Good	Not Good	Good
Landscape	The shape of the structure must be designed in consideration of the landscape	There is no influence on the landscape.	The shape of the structure must be designed in consideration of the landscape
Physical Condition	It is necessary to build structure to avoid bridges over the Balu River.	It is necessary to make it linear so as to avoid the piles of the six existing bridges.	Even if it is reinforced embankment, the impact on the road is serious. In addition, underpass is necessary in order not to provide a railroad crossing.
Overall Assessment	Evaluated comprehensively, it is the most suitable structure.	There is no merit corresponding to cost.	The impact on the road is serious, and merit is little compared with the elevated structure.

Source: JICA Study Team

As a result of comparison study, JST recommends an Elevated Track on the Viaducts.

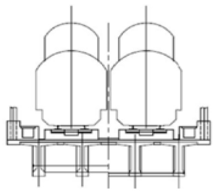
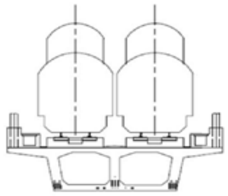
3) Selection of superstructure

According to the recommendation mentioned in the previous section, a detailed structural study of superstructures was done as follows.

(1) Standard Girder

The Dhaka MRT Line 6 adopted the PC box girder as the standard superstructure instead of PC-I section girder in consideration of its workability in an urban area, short construction period and high rigidity. Table 4.5.2 shows the comparison between PC-T girder and PC box girder. The PC one shell type box girder was adopted in MRT Line 6 because of lighter weight and easy maintenance. Further, optimum length of Girder was 30m as a result of comparison study among several lengths and their construction costs. In consideration of the effect on road traffic, JST adopted the same type of Girder on the Purbachal Line.

Table 4.5.2 Comparison between PCT Girder and PC Box Girder

	Type A : PC-T Girder	Type B : PC-Box Girder
Section		
Construction Cost	Type A is more costly than Type B	
Construction Method	• Pre-fabricate in the Production Yard • Pre-stress in the Production Yard • No need to support Girder • Ordinary truck-crane may be available • At site cast concrete to lateral girder	• Pre-fabricate in the Production Yard • Pre-stress at site to erect • Temporary support may be required • Easy erection • Minimum site concrete casting work is required • Combination Girders by using Epoxy
Time to Erect	• There is no difference because the pre-casting /segment girder is produced in another production yard. • Type A. There is some concrete casting work at the site. • Type B. Pre-stressing work at site is required.	
Structure Analysis	• Weakness against torsion, curved girder cannot be recommended. • In order to spread load, lateral girder shall be provided. • A base plate is simply supported and live load is not completely continuity. • Each beam needs bearings.	• Enough strength against torsion, curved Girder possible. • No lateral girder is required • Since live load can cause twist, the load should be dispersed. • Though the dead load is light, the bending moment can be disposed by pre-stressing.
Maintenance	• Both type Girders require similar input • Type A Girder requires more "shoes", therefore, maintenance of shoes increases.	
Appearance	Possibility of spoiling scenic beauty	Less impact on scenic beauty
Evaluation	There are many curved sections in the alignment, Type B may be recommended.	

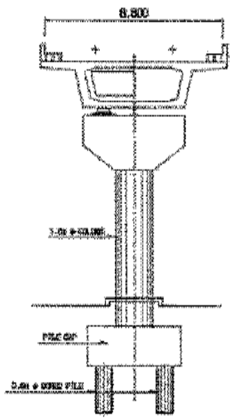
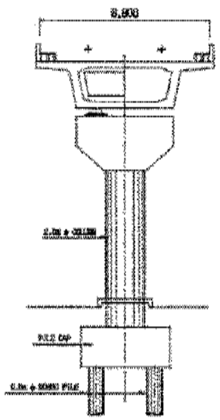
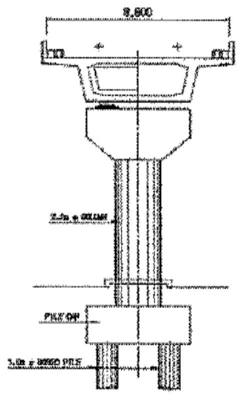
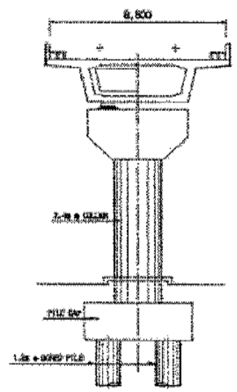
Source: NKDM

4) Selection of Sub-structure

As discussed above, although viaducts shall be constructed on the Purbachal Road as much as possible, there are some sections where viaducts cannot be placed in the road centre dividers. In that case, the piers will be provided in the green area located between the centre divider and the slope as shown Figure 4.5.3.

Table 4.5.3 shows comparison of girders, brought from the Design Report for Dhaka MRT Line 6 and recommends 30m span length substructure arrangement. Detailed study shall be made in the Engineering Study after detailed topo survey. In principal 30m or 25m span length girders are recommended as standard span length.

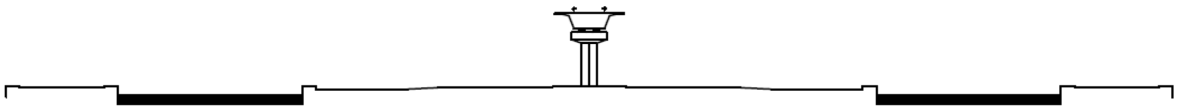
Table 4.5.3 Comparison Among Girders

		25m	30m	35m	40m
Cross Section					
Pile Cap (Φ)		Φ=1.8(m)	Φ=2.0(m)	Φ=2.2(m)	Φ=2.4(m)
Pile(Φ) Required Nos.(n)		Φ=800(mm), n=4	Φ=800(mm), n=4	Φ=1000(mm), n=4	Φ=1200(mm), n=4
Result of Analysis (R/Ra))		R/Ra=75%	R/Ra=86%	R/Ra=83%	R/Ra=70%
Cost	Item	Ratio			
	Super Structure	0.66	0.70	0.76	0.78
	Sub-Structure	0.35	0.30	0.35	0.42
	Total	1.01	1.00	1.11	1.20
Evaluation		As a result of Analysis, a 30m Span length shall be recommended.			
Conclusion			◎		

Note) As a noise protection wall, a 1.5m wall is planned to be installed for Line 5 during implementation and it is also planned for Line 5. However, a 1.5m wall is unnecessary for Line 1 since RAJUK Road is 500 feet wide and far from residences. A detail study is needed at the design stage.

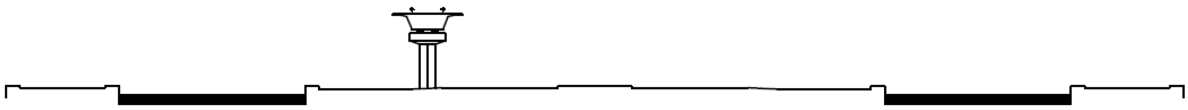
Source: NKDM

As pile foundation, it is reasonable to consider the supporting layer of 15m～30m under ground level. At the time of construction, cast-in pile is recommended taking into consideration noise and vibration from equipment.



Source: JICA Study Team

Figure 4.5.3 Between Stations Standard Cross Section (Centre Divider)



Source: JICA Study Team

Figure 4.5.4 Typical Viaduct Provided in the Green Space

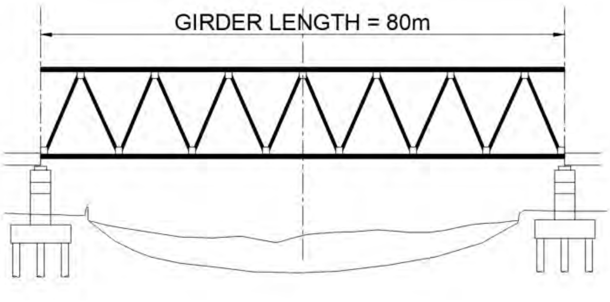
(1) Balu River Bridge

There is an existing Road Bridge over Balu River as shown Figure 4.5.5. It consists of simple girders with three (3) spans of 40m long each. Ships are confirmed to sail past this point. Ships usually pass in the centre where some 40m clearance above high water is available. Also, the western side has enough space to pass. The Study Team recommended an 80m span at the centre and a truss girder (see Figure 4.5.6).

Northern Side	Southern side
	

Source: JICA Study Team

Figure 4.5.5 Balu River Highway Bridge



Source: JICA Study Team

Figure 4.5.6 MRT Line 1 Balu River Bridge

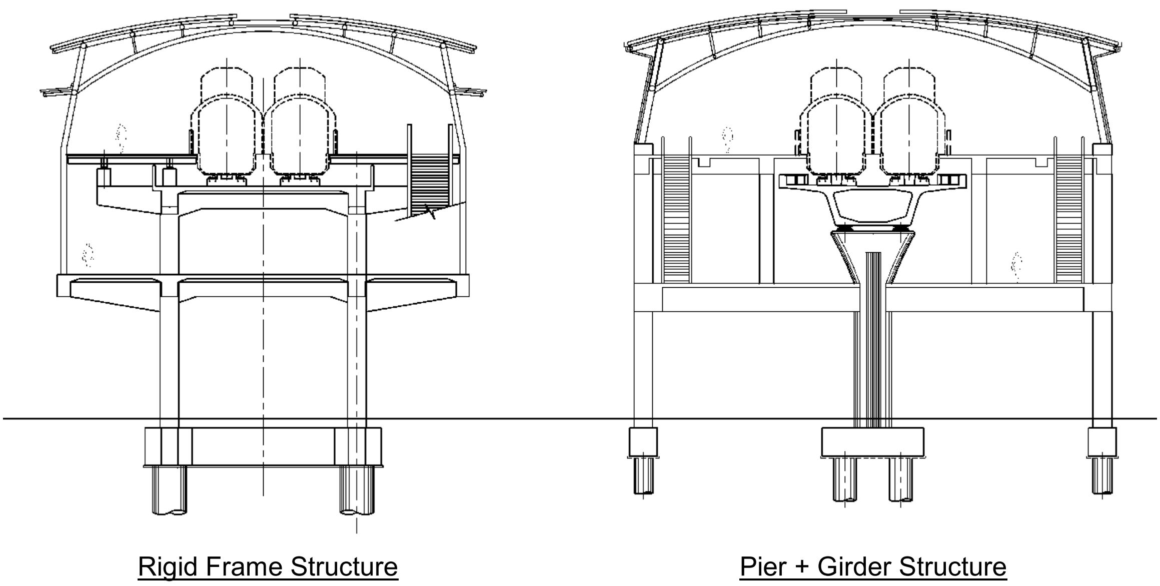
(2) Other Bridges

At present, six (6) bridges are needed for MRT Line 1 on the Purbachal Line including Balu River Bridge. Except for the Balu River Bridge others are relatively shorter, so it is possible to adopt a standard type PC Girder.

5) Structure for Elevated Station

In general, the station structures are of two types: a Rigid Frame Structure and a Pier + Girder Structure. JST selected the latter because of workability, economic reason, and impact to existing road traffic.

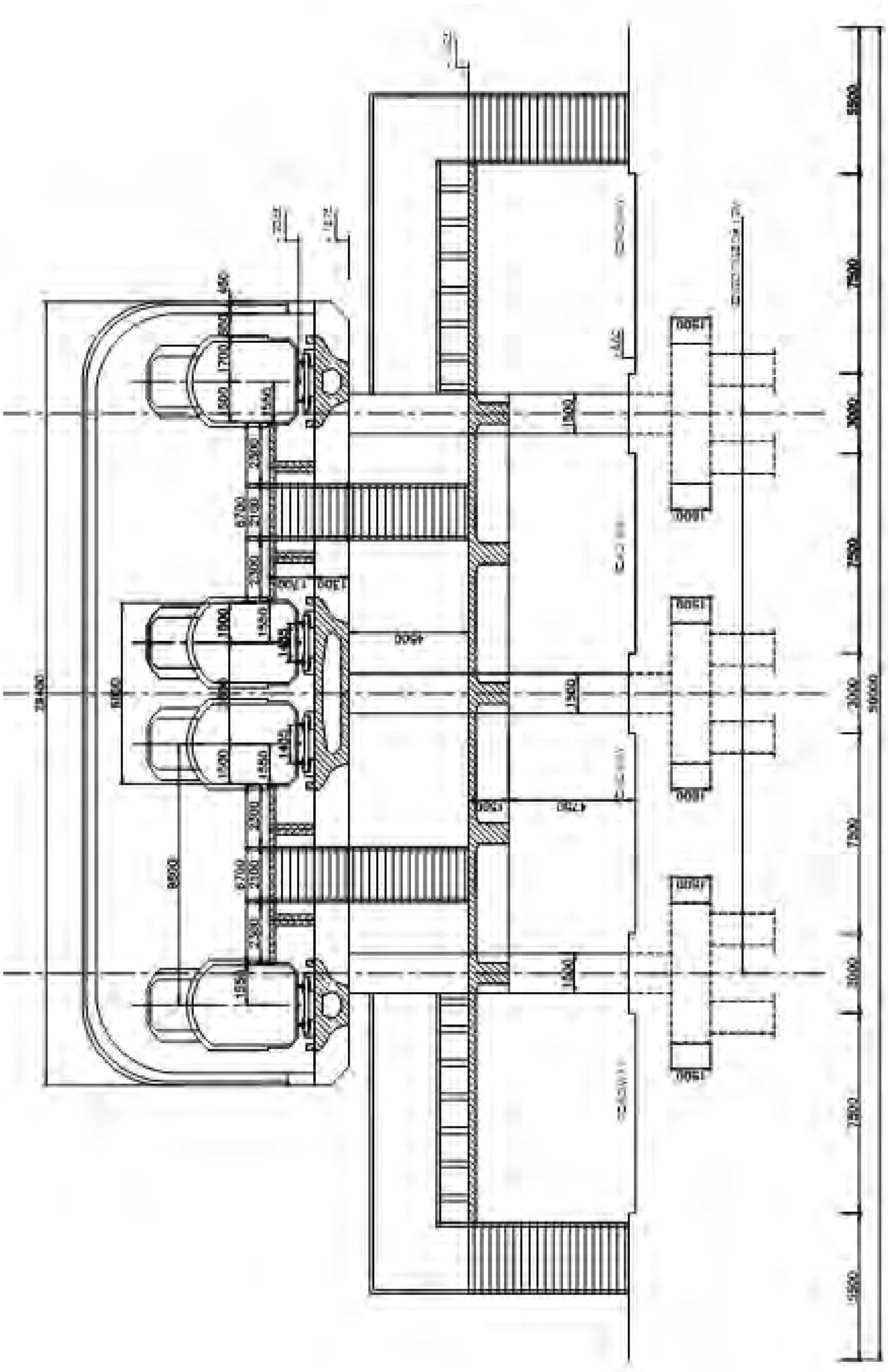
With regard to platform type (discussed in Chapter 3), JST adopts side platforms for whole elevated section.



Source: JICA Study Team

Figure 4.5.7 Structural Cross Sections of Station

With regard structure of Purbachal Terminal Station, which contains two platforms and four tracks, is shown by Figure 4.5.8 Imaged Structure Cross Section of Purbachal Terminal Station.



Source: OCG Archives Hanoi Line 2 Basic Design Report

Figure 4.5.8 Purbachal Terminal Station

4.5.2 Underground Structure

1) Tunneling Plan

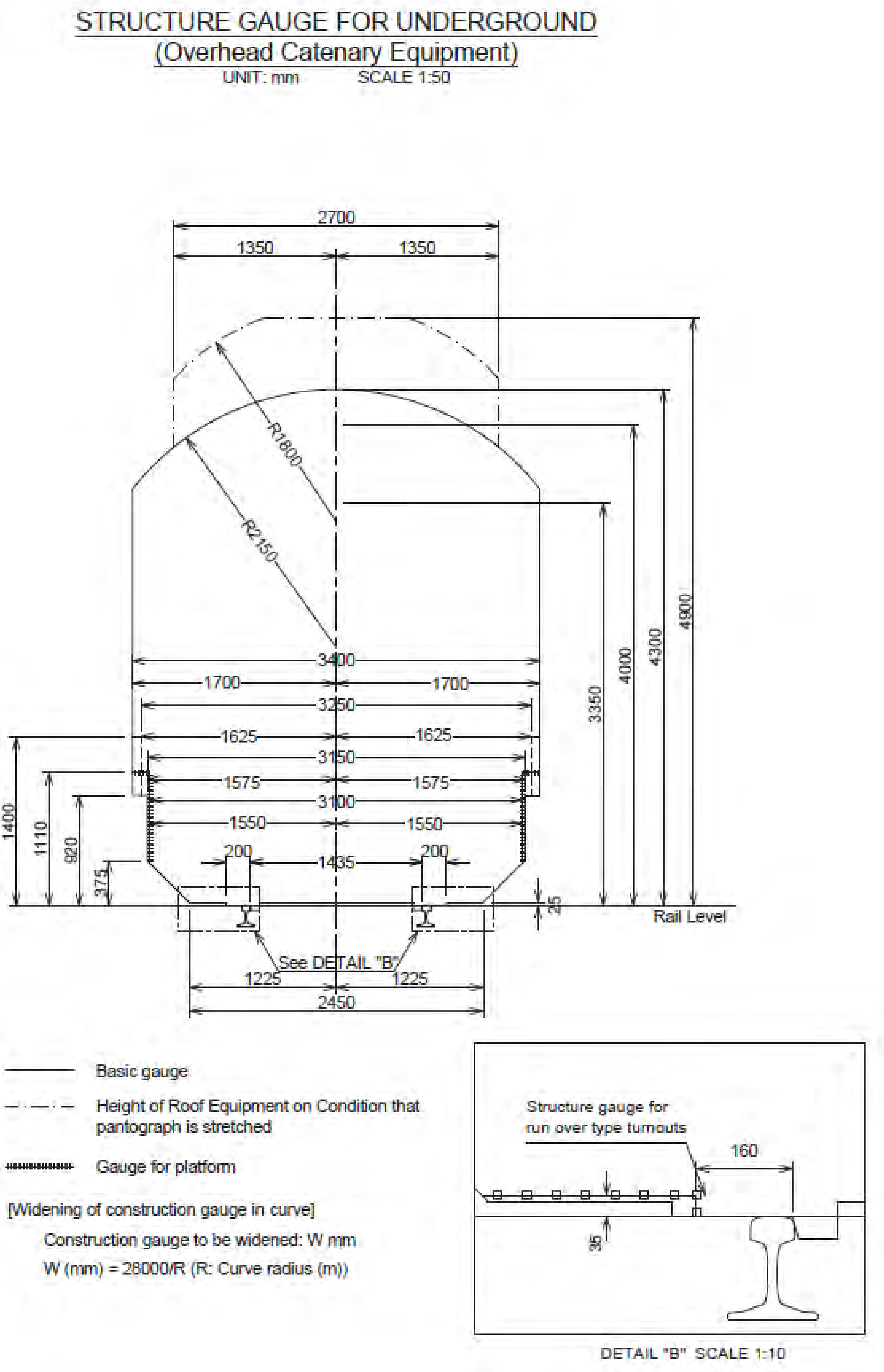
(1) Tunnelling Method

In general, tunnel construction is implemented on a major road on which a certain number of vehicles run. Not only JST but also many civil experts thought the tunnel boring machine (TBM) method is the most adequate tunneling method to keep resettlement to a minimum. Tunneling by NATM method is one of the possible methods, but the soil condition of the route does not allow use of this method.

Between stations, there are two types of tunneling: one is two tunnels with two single tracks and another is one tunnel containing double tracks. In comparing these two types, the face of tunnel of single track-double tunnel is 77m^2 while the latter is 79 m^2. As a result, JST recommends two tunnels with two single tracks type.

(2) Construction Gauge of Underground section

The following figure is adopted by MRT Line 6 as recommended by STRASYA (Standard Urban Railway System for Asia) and applied for the Jakarta MRT, Ho Chi Minh Line 1, and Hanoi Line 2. The Dhaka MRT Line 1 shall use the same.



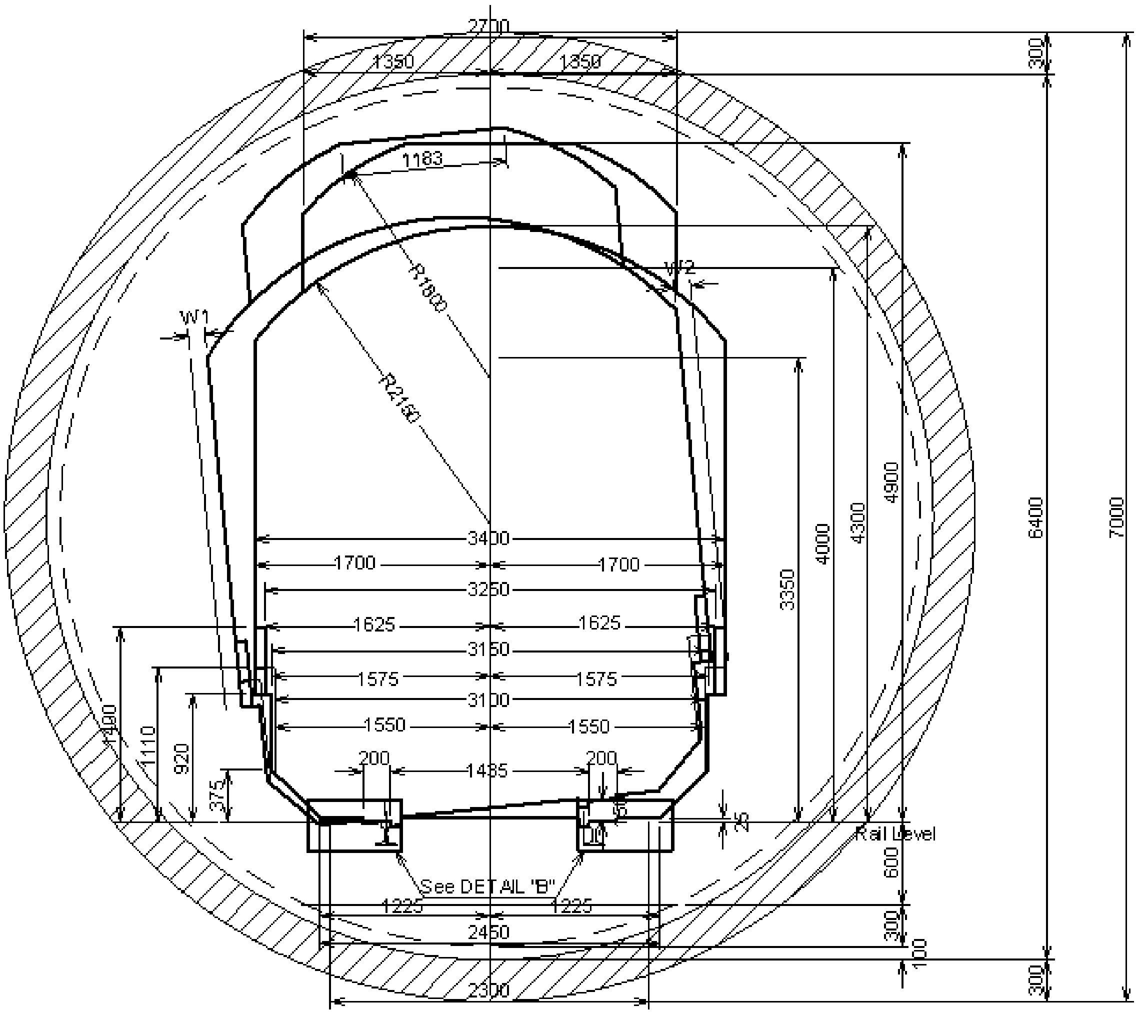
Source: STRASYA

Figure 4.5.9 Construction Gauge Recommended by STRASYA

(3) Cross Section of Tunnel

a. Cross Section of Tunnel

The tunnel cross section design shall be made based on the Rolling Stock Envelopment, Track Structure, Drainage System, Management & Maintenance Staff Passageway and space for Facilities. In addition to this, construction allowance shall be taken into account. The distance from Rail Level (RL) to the Formation Level (FL: Level at surface of the Invert Concrete) is 600mm. The distance from FL to face of Shield Segment is 300mm. Furthermore, the gap between the Construction Gauge and Rolling Stock Gauge is 100mm. As a result, the radius of tunnel becomes 6,400mm. In this FS, facilities put into tunnel are still rough estimates; therefore, JST added some allowance and the tunnel radius becomes 7,000mm. The following Figure 4.5.10 shows the cross section.



W1 ; Deviation towards the inside of curve
W2 ; Deviation towards the outside of curve

Source: JICA Study Team

Figure 4.5.10 Cross Section of Tunnel

b. Segment

There are several types of segments, such as RC segment, composition segment, ductile segment, and steel segment. According to the site condition, the designer makes the decision which segment type shall be adopted. As a normal practice, considering the economical advantage, RC segment is widely used. But under special conditions like under buildings, which is a unique condition, sometimes the ductile segment is utilized. In MRT Line 1, at Malibagh, tunnel boring through the station and later segments shall be discontinued to connect the Station Box and tunnel. JST considered the segment made of ductile iron or steel as suitable for this works.

In general, the depth of RC segment shall be 4% of tunnel radius, outside of segment. According to this practice,

$$t \geqq (6400+2t) \times 0.04 \quad \rightarrow t \geqq 280\text{mm}$$

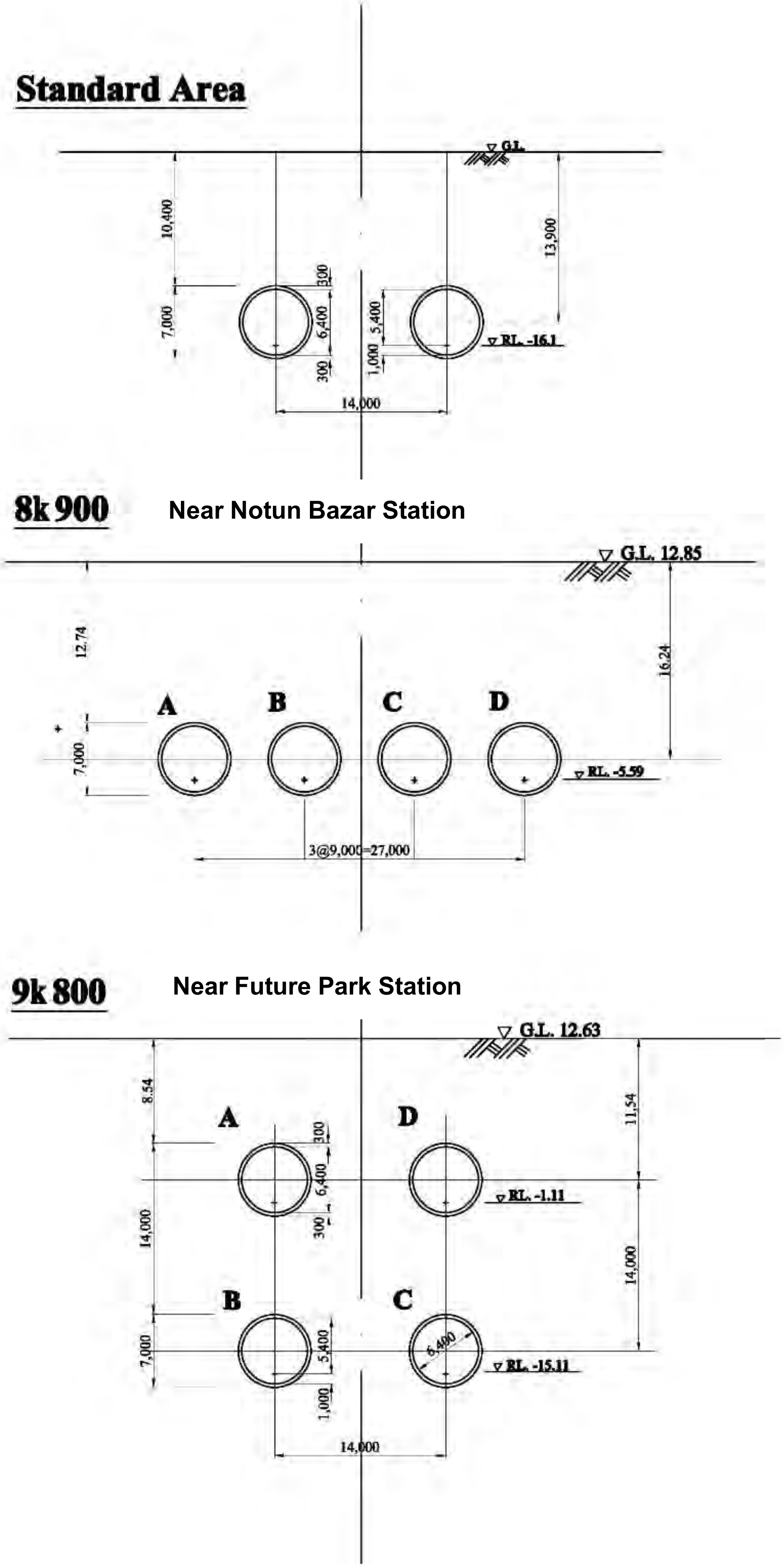
Further allowance was added and t=300mm was found.

Based on this idea, segment external radius is D= 7.0m.

With regard the length of segment ring, according to normal practice in Japan, L=1.2m is adopted.

c. Distance between TBMs

Distance between TBMs shall be kept at 1D (7m) as normal practice.



Source: JICA Study Team

Figure 4.5.11 TBM Arrangement

2) Underground Station Structure Plan

The cut and cover method is commonly used for underground station construction because of economic and physical reasons. In the construction of MRT Line 1, the underground station shall be designed by the cut and cover method.

(1) Depth of soil cover

There are normal lifeline utilities such as water, sewage, gas, electrical facilities, and phone cables laid under the road. In order to keep such spaces, a station box will be constructed 3m deep from ground level. When MRT Underground construction takes place, all such utilities shall be relocated safely and properly. The who, when, how, financial responsibility, permission from related authorities, etc. of utility diversion in Detail Engineering Design Stage shall be discussed with utility owners.

(2) Underground Structure Plan

a. Typical Station Structure

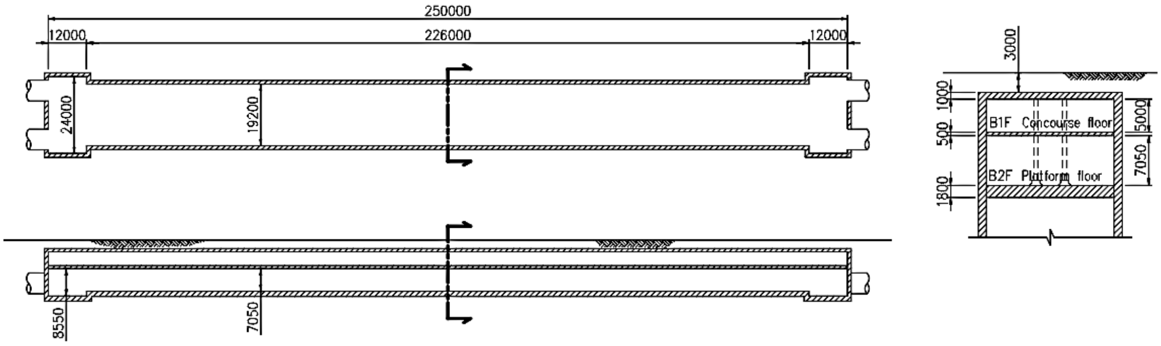
As far as underground stations are concerned, the storage of train operation facilities such as signal & telecommunication equipment, air-conditioning equipment, cooling facility, electrical distribution facility, fans, and station operation equipment, a 2-layer station is economical and reasonable for future operation. From previous experience in Japan and other Asian countries, a 19m wide and 250m long station box is enough for storage of such equipment.

B2 floor level shall be used as platform level. As discussed in Chapter 3, an island type platform shall be provided with standard width of 11m. Outside of the construction gauge, a width of 850mm is kept for advertisement boards, several stations and train operation service. A width of 19.2m is the station standard. With regard to station length, 10m is added to 160m train length.

Taking seismic design into consideration, a 2-column cross section type station is recommended, and at the end of station, shield machine launching shaft will be provided.

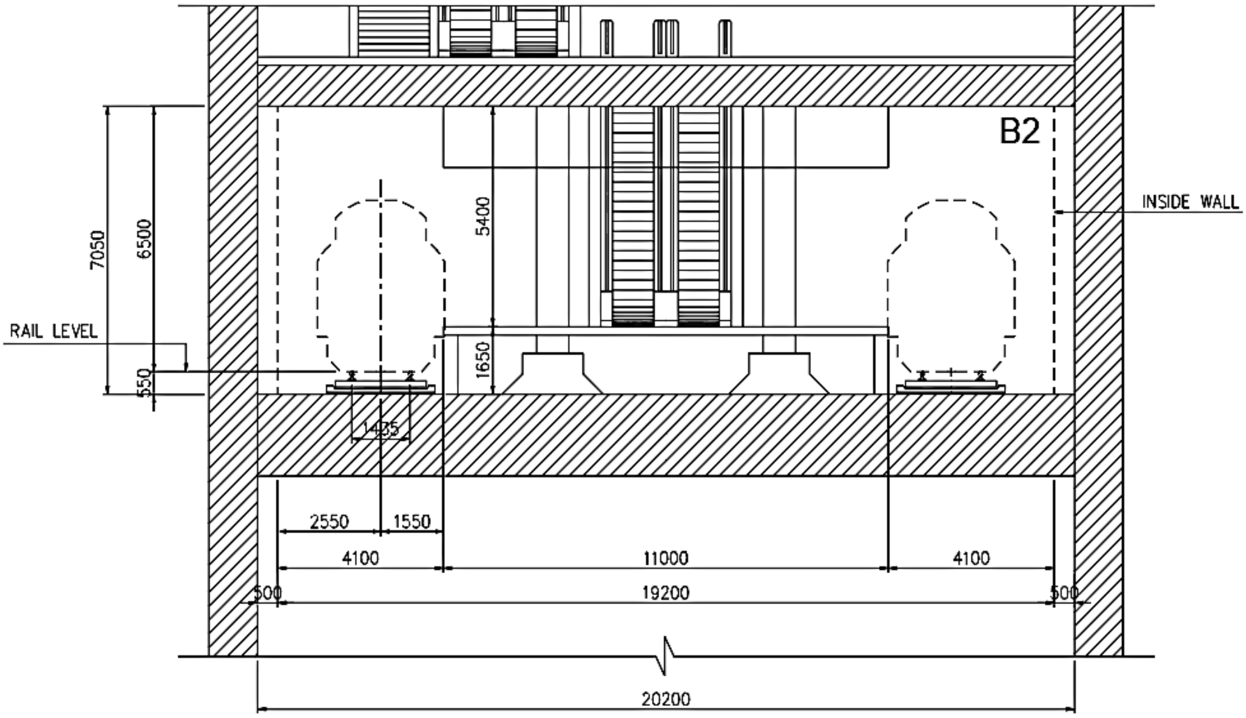
All stations contain an access/exit, ventilation shaft, and a pumping system. In order to facilitate equipment use, the effective ceiling height of 5m is provided for B1 Concourse level. Number of access/exit staircases is 4.

Figure 4.5.12 shows a standard underground plan and cross section and Figure 4.5.13 shows a standard station platform with 2 columns.



Source： JICA Study Team

Figure 4.5.12 Standard Underground Plan and Cross Section



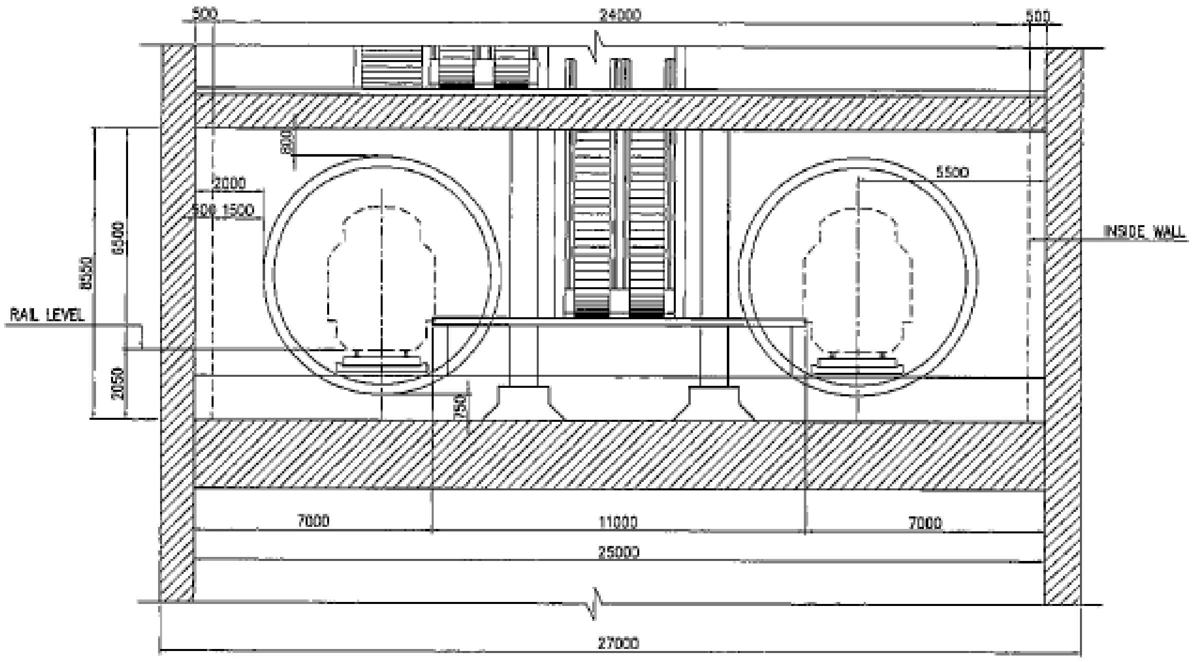
Source: JICA Study Team

Figure 4.5.13 Standard Station Platform with 2 Columns

b. Form at the End of Station (Used as TBM Launching Shaft)

The station box will be widened at the end for the TBM launching shaft. At the time TBM launches or arrives, the inner wall is not constructed yet. The distance between diaphragm wall and TBM shall be 2,000mm as shown Figure 4.5.14. Furthermore, as shown in Figure 4.5.15, for dispatch of equipment, 750mm shall be taken into account. At present, the tentative distance between outside of TBM and centre of TBM is assumed at 7m, but skin plate thickness, gap between segment and skin plate are omitted. In the detailed study, such factors shall be considered. It may be possible to reduce the thickness of segment based on the actual geotechnical condition.

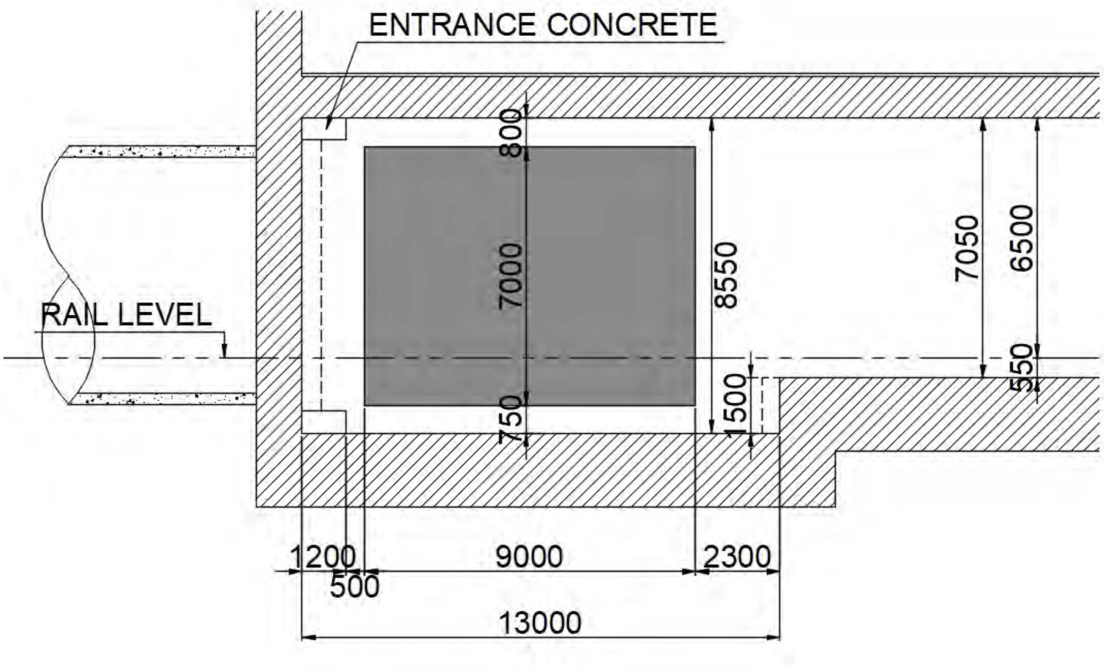
Regarding longitudinal direction, the length of launching shaft is assumed at 13m taking into account TBM L=9000mm, temporary facilities of 2300mm and allowance of 500mm. After launching or arrival of TBMs, the shaft shall be set up and the wall then becomes L=12m.



