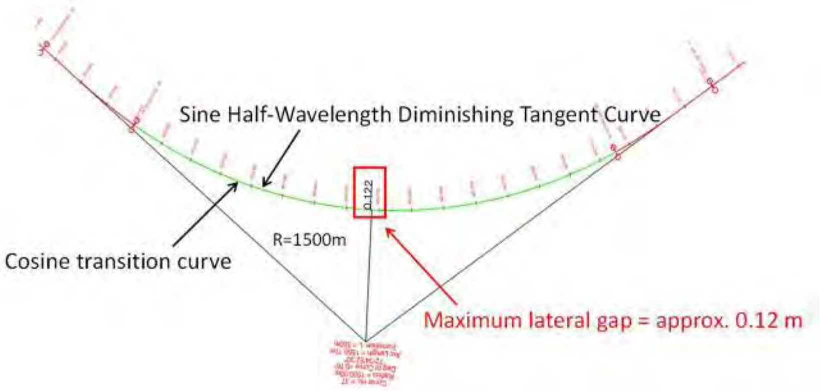
Chapter 8 Review of the Final Location Survey (which will be implemented by the Indian Side)

Before carrying out the Final Location Survey, there are some technical issues to be solved. In 8.1 Technical Issues, these issues and the policy are described. Then, in 8.2 Final Alignment Design (FAD), the basic policy, workflow, implemented contents, etc. of final alignment design are described.

8.1 Technical Issues

8.1.1 Shape of transition curve

For the Shinkansen system, a sine half-wavelength diminishing tangent curve has been adopted as the shape for a transition curve. However, at the stage of the Joint F/S, a cosine transition curve had been adopted due to constraints in Power Rail Track design software of Bentley. Therefore, at the stage of final location survey, in order to avoid differences in calculation by software, AutoCAD Civil 3D which incorporates a sine half-wavelength diminishing tangent curve is used. These issues were discussed on 19th and 30th May 2016 with MOR and agreed.



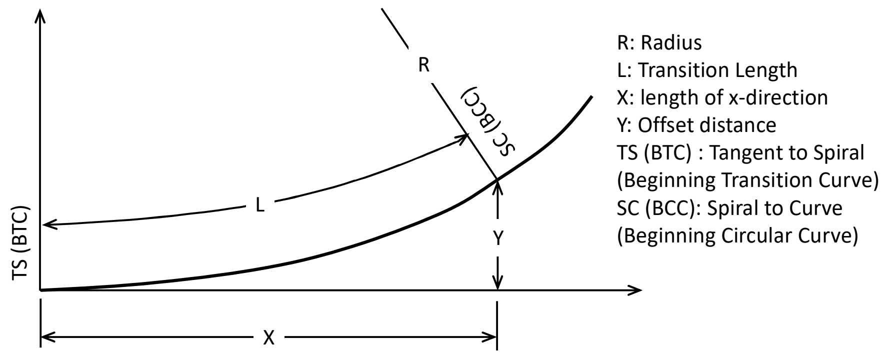
Source: The Study team

Figure 8.1.1-1 Difference between Cosine Transition Curve and Sine Half-wavelength Diminishing Tangent Curve (an example)

The formula of a sine half-wavelength diminishing tangent curve is as follows:

$$X = L - \left(\frac{2\pi^2-9}{48\pi^2}\right) * \frac{L^3}{R^2} = L - 0.0226689447 * \frac{L^3}{R^2}$$

$$Y = \left[\frac{1}{4} - \frac{1}{\pi^2}\right] * \frac{X^2}{R} = 0.14867881635766 * \frac{X^2}{R}$$



Source: The Study team

Figure 8.1.1-2 Formula for Sine Half-wavelength Diminishing Tangent Curve

8.1.2 Study for lowering rail level

This study had examined this technical issue before the alignment had been changed to a fully elevated one.
The result of this analysis for lowering rail level is given below:
The embankment section, which accounts for approx. 60 % of the whole route, was considered for lowering the box culvert from the existing ground level, as had been carried out in the construction of the DFC.