Source: JICA Study Team

Figure 4.5.14 Station end Cross Section

The following figure shows longitudinal cross section.



Source: JICA Study Team

Figure 4.5.15 Station End Longitudinal Cross Section

(3) Special Type of Underground Station

Due to narrow space at Malibagh, the standard type of underground structure is not feasible. In addition, in front of Future Park Amusement, the station shall have two platforms for the train operation. But the narrow space makes it difficult to construct two platforms and four tracks in the same layer, unless land is added to widen the space. JST makes plans for 3-layer station boxes.

The standard station length is L=250m (outside of walls), but Rampura Station has a crossing for emergencies where the TBM method shall be terminated in front of station boxes with some distance that are built by cut and cover method. In comparison with the space required for a station box, such space for track crossing is small, and the JST is concerned about D-Wall's cost performance. In the Detailed Design stage, Soil Mixed Wall (SMW) or Sheet Piling shall be studied.

(4) Structure Plan for Each Underground Station

a. Kamalapur Station (Standard + Open cut extended)

This Station shall be the project starting point, connecting with BR and even MRT Line 6. In the future, MRT Line 1 will be extended toward Jhilmil.

In general, it is preferred to provide two platforms and four tracks at the terminal station for easy train operation; however, a station with one platform and two tracks is unavoidable due to land issues. Thus, room for expansion is to be taken into consideration when deciding on a connection through underground pass to BR and future commercial development.

In FS, JST tentatively planned a standard underground station measuring 20m wide and 250m long. As at the Airport end, a scissors crossing will be provided. About 85m from outside of 250m station box will be constructed for TBM launching shaft. The extended box culvert contains intermediate columns. The cut and cover method will be used to construct a 250m Station Box with diaphragm wall, while the extended box culvert and TBM launching shafts shall be built by cut and cover method with SMW or sheet piling.

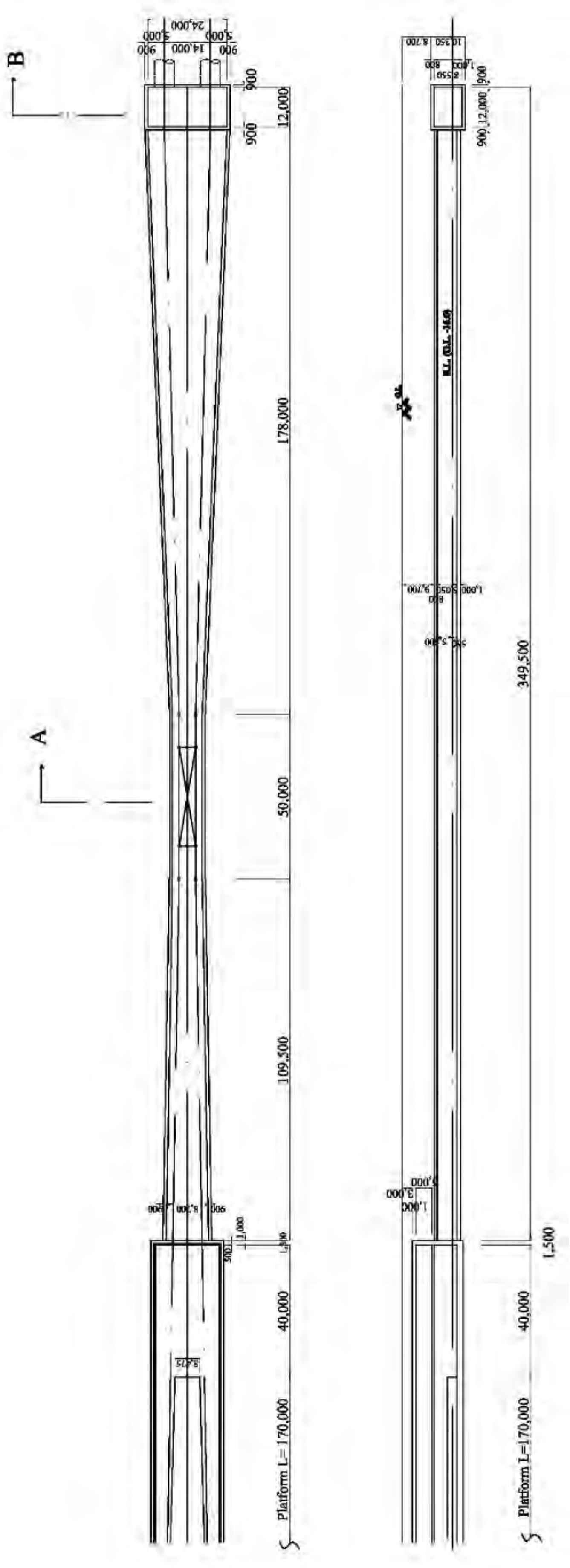
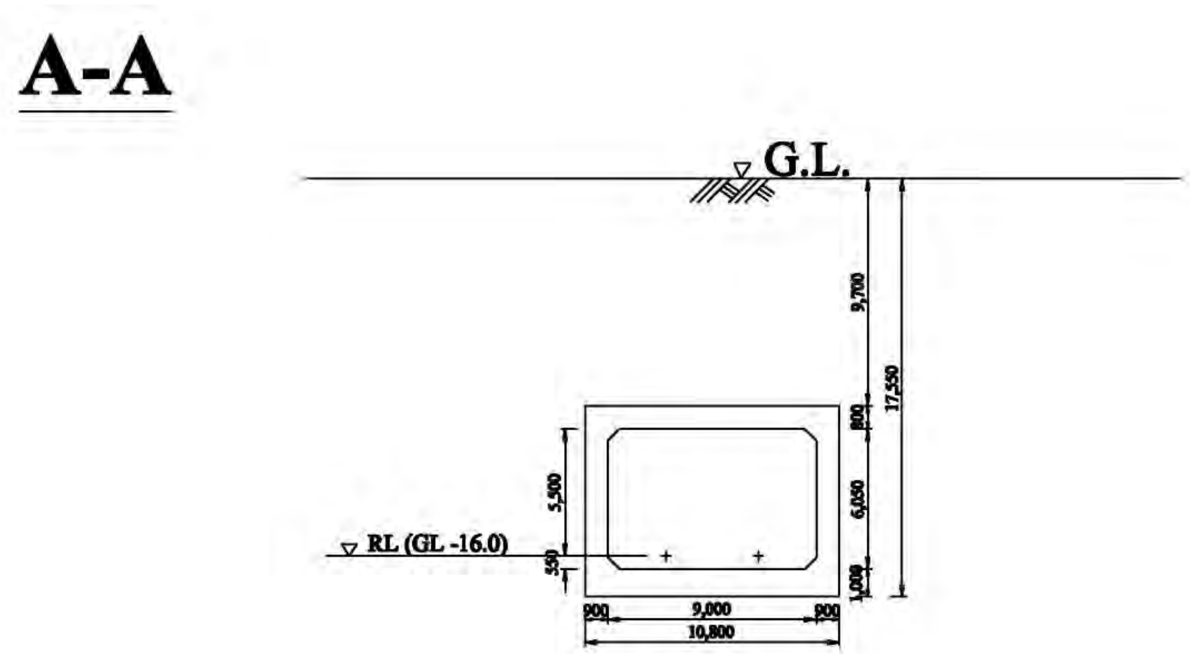
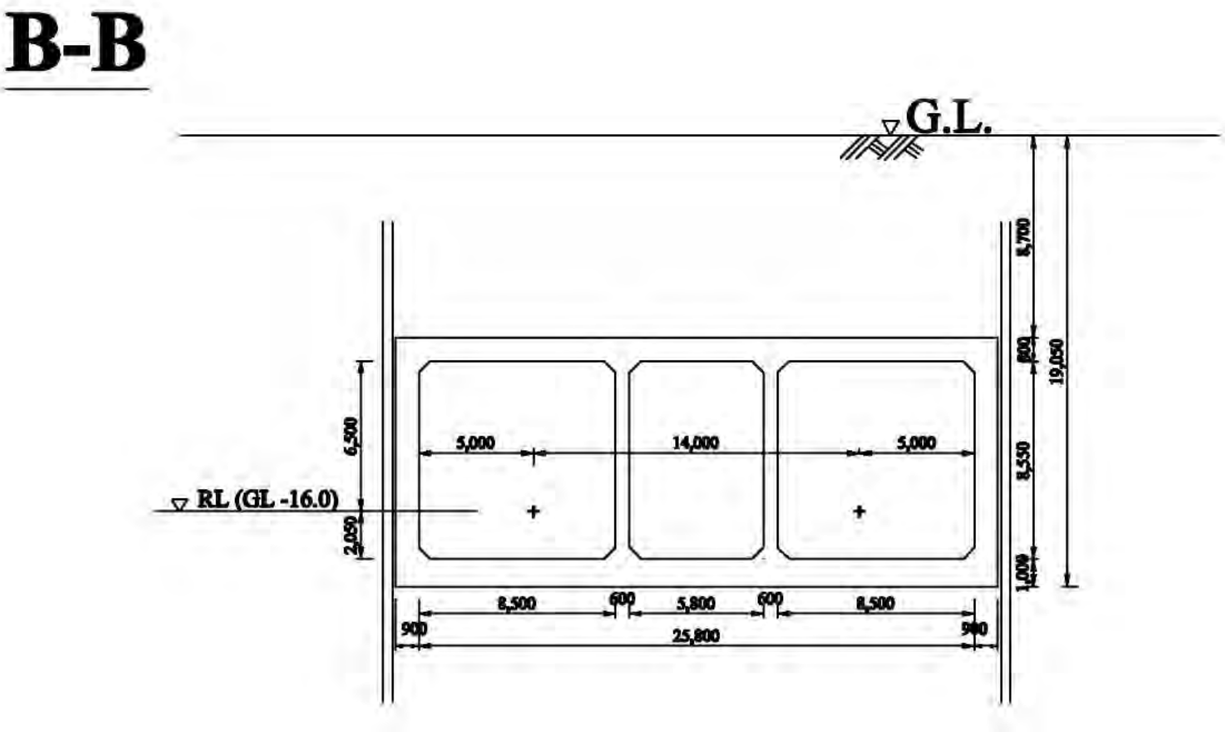


Figure 4.5.16 (1) Kamalapur Station Plan



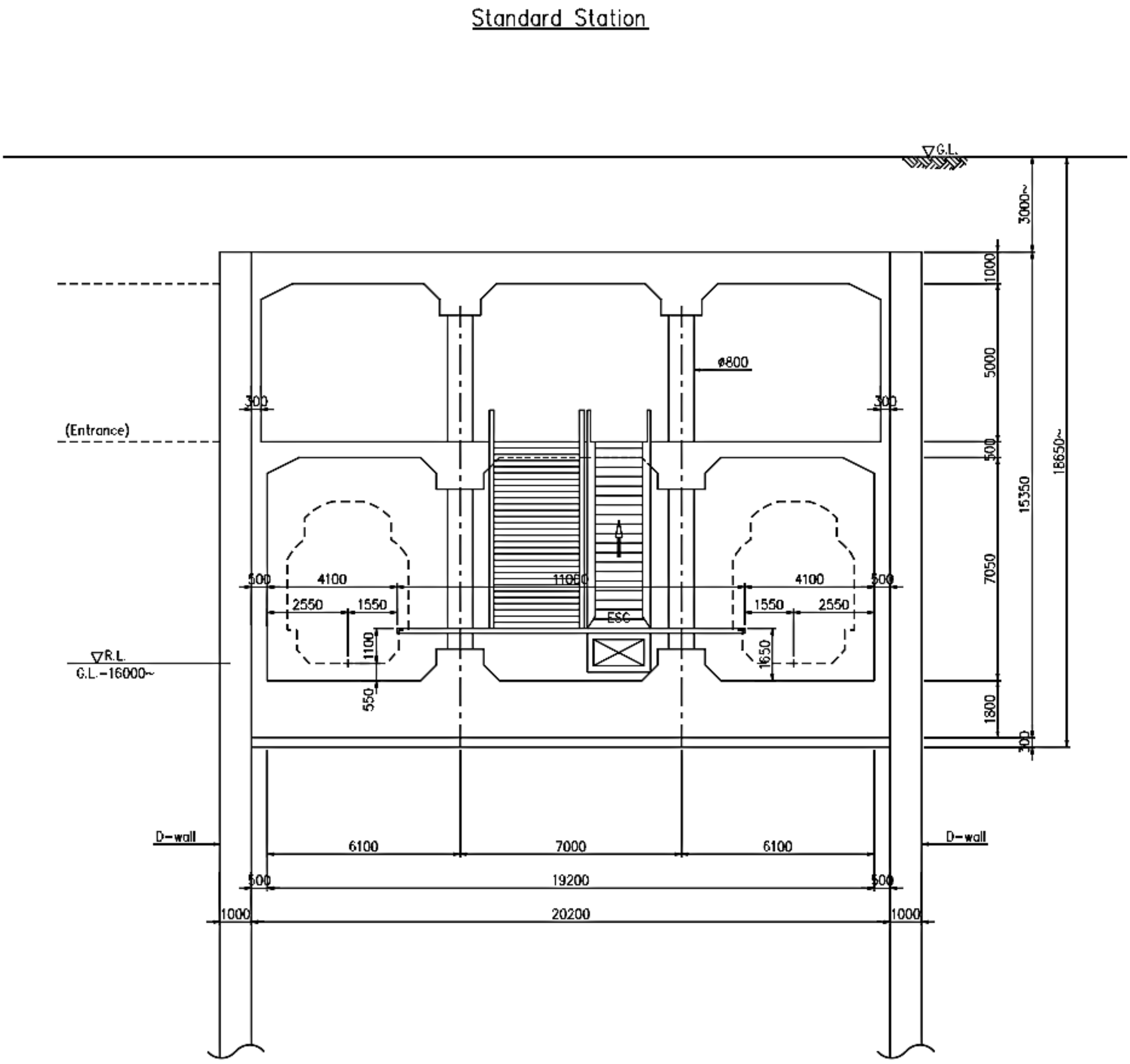


Source: JICA Study Team

Figure 4.5.16 (2) Kamalapur Station Cross Section

b. Rajarbagh Station (Standard-type Underground Station)

Since there are big spaces owned by the Police Authority, a station will be provided in the Outer Circle Road, on the south side of the Police line.

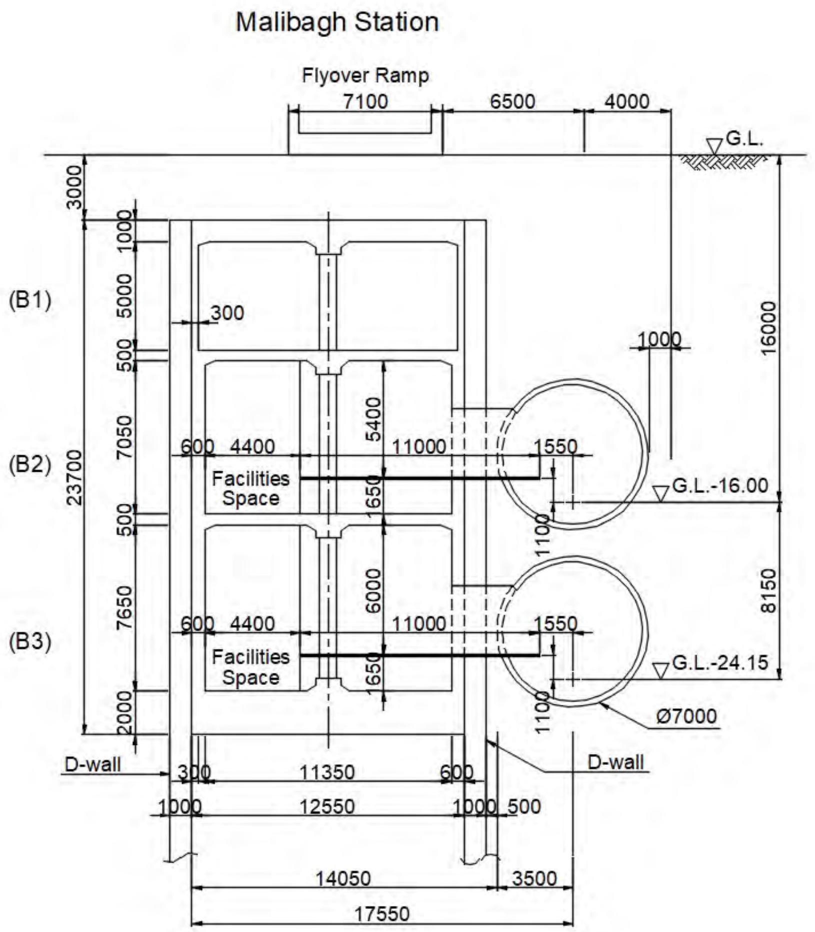


Source: JICA Study Team

Figure 4.5.17 Standard Underground Station

c. Malibagh Station (Special Station)

Ramps for the elevated road are located south of this station. The station will be constructed northward 50m from the end of the ramps. Since land for exits or ventilation towers cannot be found there, purchasing some buildings and land will be necessary. As enough land for the shielded tunnel cannot be prepared, the tunnels will be constructed with two levels on the east side of the shaft, and a station structure is constructed by connecting with the narrow width station and the tunnel of two levels in the underground. The length of the station will be longer than that of the platform to create a space for station facilities. Some parts of the segments will be removed to connect with the station in the underground. In that range, ductile cast iron segments will be used (see figure below).



Source: JICA Study Team

Figure 4.5.18 Cross Section of Malibagh Station

d. Rampura Station (Standard＋Extended Open Cut)

In consideration of the location of Malibagh Station, an interval of about 1km shall be prepared. Since a crossover at the airport side is planned, the station shaft will be extended about 85m. The extension section consists of a box culvert with pillars.

At the site, land for exits cannot be found, so the exits can be set at the buildings. North west of the station, there is about 20m×17m of land available and the ventilation tower will be set there.

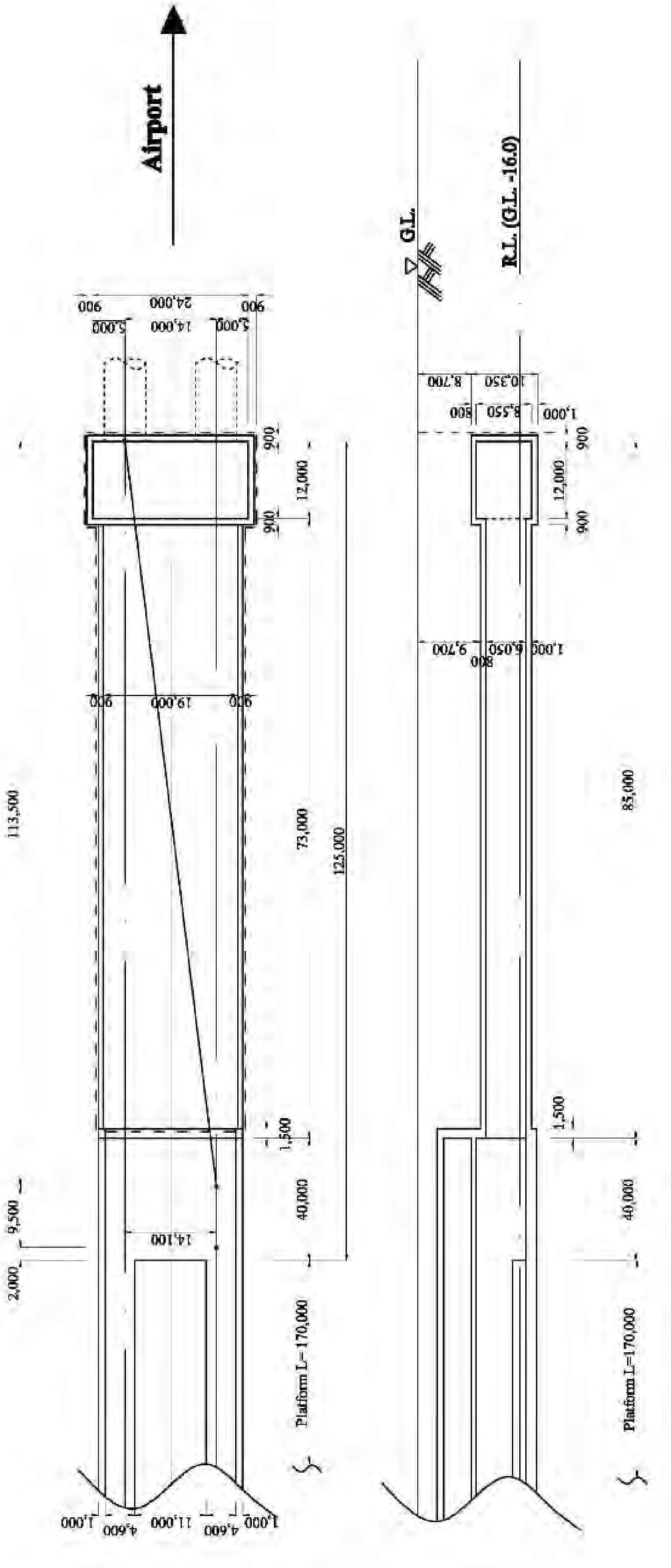
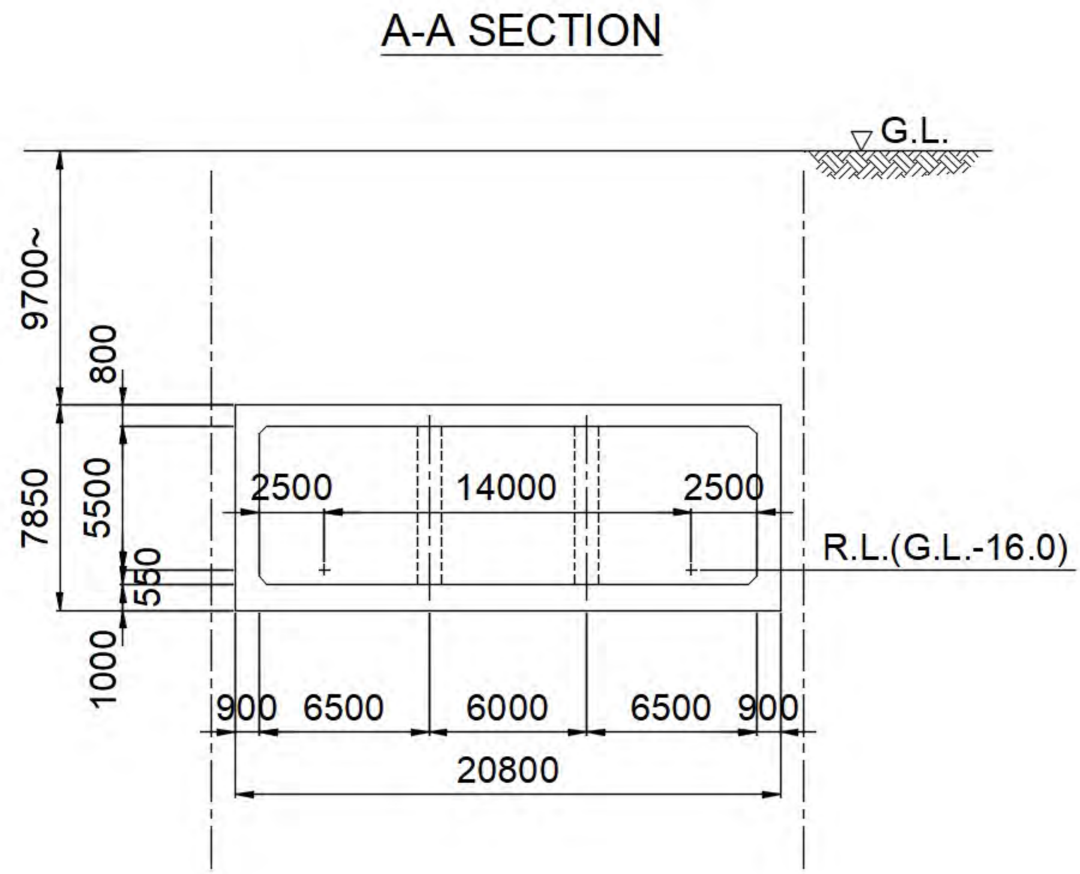


Figure 4.5.19 (1) Rampura Station Plan



Source: JICA Study Team

Figure 4.5.19 (2) Cross Section of Rampura Station

e. HatirJheel Station (Standard-type Underground Station)

There is available land for the ventilation tower southwest of the station. Piles can be driven in the storage reservoir and the land can be used for material storage or an office by installing cover piles.

At the north of the Rampura Bridge a standard type of underground shall be provided as Hatir Jheel Station. An entrance shall be provided on the east side of station box. At the eastern side of this station there is DCC which has wide land, which at present is used as a material stock yard for the construction of a U-turn bridge. Now the U-turn bridge construction is close to completion. DTCA proposed to JST using the land for a Ventilation Tower, Cooling Tower and sub-station, and JST confirmed that there is enough space for the above structures and temporary construction material stock yard.

f. Badda Station (Standard-type Underground Station)

This station will have a standard-type underground Station. Land on the east and west side of the station can be prepared for the ventilation tower.

g. Uttar Badda Station (Standard-type Underground Station)

This station will also have a standard-type underground station. Land at the west of the station can be acquired for the ventilation tower, but it is necessary to study land for entrance/exits.

h. Notun Bazar Station (Special Underground Station)

The planned station has a very unique structure in that four TBMs are dispatched from there.

There are two platforms and four lines. The two lines on the inside reach the third floor of the Future Park station and go to the Airport Station. Next, two lines outside reach at the third floor of the Future Park Station, pass by the shaft, turn to the east, and go up on ground level in front of the Bashundhara Station. Then, by way of the elevated lines, these lines will be connected to Purbachal Terminal Station.

Since scissors crossovers are located at the front and end of the station, the shaft length of the station is 775m, which is longer than that of the general station (see Figure 4.5.22). The 775m station box may be built with SMW method to reduce the duration of construction.

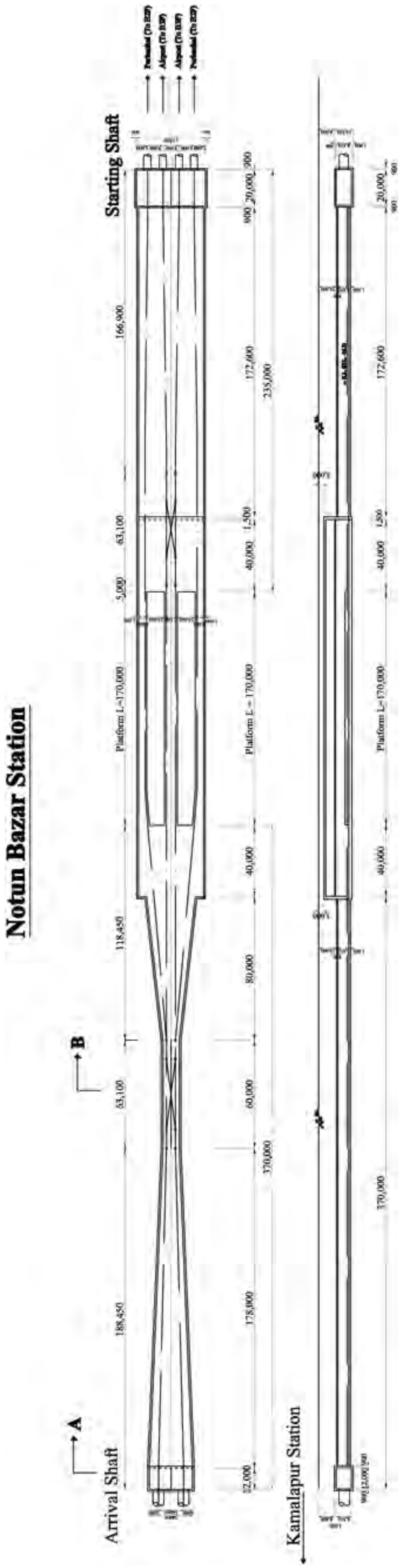
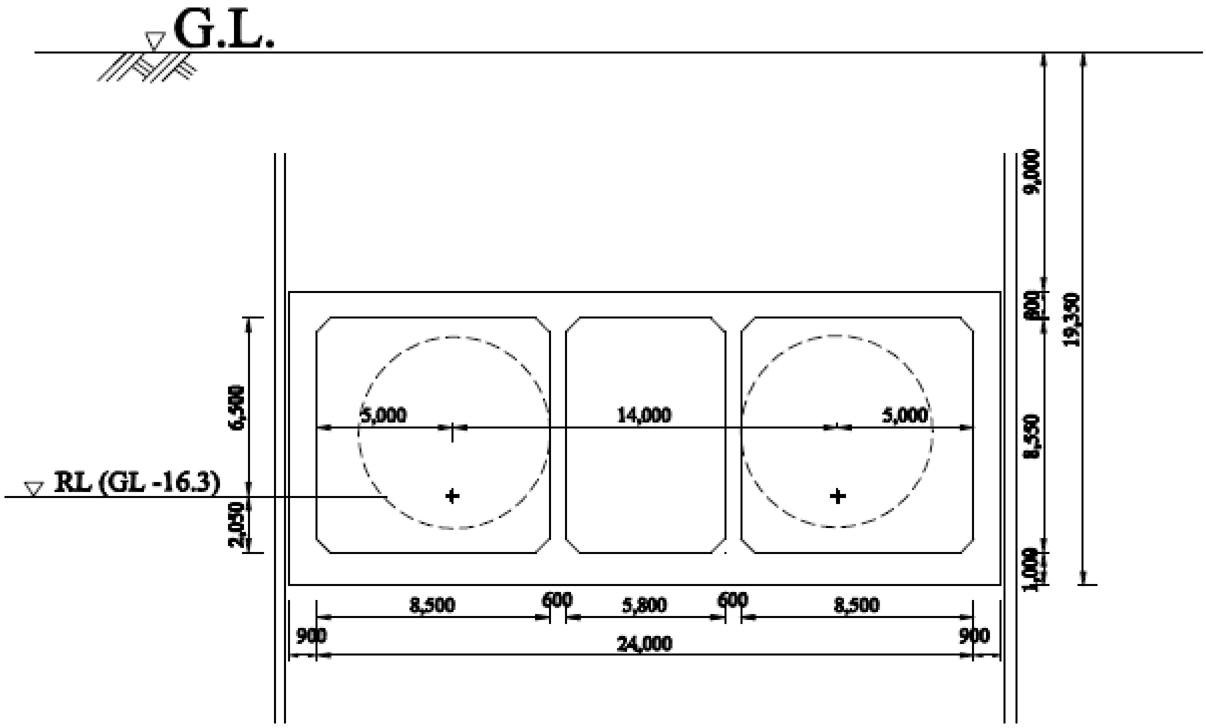
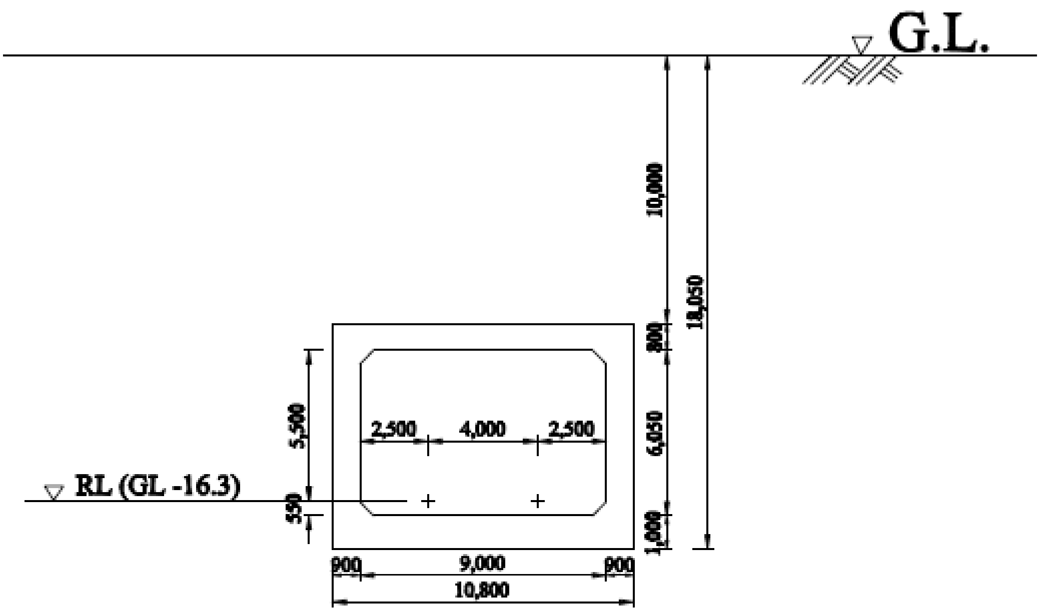


Figure 4.5.20 Notun Bazar Station Plan

A-A Section

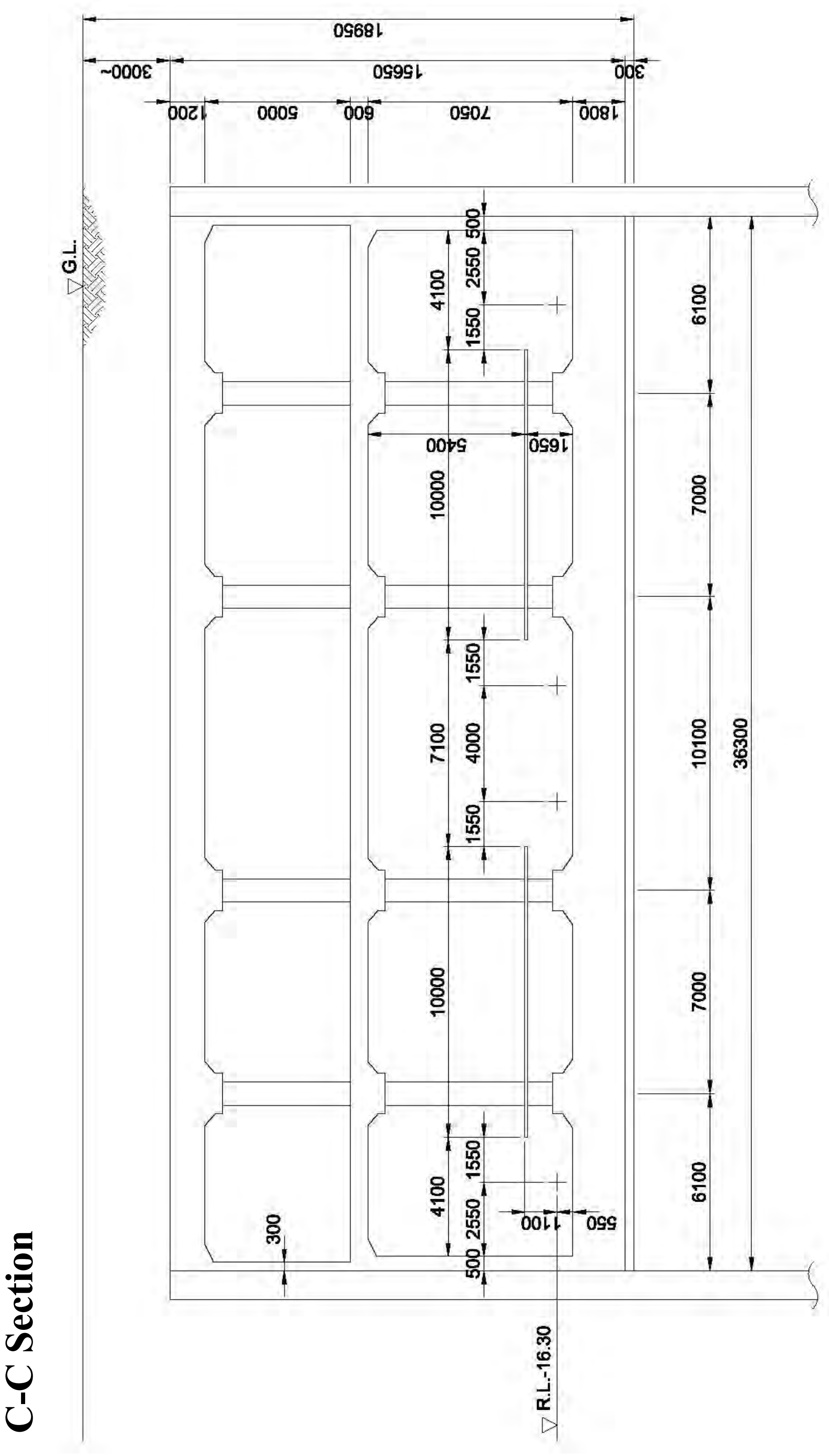


B-B Section



Source: JICA Study Team

Figure 4.5.21 Notun Bazar Station Cross Sections (A-A Section, B-B Section)

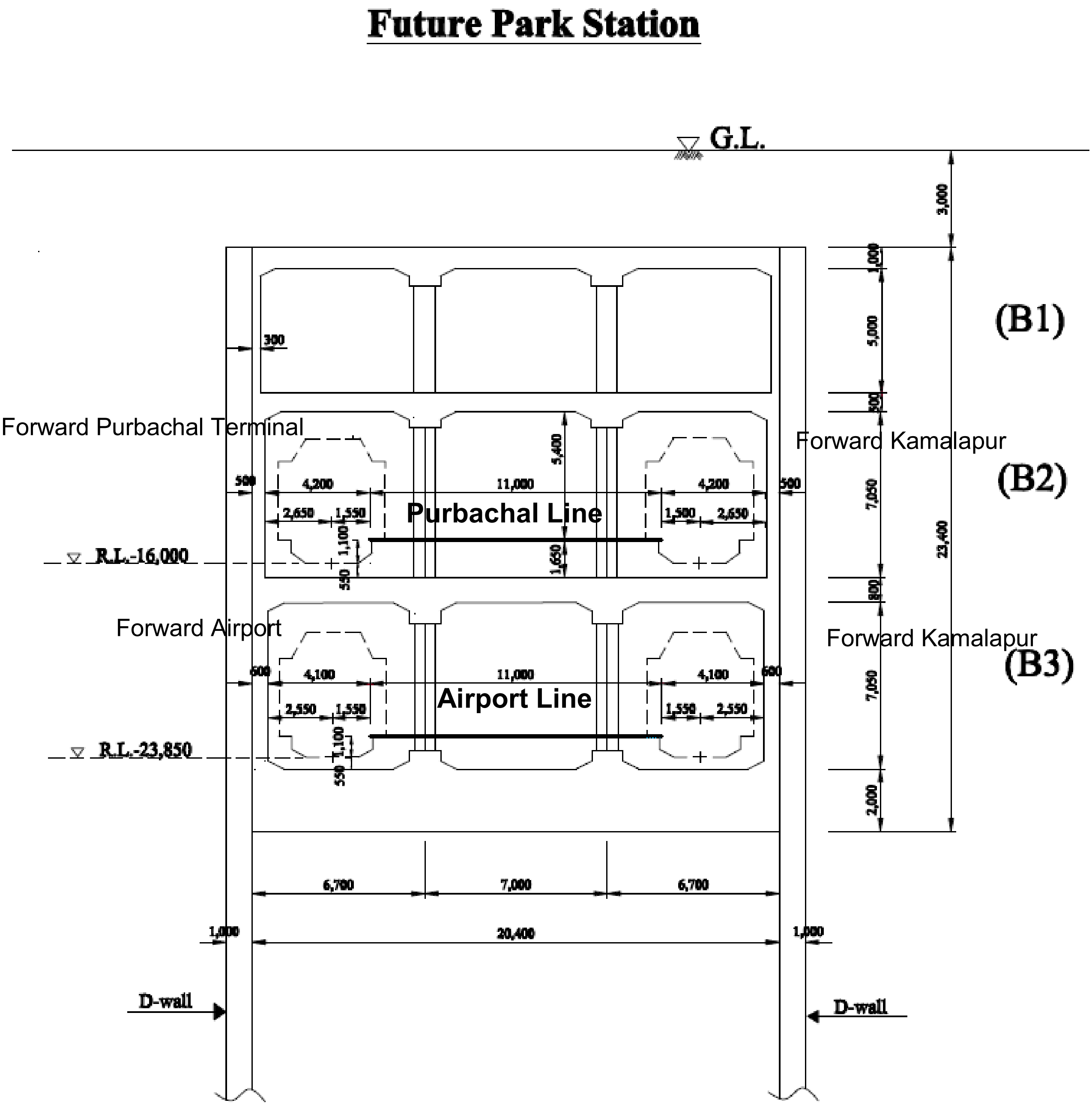


Source: JICA Study Team

Figure 4.5.22 Notun Bazar Station Plan and Cross Sections (C-C Section)

i. Future Park Station（Special Type Underground）

Future Park station can accommodate two floors and two lines operating in four shielded tunnels from Notun Bazar Station; the upper two lines (B2F) will be Purbachal Lines and the lower two lines (B3F) will be Airport Lines (see Figure 4.5.23).



Source: JICA Study Team

Figure 4.5.23 Cross Section of Future Park Station

j. Khilkhet Station (Standard-type Underground Station)

The shielded tunnel from Future Park Station goes through an area where elevated roads of DEE are randomly located. The station will be constructed at the east side of the main roads and at the west side of the Bangladesh Railway, so high level techniques of control and management of TBMs are required.

k. Airport Terminal 3 Station (Standard -type Underground Station)

The station will be constructed on the east side of the main roads and an underpass shall be constructed to the west side of them. Although there is another plan for BRT (bus routes), it does not have to be considered now since the project is still under review including its necessity.

At present, the design of a new airport and Airport Building Terminal 3 are planned. If underground stations will be set under the new airport on the west side of the main road, this will make it convenient for passengers heading to the airport. However, as a result of several discussions, it was decided to locate the MRT Line 1 Airport Terminal 3 station at the eastern side of the New Airport Road. The connection between MRT Station with the Airport Terminal 3 shall be facilitated by such equipment as people mover. With regard to the southern part of BRT Line 3, the World Bank (WB) is still to clarify the project validity.

l. Airport Station (Standard-type Underground Station with draw-op track)

Since the range for the station shaft becomes larger due to the scissors crossover at the south side of the station, the area for open cut will be connected between the stations because the open cut interval is 260m and results in small distance between stations. The extension range will be constructed by the open cut method with steel sheet piles, and the structure will be constructed as a box culvert. In addition, the northern part of the station will be extended and constructed by the open cut method with box culverts.

If the Airport Terminal 3 Station is shifted to the west side, it will be close to the airport on the west side.

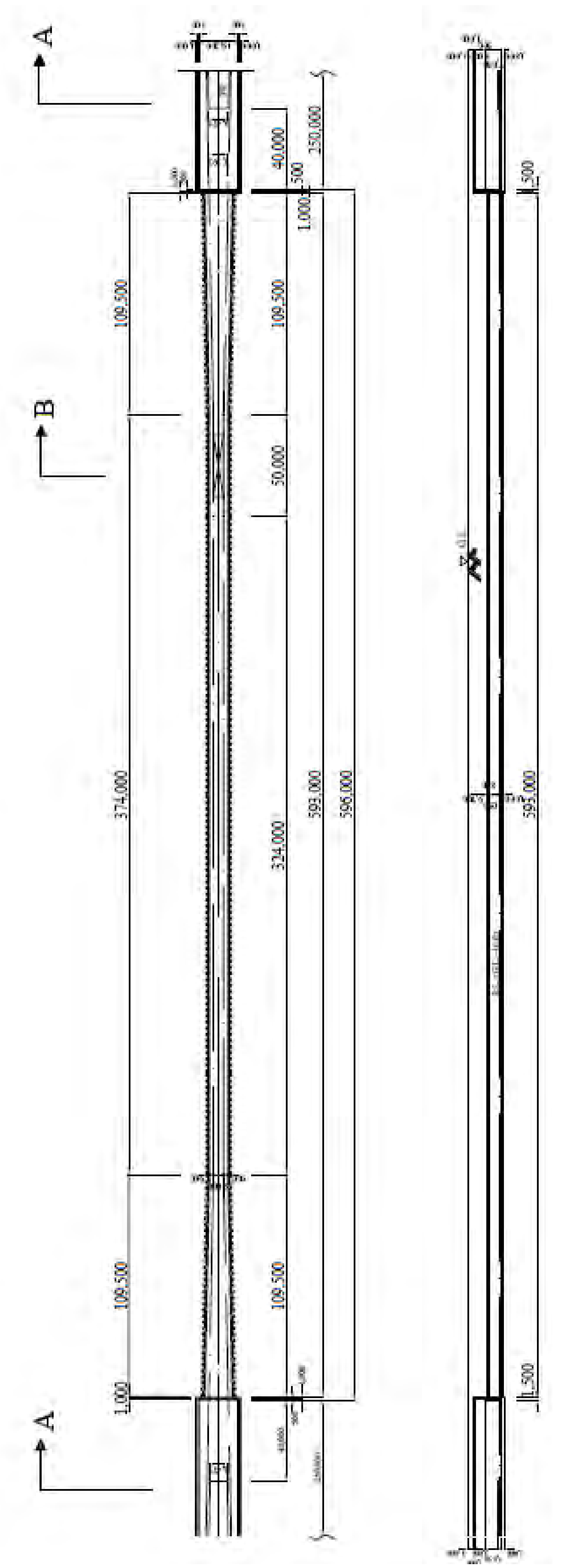
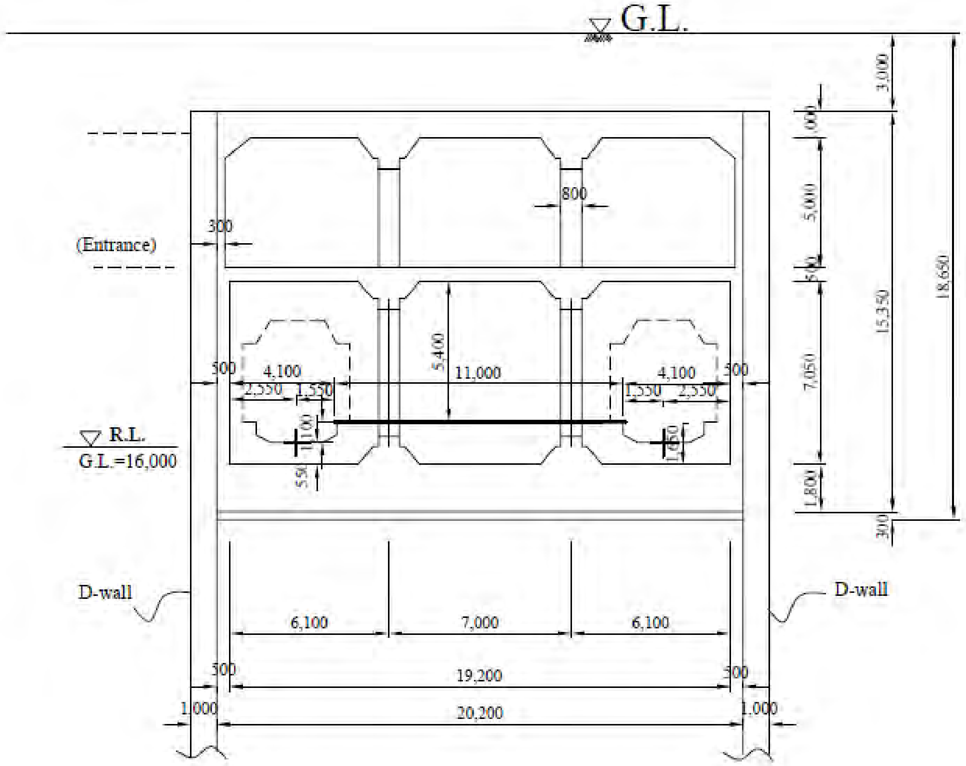
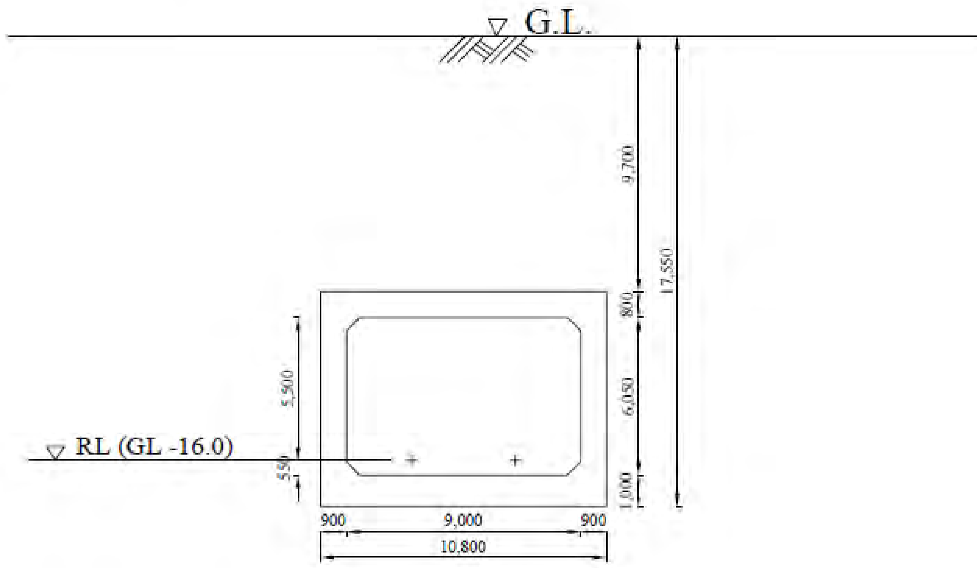


Figure 4.5.24 (1) Airport Terminal 3 Station - Airport Station Plan

A-A Section



B-B Section



Source: JICA Study Team

Figure 4.5.24 (2) Airport Terminal 3 Station - Airport Station Cross Section

Figure 4.5.26 shows the northern part of Airport Station.

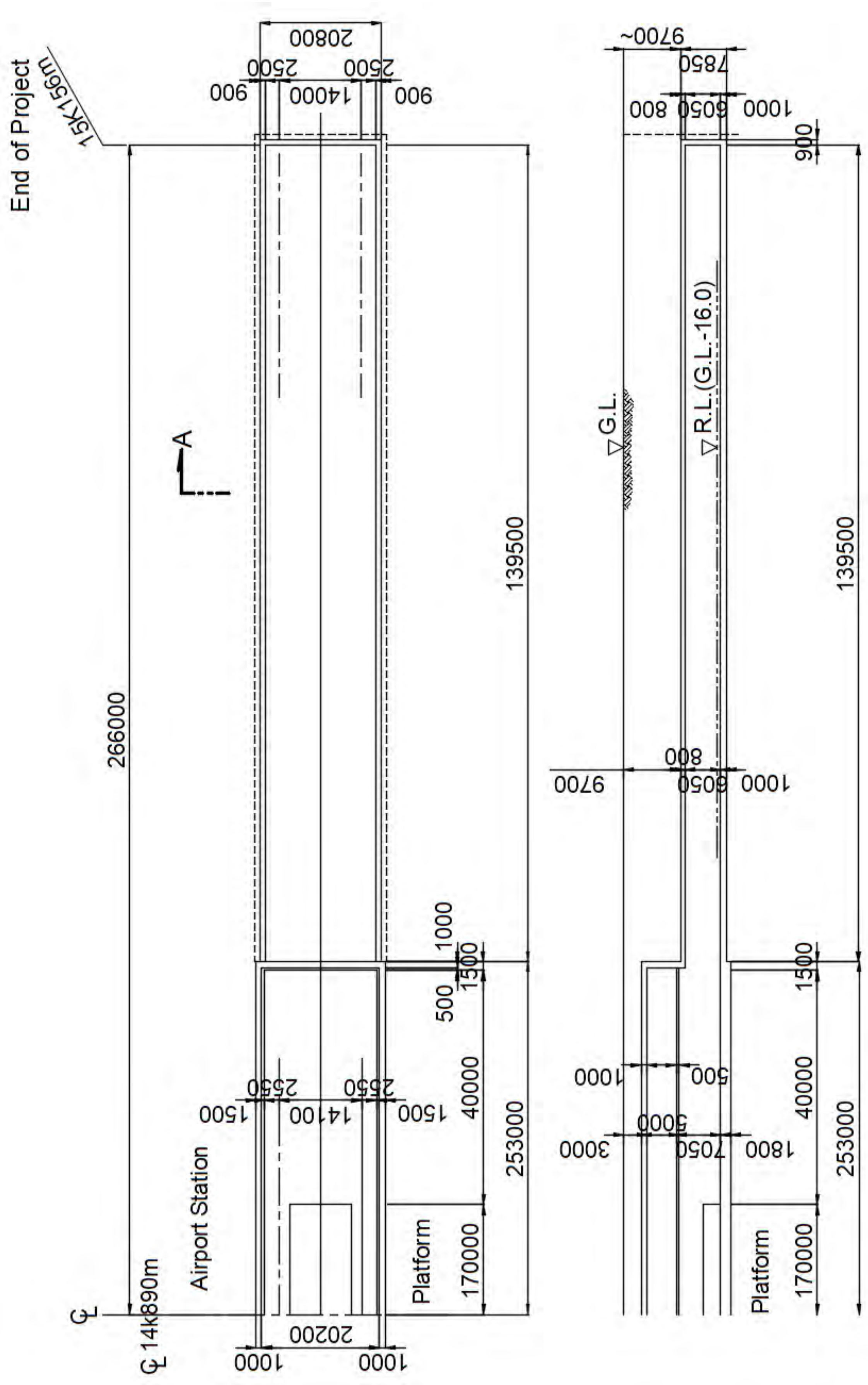
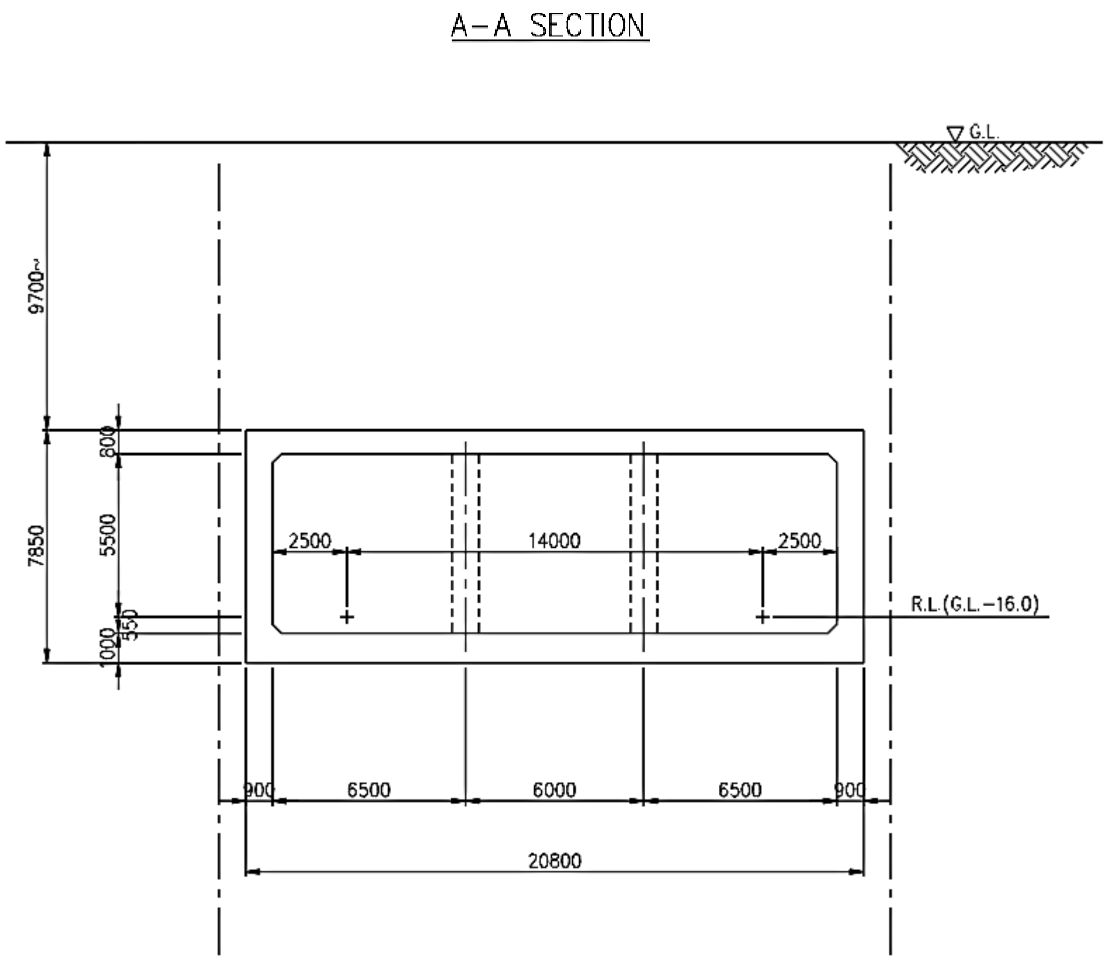


Figure 4.5.25 (1) Airport Station ~ Construction Ending Point Plan



Source: JICA Study Team

Figure 4.5.25 (2) Airport Station ~ Construction Ending Point Cross Section

(5) Between Stations

Tunnel boring machines will be used to build the tunnel between stations. There are two tunnels, and a single track. This section will discuss major issues to solve.

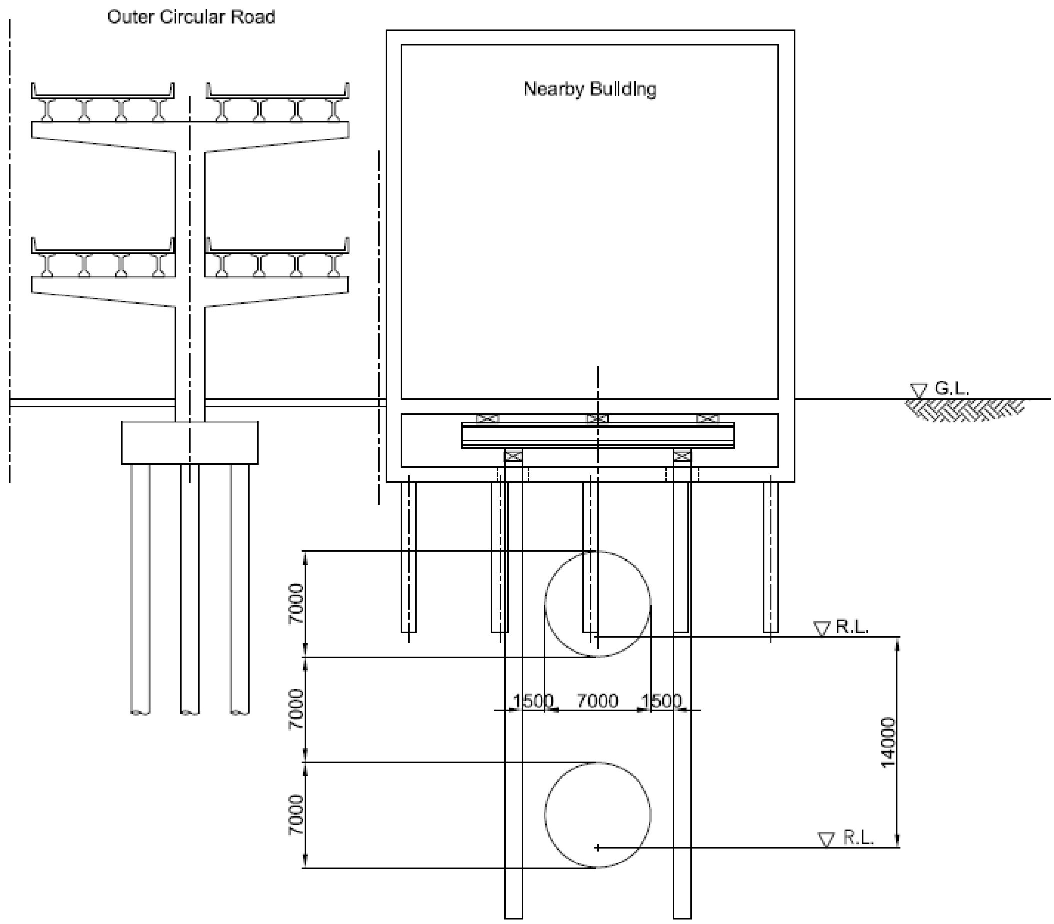
a. Rajarbagh Station - Malibagh Station

The tunnel boring started from Rajarbagh shaft at the same level and comes vertically parallel, keeping a 200m radius run under buildings, as shown in the drawing below. As discussed in section 4.2.3 (1), at present, detailed information of existing buildings is not available, but site observation indicates that these buildings are four layers and eight layers.

The surrounding area of the buildings is quite high, and it is hard to find land for underpinning temporary works. It is assumed that the buildings have a basement and that it would be available for temporary works.

In the plan, piles shall be driven from the basement by a pile driving machine with a restricted height. Upon completion of the piling, a rigid beam shall be inserted. The beam will support the existing buildings. Further detailed studies shall be done such as available height, availability of piling equipment, transport of equipment, and casting equipment.

Information related to the existing buildings are inevitable. Figure 4.5.26 shows underpinning works.



Source: JICA Study Team

Figure 4.5.26 Concept of Protection of Existing Buildings

b. Notun Bazar Station - Future Park Station

Between Notun Bazar Station and Future Park Station, track alignments are changing, four TBMs initially of same level changes to vertically parallel. Intensive TBM operation is required.

c. Future Park Station - Bashundhara Station（Underground to Elevated Transition）

Purbachal Line to the east, which starts from Future Park station (underground station), passes through the many piles under the Kuril fly-over and goes out at the centre of Purbachal Road, is shifted to an elevated track.

The connection part to the ground is around 100m ahead of where the fly-over slopes down, and a shaft, where TBMs arrive and TBMs are removed, will be set at that location. Then, the section is changed to be a box culvert with a retaining wall, and the elevated structure is on the ground level. Since the shielded tunnel reaches there by two single lines with 14m interval, the arrival shaft will be about 25m x 15m shape. The location of the shaft is set at around 11.9km from the starting point on the ground. Around the arrival shaft, construction techniques or soil improvement shall be considered because the depth of the TBM will be shallow.

The distance between centres of the tracks is changed from 14m to 4.9m in the box culvert. A circular curve and transition curve is set and the reduced distance is set at about 150m. Since this section is in the longitudinal gradient section, the specific condition has to be satisfied.

Installation of a drain pit shall be planned at the arrival shaft for TBMs at around 11.9 km.

The earth retaining method is the steel sheet pile method, which is easy to construct, economical and has a short construction period.

The box culvert and U-shaped retaining wall are also constructed of steel sheet piles.

Although the construction area is located at the northern side of the road, road traffic on the existing road may be disturbed. Both sides of the existing road are to be expanded as temporary roads which dispenses with the management.

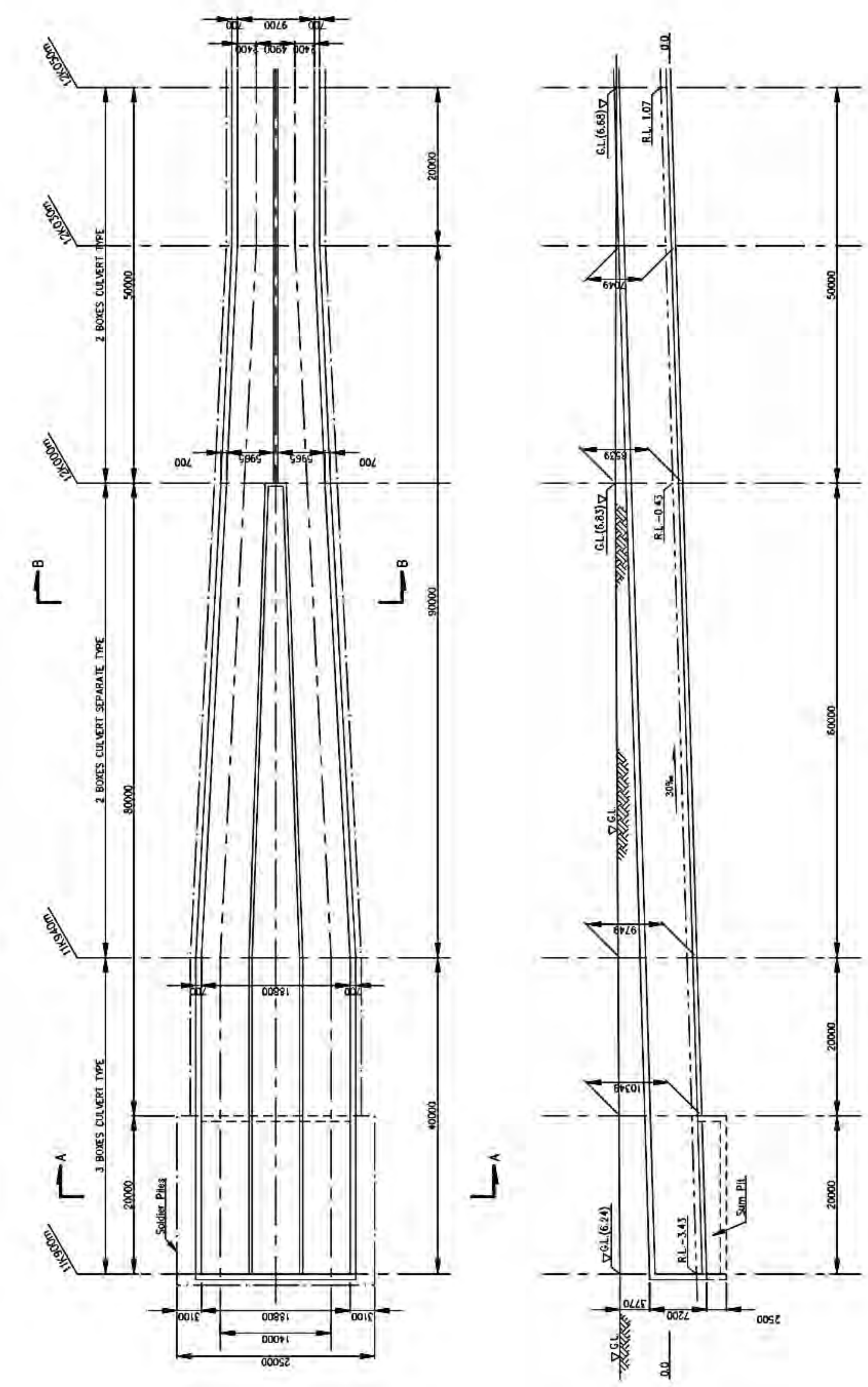


Figure 4.5.27 Plan and Profile at Transition Between Future Park Station - Bashundhara Station (1)

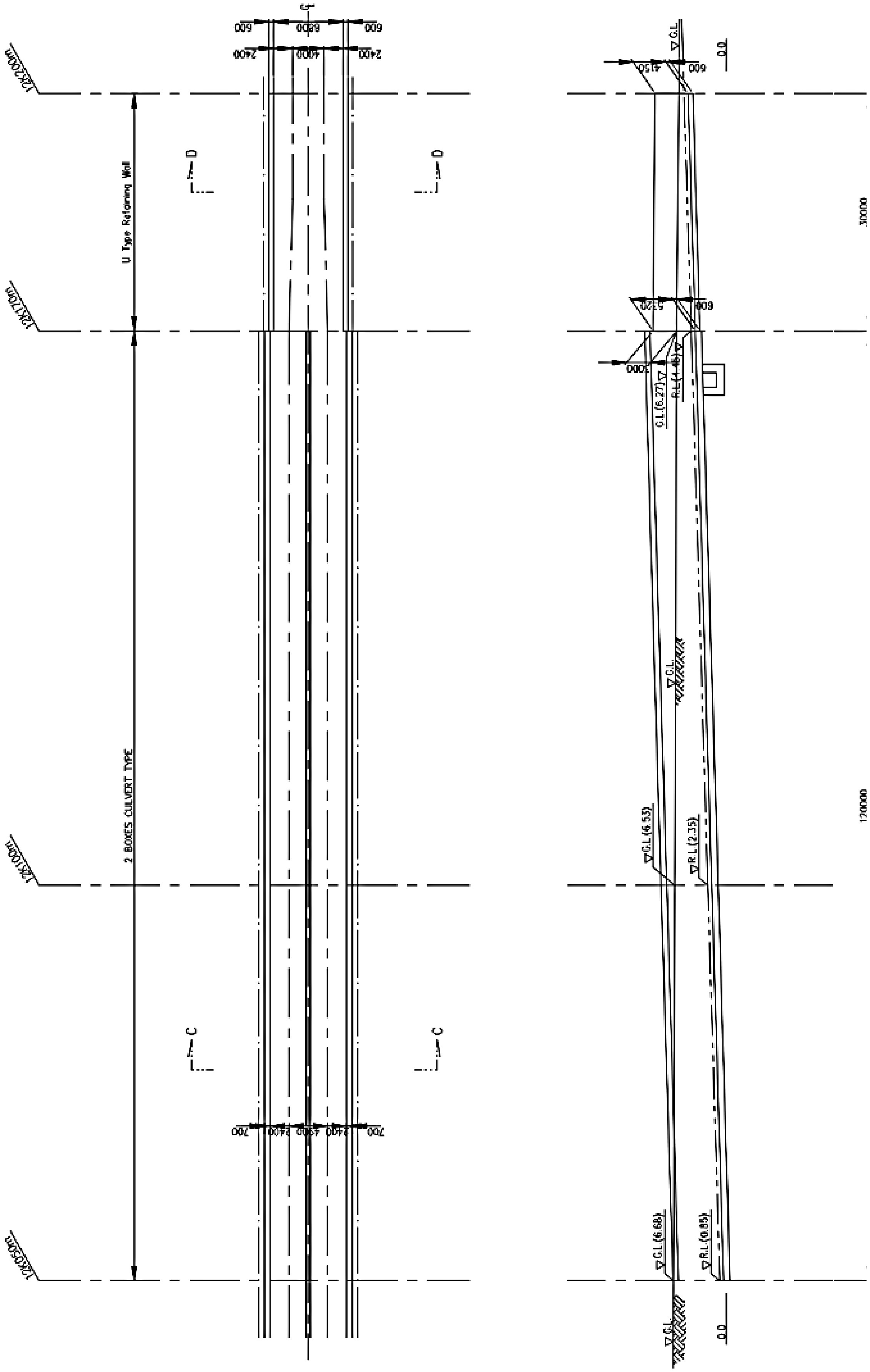
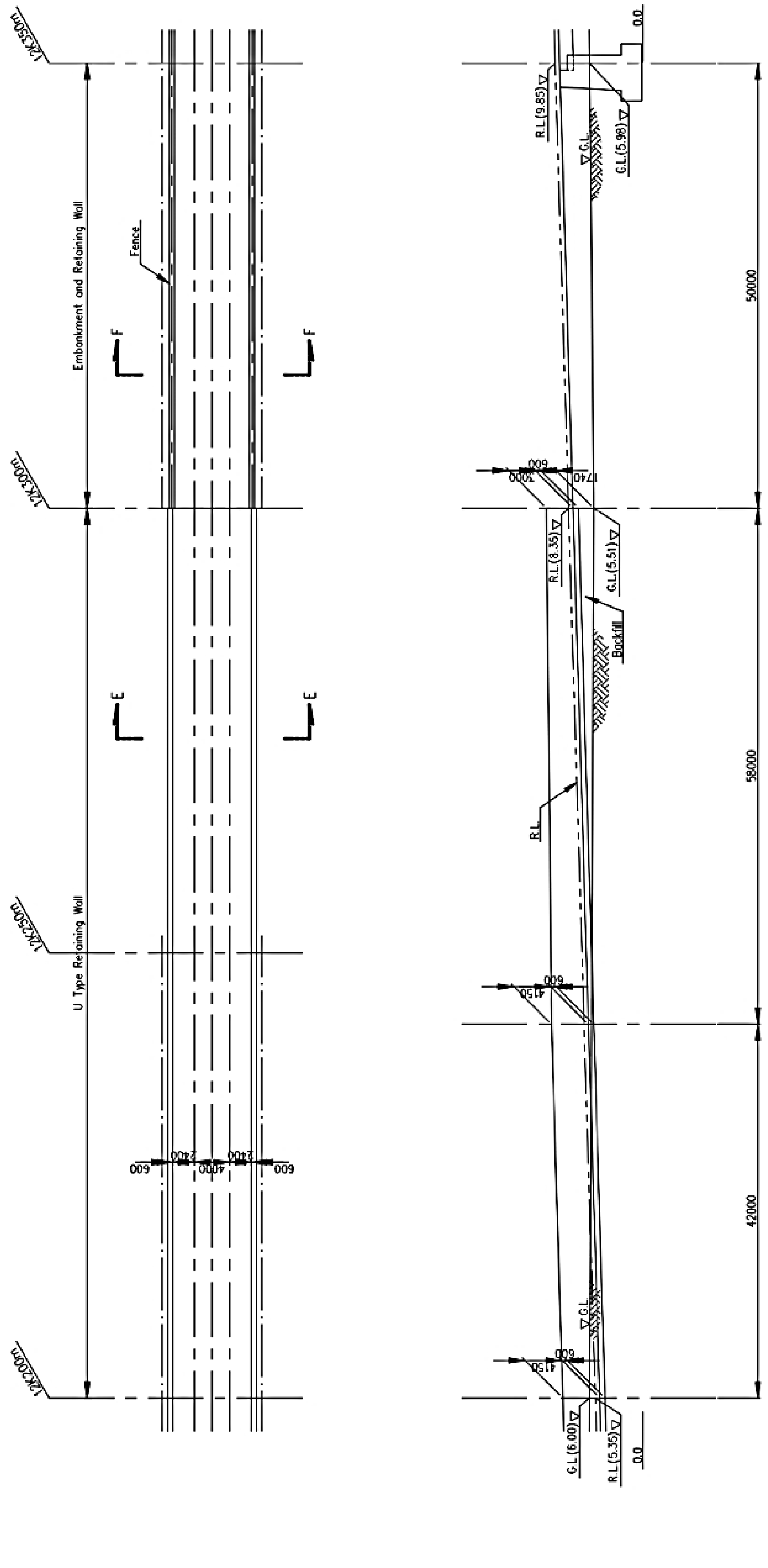
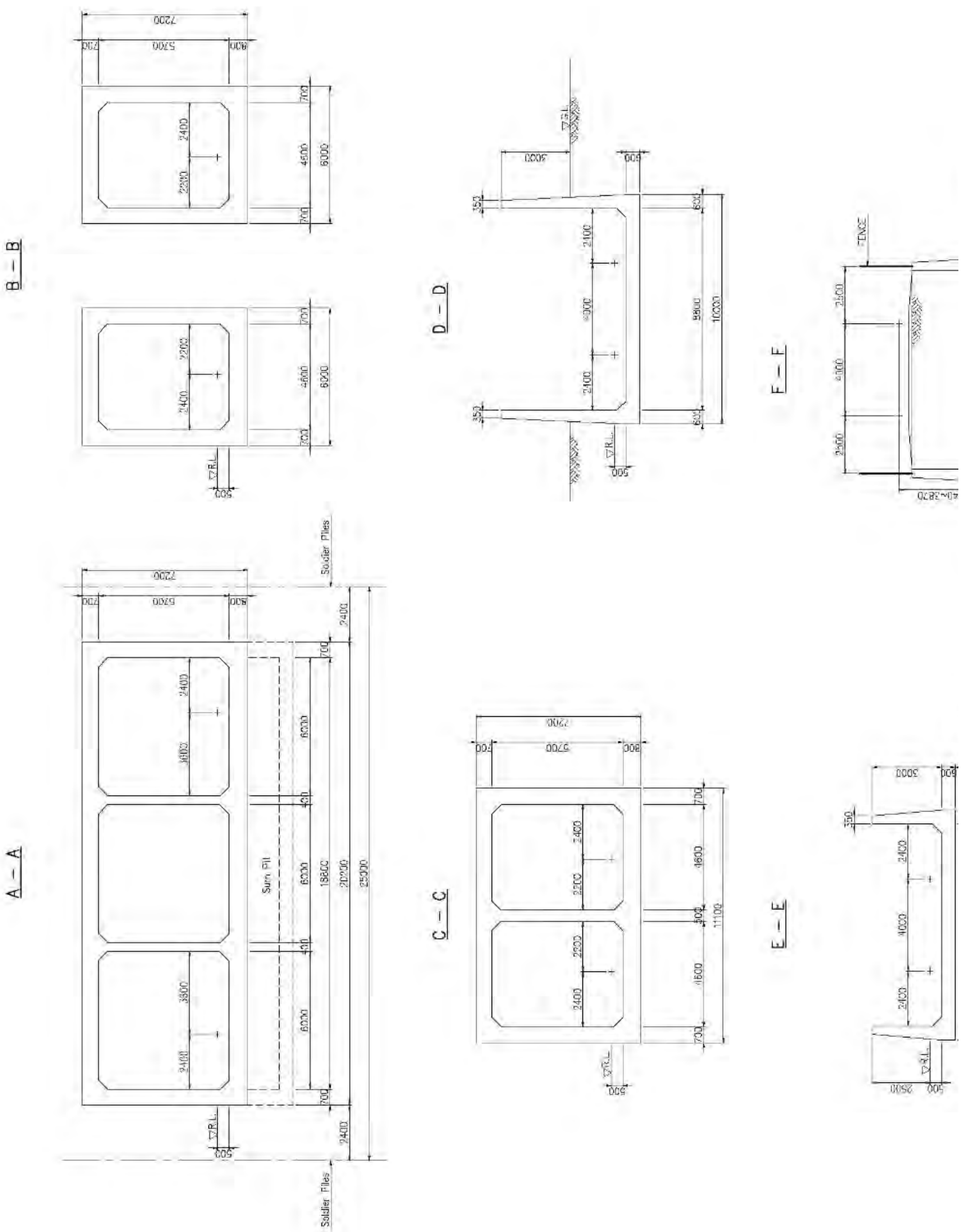


Figure 4.5.27 Plan and Profile at Transition Between Future Park Station - Bashundhara Station (2)



Source: JICA Study Team

Figure 4.5.27 Plan and Profile at Transition Between Future Park Station - Bashundhara Station (3)



Source: JICA Study Team

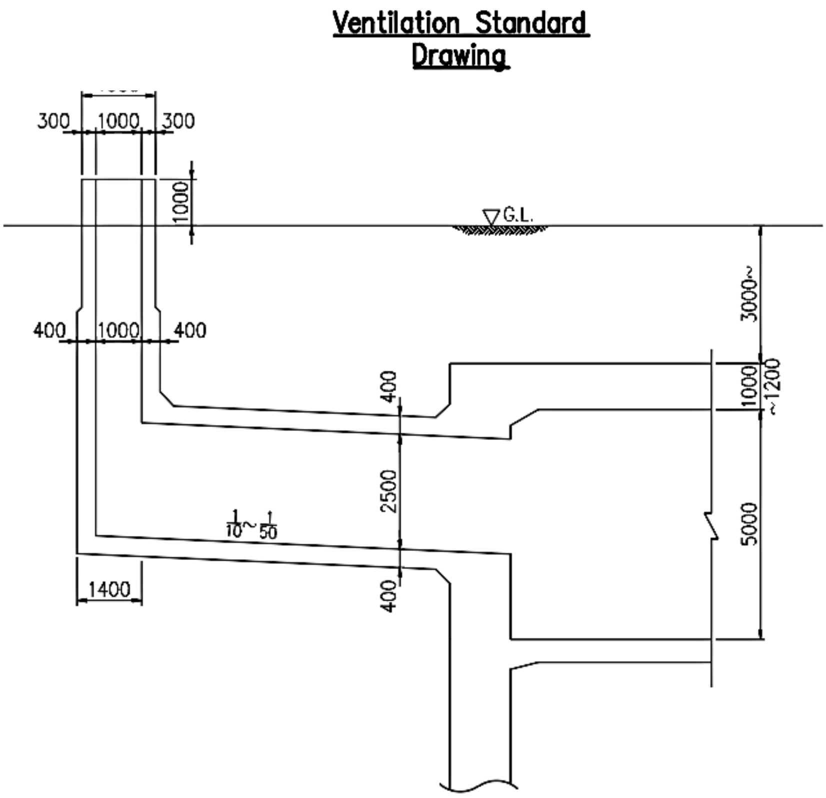
Figure 4.5.28 Cross Section of Transit between Future Park Station - Bashundhara Station

(6) Ventilation of Underground Station

In Japan a ventilation shaft is attached to an access/exit staircase, like what is shown in the photograph below, on the pedestrian passageway; but the street on which MRT Line 1 runs is not wide enough. JST looked for land where the ventilation tower shall be built.