(1) Issues

1) Advantages
- Reduction of construction cost and land acquisition cost
- Reduction of embankment collapse

2) Disadvantages
- Submerged due to underpass when rail falls

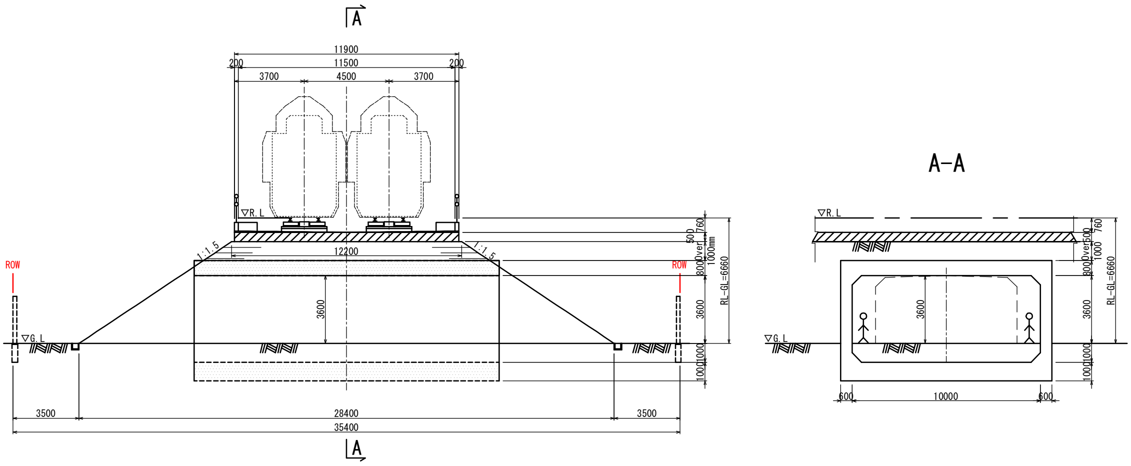
(2) Contents to be conducted

At the stage of the Joint F/S, due to a "shortage of the number of geotechnical surveys", "undecided design method" and "no consultations with authorities concerned", reports and drawings in the Joint F/S are based on the following assumptions:
1) Structure arrangement (e.g. embankment or viaduct) is an assumption. Viaduct sections are assumed on only sections where the Rail Level (R.L.) is high, around rivers or urban areas.
2) Shapes and dimensions of structures are assumptions.
3) Construction methods of structures are assumed. Extra space between the bottom of girder and road gauge is assumed to be 1.0 m for simple girders and 2.0 m for cantilever bridges. It is possible to reduce cost by adding the limit on the road gauge during the construction period.
4) Locations of substructures at the cross points with rivers, railways, roads are assumed. Those locations shall be decided based on the results of geological survey and in consultations with the authorities concerned.

Therefore, for lowering the rail level on embankment sections the following should be considered:
1) Necessary clearance at road crossing
2) Possibility of underpass at road crossing
3) Integration and abolishment of existing crossing roads and channels
4) Replacement of existing crossing roads and channels
5) Setting future lane
6) Clarification of flood area for decision of embankment or viaduct
7) Clarification of black cotton soil area

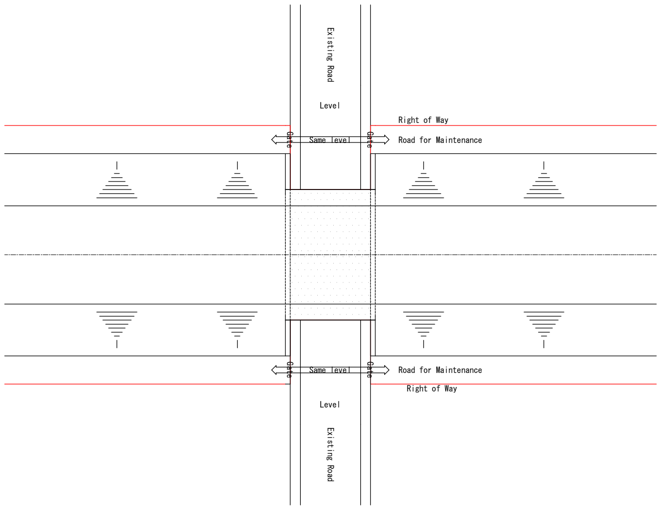
(3) Proposed box culvert section for lowering rail level

In the Joint F/S stage, the ground level before and after box culverts and the ground level in box culverts is the same. Therefore, existing roads and maintenance roads are at the same level and the passage of maintenance cars is smooth. In addition, when rain falls there is no risk of submergence of the box culvert.