Source: JICA Study Team

Figure 4.5.29 Ventilation Tower attached to Entrance



Source: JICA Study Team

Figure 4.5.30 Ventilation Duct and Tower

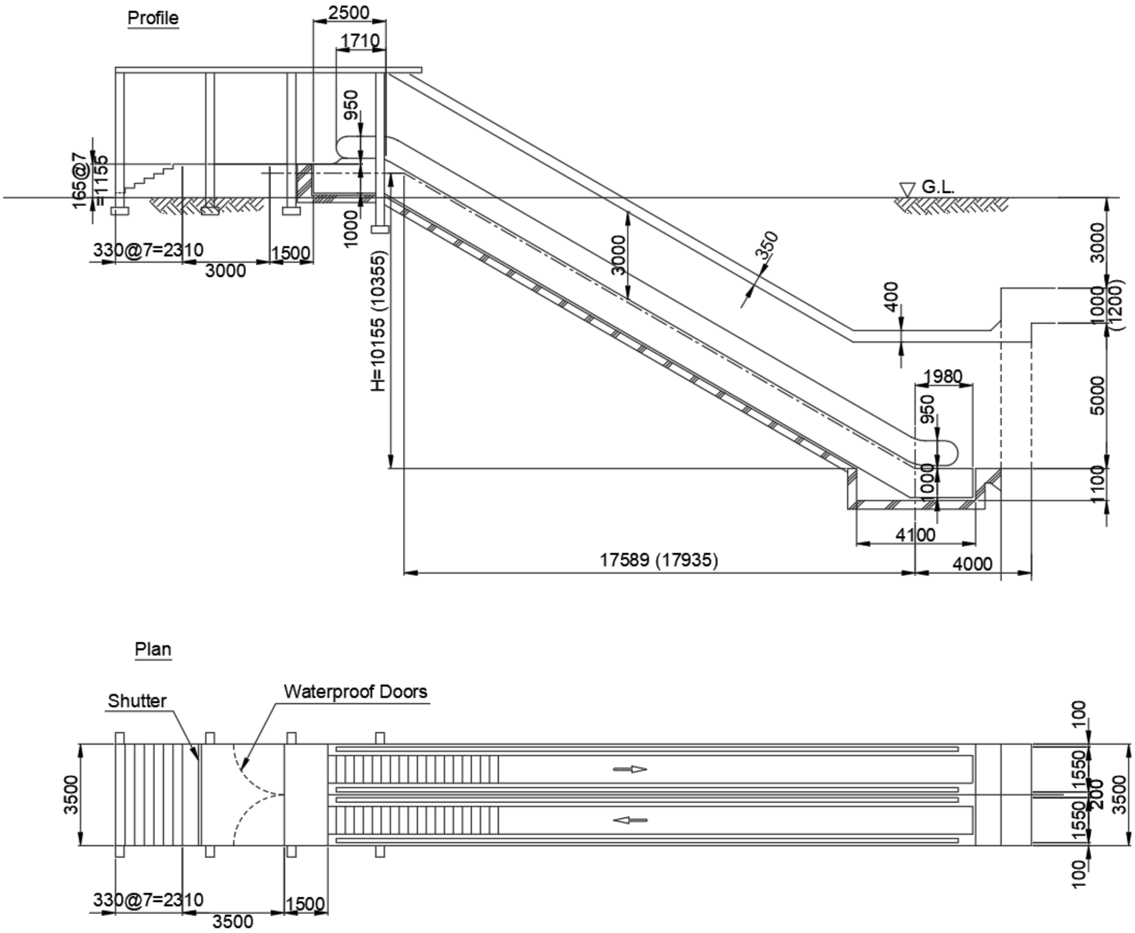
(7) Entrance

Entrances are provided on pedestrian passageways or to adjacent buildings according to site conditions. All entrances will be provided with elevators, and escalators will be installed, at least one per direction. But according to the site survey, it is not easy to provide both an elevator and escalator. Further study shall be made.

The following figure is an example of an entrance in Tokyo Subway.

Source: JICA Study Team

Figure 4.5.31 Entrance at Pedestrian Passageway



Source: JICA Study Team

Figure 4.5.32 Escalator Detail

(8) Connection with BR Kamalapur St.

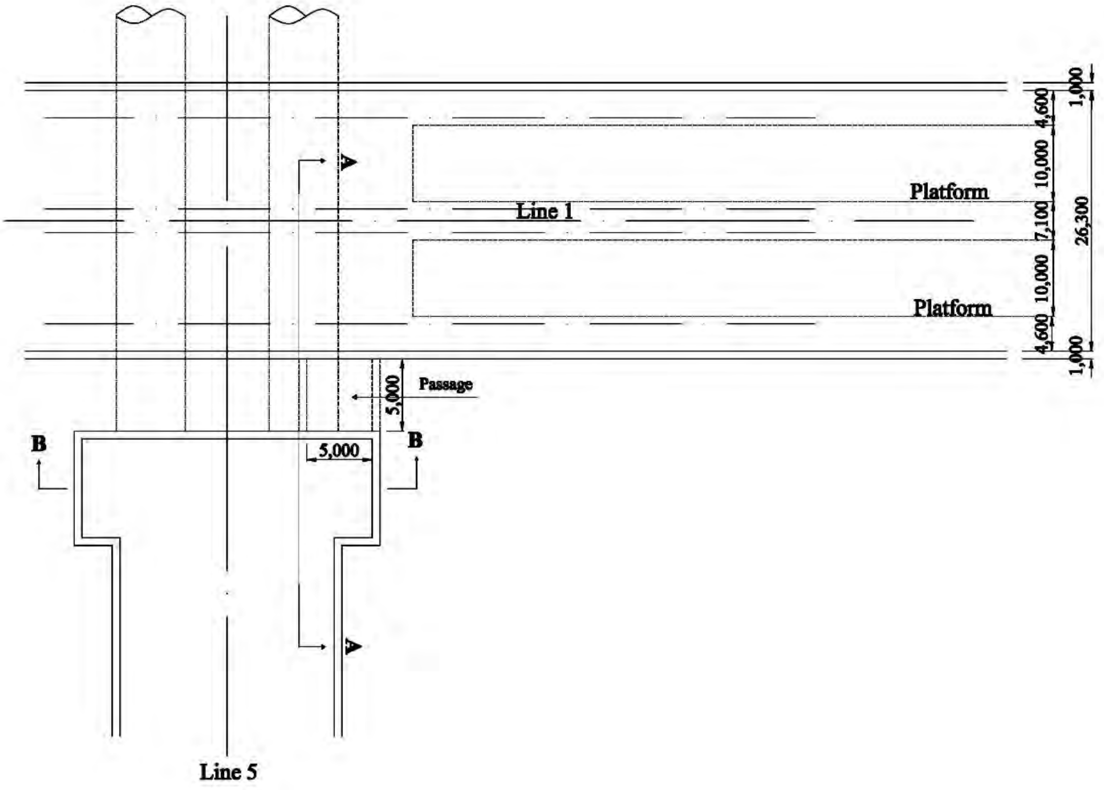
A special facility for transfer passengers is not considered. The present distance between the BR Main Entrance and MRT Line 1 entrance is some 50m. Passengers are requested to walk to shift to car mode on the ground level. The present green area in front of BR Regional Management Building may be developed as a multi-hub terminal, a transferring park in which other modes are available such as buses, taxis and rickshaws.

(9) Connection with MRT Line 5

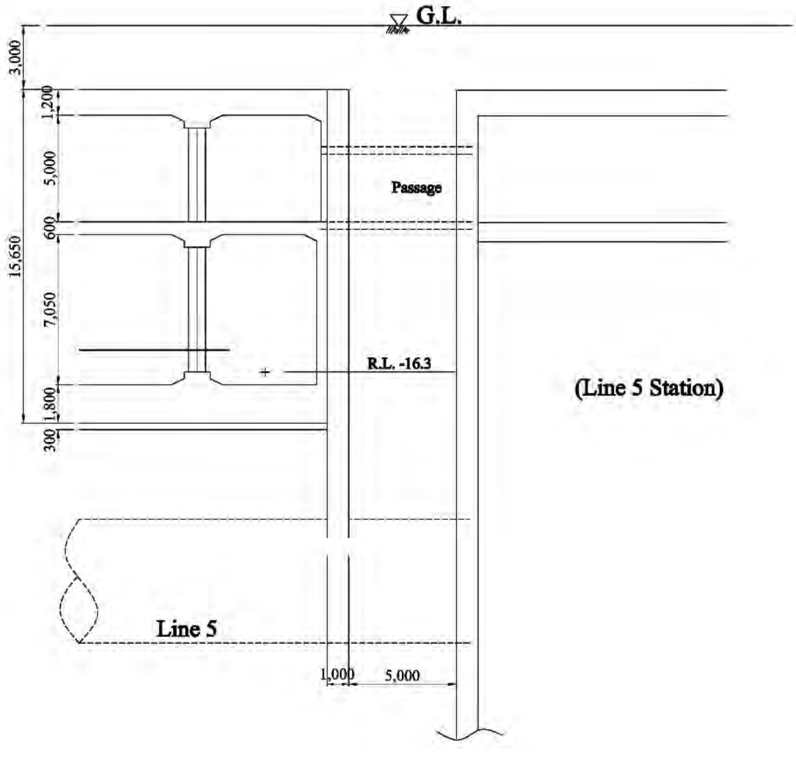
MRT Line 5 runs under MRT Line 1 at Notun Bazar. Underground passage will be provided. The passageway has a width of 5m and a height of 3m connecting the concourses to each other. The passageway shall be constructed with sheet piling system. At present, when writing this report, Line 1 shall be first built, and Line 5 may follow. Therefore, the passageway shall be built in the Line 5 Construction project. Design of MRT Line 1 shall be implemented in considering the connection with the MRT Line 5.

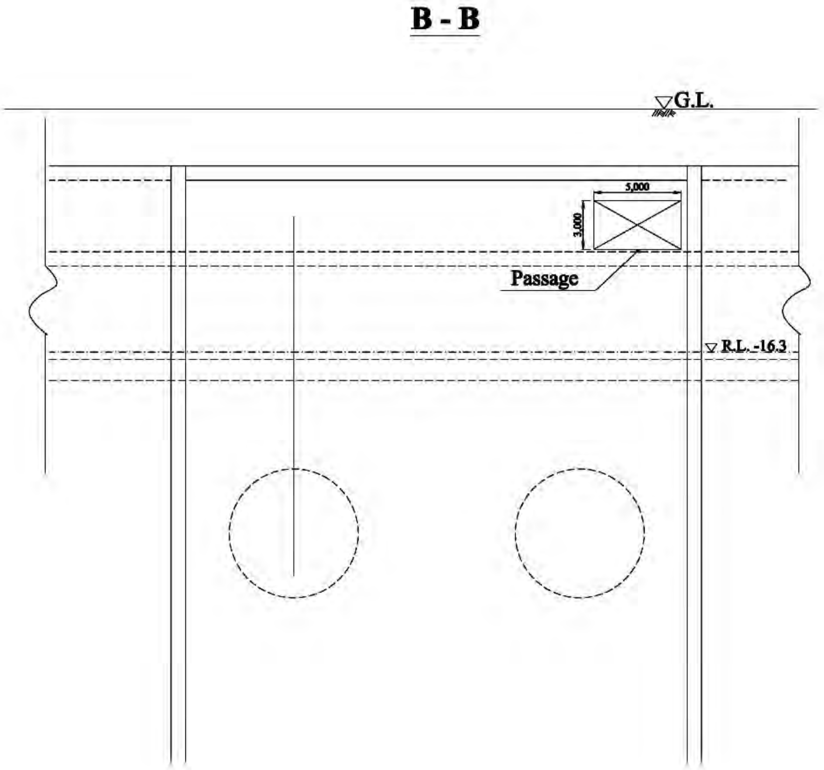
The locations and sizes of the passageways are shown in the figures below.

Passengers can transfer from/to line 1 and 5 by the passageway which connects at B1 concourse.


1,000
4,600
10,000
7,100
10,000
4,600
1,000
26,300
Platform
Line 1
Platform
A
A
Passage
5,000
B
B
5,000
Line 5

A-A


G.L.
3,000
1,200
5,000
600
15,650
7,050
1,800
300
Passage
R.L. -16.3
(Line 5 Station)
Line 5
1,000
5,000



Source: JICA Study Team

Figure 4.5.33 General Layout of Passageway, Lines 1 & 5

(10) Connection with BR Airport Station

There is no special facility to connect MRT Line 1 and BR except an entrance in front of BR Airport Station.

(11) Flooding Prevention and Dewatering Plan

There should be flooding countermeasures in the design of the station building. Particularly, leakage from the river bed into the tunnel needs to be carefully managed so that the back-filling mortar is sufficiently covering the segment. Furthermore, covering the wall with a waterproof sheet should be considered.

Stations are expected to be flooded in five places: (1) station exits; (2) ventilation openings/ventilation towers; (3) entrances of tunnel; (4) river bottoms; and HatirJheel Station. Measures for (1) is to install a water stop panel or a waterproof gate at station exit. Measures for (2) is to equip the ventilation opening on ground level with a flood detector, resulting in automatic closing at rainfall time. Openings of ventilation towers for mechanical ventilation are installed high. Measures for (3) is to design a retaining wall in transition section from underground to viaduct that is long enough to prevent surrounding water from flowing into track. Rainfall in tracks is pumped out when needed. At present, the entrance of the tunnel (transit) is planned to be at PURABACHAL RAJUK Road adjacent to the reservoir regulator, and thus water is thought to run to the reservoir. In the case of (5), HatirJheel Station is in the immediate vicinity of Rampura Khal; therefore, it is necessary to consider enough waterproofing. In particular, leakage from the river bed to the tunnel must be carefully managed so that the backfill mortar sufficiently covers the segment. In addition, it is necessary to pay attention to covering the wall with a waterproof sheet so as to prevent leakage into the station.

The following measures can be considered for the facilities: (1) installation of a waterproof door, (2) installation of a camera that constantly monitors the level of the adjustment tank during heavy rain and floods, (3) installation of the pump power supply box at high altitude. Regarding these, capacities, places, numbers, etc., should be considered at the design stage.

Currently the electric current is often cut off. Thus, each station is provided with UPS and generators in order to continue the station operation for about two hours. The UPS/generator capacity makes possible the distribution of necessary power to continue air ventilations, emergency lights, illuminations, and station operation.

Daily station operation causes sewage water discharge from toilets and from cleaning. Generally, the sewage facility has to be designed based on regulations of sewage in Bangladesh. If the regulation does not exist, the Japanese design standard is applied after discussion with the client. The water volume used in toilets is calculated as the estimated number of passengers and then the septic tanks corresponding to the volume are planned. In Japan the sewage treatment capacity is high enough to run the sewage water directly to the public sewerage system; however, it is judged based on survey in Bangladesh whether the same method is applied or not. In detail, at the first existing network of sewage system shall be investigated, the purpose of the existing system i.e., only for rainfall water treatment or sewage water also being treated. And national standards, low and regulation and also practice for sewage shall be studied. Furthermore, the diameter of exiting pipes, and the capacity of the treatment plan.

According to subway construction projects in Southeast Asia in recent years, the sewage water discharged from toilets is designed to be separated from household sewage drainage, stored in pit under platform floor, pumped up, run through septic tanks installed on ground and finally run into public sewage. Sewage water discharged from cleaning, toilet sinks or kitchens runs to household sewage after confirming that its biochemical oxygen demand (BOD) is less than the amount regulated by law in Bangladesh. For example, BOD is regulated as less than or equal to 30 PPM in subway projects of Jakarta, Hanoi and Ho Chi Minh City but 50 PPM in elevated railways of Manila.

(12) Barrier Free Design

It is important that handicapped persons, the elderly, etc., are to be taken into account in station design. As a normal practice, a barrier free design and universal design are widely adopted in Railway Station Design (refer to section 4.6.16, Detailed Barrier Free Design).

In order to keep uniformity with MRT Line 6, which is an ongoing project, the same philosophy should be utilized. However, MRT Line 6 is an elevated railway system while Line 1 has underground segments. In designing underground stations, special attention to the handicapped people should be paid. Especially, an emergency manual tailor-made for this purpose should be prepared. Persons who cannot read shall be assisted using pictorial symbols and signage, especially for the escape route.

Furthermore, with regard to passenger safety and security, the MRT management and consultant shall plan for emergencies and conduct drills prior to service opening.

(13) Disaster Prevention Plan

a. Comparison between Article 29 of MLIT and NFPA 130

In Japan underground railway system design is implemented according to "Article 29 of Ministerial Ordinance of the Ministry of Land Infrastructure, Transport and Tourism" (hereinafter referred to as "Article 29 of MLIT). In this section, it is described about "NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail (hereinafter referred to as "NAPA 130") issued by National Fire Protection Association (NFPA)comparing with Article 29 of MLIT, which is widely adopted in Metros in South and South East Asia such as India, Thailand, Singapore and Vietnam etc.

The main differences between Article 29 of MLIT and NFPA 130 are summarized in the following table.

Table 4.5.4 Comparison between Article 29 of MLIT and NFPA130

Items	Article 29 of MLITI	NFPA 130, 2017 Edition
Tunnel section at between stations	Tunnel is not used for evacuation passage of passengers except for emergency case.	Tunnel can be used for evacuation passage of passengers.
Fire control at between stations	Generally, train made of non-combustible material runs to next station.	It specifies evacuation method for passengers in case of tunnel fire to evacuate to outside of the burned tunnel on foot based on the concept that train has the potential to burn.
Tunnel structure	No requirement for cross passageways for twin bores and no requirement for fire walls for double line-single bore	-Cross passageways at 244m maximum interval are installed for twin bores having station distance is more than 762m. - A minimum 2-hr rated fire walls are installed for double line-single bore.
Emergency exit signs	Mention	No mention
Smoke control equipment	It is required to install smoke control equipment except that sufficient flue gas is expected by natural ventilation opening. It can be used for mechanical ventilation equipment.	-A mechanical emergency ventilation system is installed to make provisions for the protection of passengers, employees, and emergency personnel from fire and smoke during a fire emergency. -An engineering analysis to determine the need for the mechanical emergency ventilation system is conducted where the length of the underground is greater than 61m.
Emergency facility design	• It is divided into an ordinary fire and a large fire (arson with 4 litres of gasoline). • In case of an ordinary fire at platform level, smoke density Cs shall be less than 0.1 (1/m). • In case of an ordinary fire at platform level, smoke diffusion volume shall be greater than the value derived from the evacuation time. • In case of a larger fire at platform and concourse levels, evacuation time shall be less than smoke descending time that is time for smoke descending to 2.0 (m) higher of the floor.	• The platform occupant load is specified. • Platform Evacuation Time: It is designed for sufficient egress capacity to evacuate the platform occupant load from the station platform in 4 minutes or less. • Evacuation Time to a Point of Safety: The station is designed to permit evacuation from the most remote point on the platform to a point of safety in 6 minutes or less. • Travel Distance: The maximum travel distance on the platform to a point at which a means of egress route leaves the platform is not exceed 100 m.

Source: Summarized by study team based on Article 29 of MLIT and NFPA130 2017 edition

Design philosophies for both standards are vastly different as mentioned the above table. While Article 29 of MLIT specifies rolling stocks to be made of non-combustible material and basically the tunnel between stations is not permitted to use for evacuation passage, NFPA130 allows to use the tunnel as evacuation passage considering possibility of burns.

Therefore, although Article 29 of MLIT does not specify for cross passageways for twin bores, NFPA130 stipulates cross passageways at 244m maximum interval for twin bores where station distance is more than 762m. The presence of cross passageways is often focused on as a difference for both standards.

b. Cross passageways specified by NFPA 130

NFPA 130 was often revised and details of cross passageways were also revised following the revisions as shown in Table 4.5.5, Figure 4.5.34 and Figure 4.5.35.

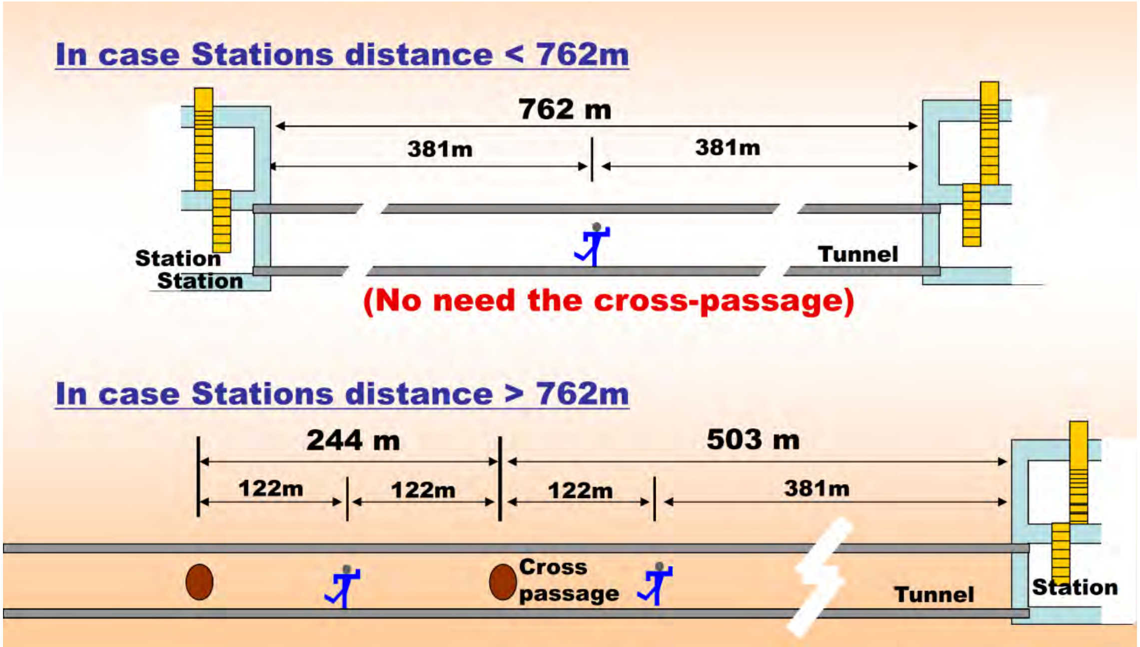
In more details, in 2007 edition, cross passageways were specified as "cross passageways shall not be farther than 244 m from the station or portal of the enclosed trainway.", meaning it became restrictive compared to the previous revision.

However, the details of cross passageways have not been revised since the above revision.

Table 4.5.5 Standards for Emergency Exit for Underground Trainways by NFPA 130

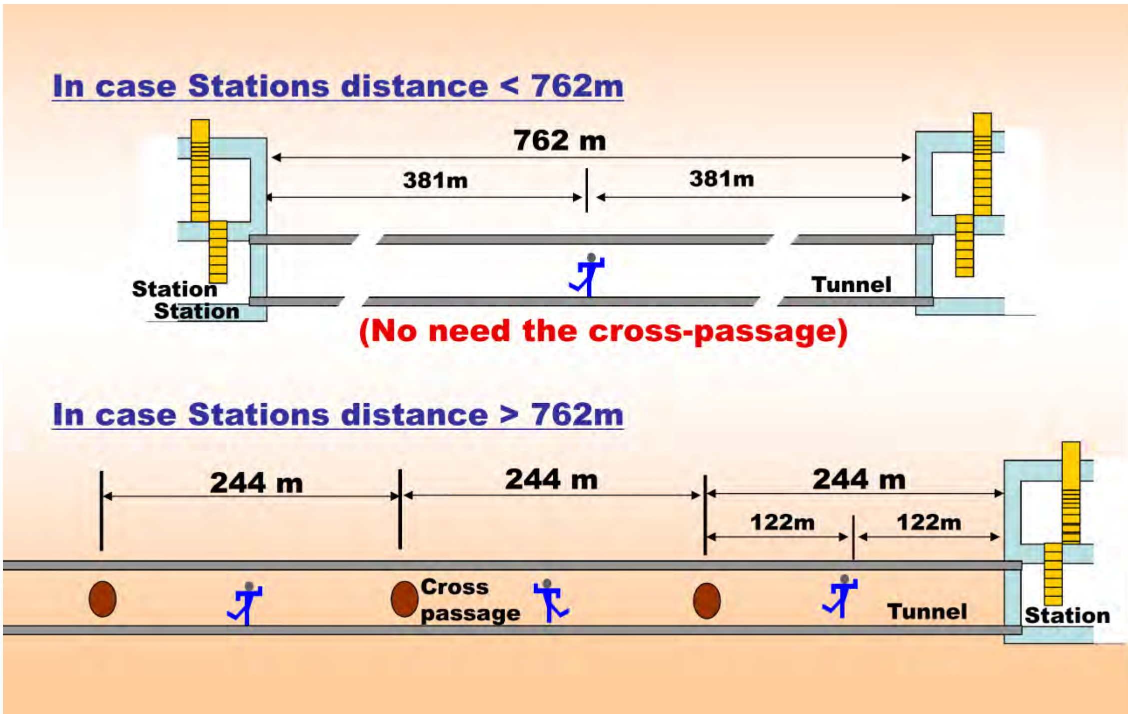
	Emergency Exit Details	Cross passageways utilized for emergency exit
1997 edition 2000 edition	3.2.4.2 Distance to an emergency exit <381m	3.2.4.3 Cross passageways <244m apart
2003 edition	3.2.4.2 Maximum distance between exits <762m	3.2.4.3 Cross passageways <244m apart
2007 edition 2010 edition	6.2.2.2.1 Maximum distance between exits < 762m	6.2.2.3.2(1) Cross passageways < 244m apart 6.2.2.3.2(2) Cross passageways from the statioNotunnel portal <244m
2017 edition	6.3.1.4 Maximum distance between exits < 762m	6.3.1.6 (1) Cross passageways < 244m apart 6.3.1.6 (2) Cross passageways from the statioNotunnel portal <244m

Source: Summarized by study team based on NFPA130 1997, 2000, 2003, 2007, 2010 and 2017 edition



Source: JICA Study team

Figure 4.5.34 NFPA130 1997 Edition



Source: JICA Study team

Figure 4.5.35 NFPA130 2010&2017 Edition

c. Considerations and Recommendations

It is often described differences between Article 29 of MLIT and NFPA130 as just focusing on the presence of cross passageways and concluded that NFPA130 is safer standard compared to Article 29 of MLIT.

However, since NFPA 130 is overall standard for railway fire protection and therefore it is described less information regarding station equipment compared with Article 29 of MLIT.

For instance, it is not mentioned about emergency exit signs and less information for smoke control equipment, although Article 29 of MLIT describes details of these issues.

It should be noted again that both standards are different design philosophies as mentioned in (1) Comparison between Article 29 of MLIT and NFPA 130. Hence, it should be discussed which standard is adopted considering whole railway system including rolling stocks not focusing on specific items and discuss which standard is superior or safer.

This study recommends adopting excellent Japanese railway system. Therefore, it is highly recommended using the standard for railway fire protection by Article 29 of MLIT.

(14) Water Main Project along Prangai Sharani

The Project for a New Water Supply Network, consisting of a 1.4 m diameter pipe, along Prangai Sharani is progressing. Tunneling by TBM may not affect the pipe because the TBM run 8 – 10m below the ground level. On the other hand, station boxes will be made 3 m below the ground surface. In the Basic Design stage discussion with WASA regarding the exact pipe location, size, material and protection method shall be held. The agreed protection method shall be specified in the Bidding document.

3) Construction Methodology

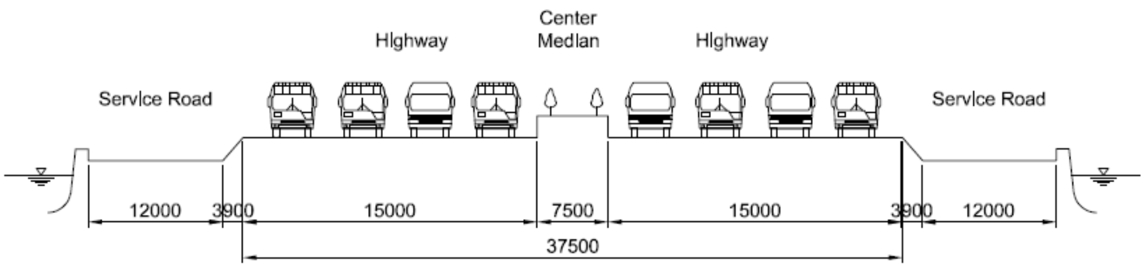
(1) Elevated Section

a. Piling and Substructure

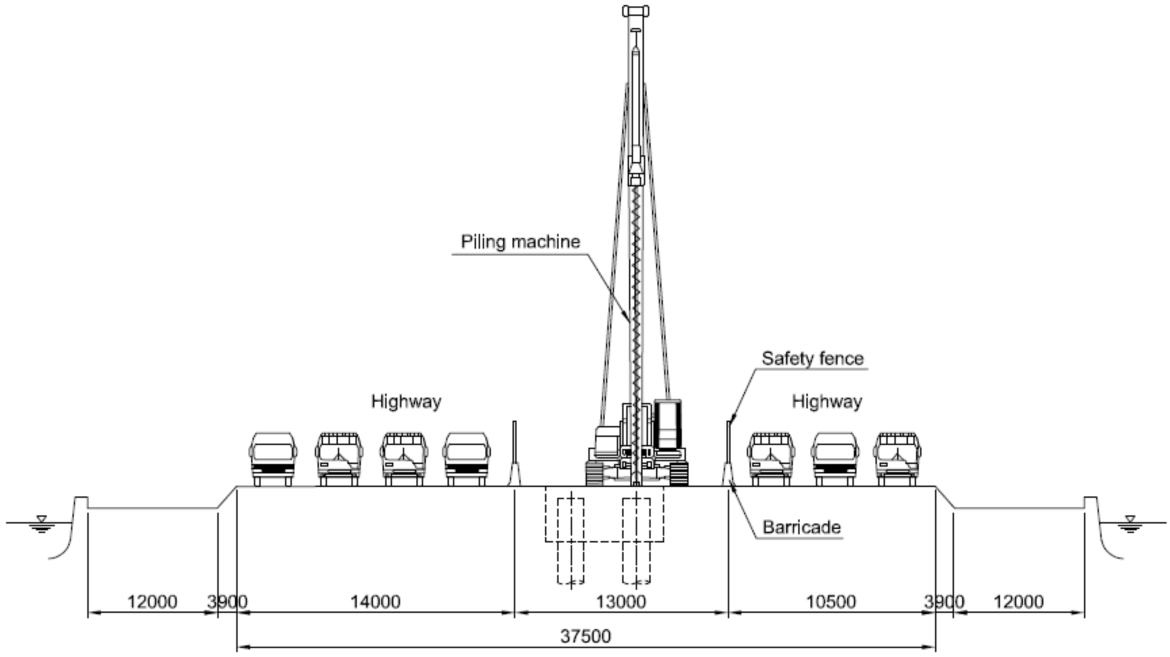
As discussed in section 4.5.1 1, Purbachal Road, which is 70m wide, contains a canal at both sides of the road. It is assumed that when viaduct construction starts, Purbachal Road will have been completed.

Since the viaduct is constructed at the centre of Purbachal Road, the lanes at each side are reduced by one during construction as shown in Figure 4.5.36.

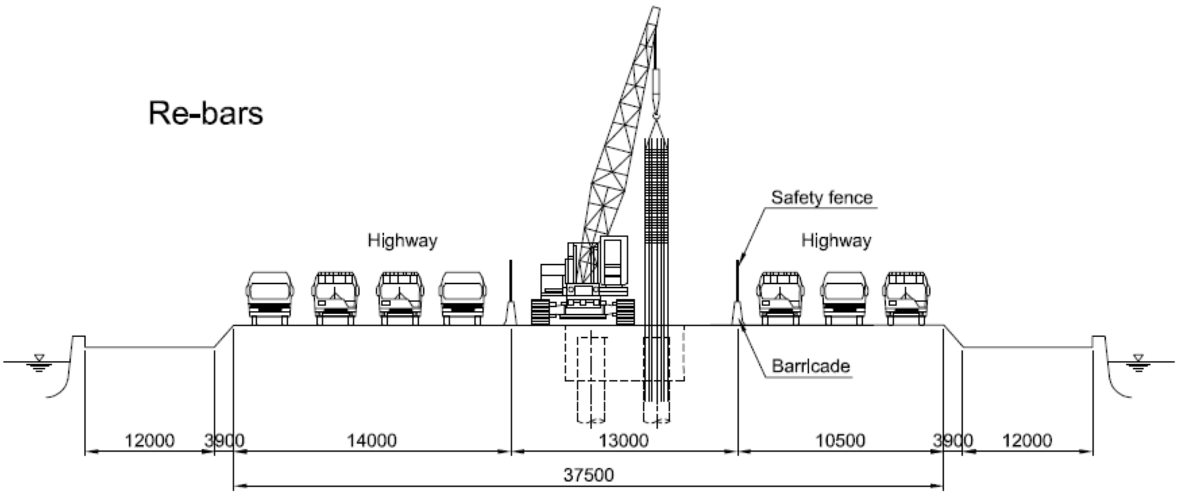
(a) Present



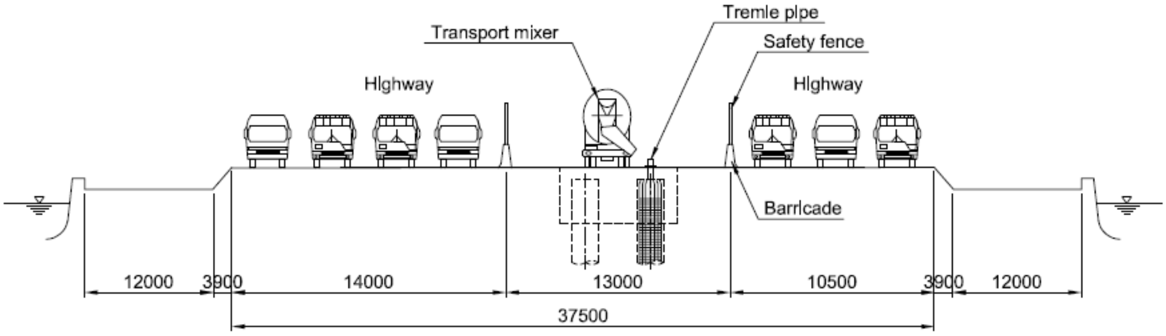
(b) Piling excavation works



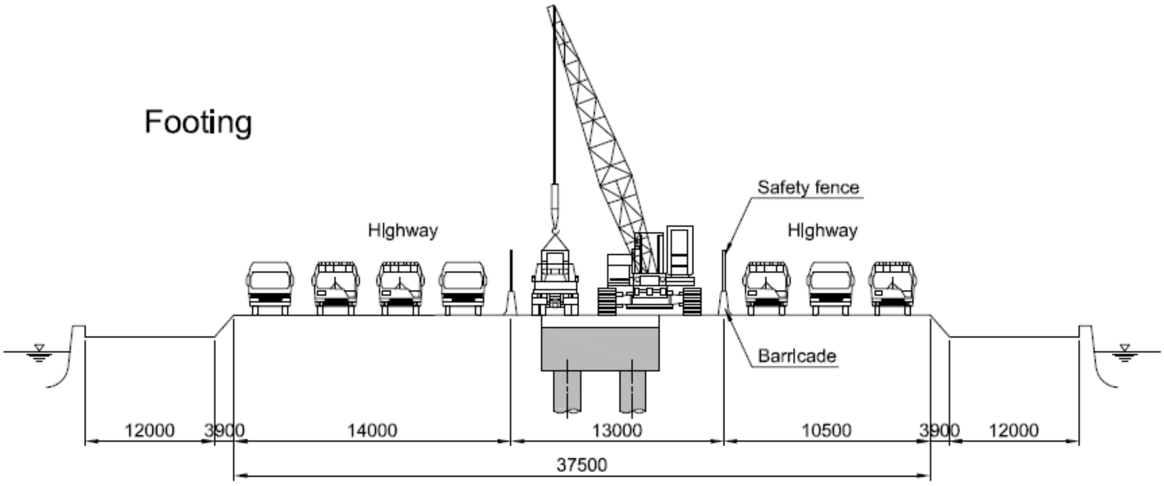
(c) Basket of Reinforcement put into hole



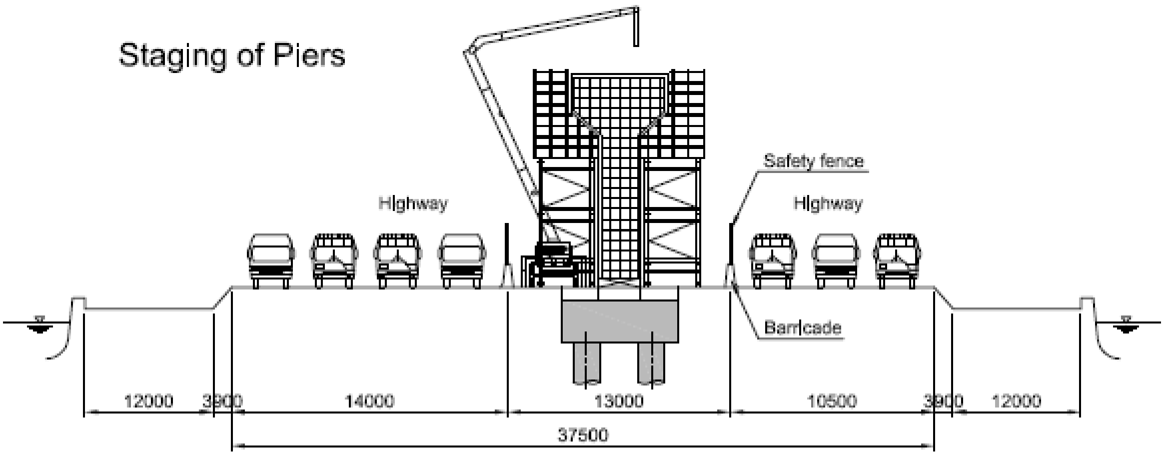
(d) Concrete Casting



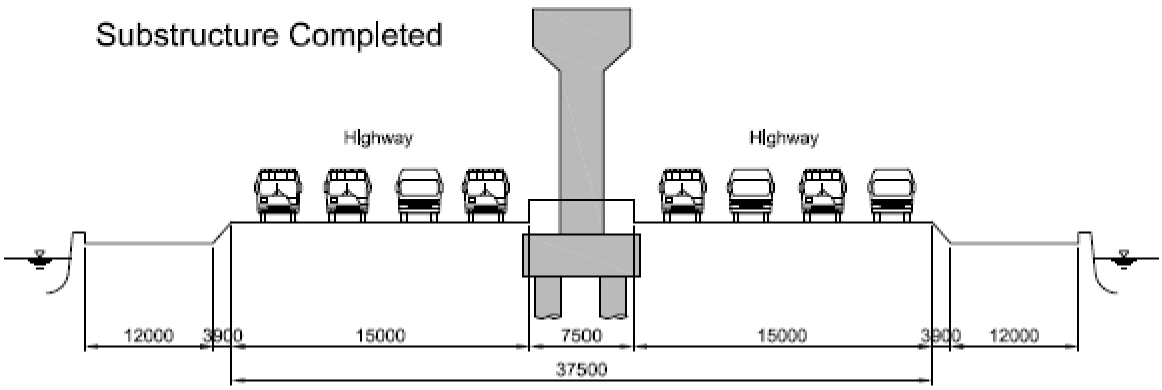
(e) Staging for column construction



(f) Casting Concrete to Substructure



(g) Completion of Substructure



Source: JICA Study Team

Figure 4.5.36 Piling Foundation and Substructure Construction

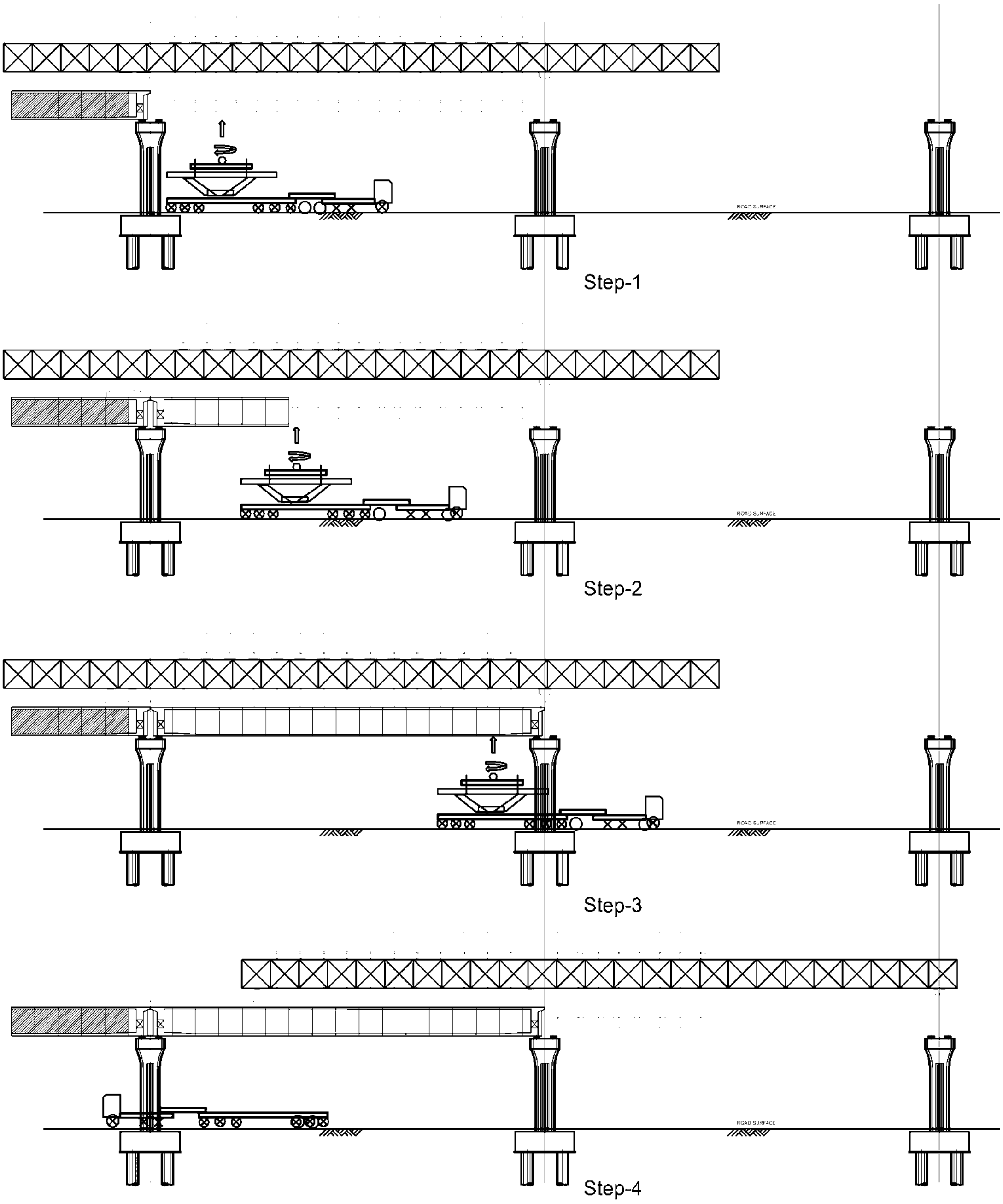
b. Superstructure

For minimizing the impact on surrounding traffic, it is preferable to apply a span by span construction method same as MRT Line 6. This is a construction method in which a precast block manufactured by a segment yard is lifted from the road by erection girder, installed in a predetermined position above the ground, and tensioned by a PC cable to be integrated. Construction and tension work is carried out in the air, so it is possible to minimize the construction yard on the road. In order to minimize the impact on existing traffic, it is desirable to transport the precast block to the site at night time. It is preferable to establish Girder Fabrication Yard near to construction site in order to minimize transportation. Fortunately, Purbachal Line will be built on the Purbachal Road which locates developing area, it is expected to find the fabrication site near such road.

The construction procedure is as shown below.

Source: http://www.fujips.co.jp/results/r-bridge/sub21090/2072

Figure 4.5.37 The Span by Span Method Girder Erection



Step 1 : Erection Girder (EG) is in position. 1st precast segment (edge segment) is transported by a long trailer from the construction yard and its position should be just under EG. The segment is hanged by suspension cables with EG and turned by 90 degree and is in placing.

Step 2 : 2nd segment also is repeatedly in placing and this segment is pulled and connected to the previous segment after application of epoxy resin to the joint of matched cast segment . This operation should be repeated up to the end of this span.

Step 3 : PC work should start and be complete for connection of all segments for single span girder. The girder should be lowering to the required position and level.

Step 4 : The rear leg of EG should be shifted to the end position of the girder completed and the front leg of EG will be shifted on to the next pier head and EG is in position for next span erection.

Source: JICA Study Team

Figure 4.5.38 Construction Method by Span by Span

(2) Underground Section

a. Cut and Cover Method for Station Box Construction

At the time of writing this report, the available geotechnical data is limited. This Study used the boring data obtained at Kuril. Once all boring survey and laboratory test data becomes available, this construction plan shall be reviewed.

Although SMW as an earth supporting system method has an advantage in economic aspect and construction duration, it requires a larger width, and the resulting noise and vibration from digging machine affects surrounding buildings. JST proposes a diaphragm wall (D-wall) which has enough rigidness. But to stop water from leaking within D-walls, a second wall 50cm thick will be provided. With regard to the procedure of construction, taking into account waterproofing during the operation phase, the open cut method (Bottom-Up Method) shall be applied instead of the Top-Down Method, which was adopted in the Delhi MRT construction. As discussed in 15.2 of chapter 12, JST recommended to adopt the SMW method as earth supporting system to the TBM launching shaft in order to accelerate TBM launching by about one month. The TBM launching shafts are constructed at Kamalapur, Badda (south and north).

The following table compares earth supporting systems.

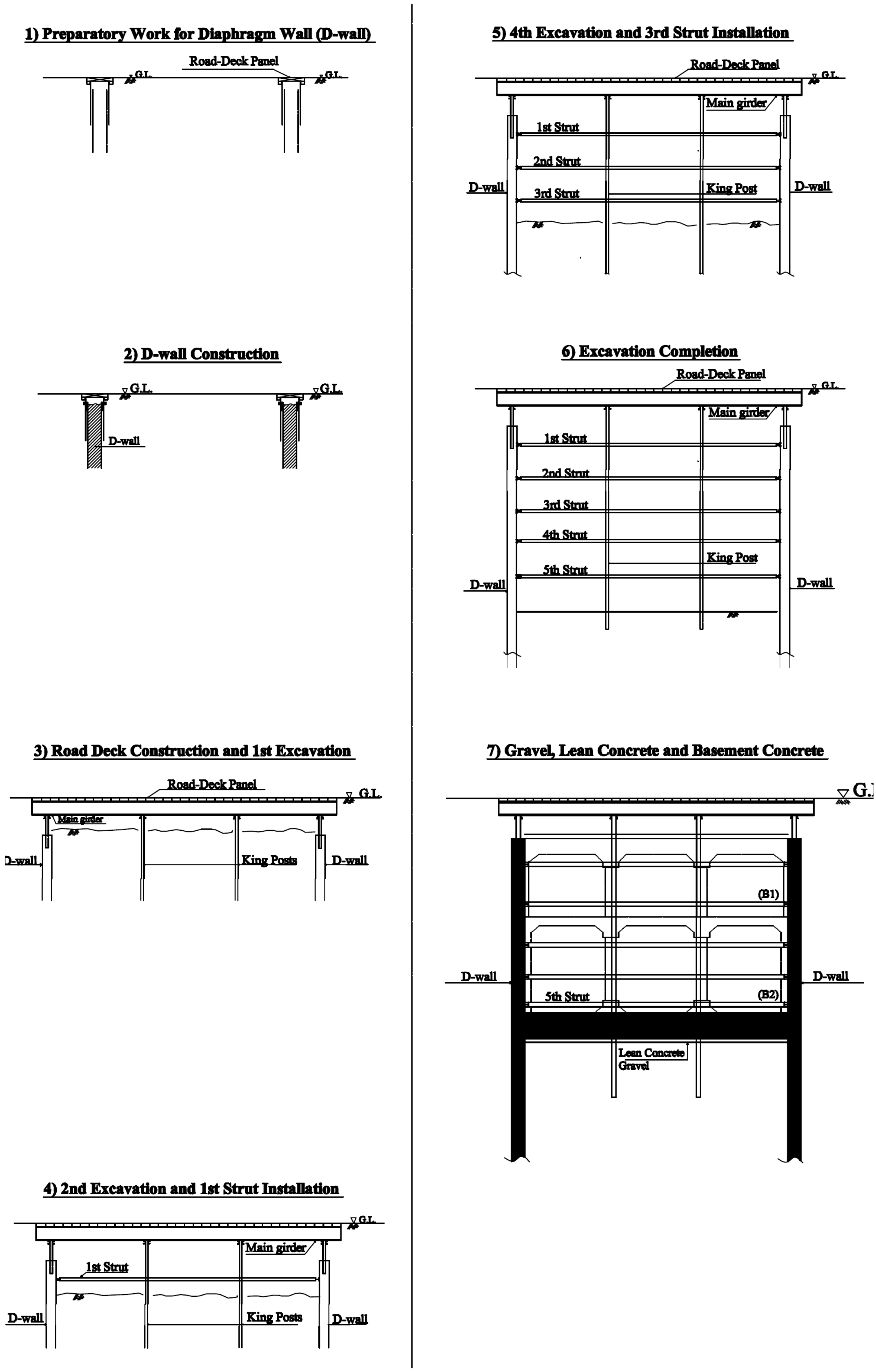
Table 4.5.6 Comparison of Earth Supporting Systems

	RCD-Wall (Stand-alone)	RCD-Wall (Composite)	SMW
Design	**Structure** High rigidness is expected, design as permanent structure	**Structure** High rigidness is expected, design as permanent structure	**Temporary** Low rigidness, not permanent structure
Procedure of Const.	Top-down	Bottom-up	Bottom-up
Advantage	➢ Since the main frame is utilized, steel materials for temporary construction such as short struts and wailings are not necessary. ➢ Since temporary retaining walls are not necessary, sufficient space for utility diversion can be secured. ➢ Road will be opened to road traffic relatively earlier than bottom up method.	➢ Since the main frame is utilized, steel materials for temporary construction such as short struts and wailings are not necessary. ➢ Since second wall is provided within D-wall, leakage water can be prevented ➢ Recover quality that is a concern by inner wall. ➢ Durability of structure is high.	➢ Period for wall construction is relatively short. ➢ Since plant facility is simple and can be moved in accordance with the construction, a separate plant yard is not necessary. ➢ Since construction of permanent structure is done in site, quality is high. ➢ Relatively easy preparation works than D-Wall
Disadvantage	➢ Period for wall construction is relatively long. ➢ Casting concrete into muddy water, quality is a concern. ➢ Since plant facility is large and it is difficult to move during the construction, a separate plant will be necessary. ➢ Against heavy equipment, ground shall be improved by mortar concrete in wide area ➢ For digging the wall, a trench shall be constructed by concrete	➢ Period for wall construction is relatively long. ➢ Since plant facility is large and it is difficult to move during the construction, a separate plant will be necessary. ➢ Against heavy equipment, ground shall be improved by mortar concrete in wide area ➢ For digging the wall, trench shall be constructed by concrete	➢ This technique is very unique and only a special contractor can carry it out ➢ Rigidity is low, affects the surrounding building, or road surface is a concern.

Source: JICA Study Team

There are three types of D-Wall: 1) Stand-alone type, 2) Composition type, and 3) Double Layer Type. Type selection shall be made according to soil condition, depth of excavation, shape and size of structure. This FS is based on the D-wall composition.

The following figure shows the construction procedure.



General practice of construction by Cut – Cover method

Prior to D-wall construction, underground utilities shall be protected or relocated by the owner.

First Step (figure 1 above) Preparation works for D-wall construction; to create working space road diversion is required.

Second Step (Figure 2 above) D-wall construction and drive H-shape steel which supports road deck panel.

Third Step (Figure 3 above) Road diversion and excavation work under deck panels by 1st slut system.

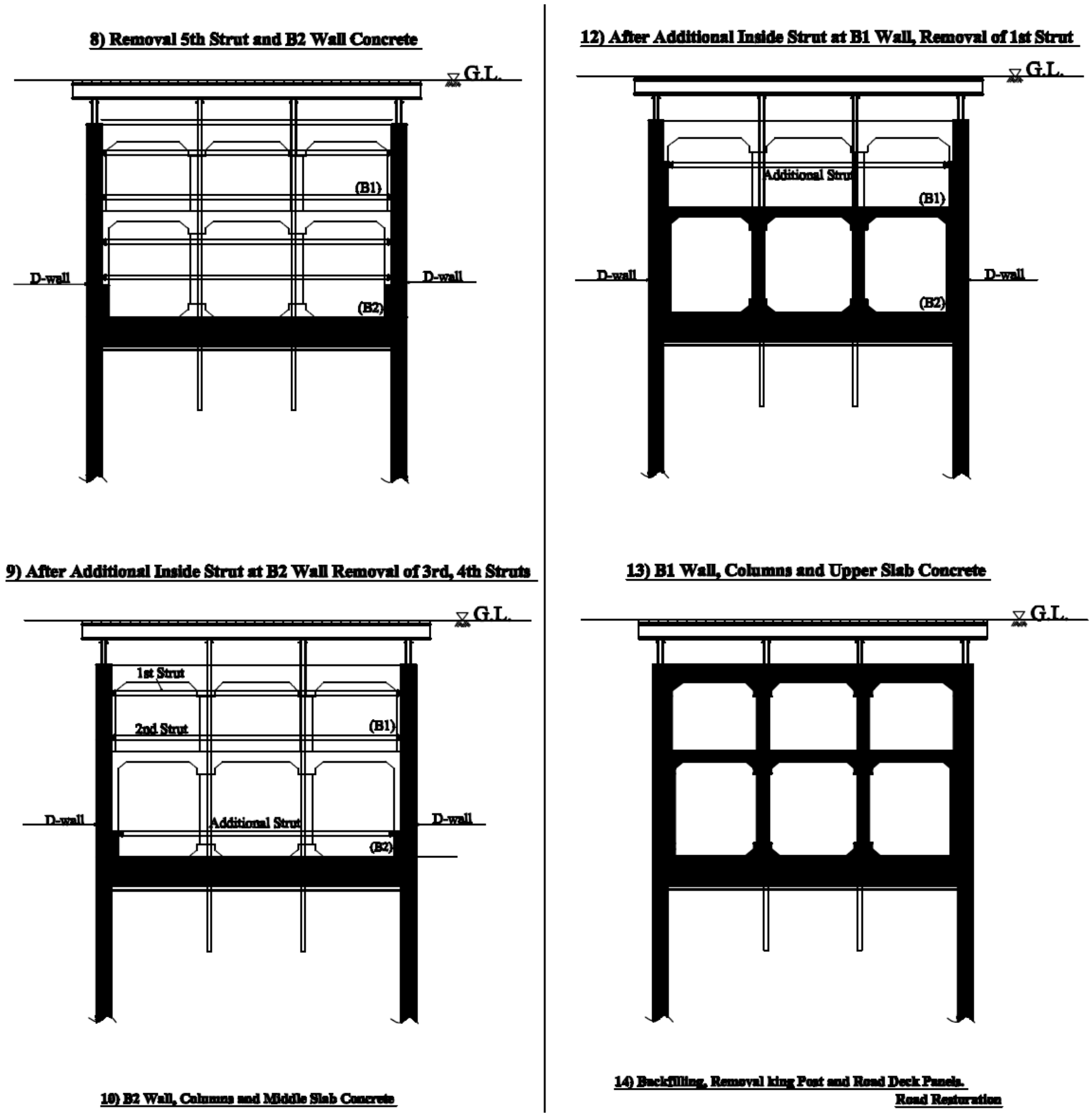
Forth Step (Figure 4 above) Excavation by 2nd slut.

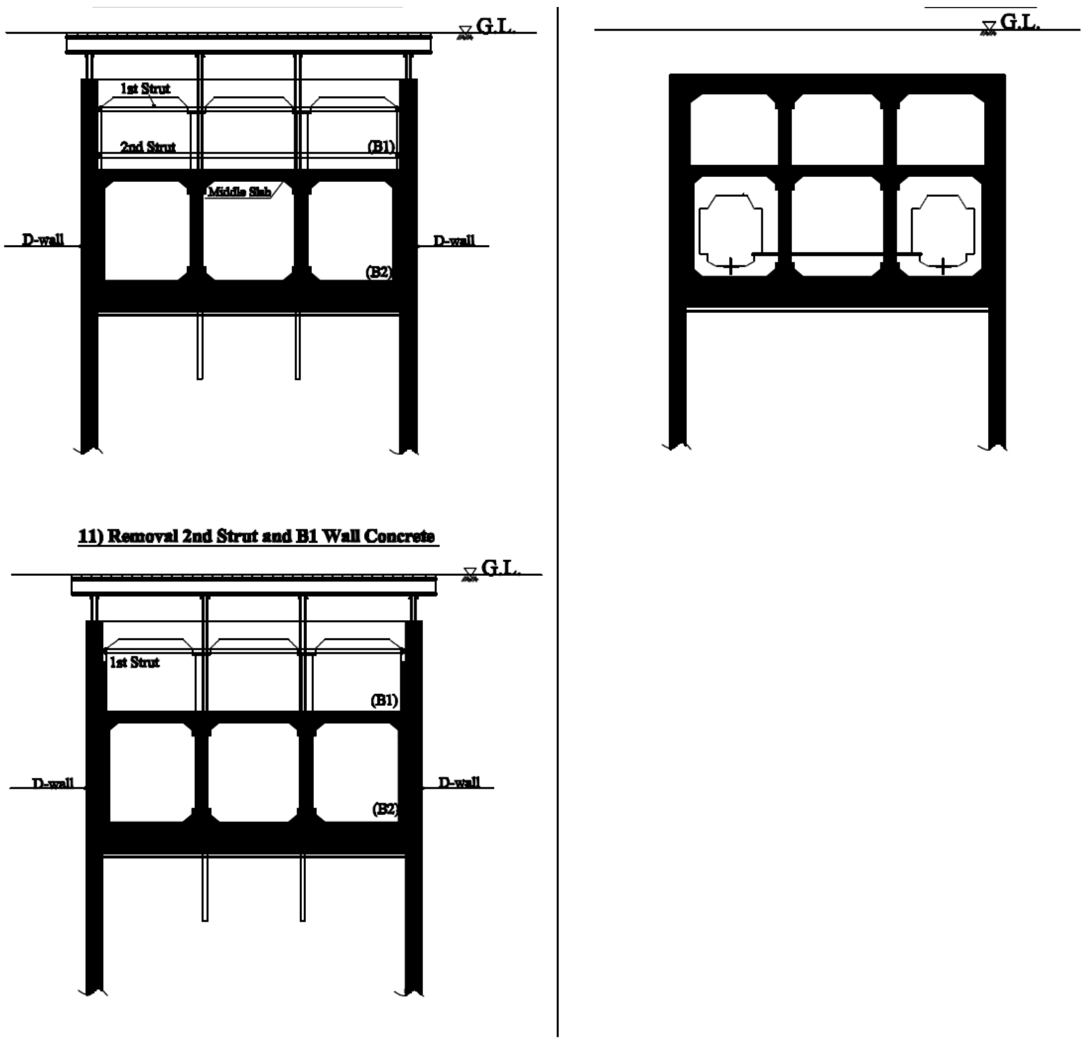
Fifth Step (Figure 5 and 6 above) Excavation by designed bottom depth.

Sixth Step (Figure 7 above) Bottom concrete slab and wall construction.

Seventh Step (Figure 8 - 13 below) Casting concrete to concourse floor slab, and upper slab.

As Step 14 Complete Construction of Station Box.





Source: JICA Study Team

Figure 4.5.39 Proposed Station Box Construction Procedure

Timing of the second wall (inner wall) construction shall be made taking into consideration TBM launching/arrival time. JST proposes as a first priority to give the works of launching shaft construction. Upon completion the TBM launching shaft, TBM shall leave to arrival shaft. Station box shall be constructed with diaphragm which is designed as permanent structures. SMW for TBM launching shaft and diaphragm for station box, there two system for earth support, and result in one-month time-save for construction of tunnel and underground station box. Breakdown of one month, are estimated as follows: 1) 2 – 3 weeks for ground improvement for heavy equipment, 2) 1 – 2 weeks for a concrete trench for D-wall excavation, 3) 1 – week for drilling and concrete casting. But as equipment for SMW is not available in Bangladesh, import from Japan is inevitable. This will result in a construction cost increase. Therefore, in the detail design stage, the designer shall discuss with DMTC.

(a) Malibagh Station

Two shield machines collide at the eastside of the Malibagh Station end. The point of meeting is out of platform. Tunnel construction shall be done successively starting with the lower tunnel and then the upper tunnel to avoid affecting the work cycle in each tunnel. Taking into account the connection between the Station Box and Tunnels, the ductile segment, which would allow separation of the ring, shall be used where the separation is considered.

Soil improvement shall take place after completion of the station box. Upon confirming the ground conditions, from the station box, a beam is inserted into the tunnel, which shall have an inner supporting system. The work of separating the ductile segment and inserting a beam takes the same time. Also, the lower tunnel shall be connected with the station box first, then the upper tunnel.

After connecting the tunnel and station box, platform construction takes place. Detailed analysis is required prior to structural works to ensure safety.

(b) Notun Bazar Station

Tunnelling by 4TBMs starts north of the Notun Bazar Station. According to construction schedule, the intermediate two TBMs are going to launch first aiming at Future Park Station, Level 3; the outside two TBMs work toward Future Park, B2 level. Since the backyard of TBMs is quite large, it is expected to start shaft construction.

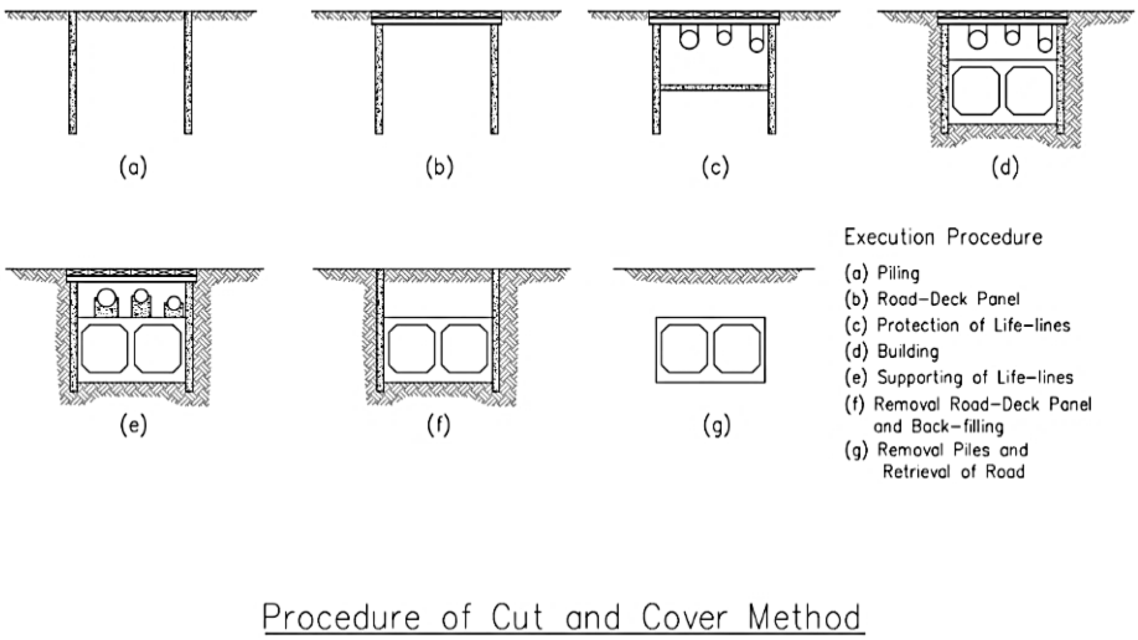
The station box connects at both sides with box culverts where tracks have crossovers. These are built by cut and cover method (refer to Figure 4.5.22).

(c) Future Park Station

After the arrival of two TBMs from the Notun Bazar Station end, B3 upper slab shall be built as soon as possible, and two other TBMs that will arrive shall be put to use for B2 level. From B3 level, TBM shall go to Khilket Underground Station; on the other hand, from B2 level, the two TBMs go forward to the transit provided in PURBACHAL Road. TBMs are pulled up at arrival shaft and then moved to the launching shaft provided at the opposite end of the station.

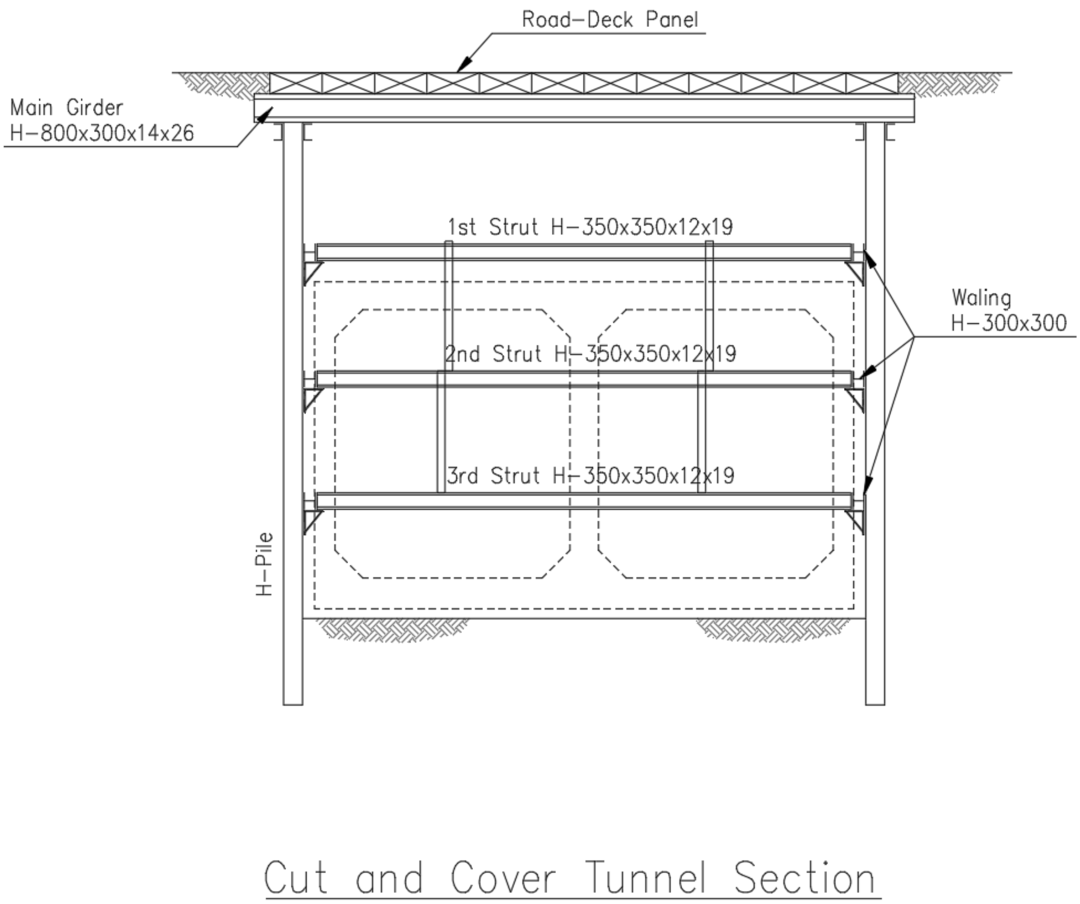
b. Box Culvert at Transit, U- Shaped Retaining Wall

Excavation for the construction of the box culvert and U-shaped retaining wall at transit shall use sheet piling method to support the earth. Between the TBM arriving shaft and the transit box, culverts of several sizes will be built due to track alignment, until finally reaching the U- shaped Retaining Wall which connects with viaducts. At U-shaped Retaining Wall, a dewatering facility is required. Figure 4.5.40 shows the procedure of cut and cover tunnelling.



Source: Sankaido Underground Railway Construction Method (1975)

Figure 4.5.40 Procedure of Cut and Cover Tunnelling



Source: Sankaido Underground Railway Construction Method (1975)

Figure 4.5.41 Cross Section of Cut and Cover Tunnel

c. Shield Tunnelling Method

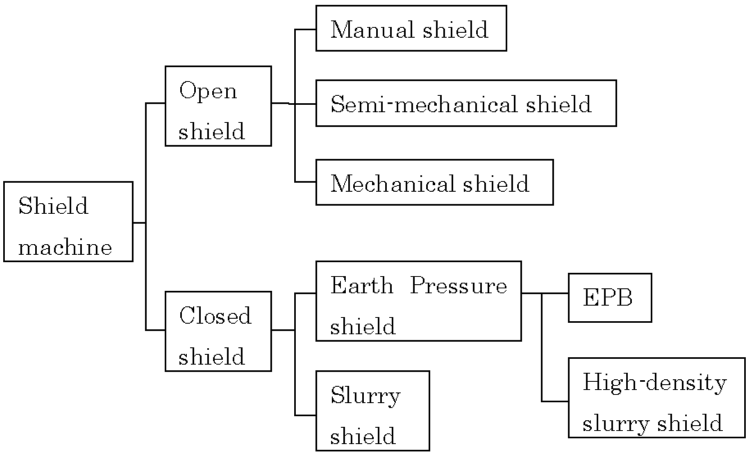
c.1 Selection of Tunnel Machine

MRT Line 1 construction requires highly skilled tunnelling machine operation to pass the circumstance such as existing buildings close to the alignment, parallel TBM arrangement, steep curvature, and passing between piles. The tunnelling machine shall be selected among several types of TBMs according to circumstance. In selecting TBM, priority shall be given to less settlement of ground.

c.2 Kinds of Shield Boring Machines and Selection for MRT Line 1

There are two types of shield machines: one is a closed type shield and the other is an open type shield. The open type shield can be used in the condition where there is no water in the ground and the face can be independently stable. However, this method affects the above ground level, and a slightly bigger settlement is expected. JST cannot recommend this type of shield machine. Studies about the Earth Pressure Shield method and Slurry Shield were compared.

Figure 4.5.42 shows the kinds of shield boring machines.



Source: JICA Study Team

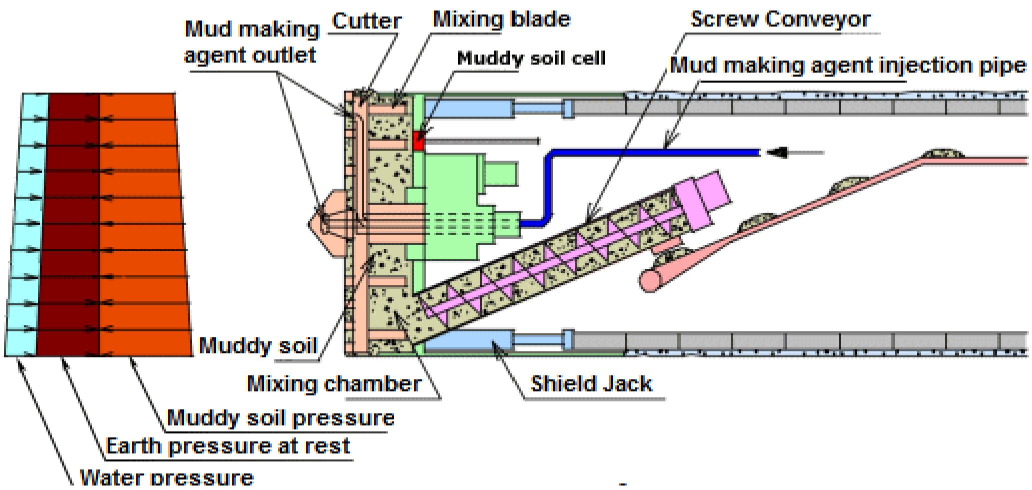
Figure 4.5.42 Kinds of Shield Boring Machines

(a) Characteristics of Earth Pressure Shield

Earth Pressure Shield machines excavate the ground while securing the face for stabilization by pressurizing the muddy soil inside the chamber with shield thrust force and discharges the excavated soil with the screw conveyor. This type of shield machine can be categorized into two: Earth Pressure Balance (EPB) shield machine, which has an inlet for additives to improve the properties of excavated soil, and normal earth pressure shield machine, which is not equipped with the mechanism that EPB shield machine has. However, EPB shield machines are more popular regardless of the use of additives.

Characteristics of face stability mechanism for the earth pressure shield machine are as follows:

- For EPB, excavated soils are to be improved to contain plastic flow and water tightness by adding additives and by forcing to mix using the cutter head and blades. Additives will not be applied for normal earth pressure shield machines, only mixing is applied.
- The chamber and screw conveyor are filled with muddy soil, then the muddy soil is pressed by the thrust of a jack to resist earth pressure and water pressure acting on the face.



Source: Taiho Construction Company HP

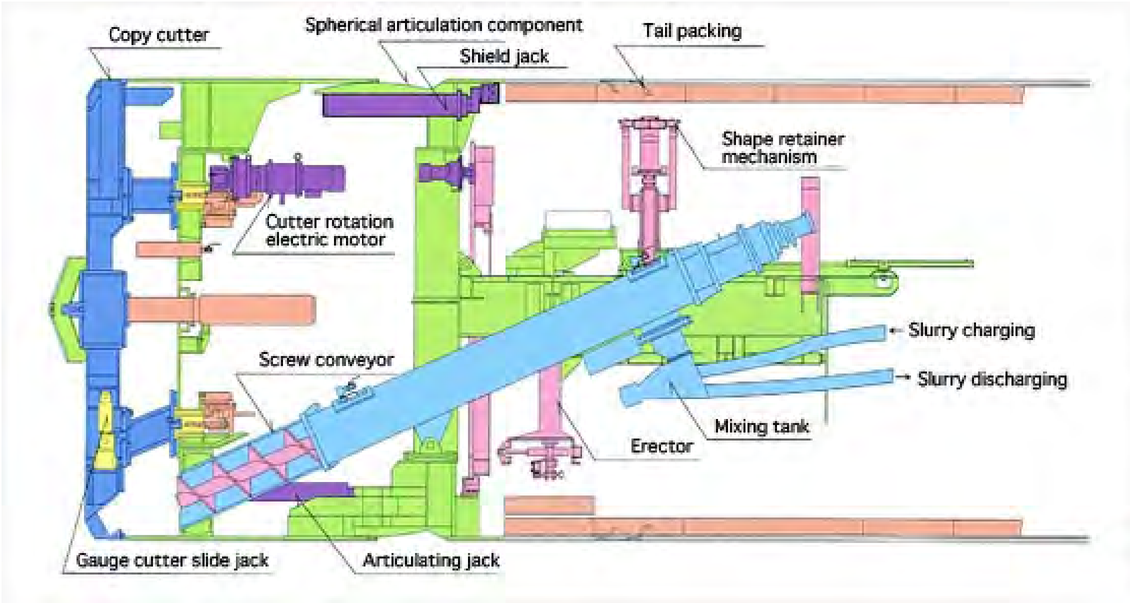
Figure 4.5.43 Overview of Earth Pressure Shield Machine

(2) Characteristics of Slurry Shield

Slurry shield machines excavate the ground while stabilizing the face by pressurizing the slurry inside the chamber using the fluid transporting pump through the discharging pipe, and discharges the excavated soil with the slurry inside the chamber through the discharging pipe.

Characteristics of face stability mechanism for the slurry shield machine are as follows:

- Impermeable mud film is formed on the face so that the pressure can effectively act on the face.
- The strength of the ground will be increased as the slurry penetrates the ground since the fine fractions such as sand and silt penetrate apertures.
- The slurry pressure more than the earth/water pressure applied to the face can stabilize the face while adjusting the speed of rotation for the fluid transporting pump.



Source: Nishimatsu Construction HP

Figure 4.5.44 Overview of Slurry Shield Machine

(3) Selection of TBM

JST proposes a slurry shield machine due to its operation ability. Because of some circumstances of MRT Line 1, sensitive TBM operation is required. However, this method contains several disadvantages compared with the earth pressure shield machine, as follows:

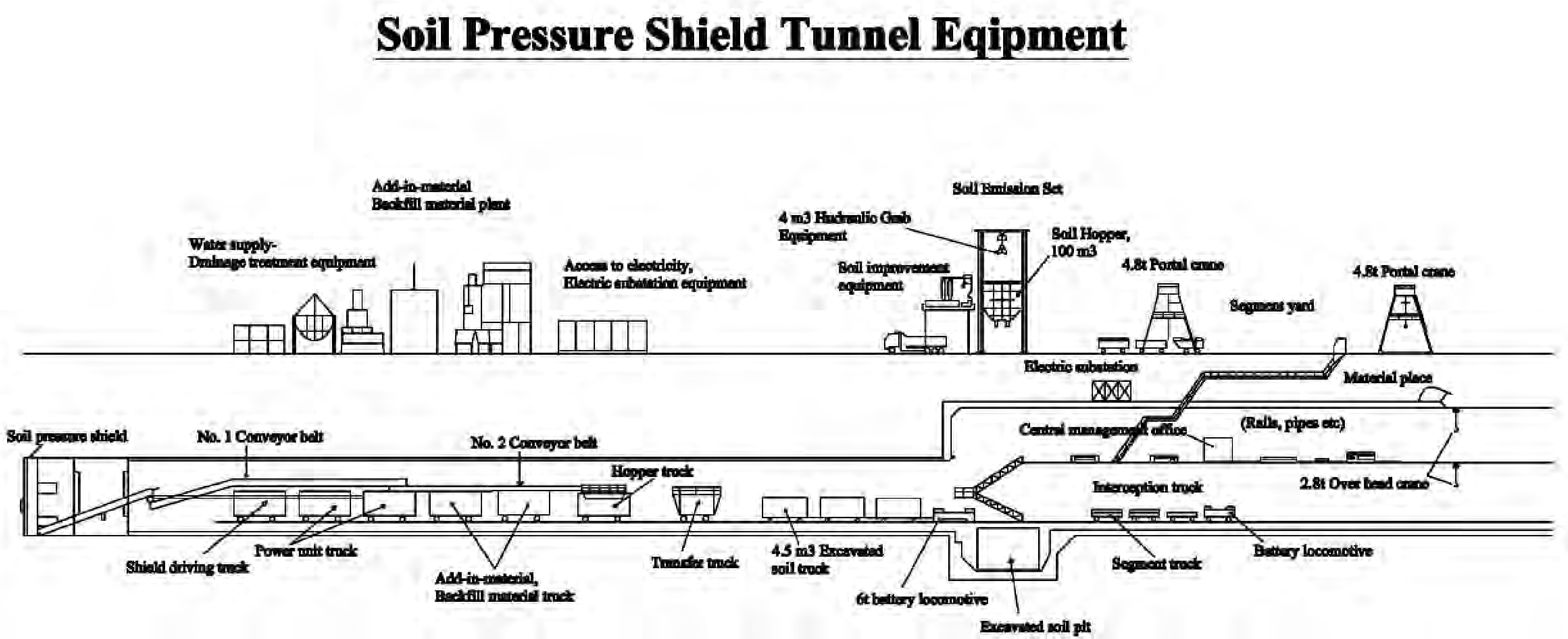
a) In the dry season, it becomes hard to keep the face stable; and
b) Backyard equipment is larger than EPB and requires wider space.