Note: Clearance should be confirmed with road administrator
Source: The Study team

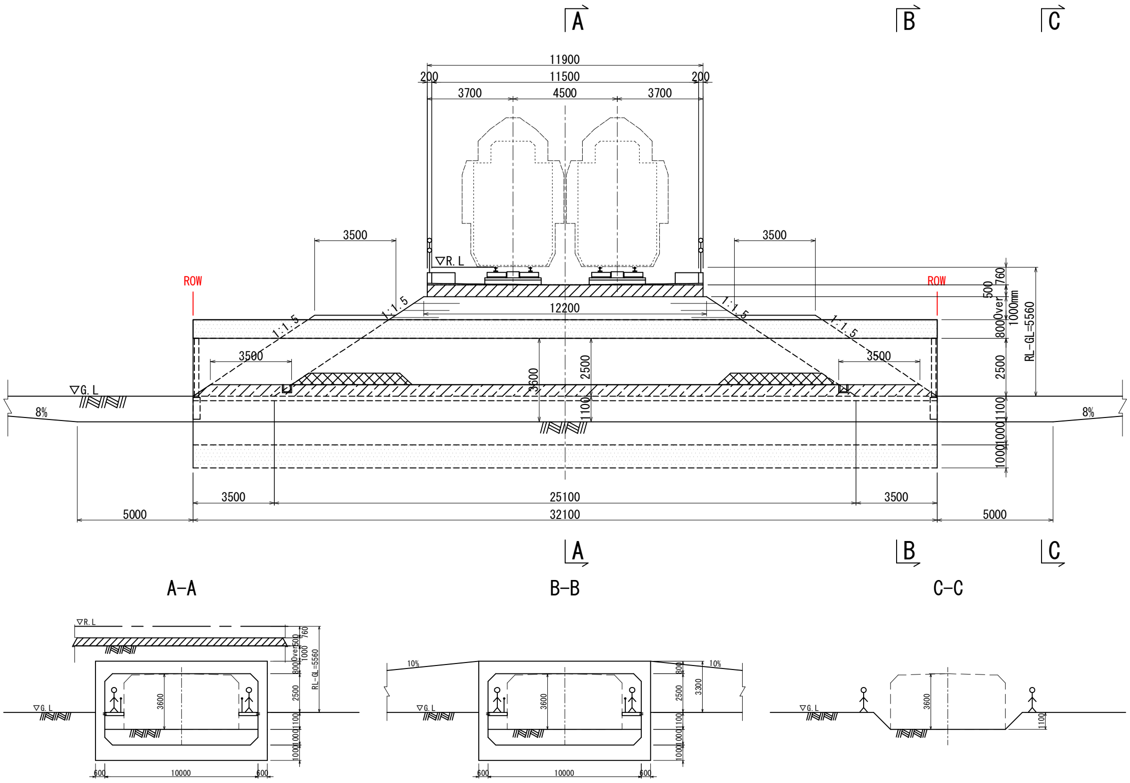
Figure 8.1.2-1 Proposed Standard Cross Section in the Joint F/S Stage