At the time of writing the report, the geological condition is not known. A detailed study is needed anew in the design stage taking into account geological condition, available working depot space, and the environment of the working site.

c.3 Method of Tunnelling by TBM

In general, two shields are arranged, i.e., an upper shield and a lower shield. The lower shield is constructed in order to avoid damage to other tunnelling works. After confirmation that no damage is expected, a later tunnel machine shall be dispatched. Ground settlement shall be within an allowable range and further analysis shall be carried out.

The following shows the general arrangement of the shield machine.

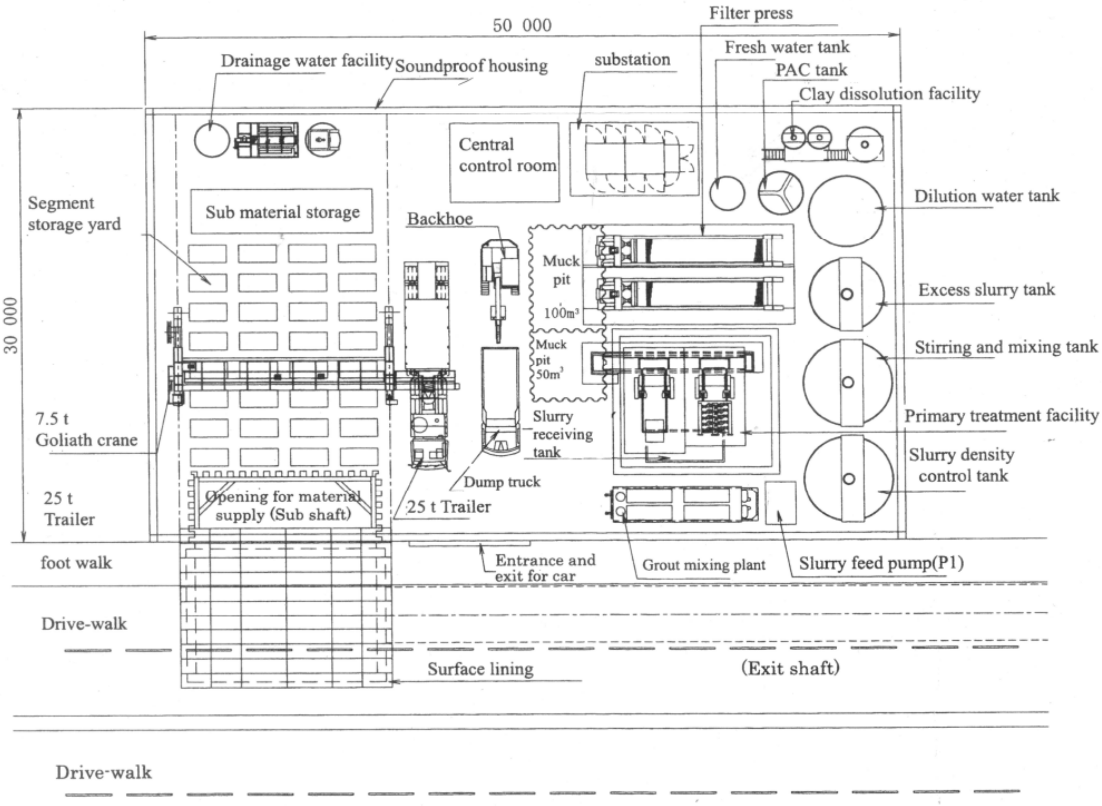


Source: HP Nishimatsu Construction Company

Figure 4.5.45 Sample of Back Yard Facility (Slurry Shield Machine)

d. Work Depot

Following figure shows general layout of TBM Operation Yard which requires about 30m width x 50m length.



Source: OCG Archives Hanoi Line 2 Basic Design Report

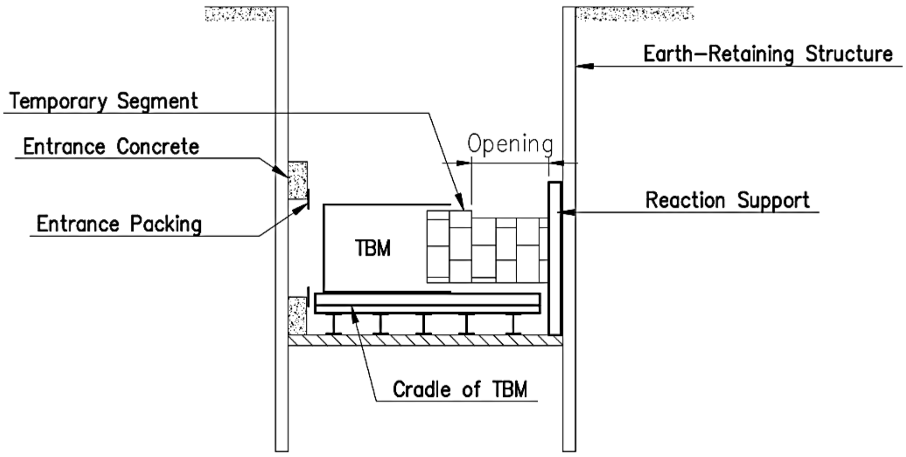
Figure 4.5.46 Example of Arrangement of Surry Shield Tunnelling Ground Facility (Japan Civil Engineering Society)

e. Protection of Launching and Arriving Shaft

The launching/arriving shaft requires space that is some 1.5–2.0m wider than that for the ordinary station box. When the TBM is dispatched, the diaphragm wall shall be removed after confirming that the face is stable or that the TBM can break directly through the diaphragm wall. The Study Team recommends the former because of its economic advantage.

The Jet Grouting Method was studied in this FS.

The equipment that is dispatched along with the TBM consists of TBM Support, reaction receiver and entrance packing, etc., as shown below.



Source: JICA Study Team

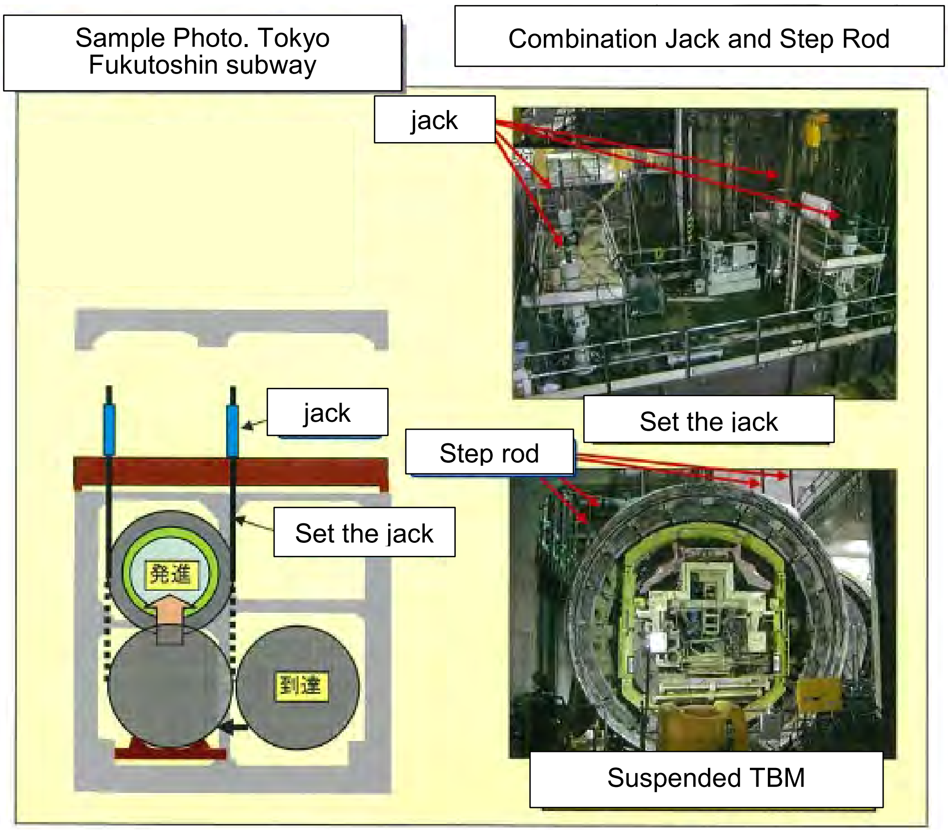
Figure 4.5.47 TBM Launching Shaft

f. TBM Transportation between Arrival Shaft and Launching Shaft

When TBM reaches the arrival shaft, the machine is transferred to the launching shaft, which is provided at the opposite side of the station box. There are two ways to move the TBM: one way is to pull it out from arrival shaft and then transport it to the launching shaft; another way is to move it in the station box by a TBM mover. A study on which method is adequate shall be made in such aspects as financial, construction schedule, and ground conditions.

In the case of transporting the machine in the station box, enough space to move shall be provided and structures shall be designed accordingly. In general, the track level space needed is about 7.8m, and vertical struts are not available within this area. The diaphragm shall be designed considering this issue. JST was concerned about the reinforcement volume and the structure becoming bigger. Reinforcement in the diaphragm restricts workability of concrete casting. There is much concern about the quality of the diaphragm which leads to future water leakage.

Accordingly, JST recommends moving TBMs on ground. Now this method is thought to be applied at Rajarbagh, Rampura, Hatir Jheel, Uttara Badda, and Future Park. The following figure shows an example of how this is done.



Source: Tokyo Metro

Figure 4.5.48 An Example:
TBM outer radius 6.7m, weight 360t was lifted up by 6.2m with 4 x 150t jacks

JST has an idea that two 200-ton cranes will pull out the TBM, which is some 350t after removing inside equipment. Expected weight of TBM is 180t – 120t. The pulled out TBM is transported by trailer to the opposite side and set down to the position required by two 200-ton cranes.

g. Production of RC Segment

The RC segments will be produced at pre-fabrication factories in Bangladesh; however, steel works such as formworks, bolts and nuts, and ductile segments shall be brought from abroad. JST developed the MRT Line 1 project scheme so that existing facilities shall be utilized as much as possible. With regards to the Concrete Segment which may be produced by present pre-fabrication factories which produce PC piles or PC panels. However since the concrete segment is required to have high strength, high level quality control is required.

Since lots with 5 segments are needed concurrently, it is highly possible that the factories will be far from Dhaka City. However, the transportation distance will not affect the work schedule much. This is because the segments necessary for a few days will be stocked near the launching shaft. Normally, 10 rings will be necessary per day, thus a minimum for 2 days should be stocked. There is also the option to temporary place at the depot and transport to each construction site but loading and unloading of the segments to trailers will occur 2 times in this case, so it is not efficient. Also, a considerable number of vehicles will enter and leave the depot for works such as track circuit construction after land reclamation or building construction. On the other hand, the access road which will be made along the Approach Line will be used as the access road to the depot. A facility for

Padma Oil will be built nearby and access of large trailers may be restricted, thus it is not appropriate to store the segments in this area. There are examples that segments produced near Utsunomiya were used for shield construction in Tokyo, thus the distance between the factories and the construction site will not affect the work much. However, it is recommended that materials for works of 3 to 5 days to be stocked near the launching shaft.

h. Adjacent Structure Protection

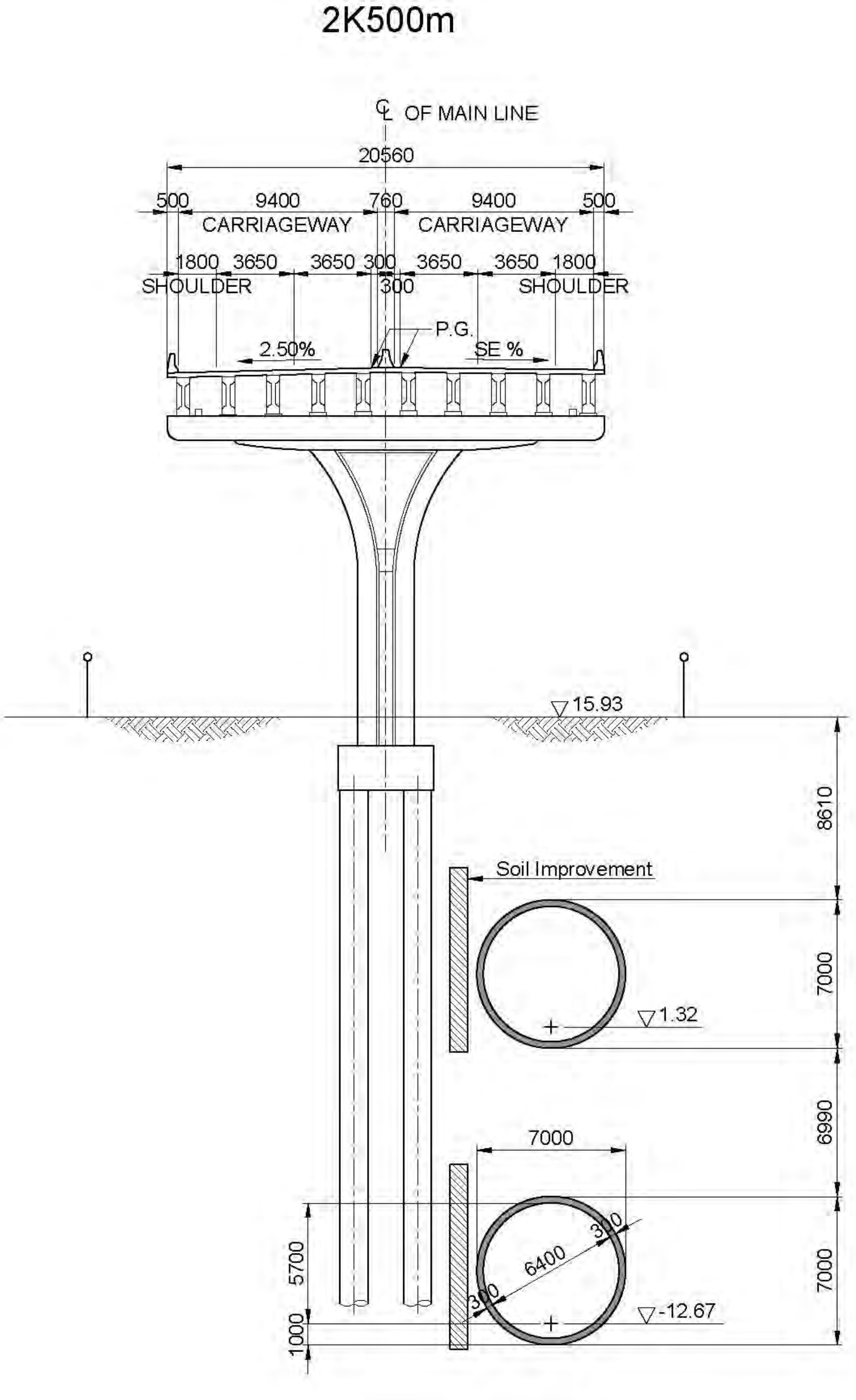
As a normal practice, prior to construction work commencement, all adjacent structures including houses, buildings, flyovers, infrastructures and wells, etc. are recorded in detail to document their existing status. Scope of study is inclinations of houses, cracks on wall and well-water levels. Photos of the existing status are taken before construction commencement. After completion of construction, they will be investigated for any change/alteration.

If necessary, adjacent buildings, bridges, and houses are to be equipped with devices to measure any movement, such as subsidence, inclination, et al. The status prior to construction commencement is studied; besides, the impact after construction completion is expected. Hence, the periodic measurement is implemented during the Defects Liability Period. That is written in tender documents.

Special investigation may be required for the following sites.

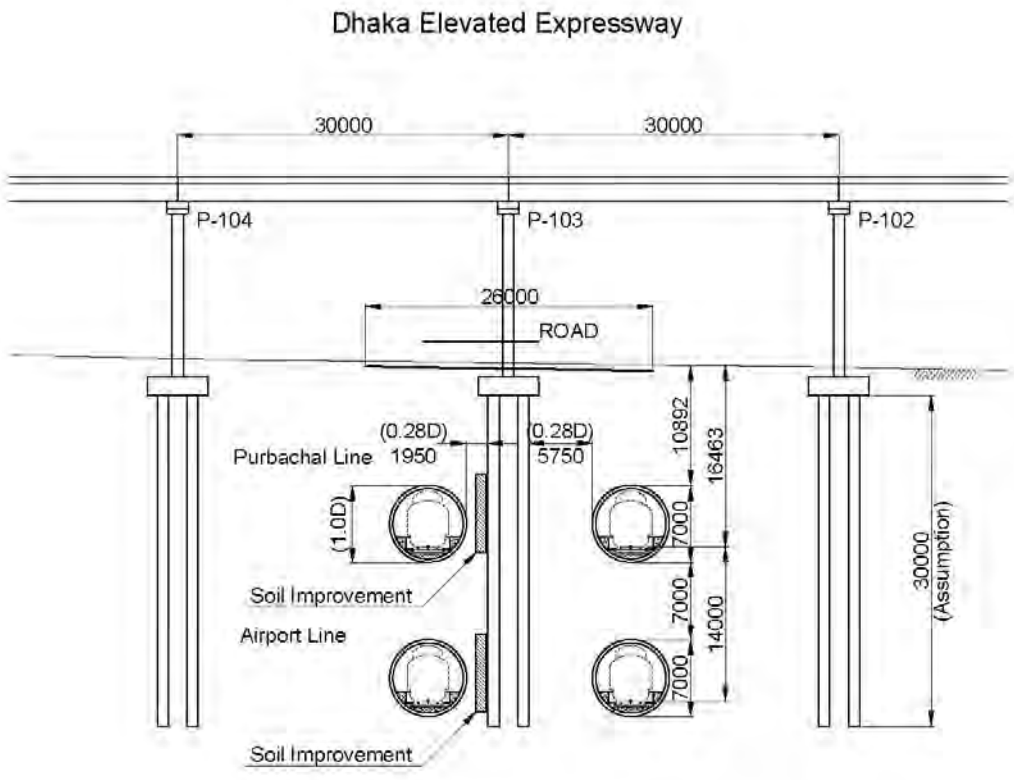
1) Highway Fly-over between Rajarbagh Station and Malibagh Station, and existing buildings, and existing railway,
2) Rampura Bridge
3) Kuril Fly-over, and
4) Buildings adjacent to underground stations

As example, prior to design settlement caused by tunnel construction shall be analyzed by FEM Analysis Method. Figures below are sample of Protection by soil improvement.



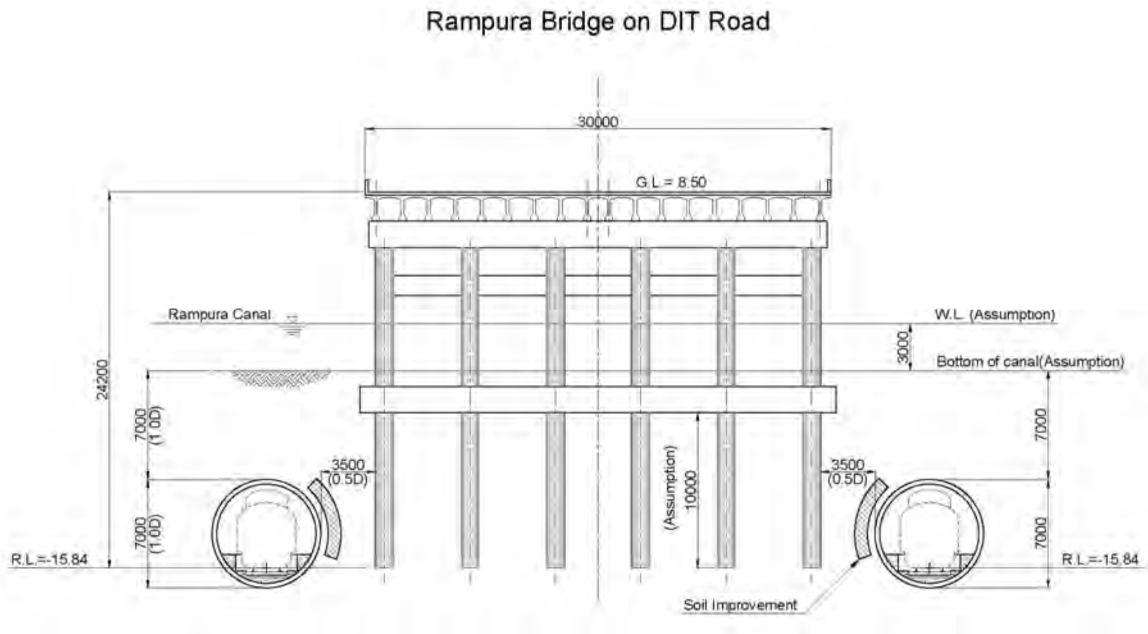
Source: JICA Study Team

Figure 4.5.49 Protection of Viaduct at 2K500m



Source: JICA Study Team

Figure 4.5.50 Protection of Rampura Brigde



Source: JICA Study Team

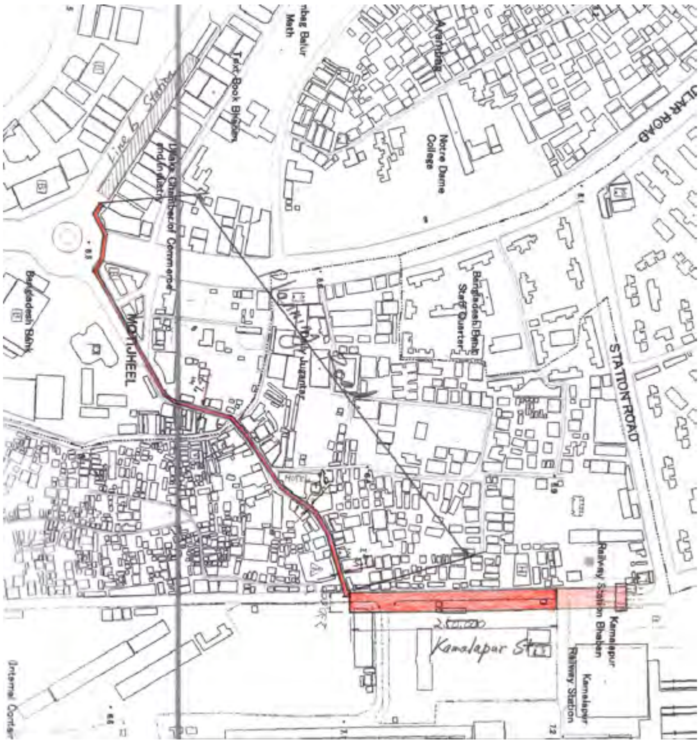
Figure 4.5.51 Protection of Kuril Fly-over

(3) Connection with MRT Line 6

a. Introduction

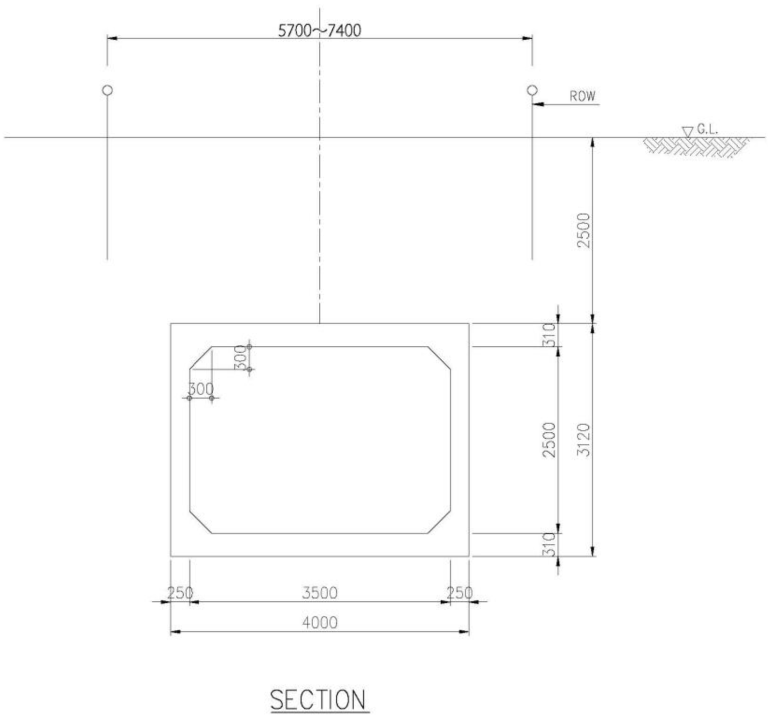
In MRT Line 1, the Airport Line will be constructed underground, while MRT Line 6 is under construction with an elevated system. The MRT Line 6 nearest station is the Motijheel and the JICA Study Team of Line 1 tried to connect Lines 1 and 6. As a result of several studies, connecting both lines appears to be difficult. But the Study Team recommends constructing an underpass beneath the Kamalapur road with concrete box culverts some 650m long, as shown below. The underpass will be constructed with pre-cast concrete materials.

b. Location and Size of Box Culvert



Source: JICA Study Team

Figure 4.5.52 Connection with MRT Line 6 by Underpass



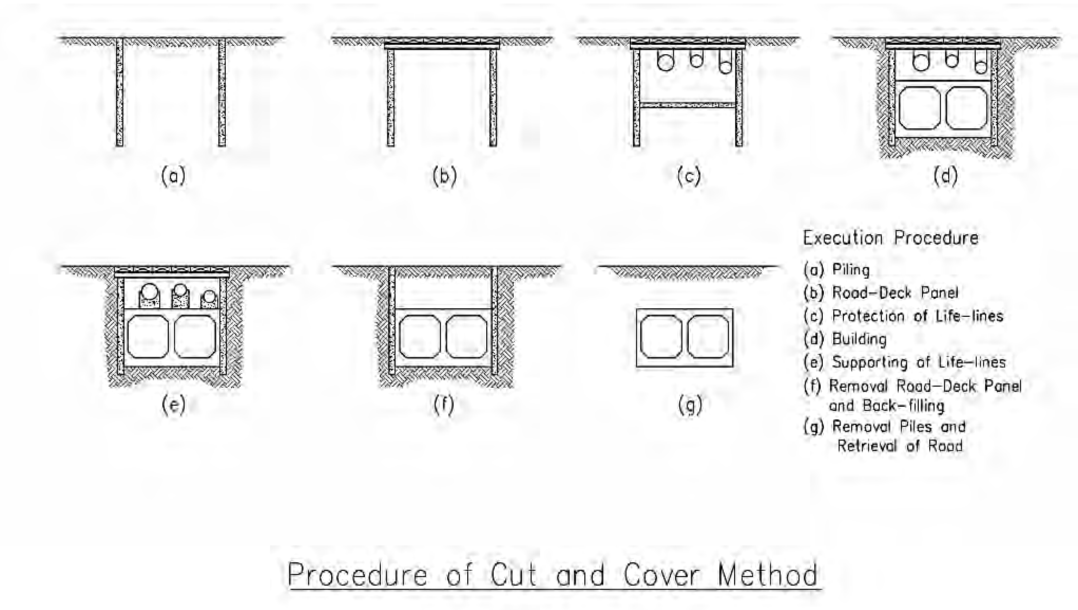
Source: JICA Study Team

Figure 4.5.53 Box Culvert Cross Section

c. Construction Plan

(a) Method

The generally utilized open cut method shall be applied. But the underpass construction works will take place at night, in consideration of the effects on the surrounding residences, retail shops and traffic above. Figure 4.5.54 shows the procedure of construction.



Source: Sankaido Underground Railway Construction Handbook

Figure 4.5.54 Procedure of Construction Box Culvert

(b) Quantities

As far as can be determined from the drawings available, an underpass with a length of about 650m is expected.

Excavation: V=19,240m^3

Concrete Volume: V= 2,542m^3

Backfilling: V=19,240m^3

Steel Sheet Piling (Type III、L=8m): n=3,250 pieces

(c) Expected Schedule

Site works expected are as shown in the figure below.

Pre-cast concrete box culvert shall be separately manufactured at the concrete factory in advance.

Schedule of the connection between Line 1 and Line 6

ITEM		1 year												2 year												3 year		
	M	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Temporary Works	1.0	—																										
Buried pipes and culverts, Diversion, Guard	3.0		—	—	—																							
Steel Sheet Piles	7.0					—	—	—	—	—	—	—																
Road Deckings	1.0												—															
Excavation, Earth-Retaining Structure	6.0													—	—	—	—	—	—									
Installation of Boxculverts	4.0																			—	—	—	—					
Backfilling	1.0																							—				
Removal of Road Deckings	1.0																								—			
Clearance	1.0																									—		

Source: JICA Study Team

Figure 4.5.55 Schedule of Underpass Construction

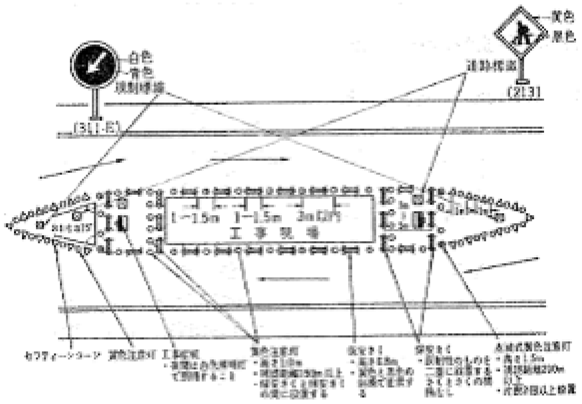
(4) Traffic Management Plan and Safety Management

a. Traffic Management Plan

As the first step, in order to keep car lanes open for road traffic, the existing pedestrian path shall be reduced in its width to 1.0m. Before work commencement, necessary announcements shall be made to the residents and workers. Also, car parking shall be restricted along the corridor not only where the road is directly affected but also the detour roads. Existing traffic lanes shall be kept during construction. For example road deck panels installation is a commonly used method world-wide. The deck panels may be used for long duration, and it is difficult to repair or replace during construction. The deck panel installation working method shall be studied in detail with discussion with related authorities such as police and road owners. The construction of the diaphragm wall shall take place at night, and the road traffic lanes shall be kept open as much as possible at daytime. The works shall be limited to available works in the central working area shown below. Traffic controllers are required at both sides of the working area. Further, it is important to coordinate with adjacent sites to minimize traffic-related construction problems.

Without the Airport Road the width of the road above MRT Line 1 is approximately 30 to 40 meters including pavements. In order to build a central working island (about 10m wide by 65m long) as shown in the figure below, it is required to narrow pavements to make space for roadways. Furthermore, an additional space of roadway shall be ensured by narrowing the width of the existing single lane road from 3.6 ± 1 to 2.75 meters. If the reduction on the number of lanes is unavoidable, the plan is that at least a single lane on each side is ensured. As mentioned above, the open cut excavation in station section shall take place with road decking panels during night time in order to minimize the negative impact to road traffic. Additionally, it is necessary to let road users take a detour by providing them with information.

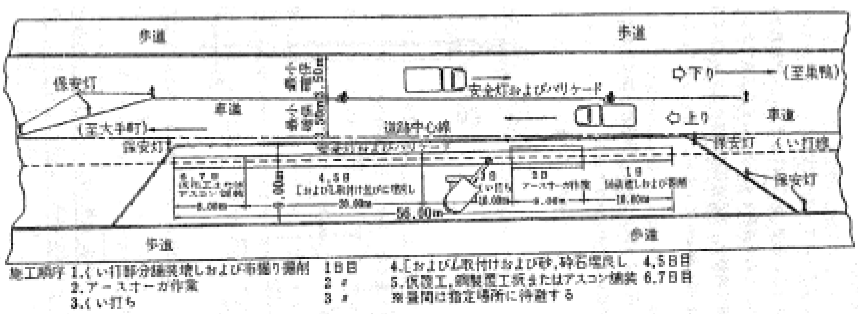
〈Working Island provided at Centre of Road〉



Source: Sankaido Underground Railway Construction Handbook

Figure 4.5.56 Central Working Island

〈One side Working Island〉



Source: Sankaido Underground Railway Construction Handbook

Figure 4.5.57 One side Working Island

b. Safety and Security Management Plan

The contractor shall respect all Bangladesh laws and practices related to construction works, safety and environmental management. Related laws and practices shall be studied by the consultants who are engaged in the engineering services. Lack of safe practices shall be found and reported to the Client for necessary actions. With regard to safety regulations and practices for underground works, a new regulation will be required. In Bangladesh, there is no experience of underground facility construction such as underground railway, underground shopping complex or underground utility, new practice/standard shall be established in prior to construction of MRT Line 1. In the project of MRT Line 6, tailor made safety manual has been created and provided to the Contractors as guideline to establish Contractor's Safety Plan. Such manual has been made according to Bangladesh Labor Act and Labor Low in adding British Standards EN, US Standards, NFPA, IIEC (International Electro Technical Commission), and OSHA

(Occupational Health and Safety Management System, USA) concerned articles related to viaduct construction. In construction MRT Line 1 JST recommend to add to this MRT line 6 Safety Manual following subjects related to Underground Works.

- Prevention of deficiency of oxygen
- Water Pollution Prevention
- Waste Control/Management
- Chemical Grouting, and
- Safety of Third Parties

Risk analysis shall be conducted prior to the commencement of the works. Emergency practices shall also be established.

The Construction Safety Manager shall be given enough power by management to ensure that health and safety standards are respected. The Safety Manager and his staff shall patrol every site and working place every day. All safety activities shall be recorded and regularly reported to the Company Management.

According to the project survey conducted by JICA, "The Guidance for the Management of Safety for Construction Works in Japanese ODA Projects", the trend of safety management is as follows:

In developing counties, laws and regulations of the country in order to establish a safe and health-conscious working environment have been improved. However, in an actual construction project, the laws regarding construction or management standards, which are the base for safety management, are not implemented enough. Then, since there are only a few experts who have been in charge of big projects such as ODA construction projects, in reality it is difficult in the construction field for the knowledge or data regarding safety management from one project to be taken over to the next project. Under these circumstances, the role of a consultant, who manages a project instead of the local government, is crucial to implement the ODA construction project smoothly. On the other hand, the implementing body, in this case the local government, has to fully understand the importance of safety management to enhance a consciousness of safety management at a construction site.

The first responsibility belongs to the contractor, but, in order to minimize the number of accidents, the Client, consultants and contractor shall develop the safety management system and implement it.

The ES consultants will prepare the "Safety Management Guidelines" during the ES and these will be incorporated into the Bidding Documents. The contractor shall include an Initial Safety Management Plan in bid submission.

In order to ensure the safety of project personnel, it is necessary to establish and operate safeguards for both the temporary office, which will be fixedly used, and for construction sites, which will move according to the progress of the project.

【Temporary Office】

- In order to prevent easy breakthrough even from external attacks using rifles or explosives, walls of 30 cm in thickness and more than 2.0 in high shall be established around the temporary office (1,500 m in total circumference), and a fence (more than 1.5 m in height) with barbed wire with a diameter of more than 0.5 m shall be placed within.

- Two entrances shall be established for the temporary office, with security guards at all times with entries and exits controlled.
- Three escape doors shall be established for escape outside in case of emergencies.
- Monitoring towers shall be established at four corners of the outer fence, with security guards placed and CCTV cameras installed to constantly monitor along the outer wall and far off.
- A total of twelve CCTV cameras shall be installed along the outer fence, entrance and within the office to monitor day and night in the security control room, with the video recorded (at least for 30 days), and control and operate the guards in case of emergencies.
- Six guards shall be arranged at all times, controlling entries and exits, monitoring and taking care of incidents.

【Construction Site】

- Two facilities (Base Camp and Sub Camp) shall be established at the construction site, with a fence (more than 1.5 m in height) with barbed wire with a diameter of more than 0.5 m surrounding a space of 250m×25m shall be placed within with six guards at all times to protect them.

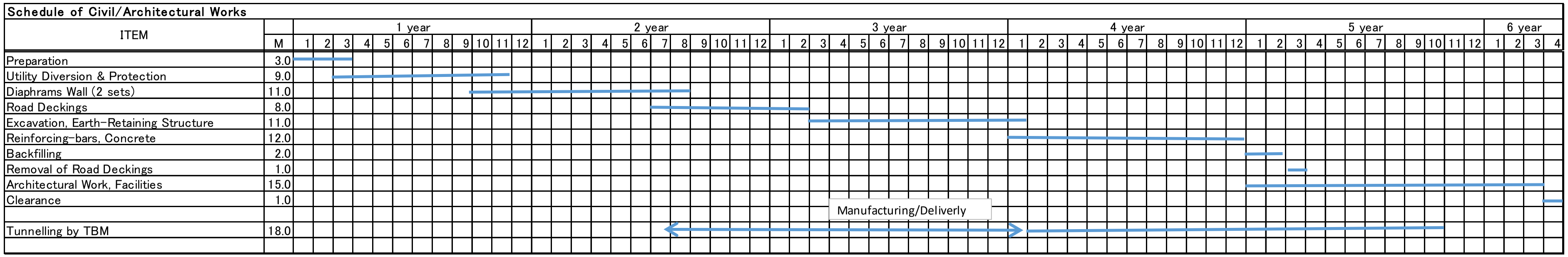
c. Water management during construction

The following matters must be stated in the bidding document. Prior to the start of the construction work, the constructor must conduct a water quality inspection for the existing well and record the water level. Furthermore, it is necessary to regularly observe the water quality and water level according to the progress of construction. Regarding the definition of the distance from the tunnel and the underground station and the range within which the impact can be tolerated, the case of foreign countries shall be examined and decided.

(5) Underground Section Construction Schedule

In making the Construction Plan, the Station Box (TBM Dispatch Shaft) and Shield Tunnelling were separately studied. There are twelve underground stations, and some stations contain a scissors crossing or a crossover. There are two-level and three-level stations. In this FS, the standard type of underground station was the subject of the study. With regard to shielded tunnelling, the Study Team assumed one contractor would construct 2.5 km with two TBMs. In the construction of an ordinary underground station, the Study Team assumed two groups of workers and 2-shift system. To meet the schedule for the standard underground stations, the number of workers per group shall be increased in case special type of stations.

With regard to the transition where the underground track rises up to the ground level and then to the elevated level, other groups of workers shall be engaged. Therefore, this transition construction is not critical.



Source: JICA Study Team

Figure 4.5.58 Underground Civil Works Construction Schedule

Schedule of TBM

Item	M	1 year	2 year
Preparation for Launch	1.0		
Assembly of the TBM	1.5		
Assembly of Launch Equipment	0.5		
Cutting Face	0.5		
Beginning of Boring	1.0		
Exchange of Equipments	0.5		
Bored Excavation (2.5km)	8.0		
Protection of Arrival Shaft	1.0		
Removal of the TBM	1.0		
Cleaning of Invert	1.0		
Invert Concrete	1.0		
Supporting Concrete	1.0		
Cleaning of Tunnel	2.0		
Construction of Refuge	0.5		
Total			

Source: JICA Study Team

Figure 4.5.59 Tunnel Construction Schedule by TBM

(6) Rough Estimation of Quantities

Major works of construction underground section is summarized in the following table:

Table 4.5.7 Major Works Quantities

Calculation of Quantity

St. Type	Chainage	Station Name	Length(m)	Segments L(m)	O Width(m)	O Length(m)	Depth(m)	D-wall Plan L(m)	Exc Volume(m3)	Concrete V(m3)
Standard	0k125	Kamalapur St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			874	874	–	–	–	–	67,268.9	
Standard	1k249	Rajarbagh St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			1,856	1,856	–	–	–	–	142,850.3	
Special	3k355	Malibagh St.	250	–	14.55	253.0	27.00	531.1	85,765.4	
		Ductile Segments	–	250	–	–	–	–	19,241.7	
			702	702	–	–	–	–	54,030.7	
Standard	4k307	Rampura St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			933	933	–	–	–	–	71,810.0	
Standard	5k490	Hatir Jheel St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			811	811	–	–	–	–	62,420.0	
Standard	6k551	Badda St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			782	782	–	–	–	–	60,188.0	
Standard	7k583	Uttar Badda St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			595	595	–	–	–	–	45,795.2	
Special	8k568	Notun Bazar St.	530	–	38.3, 43.1	530.0	18.95, 20.45		370,472.5	
			1,194	1,194	–	–	–	–	91,898.3	
Special	10k152	Future Park St.	250	–	22.4, 27.2	253.0	26.70, 28.20	566.0	141,029.6	
			2,215	4,430	–	–	–	–	170,481.4	
Standard	12k617	Khilkhet St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			1,177	1,177	–	–	–	–	90,589.9	
Standard	14k044	Airport Terminal 3	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			596	596	–	–	–	–	45,872.2	
Standard	14k890	Airport St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8	19,630
			141							
		Sub Total	15,156	13,950					2,400,470	176,670

Source: JICA Study Team

(7) Other Issues to Study in ES

a. Excavated Soil Disposal

Principally, the excavated soil shall be utilized by other consumers. There is a possibility that the soil produced by the shielded tunneling will contain contaminants and will not be suitable for re-use. At present, we have not done a soil investigation yet. The ES consultants shall carry out detailed soil investigations and establish waste control plans.

Excavated soil shall be treated on site before bringing it out from the site. The method of treatment shall be carefully studied in accordance with geological practices, method of transportation and availability of land for a treatment plant.

As a method of treatment, there are two types: physical treatment (like dewatering, natural air drying, compel type, etc.) and chemical treatment such as mixture with chemical materials (cement, lime and highly polymerized compound, etc.).

JST considers that the excavated material from the underground station could be brought to a temporary stock yard and re-used as backfill.

Excavated material is expected to be suitable for backfilling; they shall be utilized for other projects. Once there is no possible project, such material shall be brought to the candidate site for expansion of depot and used as pre-loading. If such material is deemed contaminated by Bangladesh laws on environmental protection, the material shall be correctly treated. A more detailed study shall be made at the period of Engineering Service.

Since the excavated soil may contain wastes, the soil is tested periodically and then discarded in accordance with the regulation of Bangladesh.

b. Coordination between Airport Terminal 3 Station and MRT 1 Underground Station

There is a plan for a Dhaka International Airport Terminal 3 Construction Project.

For airport passengers and employees of the airport, MRT 1 Underground Station is recommended by JICA. Accordingly, the JICA Study Team studied the location and size of such underground station.

At present, Airport Terminal 3 is planned at the south of the existing international airport and is connected with MRT Airport Terminal 3 Station under the Airport Road. As the convenience of airport users with baggage is considered, people movers and lifts and escalators in stations should be installed.

c. Underground Structure and Alignment

A detailed study at some locations shall be carried out when the topographic survey data is available. There are concerns about land acquisition and difficulty of construction. During the engineering survey, the existing alignment plan shall be reviewed.

d. Track Alignment

At the time of writing this report, the topographic survey remains to be done. In ES stage, a detailed survey is inevitable. The Study Team is concerned that structures provided within road ROW encroach private land and results in additional land needed.

e. Ready Mixed Concrete/ Concrete Production Plant

Since concrete volume required is so much, it is concern to meet the demand by existing ready mixed concrete factories near Dacha. Even they produce enough ready mixed concrete, traffic condition in Dacha is one big issue. In order to meet specification requirement, the ready mixed concrete shall be delivered to the site within specified time. Further ready mixed concrete mixing vehicles may cause traffic congestion in the city. Then JST propose that the contractors shall have own concrete plants near the site.

4.6 Station Architectural Works and Facility Plan

4.6.1 Architectural Works Plan

Condition of Station Planning

Passenger stations are planned considering demand forecast, car numbers, track alignment, civil structure, mechanical and electrical facilities, O&M planning, city planning and intermodal access. This section discusses the conditions and basic ideas related to the station architectural works.

1) Station Size

Station size is basically defined according to the following criteria:

- Concourse floor length is designed in consideration of accumulated dimension of minimum concourse length + station office + E/M rooms + station tunnel ventilation rooms and praying facility.
- Platform length is designed in consideration of train length+5m of clear space at both ends of the platform.
- Platform width is an accumulation of minimum stairway width + Escalator + wall + reasonable width between stairway walls to Platform Screen Doors (PSD) (Minimum of 2.0m)

Station size including platforms, concourse, stairs, and ticket gate numbers is basically defined to keep passengers' safety, comfort and serviceability at peak hour. In MRT Line1, PSD are planned to be installed in every station. PSDs can secure passenger safety, but a congested platform tends to cause troubles and delays in train operation. Vertical access routes between concourse and platforms shall have adequate capacity, so that passengers can move out of the platform before the next train arrives, and at the same time, the platform shall have enough space to accommodate passengers waiting for next trains.

2) Ticket Gates and Security Check Gates Planning

There are four main access routes from the street level to the B1 concourse level designated at both sides of public area (layout is shown in section 4) of 4.6.1There is one ticket gate at the centre of the concourse. Entrance and exit are clearly separated. Number of ticket gates will be calculated based on demand forecast, and it shall be later verified by final demand forecast for each station. In this study, width of ticket gates is planned based on the MRT 6 station plan.

If necessary, provide a security check gate which has an area of 2.5m x 3.5m to arrange the gate checking itself plus security staff and baggage check table. Basically 2 check gates should be provided at each entrance. There should be wide space not only in front of ticket gates, but also at security check gates as queues at check gates are expected.

3) Station Office and Ticket Machines

The station office area is planned based on the MRT Line 6 station plan. There are the control room, station office, station master room, security guards room, maintenance room, staff mess, prayer room, first aid room, staff toilet, storage, etc.

The size of the area is estimated to be 450m^{2}including corridors.

4) Public Toilet

Passenger toilets shall be provided in paid areas in every station. Men's toilet, women's toilet and a toilet that caters to the needs of physically challenged persons will be provided.

5) Elevators and Escalators

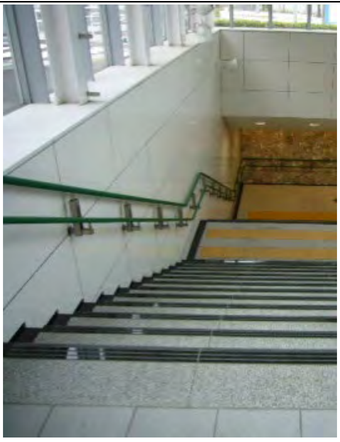
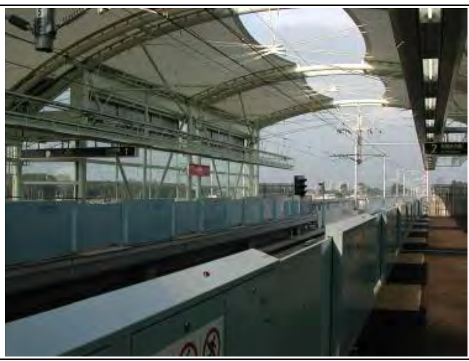
Escalators shall be provided in every station from the ground level to the concourse level, one at the north side and another one at the south side of the street. At least one set of up-down escalators shall be provided from concourse level to platform level.

At least one elevator shall be provided from ground level to concourse level and concourse level to platform level for physically challenged persons.

Stations with large numbers of passengers and for transfer stations, more escalators and elevators will be provided. The number of escalators and elevators will be determined by the passenger demand.

6) Barrier Free/ Universal Design

Stations, as part of public transportation system, need to be more disabled-friendly by means of installing facilities that will provide easier access to passengers with physical and visual disabilities. Disabled-friendly design shall basically be performed in accordance with the Bangladesh Code; and the design can be further improved by applying advanced design concepts, referring to "Barrier-Free Design Guidelines (Passenger Facilities Edition)" by the Ministry of Land, Infrastructure, Transportation, and Tourism of Japan. Related features are shown in figures below.

	
Automatic Escalator with 3 flat steps	Guiding/ Warning Blocks for the blind
	
Level of handrails and colour of nosing	Elevator with wheelchair turning space
	
Half-height platform screen Door	Low height counter at ticket gate
	
Level of bench	Toilet with equipment and accessories for Physically Challenged Persons

Source: JICA Study Team

Figure 4.6.1 Barrier – Free Design Related Features

(1) Access to Stations

Each station shall have at least one designated barrier-free route. This is a route with an elevator allowing passengers in wheel chairs to move smoothly between the ground level and platform level. The approach to the elevator at the ground level should have a ramp or a ramp plus stairway installed. Guiding blocks for visually impaired persons shall be installed along the barrier-free route.

(2) Concourse

The concourse floor should not have a floor level gap, but if a floor gap is unavoidable, a ramp shall be provided which complies with the barrier-free guidelines. The floor surface of a concourse should be made of non-slip material.

(3) Ticket Gates

At least one of the ticket gates should be wide enough to allow wheelchair users to pass through easily.

(4) Automatic Ticket Vending Machines

The coin slot should be at a suitable height for easy insertion of coins by wheelchair users. A knee recess beneath the ticket vending machines should be provided.

(5) Stairways

The stairways for passengers should have two levels of handrails which comply with the barrier-free guidelines and match the universal design concept.

(6) Platforms

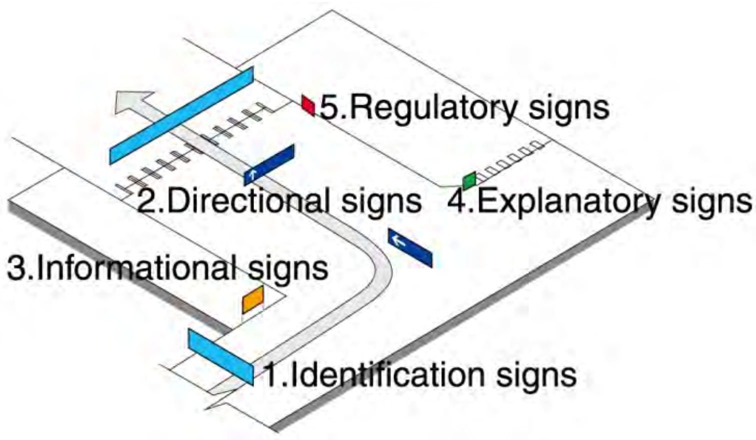
At platforms at least one designated route with guiding blocks for a visually impaired person shall be provided. The surface of the platform must be made with a non-slip material.

(7) Signage Design

In railway stations, signage shall be easy to understand for various passengers. Signage such as direction, indication, and information signs should be located at the proper places and should be clearly recognized. Types of signage and their examples are given in the following Figure 4.6.2.

7) Pray Room

This capacity and required facility should be decided in agreement with owner.

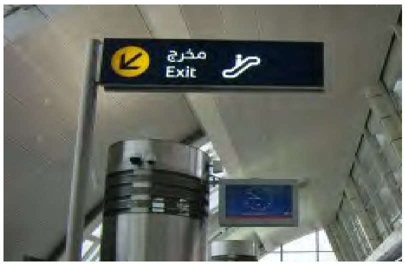


1	Identification Signs	Identify facilities
2	Directional Signs	Direct passengers to platforms, etc.
3	Informational Signs	Provide information about station facilities
4	Explanatory Signs	Train Maps, Fare Chart, etc.
5	Regulatory Signs	Prohibitions, Rules


Informational sign


Train operation sign

Ceiling mounted directional sign

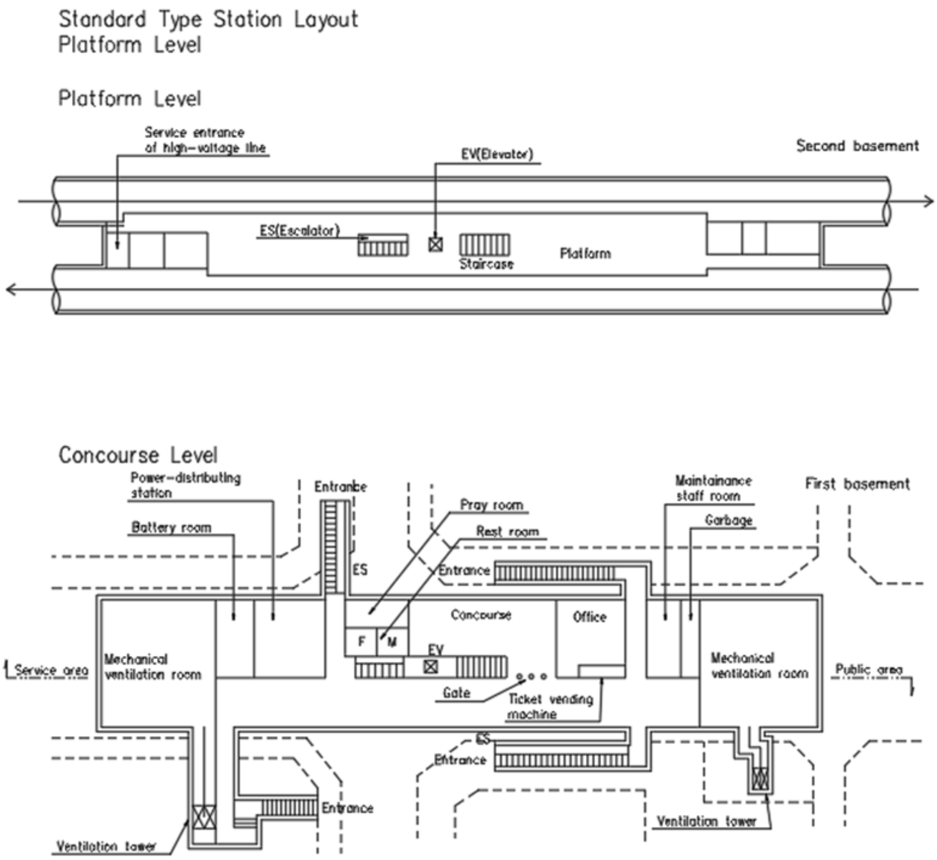


Standing directional sign

Source: JICA Study Team

Figure 4.6.2 Type of Signage

A standard station layout is shown below.



Source: JICA Study Team

Figure 4.6.3 Standard station layout

4.6.2 Mechanical Facilities

1) Air-Conditioning Facilities

(1) Introduction

The purpose of air-conditioning facilities is to provide comfort in the station. However, the structure of the station is different from a normal building and the method of air-conditioning is also different. The station is an elongated structure in a longitudinal direction. In addition, the platform and concourse are connected to the outside through the exit/entrance and the efficiency of air-conditioning is decreased by these circumstances. The design heat load per unit area is bigger than that of normal buildings. In addition, the air-conditioning system in the station should be a simple component and structure, taking into consideration the ease of operation and maintenance work.

(2) Cooling Method

a. Central Cooling System

The central cooling system is applied for large spaces such as the platform, concourse and station offices.

b. Stand-Alone Cooling System

The stand-alone cooling system is basically applied for the electric and communications facility rooms (substation, 4-109ignaling equipment room, and communications equipment room). These rooms are very important for train operations and refuge guidance in case of emergencies. Thus, standby facilities are used as emergency backup.

(3) Air-Conditioning Method

a. Unit Duct System

The unit duct system is used for large spaces such as the platform and concourse.

b. Fan Coil Unit System

The fan coil unit system uses a central cooling system and is locally controlled. It is applied in the station office and rooms where station staff stays.

c. Package Air-Conditioning System

The package air-conditioning system is a stand-alone system. Therefore, it could be used separately from the central cooling system, which is stopped when the train is not in operation. It is applied for electrical facility rooms (substation, 4-109ignaling equipment room and communications equipment room) and rooms related to station operations. This system is also applied to the elevated stations.

2) Ventilation System

(1) Introduction

The purpose of ventilation is to provide comfortable and hygienic space in the station by taking in fresh air from outside the station, and removing polluted air from inside the station. Ventilation is also purposed to control the temperature inside the station, which is raised by the heat emitted by passengers, trains and other facilities. Mechanical ventilation is used for the project. In the stations where full-height platform screen doors are applied, the ventilation system of the platform is separated from that of the tunnel. Therefore, such ventilation systems are designed as separated and segregated systems.

(2) Ventilation Method

a. Ventilation Method of Platform

The purpose of ventilation in the platform is to provide fresh air from outside and provide comfortable and hygienic conditions for passengers, and to exhaust heat generated in the platform. Based on the structure of the station and the requirements of the huge volume of fresh air, the Type 1 ventilation system is applied and the ventilation system doubles as an air-conditioning system.

b. Ventilation Method of Concourse

The system for ventilation of the concourse is the same as that of the platform.

c. Ventilation Method of Station Office, etc.

The ventilation of the station office and other rooms where the station staff stays longer is planned to meet the requirement of Japanese and local standards as well as other related standards or regulations.

d. Ventilation Method of Tunnel

The purpose of ventilation of the tunnel is to provide fresh air from outside and to draw out the heat in the tunnel. In the mechanical ventilation method, the air in the tunnel is supplied and exhausted mechanically by fans. This method has the advantage of having a high capability of ventilation for the huge amount of generated heat in the tunnel as compared with the natural ventilation method.

3) Smoke Exhaust System

(1) Introduction

In the event of accidental fires in the station and tunnel, the smoke exhaust is one of the essential factors for passenger evacuation and fire fighting. The smoke exhaust system is designed based on Japanese Standards (the Standard of Fire Safety Management for Subway Station, etc., Ministerial Ordinance of the Ministry of Land, Infrastructure, Transportation and Tourism, Japan), and other related standards or regulations. The dedicated exhaust duct and fans are provided for these areas.

(2) Smoke Exhaust Method

a. Smoke Exhaust for the Platform

The volume of the smoke exhaust is large and it is not economical to install the air duct only for the purpose of smoke exhaust. In addition, the space above the platform level is limited. Thus, it is reasonable and economical to use the ventilation system for the smoke exhaust in case of an accidental fire. The basic policy of the smoke exhaust is as follows:

- Shared use of exhaust duct
  Type 1 ventilation (mechanically supplied and exhausted) is applied for the ventilation of the platform. Therefore, the exhaust duct for the ventilation is used for the exhaust of smoke in case of fire.
- Exhaust Mouth in Residential area
  If the mouth of the exhaust shaft is located in the residential area, the air supply duct will be used for the smoke exhaust after the duct is turned and the direction of air flow is reversed.

b. Smoke Exhaust Method of the Concourse

The smoke exhaust system is designed based on the volume of diffused smoke.

c. Smoke Exhaust Method of the Station Office and Other Rooms where the Station Staff or the Passengers stay longer

The smoke exhaust system is designed based on Japanese and local standards, and other related regulations. The dedicated exhaust duct and fans are provided for these rooms.

d. Smoke Exhaust Method of the Tunnel

In case of an accidental fire in the tunnel, the tunnel ventilation fans are used for the exhaust of smoke. The air speed for the smoke exhaust has to be smooth in order to secure the safety of passengers and to help in fire fighting. The power of the exhaust fans is to be designed considering that the smoke exhaust system doubles as a ventilation system.

4) Water Supply & Drainage and Fire Fighting System

(1) Water Supply System

The amount of water supply in the station is determined by the number of passengers in the station, the number of station staff and the requirements for air-conditioning. The following are the three main types of water supply system:

a. Direct connection to public water supply pipe

Water pressure is influenced by the fluctuation of water pressure of the public water supply pipe, and it is necessary to connect it with a large diameter pipe in order to secure the large demand of water during peak time. Moreover, this system does not have a local storage water tank in the station, and there is a possibility that the water supply is stopped due to a stoppage in the public water supply. Therefore, this system is not suitable for water supply of the station.

b. Domestic water supply with the gravity tank

It is difficult to secure enough space in the ground level for the installation of a gravity tank. Therefore, this system is not suitable for water supply of the station.

c. Domestic water supply with the pressurized tank

This system is suitable for the stable water supply of the station.

(2) Drainage System

The metro station is located underground. Thus, drained water is collected in the storage tank and pumped up to the ground level. Drained water is classified into two systems: one is wastewater and the other is rainwater and groundwater.

a. Wastewater

Wastewater is collected from many places in the station and the length of the pipe tends to be longer. In order to secure appropriate hydraulic gradient, the station will be divided into several zones and the storage tank will be assigned in the appropriate position. Sewerage treatment facilities will be required for effluent to be discharged into public sewage based on local standards.

b. Rainfall and Groundwater

Rainwater and groundwater from the tunnel are collected at the end of the platform where the storage tank is installed.

(3) Fire Fighting System

In order to prevent and minimize accidental fires, the following fire fighting systems will be installed:

- Hydrant for platform, concourse and other areas
- Automatic sprinkler for station staff room, etc. and storage room
- Water supply pipe and hydrant in the tunnel
- Special fire extinguishing equipment for facilities vulnerable to water damage such as substations and signalling and telecommunications system

5) Station Electric Works

(1) Power Supply System

The switchboards, as part of the power supply system, will be installed at appropriate locations in the station in order to supply power to where it is needed. The types of power using items are categorized as lighting fixtures, emergency lights, socket outlets, air conditioning, ventilation, water supply and drainage, fire protection facilities, and so on. The main line and branch cables will distribute power to each piece of electrical equipment. The cables will be installed on cable trays or cable racks.

(2) Lighting equipment

The type, size and shape of lighting fixtures will be determined depending on the buildings and locations. Detailed arrangement will be coordinated in the architectural design phase. Surface mounted lighting fixtures, recessed mounted lighting fixtures and downlights shall be installed in the area with ceilings. High Illumination Discharge (HID) lighting fixtures shall be installed in high ceiling areas.

(3) Socket Outlet System

General socket outlets will be installed where necessary. Types of socket outlets are AC230V and 2P+E. The number of socket outlets for a single circuit will be a maximum of 6, and the capacity will be 6A and 16A, but not limited to these values when it is not applicable. Embedded socket outlets will be supplied in rooms for workers and exposed socket outlets will be supplied for other rooms.

(4) Fire Alarm and Detection System

Fire Alarm and Detection equipment are for the protection of life and property from disaster; thus, certain effective equipment is necessary. Fire alarms are effective for the early detection of fire. The fire alarm equipment is a system that perceives heat and smoke generated by a fire at the early stage and puts out an alert by the sound device in the station.

4.7 Track Plan

4.7.1 Design Standard of MRT Line 6

As proposed by RSTP, the Dhaka MRT line will be connected to other MRT routes and to other modes of suburban transportation networks such as BRT and BR. The plan is to have all routes of the MRT system under a single operator, i.e. DMTC.

Therefore, it is desirable to keep the specification consistent on each line for the track structure from the viewpoint of equipment and maintenance.

MRT Line 6, which is currently under construction, adopted the following track specifications, and it is also recommended that MRT Line 1 adopt the same specifications.

Table 4.7.1 Specifications of Track Structure

Item	Specification	Applicable Section
Gauge	1,435mm	All Track
Track Structure	Concrete bed track (Slab Track or Plinth Track)	Main Line (Elevated, Underground), Depot Access Line
	Concrete vibration-reducing bed track (Slab Track or Plinth Track)	Main Line (Steep curve section / Noise and vibration-reducing point)
	Ballasted track	Depot
Track width	Concrete bed track 2,060mm (Plinth Track)	Main Line
	Ballasted track 4.440mm	Depot
Thickness of Track	Concrete bed track 600mm (Including drainage concrete)	Main Line
	Ballasted track 600mm (Ballast bed depth 250mm)	Depot
Classification of Rail	UIC 60, Head-hardened Rail	All Track
Welding of Rail	Flash butt welding or Alumino-thermic welding	Main Line
Rail fastening device	Wire spring type or Plate spring type	All Track
Sleeper	Concrete bed track, PC Sleeper or Monoblock	Main Line
	Ballasted track, PC Sleeper	Depot
Simple turnout	1 in 7 type or T1 in 9 type Turnout	All Track
Crossover	Ditto	All Track
Scissors crossover	Ditto	All Track
Expansion Joint	UIC 60 type	Continuous welded rail section of Main line
Car stop	Buffer type	All Track

Source: Modified by JICA Study Team from MRT Line 6 Design Report

4.7.2 Specifications of Track Materials

1) Direct-Fixation Track

Not only Japanese Railway Companies but also many countries with MRTs have adopted the Direct-Fixation Track System (DFTS) for reducing maintenance costs. However, many track experts are of the opinion that the DFTS causes higher noise levels and bigger vibrations to the surrounding area compared with the ballasted track. Recently a new type of DFTS has been developed in which elastic mats are inserted underneath the concrete slab in order to protect the ballast and reduce noise and vibration.

The Japanese Government has recently set new environmental quality standards for noise in which the allowable noise level is 60dB for day time while 55 dB at night time. This new standard shall be applied in new railways including the MRT.

In order to meet this level, a new type of DFTS was developed by the Railway Technical Research Institute (RTRI) of Japan. Details are shown in Figure 4.7.1 below. This track system has advantages not only in vibration aspect but also in noise reduction. In comparison with conventional ballastless track systems, the new DFTS has the following characteristics that make it suitable to be adopted in MRT Line 1:

- About 20% cost reduction for construction and maintenance
- Easy to replace track consumables
- Easy adjustment, realignment due to spacers inserted underneath and at the side of sleepers
- In conventional ballastless tracks, under the slab asphalt concrete was poured, and this work require a big plant. With the new type of DFTS, only normal concrete casting is required.
- Conventional ballastless tracks need a wide area for storing RC Slabs, while with the new type of DFTS, a smaller area is required for piling up concrete sleepers.

Non-Ballast Concrete Bed with PC Sleeper embedded in half of the Rubber Box

Conventional Slab Track

Source: JICA Study Team

Figure 4.7.1 Direct-Fixation Track System

Ballast Track

In case where the geological condition is bad and the large settlement of structure is expected in future (the settlement is more than the allowable range for adjustment limit of the concrete slab), ballast track structure should be adopted instead of concrete slab track.

For the ballast track structure, the elastic rubber mat shall be installed between under ballast surface and the top surface of the structure.

The minimum thickness of ballast from the sleeper bottom to the roadbed top shall be 250mm. In the depot, the thickness of ballast shall be 250mm.

In the depot, a PC sleeper and ballast track structure is proposed, but as in the car washing track and inspection & repair track, a non-ballast concrete bed structure is preferred from the viewpoint of work enforcements.

In addition, as the structure of the repair track in the rail car plant, a pit structure shall be applied for inspection and repair and wood block paved track structure is recommended to carry out examinations of dismantled parts that are sensitive.

(1) Rails and Turnout

a. Rails for Main Line

UIC 60 rails should be used as the rail of the main line and the sub-main line. The length of the single track rail should be 18m. In addition, as the inner and outer rails of a section with less than 400m of curve radius, a quenched rail should be used in order to prevent rail wear.

b. Siding and Depot

Since the UIC 60 rails were adopted in the MRT Line 6, Line 1 was planned with the same type of rail, but JST recommends that UIC 54 be used for the siding and depot rail. Although the length of single rail was 13m in the MRT Line 6, JST recommends a length of 25m in order to reduce rail welding works. In addition, as the inner and outer rails of a section with less than 400m of curve radius, a quenched rail should be used in order to prevent rail wear.

c. Turnout

The turnout installed in main line, siding and depot is 1:9 type ordinal turnout of UIC 60 and 1:9 type scissors crossover of UIC 60; thus, the turnout installed in the safety siding should be 1:7 type continuous rail frog of UIC 60.

As the sleeper for turnout, plastic sleepers or the same quality of sleeper as the plastic sleeper should be used, and rubber sheets should be used under the sleepers in order to prevent noise and vibration in case of non-ballast track structure. In the depot, as the tracks have ballast, the vibration and resulting noise around the area are to be taken into consideration. Installation of the rubber sheet (thickness t≒25mm) under the ballast should also be considered.

d. Continuous welded rail

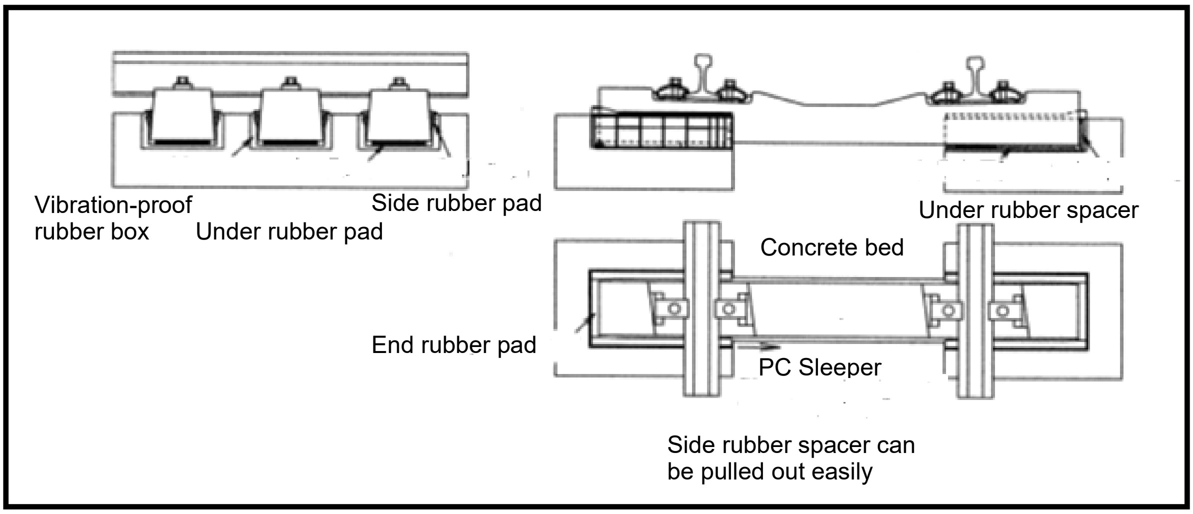
Continuous welded rail (CWR) shall be installed as far as possible for improvement of the riding comfort of the passenger, prevention of the noise and vibration from the train operation, and the reduction of the track maintenance cost.

However, as the rail in the curve section less than 400m of curve radius tends to wear out extremely fast and needs to be changed frequently, the single rail 18m long which is quenched should be used and normal butt joint type should be applied.

In case of welding the rail, the normal rail without being quenched should be used because the welding process of the quenched rail is complicated.

The structure of the “Non-ballast concrete bed with PC Sleeper in Rubber Boxes” is shown in Figure 4.7.2. Although the new type of DFTR has advantage, ballast track shall be applied at the location where the over the allowable settlement level is expected. The allowable settlement level shall be set upon in the Detailed Engineering Study stage. In generally settlement of the structure exceeds the range of adjustment that can be achieved by the spacers which are installed under the sleeper or at the side of the sleeper. A rubber ballast mat of thickness 25mm should be installed between the structure surface and the bottom of the sleeper in order to prevent noise and vibration.

The Pandrol fastening device or equivalent device shall be applied. In addition, a fastening device with which slack of 5mm can provide in the tight curve section of R less than 260m.



Source: 2011 Track Material (Tetsudo Gengyosya)

Figure 4.7.2 The Structure of the "Non-Ballast Concrete Bed with PC Sleeper in a Rubber Box"

Buffering Section

Generally, there is a big difference in the spring constant (the track softness) between the concrete slab track and ballast track, and the rolling of the vehicle grows in a structural change point that can easily become the track's weak point.

Therefore, buffering sections of more than 5m each side from the structure border should be set in order to change the track's general spring constant in stages (to keep the difference of the track's general spring constant within 2.5 times)

(2) Concrete bed

Fiberglass is used in the roadbed construction. It is mixed with concrete to make the roadbed more durable, preventing drying and cracking.

(3) Expansion joint for continuous welded rail

Expansion joints should be installed in the necessary points. As the sleeper of the expansion joint, plastic sleepers, or another sleeper type with the same quality as the plastic sleeper's, should be used attaching a protection device against vibration similar to non-ballast type turnouts.

2) Track Laying

Prior to track laying, the track centreline shall be set on the viaduct structure/ tunnel invert concrete marking the track centreline (the distance between the centreline and wall of civil structure and the height of rail surface should be written on the walls of the civil structure).

(1) Transport track materials and Track Laying

With regard to the tunnel section, the usual method is to have a crane waiting at the entrance to transport the rail to the site on the ground level.

The most suitable method shall be established by the Contractor, who shall take into account the availability of his resources like manpower and equipment, and site conditions.

About the viaduct section, a railroad crane is used to handle the rail.

It is very convenient to use a forklift for short distance transportation and rail laying arrangement.

With regard concrete slabs, fastenings, other track materials and temporary tools, these are brought to the track level from the entrance by crane. It is normal working method to use a forklift for their short distance transportation and track laying.

Concrete slab arrangement, Concrete Asphalt Mortal casting

After the transporting and track laying, the concrete slab track panels fabricated in the plant shall be transported near the material transport entrance, then gathered and brought to the track floor. For the viaduct section, it is very easy that concrete slabs are loaded directly onto the trolley by the crane.

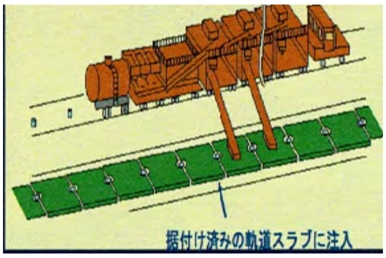
After this work stage, the track laying will be carried out by the following procedure.

Arrangement of the concrete slab → Injection of CA mortar → Installation of rail →

Welding rail (Second step) → Long rail resetting

Lifting up concrete slab and loading onto the trolley

Laying the concrete slab



Pouring CA mortar

Rail installation by portal cranes

Rail welding

Rail Setting and installation of insulation joint

Source: JICA Study Team

Figure 4.7.3 Construction Procedure

(2) Rail welding

Flash butt welding or gas pressure welding is basically desirable for the rail welding from the point of view of quality after the welding work; but even thermite welding shall be limited to the site where flash butt welding and gas pressure welding would be difficult to perform.

(3) Re-alignment of Track

The concrete slab track has been considered as the labour saving track, where little maintenance input was paid in the past. Maintenance work to the concrete slab track was not easy such as the ballast track, but recently maintenance philosophy has been changed in order to meet heavy traffic and speedy train operation. The standard values of track operation shall be kept as indicated in Table 4.7.2.

Table 4.7.2 Maintenance Standard of the Track in Japanese Railway Companies

(Unit: mm)

Kind of track irregularity	Gauge	Level	Longitudinal level	Alignment	Twist
Criteria (mm)	0～－3	Within ±2	Within ±2	Within ±2	Within ±4

Note: These values were measured statistically by a 10m cord.
Twist value contains gradual decrease value of the cant.

Source: JICA Study Team

(4) Casting Track Bed Concrete

An example of the mixing ratio of the track bed concrete is shown in Table 4.7.3. The strength of the concrete is the same value as the concrete strength of the civil structure.

Table 4.7.3 Example of Mixing Ratio of Track Bed Concrete

Strength name (N/mm^2)	Kind of cement	Maximum diameter of coarse aggregate (mm)	Slump range (cm)	Air quantity range (%)	Maximum W/C (%)	Quantity of glass fibre (kg/m^3)
24	N	25	18±2.5	4,5±1.5	55	9.1

Source: JICA Study Team

(5) Safety Facilities for track inspectors

For the purpose of track inspection, a staff passage is needed along the whole line. The passage is made by plate made of steel, etc. The track contains a rubber mat between passage plate and sleeper in order to reduce the noise and vibration from the train passing.

(6) Anti-derailment guard rail

Guard rails for derailment prevention should be installed at the inner rail side in the section where the curve radius is less than 300m and the transition curve which has the cant competes with the vertical curve.

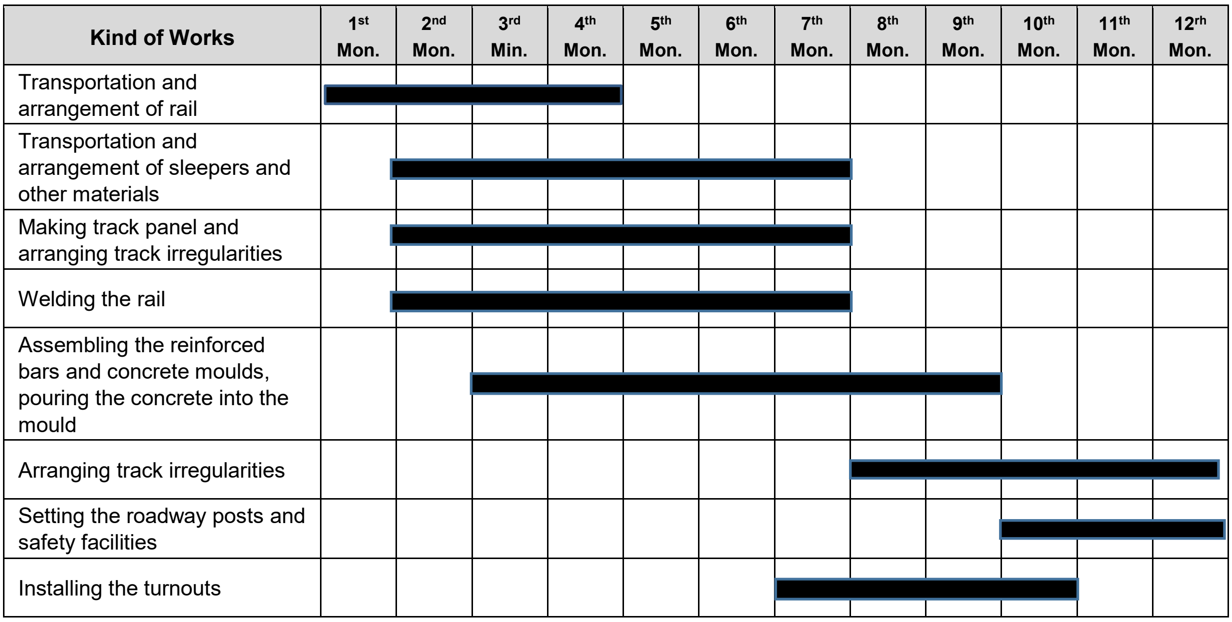
(7) Track side Signage

Individual signs for distances in kilometers, gradient, curve, versing and cant reduction, overhead clearance, etc., should be installed at the designated point.

4.7.3 Track Laying Schedule

Normally the duration of track construction is estimated at about one year as shown in Figure 4.7.4. Upon completion of civil structures, track laying is started. However, it is not uncommon that the construction schedule becomes so tight inevitably requiring a time extension owing to delays related to land acquisition or coordination with related authorities such as utilities agencies.

There are several examples of track laying work undertaken under reduced working period to meet project key dates. Therefore, other approaches should be studied and considered to catch up with the schedule.



Source: JICA Study Team

Figure 4.7.4 Normal Schedule of Track Works

4.8 Operation Planning

4.8.1 Operation Planning Data

The train operation plan must be a plan that can cope with peak traffic volume based on the passenger demand forecast. The data necessary to prepare the plan is as follows:

1) Passenger Demand Forecast

The forecast demand during peak hours and Passengers per Hour per Direction (PPHPD) are shown in Table 4.8.1. The PPHPD is used to set the number of required trains for the peak time and the number of procured trains.

Table 4.8.1 Max PPHPD

Peak Hour	2025		2035	
Airport Line	North Bound (Down)	South Bound (Up)	North Bound (Down)	South Bound (Up)
Airport				
	18,400	20,300	36,660	36,530
Airport Terminal 3				
	21,100	20,300	36,660	36,530
Khilkhet				
	20,400	23,100	47,970	47,060
Future Park				
	26,500	20,800	42,250	43,940
Notun Bazar				
	26,500	20,600	42,250	43,940
Uttr Badda				
	26,100	20,600	40,820	41,990
Badda				
	23,600	20,400	29,640	29,510
Hatir Jheel				
	23,600	23,700	28,990	28,990
Rampura				
	23,200	23,500	25,740	25,220
Malibagh				
	19,800	19,800	14,430	14,040
Rajarbagh				
	6,100	4,900	26,260	25,220
Kamalapur				

Peak Hour	2025		2035	
Purbachal Line	West Bound (Down)	East Bound (UP)	West Bound (Down)	East Bound (UP)
Future Park				
	20,700	20,000	26,000	25,090
Bashundhara				
	20,700	20,000	27,300	25,350
POHS				
	20,700	20,000	27,300	25,350
Mastul				
	16,000	12,500	17,680	18,720
Purbachal West				
	16,000	12,500	17,420	17,420
Purbachal Central				
	16,000	12,500	17,420	17,420
Purbachal Sector 7				
	7,600	6,400	9,230	9,750
Purbachal Terminal				

年	2025	2035
PPHPD（Pax）	26,500	47,970
	Notun Bazar ～ Future Park	Future Park ～ Khilkhet

Source: JICA Study Team

Note: While commercial operation will start from end of 2026, demand forecast was done for 2025. The Operation Plan Study was carried out these transport volume.

2) Transportation Capacity

Maximum transportation capacity for meeting the passenger demand, namely, the carrying capacity of each EMU, is 1,738 people in a 6-car formation and 2,332 people in an 8-car formation according to the specifications of the Rolling Stock plan of MRT Line 6, assuming the congestion rate is 180% as shown in Table 4.8.2.

Table 4.8.2 Capacity of EMU

T	End Car	Seated	45 pax		
		Standing	108 pax		
		Total	153 pax		
M	Middle Car	Seated	54 pax		
		Standing	111 pax		
		Total	165 pax	Congestion Rate	Capacity of EMU
6 car formation		4M2T	966 pax	180%	1,738 pax
8 car formation		6M2T	1,296 pax	180%	2,332 pax

Source: JICA Study Team

3) Headway

Headway is the interval time between preceding and following trains in a certain section. The headway is determined by comprehensively examining the stopping time at the station, the acceleration, and deceleration performance, the operation speed of the train, the length of the train, the function of the signal, and the like.

Stopping Time

Table 4.8.3 shows the classification of stopping time at each station according to the standards of MRT Line 6.

Table 4.8.3 Stopping Time at Station

Daily Passenger	Stopping time
Over 100,001	45 sec.
70,001 - 100,000	40 sec.
40,001 - 70,000	35 sec.
20,001 - 40,000	30 sec.
Under 20,000	25 sec.

Breakdown of Stopping time

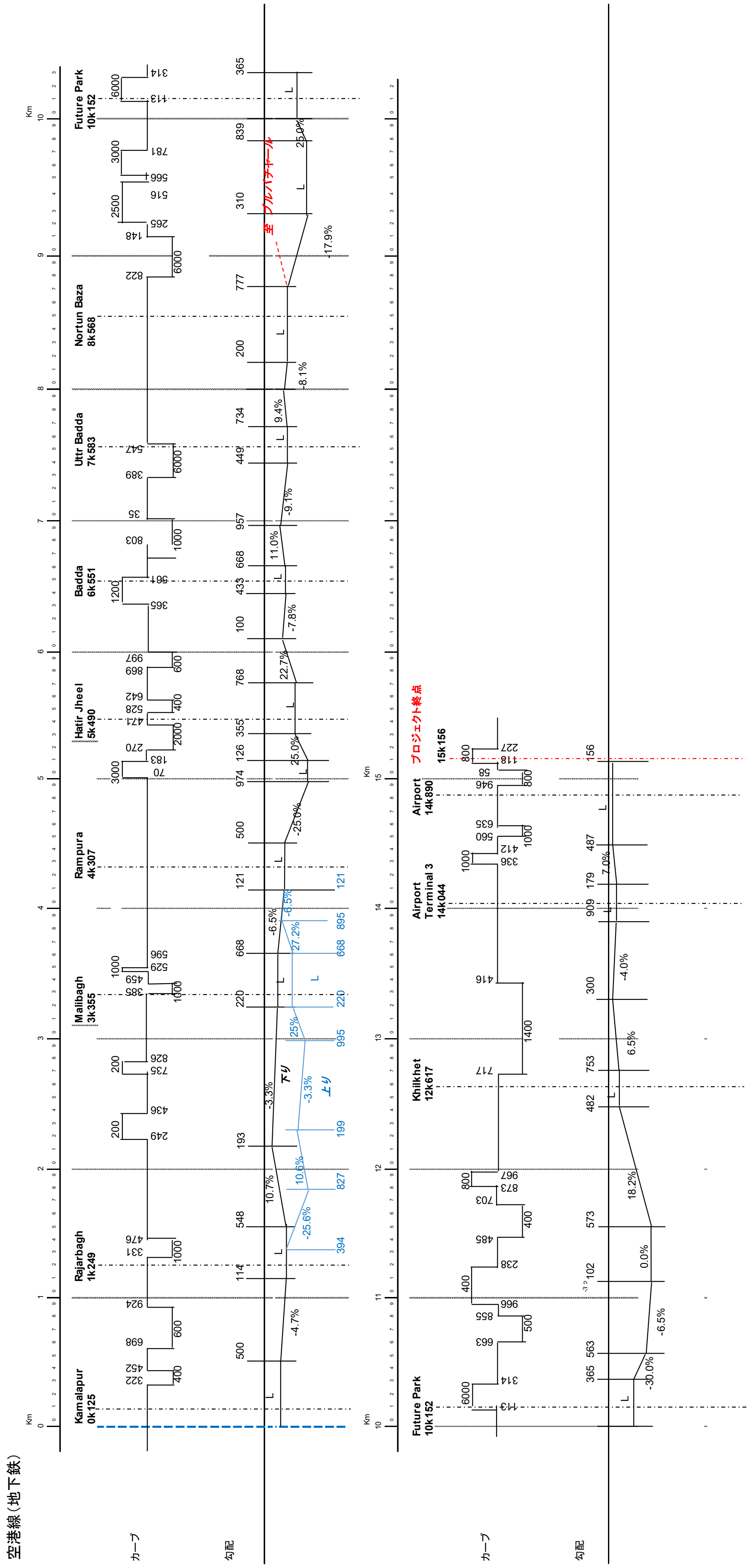
Daily Passenger Over 70,000	Time Required
- Position confirmation by driver	2.5 sec.
↓	
- Opening car and PSD door	2.5 sec.
↓	
- Passenger getting off and on	35.0 sec.
↓	
- Closing car and PSD door	2.5 sec.
↓	
- Safety confirmation by driver	2.5 sec.
Total	**45.0 sec.**

Source: JICA Study Team

4.8.2 Running Time

The trains carry passengers to their destinations by running through curves and going up and down slopes as shown in Figure 4.8.1, which is drawn according to the project profile. An efficient operation plan for the trains is created by using the operation curve in which the elapsed time and the speed are continuously calculated and graphed according to the change of the running position of the train. It is created taking into consideration the conditions of the rail and equipment, the vehicle performance, etc. In some sections, the changes in speed at each point when travelling are expressed as shown in Figure 4.8.2 while performing acceleration and deceleration so that the required time becomes the shortest within the range of the speed limit.

The running time for creating the train diagram is calculated by adding the margin time to the running time obtained from the operation curve.


空港線(地下鉄)
カーブ
勾配
Kamalapur 0k125
Rajarbagh 1k249
Malibagh 3k355
Rampura 4k307
Hatir Jheel 5k490
Badda 6k551
Uttr Badda 7k583
Nortun Baza 8k568
Future Park 10k152
Khilkhet 12k617
Airport Terminal 3 14k044
Airport 14k890
15k156
プロジェクト終点
下り
上り

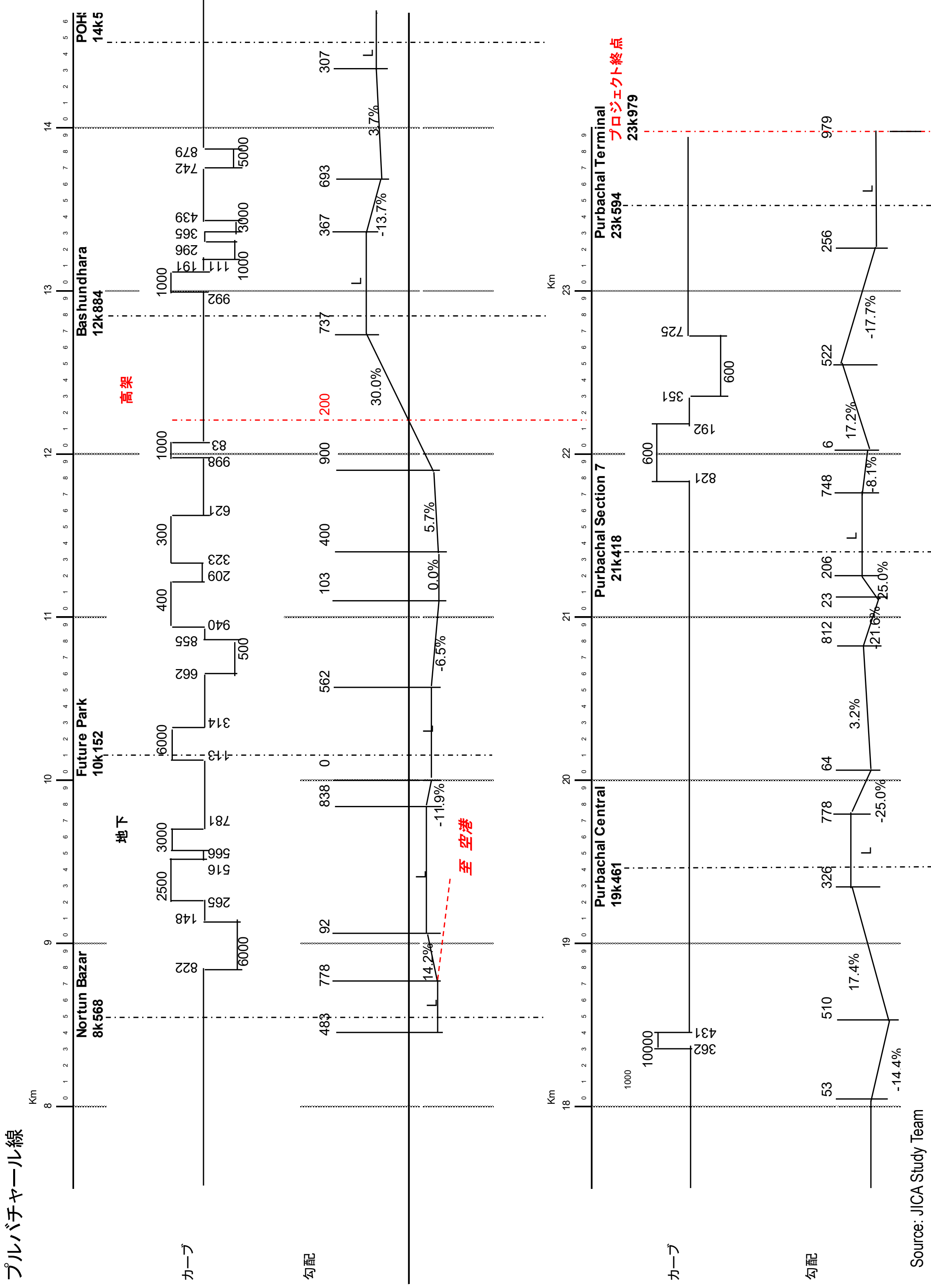
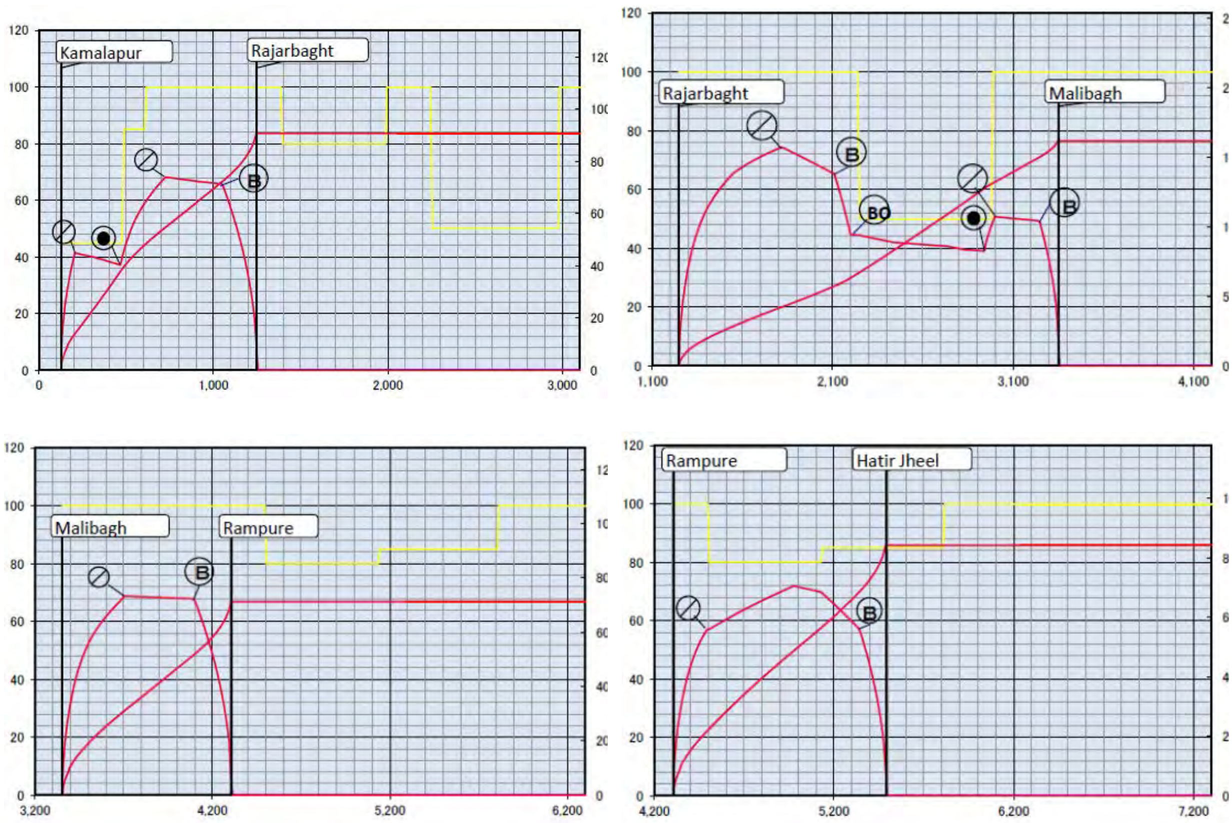


Figure 4.8.1 Railway Sketch



Source: JICA Study Team

Figure 4.8.2 Operation Curves (Example)

4.8.3 Operation Guide

The operating speed and travel time from the start point to the end point are shown in Table 4.8.4 in consideration of the travel time and the stopping time between the stations obtained by the aforementioned operation curve.

Table 4.8.4 Operation Guide

	Track Length			Outbound						Inbound					
				Operation Speed		Operation Time	Morning Peak Hour			Operation Speed		Operation Time	Morning Peak Hour		
	Accm. km		Interval km	Ave. km/h	Max. km/h	Asess. mm:ss	Stopping Time ss	Arrv. Time mm:ss		Ave. km/h	Max. km/h	Asess. mm:ss	Stopping Time ss	Arrv. Time mm:ss	
Purbachal Terminal	23.5	15.0					-	20:40	36:10				-		-
			2.2	54.6	90	02:25				52.8	85	02:30			
Purbachal Sector 7	21.3	12.8					40	17:35	33:05				40		02:30
			1.9	57.0	85	02:00				57.0	95	02:00			
Purbachal Central	19.4	10.9					45	14:50	30:20				45		05:10
			1.6	57.6	95	01:40				57.6	85	01:40			
Purbachal West	17.8	9.3					35	12:35	28:05				35		07:35
			1.6	54.9	90	01:45				57.6	90	01:40			
Mastul	16.2	7.7					35	10:15	25:45				35		09:50
			1.7	58.3	90	01:45				58.3	95	01:45			
POHS	14.5	6.0					45	07:45	23:15				45		12:10
			1.7	55.6	85	01:50				58.3	90	01:45			
Bashundhara	12.8	4.3					35	05:20	20:50				35		14:40
			2.7	57.2	80	02:50				58.9	85	02:45			
Future Park	10.1	1.6					45	01:45	17:15				45		18:00
			1.6	54.9	85	01:45				54.9	85	01:45			
Notun Bazar	8.5	—					—	—	14:55				—		20:30
Airport	14.8						-		24:20				-	-	-
			0.9	43.2	70	01:15				40.5	60	01:20			
Airport Terminal 3	13.9						40		22:25				40	01:20	-
			1.4	53.1	85	01:35				53.1	85	01:35			
Khilkhet	12.5						30		20:20				30	03:35	-
			2.4	59.6	85	02:25				59.6	85	02:25			
Future Park	10.1						45		17:10				45	06:30	-
			1.6	57.6	90	01:40				54.9	90	01:45			
Nortun Bazar	8.5						35		14:55				35	09:00	20:30
			1.0	40.0	70	01:30				37.9	65	01:35			
Uttr Badda	7.5						30		12:55				30	11:10	22:40
			1.0	45.0	75	01:20				45.0	75	01:20			
Badda	6.5						30		11:05				30	13:00	24:30
			1.1	49.5	75	01:20				49.5	80	01:20			
Hatir Jheel	5.4						45		09:00				45	14:50	26:20
			1.2	48.0	75	01:30				48.0	80	01:30			
Rampura	4.2						30		07:00				30	17:05	28:35
			0.9	43.2	75	01:15				43.2	75	01:15			
Malibagh	3.3						40		05:05				40	18:50	30:20
			2.2	48.0	80	02:45				45.3	75	02:55			
Rajarbagh	1.1						45		01:35				45	22:25	33:55
			1.1	41.7	75	01:35				44.0	75	01:30			
Kamalapur	—						-		-				-	24:40	36:10

	Section	Inbound	Outbound
Schedule Speed km/h	Kamalapur～Airport	36.5	36.0
	Kamalapur～Purbachal Terminal	39.0	39.0
	Notun Bazar～Purbachal Terminal	43.5	43.9

Source: JICA Study Team

1) Travel Time and Arrival Time

The travel time and the arrival time between the stations are shown in Table 4.8.5 based on the value calculated according to the operation guide.

Table 4.8.5 Travel Time and Arrival Time

Stopping Time	**Purbachal Terminal**	02:25	05:05	07:30	09:50	12:10	14:45	18:10	20:40		–	–	–	–	–	22:45	24:35	26:25	28:40	30:25	33:50	36:10	Stopping Time
40	02:30	**Purbachal Sector 7**	02:00	04:25	06:45	09:05	11:40	15:05	17:35		–	–	–	–	–	19:40	21:30	23:20	25:35	27:20	30:45	33:05	40
45	05:10	02:00	**Purbachal Central**	01:40	04:00	06:20	08:55	12:20	14:50		–	–	–	–	–	16:55	18:45	20:35	22:50	24:35	28:00	30:20	45
35	07:35	04:25	01:40	**Purbachal West**	01:45	04:05	06:40	10:05	12:35		–	–	–	–	–	14:40	16:30	18:20	20:35	22:20	25:45	28:05	35
35	09:50	06:40	03:55	01:40	**Mastul**	01:45	04:20	07:45	10:15		–	–	–	–	–	12:20	14:10	16:00	18:15	20:00	23:25	25:45	35
45	12:10	09:00	06:15	04:00	01:45	**POHS**	01:50	05:15	07:45		–	–	–	–	–	09:50	11:40	13:30	15:45	17:30	20:55	23:15	45
35	14:40	11:30	08:45	06:30	04:15	01:45	**Bashundhara**	02:50	05:20		–	–	–	–	–	07:25	09:15	11:05	13:20	15:05	18:30	20:50	35
45	18:00	14:50	12:05	09:50	07:35	05:05	02:45	**Future Park**	01:45		–	–	–	–	–	03:50	05:40	07:30	09:45	11:30	14:55	17:15	45
–	20:30	17:20	14:35	12:20	10:05	07:35	05:15	01:45	**Notun Bazar**		–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–		**Airport**	01:15	03:30	06:25	08:50	10:55	12:45	14:35	16:50	18:35	22:00	24:20	–
40	–	–	–	–	–	–	–	–	–		01:20	**Airport Terminal 3**	01:35	04:30	06:55	09:00	10:50	12:40	14:55	16:40	20:05	22:25	40
30	–	–	–	–	–	–	–	–	–		03:35	01:35	**Khilkhet**	02:25	04:50	06:55	08:45	10:35	12:50	14:35	18:00	20:20	30
45	–	–	–	–	–	–	–	–	–		06:30	04:30	02:25	**Future Park**	01:40	03:45	05:35	07:25	09:40	11:25	14:50	17:10	45
35	–	–	–	–	–	–	–	–	–		09:00	07:00	04:55	01:45	**Nortun Bazar**	01:30	03:20	05:10	07:25	09:10	12:35	14:55	35
30	22:40	19:30	16:45	14:30	12:15	09:45	07:25	03:55	–		11:10	09:10	07:05	03:55	01:35	**Uttr Badda**	01:20	03:10	05:25	07:10	10:35	12:55	30
30	24:30	21:20	18:35	16:20	14:05	11:35	09:15	05:45	–		13:00	11:00	08:55	05:45	03:25	01:20	**Badda**	01:20	03:35	05:20	08:45	11:05	30
45	26:20	23:10	20:25	18:10	15:55	13:25	11:05	07:35	–		14:50	12:50	10:45	07:35	05:15	03:10	01:20	**Hatir Jheel**	01:30	03:15	06:40	09:00	45
30	28:35	25:25	22:40	20:25	18:10	15:40	13:20	09:50	–		17:05	15:05	13:00	09:50	07:30	05:25	03:35	01:30	**Rampura**	01:15	04:40	07:00	30
40	30:20	27:10	24:25	22:10	19:55	17:25	15:05	11:35	–		18:50	16:50	14:45	11:35	09:15	07:10	05:20	03:15	01:15	**Malibagh**	02:45	05:05	40
45	33:55	30:45	28:00	25:45	23:30	21:00	18:40	15:10	–		22:25	20:25	18:20	15:10	12:50	10:45	08:55	06:50	04:50	02:55	**Rajarbagh**	01:35	45
–	36:10	33:00	30:15	28:00	25:45	23:15	20:55	17:25	–		24:40	22:40	20:35	17:25	15:05	13:00	11:10	09:05	07:05	05:10	01:30	**Kamalapur**	–

Source: JICA Study Team

2) Number of Trains and Cycle Time

The number of trains shows the required number operated on one route, and it is decided by the distance of the route, the operation interval, the turn-back time, and so on. In urban railways, the shortest operation headway is required at morning rush hour when the number of trains reaches the maximum number on that route. The number of cars to be used is calculated from the total number of trains multiplied by the number of train sets.

Table 4.8.6 Number of Trains and Headway (All Train Go to Kamalapur Station)

Year 2025	Most Congested Section	PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (mm:ss)	Congested Ratio (%)
6 Cars	Notun Bazar → Future Park	26,500	**1,738**	17	03:40	161.4
	POHS → Bashundhara	20,700		13	04:40	164.9
	Kamalapur→Nortun Bazar			30	**02:00**	

Year 2025	Most Congested Section	PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (mm:ss)	Congested Ratio (%)
8 Cars	Notun Bazar → Future Park	26,500	**2,332**	14	03:40	146.1
	POHS → Bashundhara	20,700		10	04:40	159.8
	Kamalapur→Nortun Bazar			24	**02:30**	

Year 2035	Most Congested Section	PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (mm:ss)	Congested Ratio (%)
8 Cars	Future Park → Khihket	47,970	**2,332**	21	03:40	176.3
	Mastul → POHS	27,300		12	04:40	175.6
	Kamalapur→Nortun Bazar			33	**01:50**	

Source: JICA Study Team

Table 4.8.7 Number of Trains and Headway (Some Trains Return from Notun)

2025 (6 cars)

2025	Most Congested Section			PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (min:sec)	Congested rates (%)
6cars	Nortun Bazar	→	Future Park	25,600	1,738	17	03:40	156
	POHS	→	Bashundhara	22,300		13	04:40	178
	Kamalapur	→	Nortun Bazar	23,800		20	03:30	123

*10 Trains on Purbachal Line shall return from Nortun Bazar

2025 (8 cars)

2025	Most Congested Section			PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (min:sec)	Congested Ratio (%)
8cars	Nortun Bazar	→	Future Park	25,600	2,332	12	5:00	165
	POHS	→	Bashundhara	22,300		10	06:00	172
	Kamalapur	→	Nortun Bazar	23,800		15	04:00	123

*7 Trains on Purbachal Line shall return from Nortun Bazar

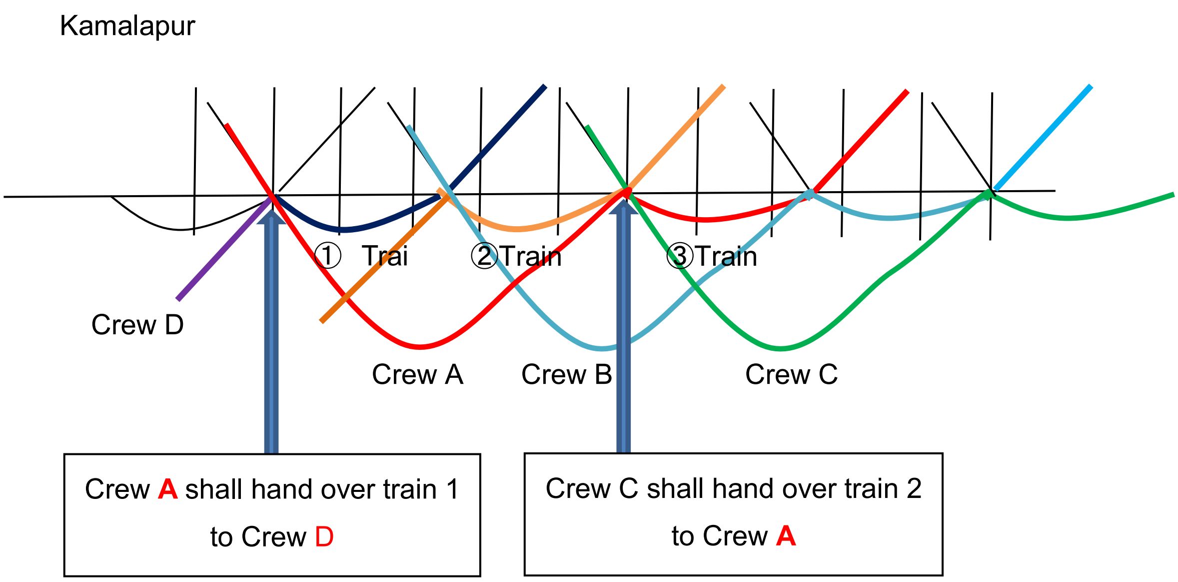
2035 (8 cars)

2035	Most Congested Section			PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (min:sec)	Congested Ratio (%)
8cars	Nortun Bazar	→	Future Park	47,970	2,332	21	03:40	176
	POHS	→	Bashundhara	27,300		12	04:40	162
	Kamalapur	→	Nortun Bazar	42,250		24	02:30	136

*10 Trains on Purbachal Line shall return from Nortun Bazar

In order to meet the 2035 forecast passenger demand, 13 trains consisting of 8 cars would operate per hour in each direction between Purbachal and DBC. Of the 13 trains, 10 trains may be returned to Notun Bazar Station according to the demand. But at Kamalapur Station trains should leave every 2 minutes 30 second interval. It is quite Sevier manner. At detailed engineering stage more detailed analysis shall be under taken, taking into vertical alignment, location of the turnout and scissors crossing, train stopping time at stations and EMU performance.

- As shown in the figure below which describes the turn back at Kamalapur Station in the 2 minutes 30 seconds headway timetable, the conductor A in charge of train ① shall hand over the train to conductor D, and crew train ③ which arrives two trains later (taking over after conductor C).

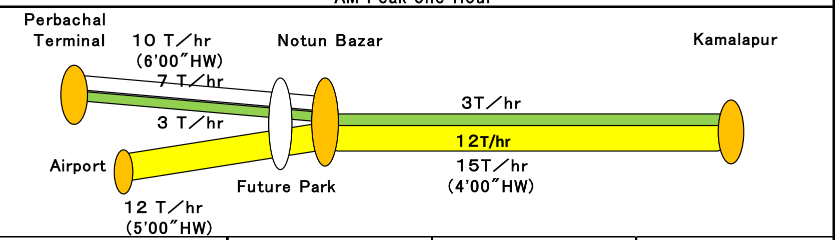


4.8.4 Number of Cars to be Formed and the Required Number of Train Sets

1) Operation Plan

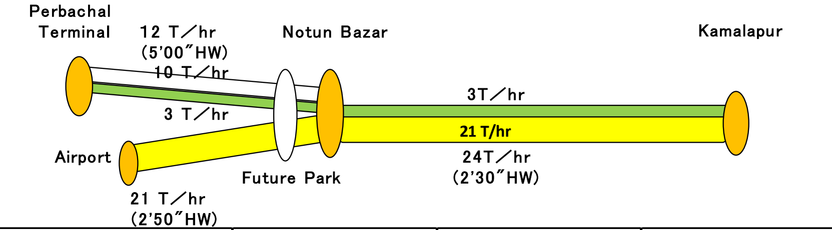
Table 4.8.8 shows the operation plan at the peak hours on weekdays for each car formation in each year.

Table 4.8.8 Operation Plan 2025 (8 Cars)

2025 (1 Train:8 cars)		Normal Day AM Peak one Hour							
Image									
Section		Kamalapur～Airport		Kamalapur～Perbachal Terminal		Notun Bazar～Perbachal Terminal		－	
Kilimetage (km)		14.8		23.5		15.0		－	
Number of Trains		12		3		7		－	
Head (Min:Sec)		05:00		20:00		08:30		－	
	Kamalapur～Notun Bazar	04:00				－		－	
	Notun Bazar～Perbachal Terminal	－		06:00				－	
Average (Min:Sec)	Up Direction	24:40		36:10		20:30		－	
	Down Direction	24:20		36:10		20:40		－	
Average (km/h)	Up Direction	36.0		39.0		43.9		－	
	Down Direction	36.5		39.0		43.5		－	
Turn Back (Min:Sec)	Purbachal Terminal	－		03:40		05:50			
	Airport	07:00		－		－			
	Notun Bazar	－		－		04:00			
	Kamalapur	04:00		04:00		－			
Required Time for 1Cycle(Hr:Min:Sec)		1:00:00		1:20:00		0:51:00		－	
Number of Trains	Composition (Car)	8						－	
	Commercial Operation	12	96	4	32	6	48	22	176
	Standby	－		－				3	24
	Total	－		－				25	200

Source: JICA Study Team

Table 4.8.9 Operation Plan 2035 (8 Cars)

2035 (1 Train:8 cars)		Normal Day AM Peak one Hour							
Image									
Section		Kamalapur～Airport		Kamalapur～Perbachal Terminal		Notun Bazar～Perbachal Terminal		–	
Kilimetage (km)		14.8		23.5		15.0		–	
Number of Trains		21		3		10		–	
Head (Min:Sec)		02:50		20:00		6:00		–	
	Kamalapur～Notun Bazar	02:30				–		–	
	Notun Bazar～Perbachal Terminal	–		04:40				–	
Average (Min:Sec)	Up Direction	24:40		36:10		20:30		–	
	Down Direction	24:20		36:10		20:40		–	
Average (km/h)	Up Direction	36.0		39.0		43.9		–	
	Down Direction	36.5		39.0		43.5		–	
Turn Back (Min:Sec)	Purbachal Terminal	–		5:10		4:20			
	Airport	05:10		–		–			
	Notun Bazar	–		–		02:15			
	Kamalapur	02:30		02:30		–			
Required Time for 1Cycle(Hr:Min:Sec)		0:56:40		1:20:00		0:48:00		–	
Number of Trains	Composition (Car)	8						–	
	Commercial Operation	20	160	4	32	8	64	32	256
	Standby	–		–				4	32
	Total	–		–				36	288

Source: JICA Study Team

2) Rolling Stock Procurement Plan

The number of required rolling stock per year based on the above operation plan is shown in Table 4.8.10 and is a reference for the rolling stock procurement plan.

Table 4.8.10 Rolling Stock Procurement Plan

Year		2025		2035	
Number of Cars	Fleet (Car)	8		8	
	Required Trains fleet/car	22	176	32	256
	Stanby fleet/car	3	24	4	32
	Total fleet/car	25	200	36	288

Source: JICA Study Team

As reserved train set, JST estimated one fleet for emergency, 2 – 3 fleets for regular inspection & maintenance and one fleet for repair for accident.

4.8.5 All Day Operation Headway and Number of Trains (Weekdays)

Table 4.8.11 shows the all-day operation headway including peak hours in the morning and the evening and off-peak hours in the early morning and late night and the required number of trains.

Table 4.8.11 All Day Operation Headway and Number of Trains

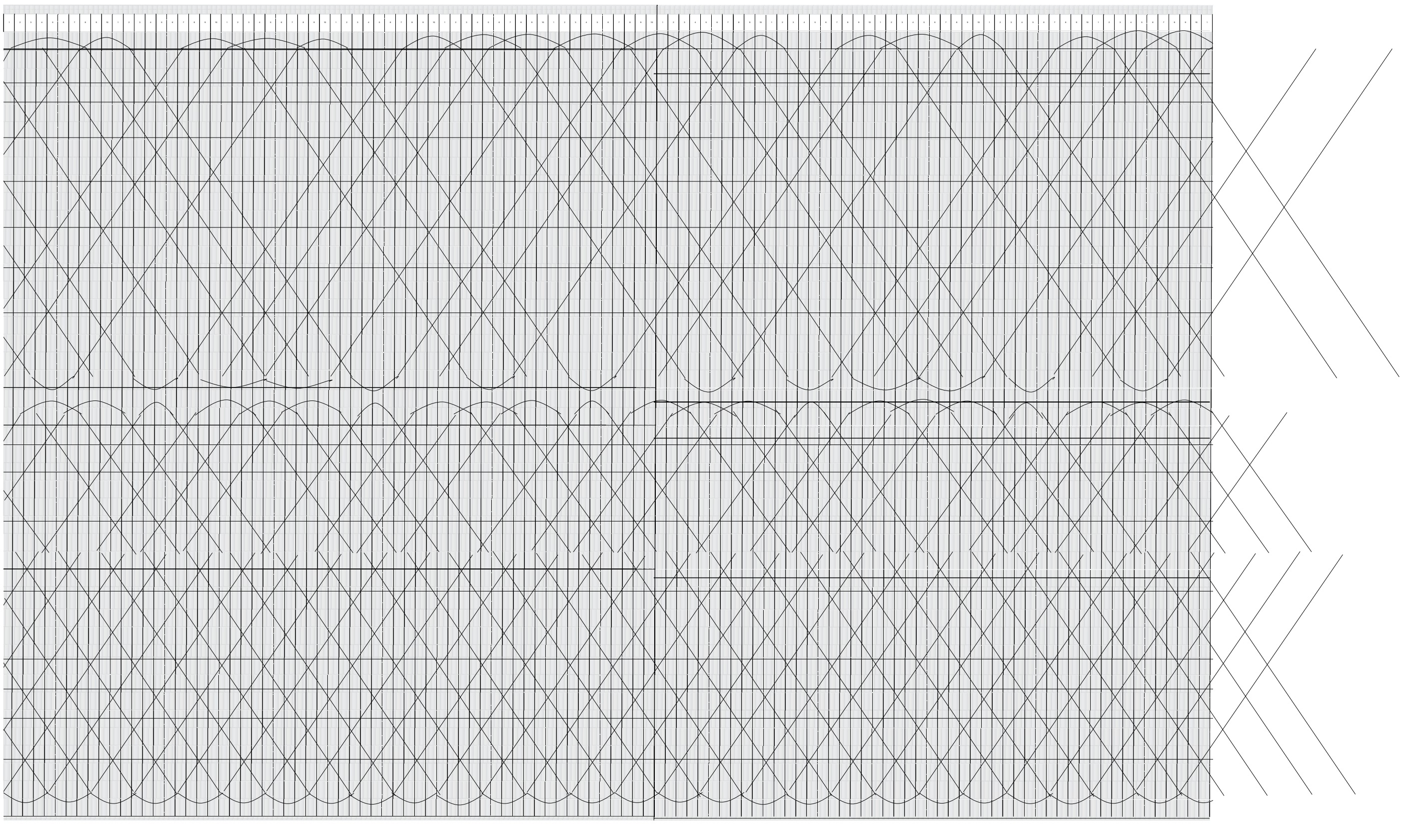
Upper: Headway, Lower: Number of Trains

Year		Section	5:30–8:00	8:00–10:30	10:30–16:30	16:30–19:00	19:00–24:00	All Day
2025	6cars	Nortun bazar – Airport	6'40″ 22 Nos	3'40″ 42 Nos	6'40″ 54 Nos	5'00″ 30 Nos	6'40″ 45 Nos	193
		Nortun Bazar – Purbachal	10' 00″ 14 Nos	4' 40″ 32 Nos	10' 00″ 36 Nos	7'30″ 19 Nos	10' 00″ 30 Nos	131
		Kamalapur – Norton Bazar	5' 00″ 29 Nos	3'00″ 49 Nos	5' 00″ 72 Nos	4' 00″ 37 Nos	5' 00″ 60 Nos	247
	8cars	Nortun bazar – Airport	8'30″ 17 Nos	5'00″ 30 Nos	8'30″ 42 Nos	6'40″ 22 Nos	8'30″ 35 Nos	146
		Nortun Bazar – Purbachal	10' 00″ 14 Nos	6' 00″ 24 Nos	10' 00″ 36 Nos	8'30″ 17 Nos	10' 00″ 30 Nos	121
		Kamalapur – Norton Bazar	6' 00″ 24 Nos	4'00″ 37 Nos	6' 00″ 60 Nos	5' 00″ 29 Nos	6' 00″ 50 Nos	200
2035	8cars	Nortun bazar – Airport	6'00″ 25 Nos	2'50″ 52 Nos	6'00″ 60 Nos	4'00″ 37 Nos	6'00″ 50 Nos	224
		Nortun Bazar – Purbachal	10' 00″ 14 Nos	4' 40″ 32 Nos	10' 00″ 36 Nos	7'30″ 19 Nos	10' 00″ 30 Nos	131
		Kamalapur – Norton Bazar	4' 40″ 32 Nos	2'30″ 59 Nos	4' 40″ 78 Nos	3' 20″ 44 Nos	4' 40″ 65 Nos	278

Source: JICA Study Team

As reserved train set, JST estimated one fleet for emergency, 2 – 3 fleets for regular inspection & maintenance and one fleet for repair for accident

4.8.6 Peak Hour Diagram 2025 (8 Cars)



Source: JICA Study Team

Figure 4.8.3 Peak Hour Diagram 2025 (8 Cars)