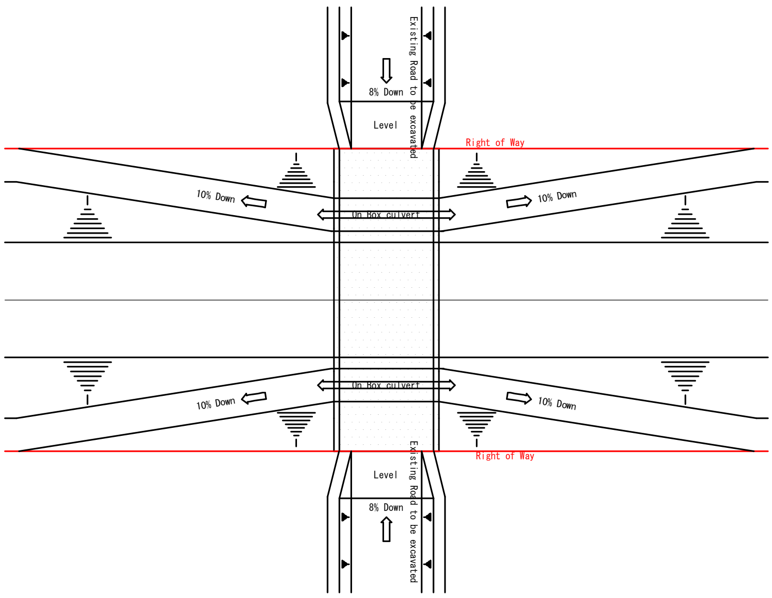
Source: The Study team

Figure 8.1.2-2 Proposed Standard Plan View in the Joint F/S Stage

Next, in the study for lowering rail level, the minimum clearance that people can pass on the sidewalk is set at 2.5 m, and the depth of the box culvert is set to ensure an inner space of 3.6 m in the roadway. In this case, the maintenance road of both sides of an embankment is interrupted at the box culvert section. Therefore, by setting a maintenance road up to the top of the embankment at a gradient of 10 %, maintenance vehicles can pass inside the land without changing the right-of-way. However, this way is undesirable from the viewpoint of maintenance due to many up-down maintenance roads if there are many box culverts to be set. In addition, at the time of rainfall, the box culvert will become submerged due to underpasses and make car traffic impossible depending on the submerged depth.



Note: Clearance should be confirmed to road administrator
Source: The Study team
Figure 8.1.2-3 Proposed Standard Cross Section for Lowering Rail Level



Source: The Study team
Figure 8.1.2-4 Proposed Standard Plan View for Lowering Rail Level

(4) Summary

Embankment width and the volume in the case of lowering the rail level or not for an embankment section is summarized in Table 8.1.2-1 and 8.1.2-2. In the Joint F/S stage, because the embankment section is assumed mainly at agricultural lands, arable lands and wastelands, vertical clearance is set almost at a height of 3.6 m. Therefore, the effects by lowering rail level in embankment section is that the level difference becomes from approx. 6.6 m to approx. 5.5 m and the embankment width changes from approx. 28 m to approx. 25 m.

Table 8.1.2-1 Dimensions of Proposed Box Culvert Section in Joint F/S Stage

	Inner width (m)	Between slope shoulder (m)	Overburden (m)	Upper slab (m)	Clearance (m)	RL-GL (m)	Embankment width (m)	Embankment volume (m^3)
District Road	10	12.2	1.0	0.8	5.5	8.56	34.1	169.0
	10	12.2	1.0	0.8	3.6	6.66	28.4	109.6
	5	12.2	1.0	0.6	3.6	6.46	27.8	104.0
Village Road	5	12.2	1.0	0.6	2.5	5.36	24.5	75.2

Source: The Study team

Table 8.1.2-2 Dimensions of Proposed Box Culvert Section for Lowering Rail Level

	Inner width (m)	Between slope shoulder (m)	Overburden (m)	Upper slab (m)	Clearance (m)	RL-GL (m)	Embankment width (m)	Embankment volume (m^3)
District Road	10	12.2	1.0	0.8	5.5 (2.5)	5.56	25.1	80.2
	10	12.2	1.0	0.8	3.6 (2.5)	5.56	25.1	80.2
	5	12.2	1.0	0.6	3.6 (2.5)	5.36	24.5	75.2
Village Road	5	12.2	1.0	0.6	2.5	5.36	24.5	75.2

Source: The Study team

(5) Conclusions

1) MOR mentioned that a submerged box culvert would not be allowed by state authorities.
2) The submerged box culvert is undesirable due to up-down maintenance roads and interference with car traffic when rain falls.
3) The vertical clearance depends on the kinds of vehicles passing on the road. Therefore, it will be needed to set the necessary vertical clearance at each intersection through consultation with the road administrator. For reference, the criteria for vertical clearance in the Joint F/S stage are shown in Table 8.1.2-3.

Table 8.1.2-3 Proposed Vertical Clearance by Road Type

Road type	Vertical clearance (m)
District road	5.5
	3.6
Village road	2.5

Source: The Study team based on "Replacement of Level Crossing by Road Over Bridge or Road Under Bridge, Indian Highways, August 2012".

8.1.3 Study on priority construction sections in Gujarat State

At the request of the Indian side, the Study team carried out prioritization of construction sections in Gujarat State. The following summarizes the policy, the candidate locations and some issues.

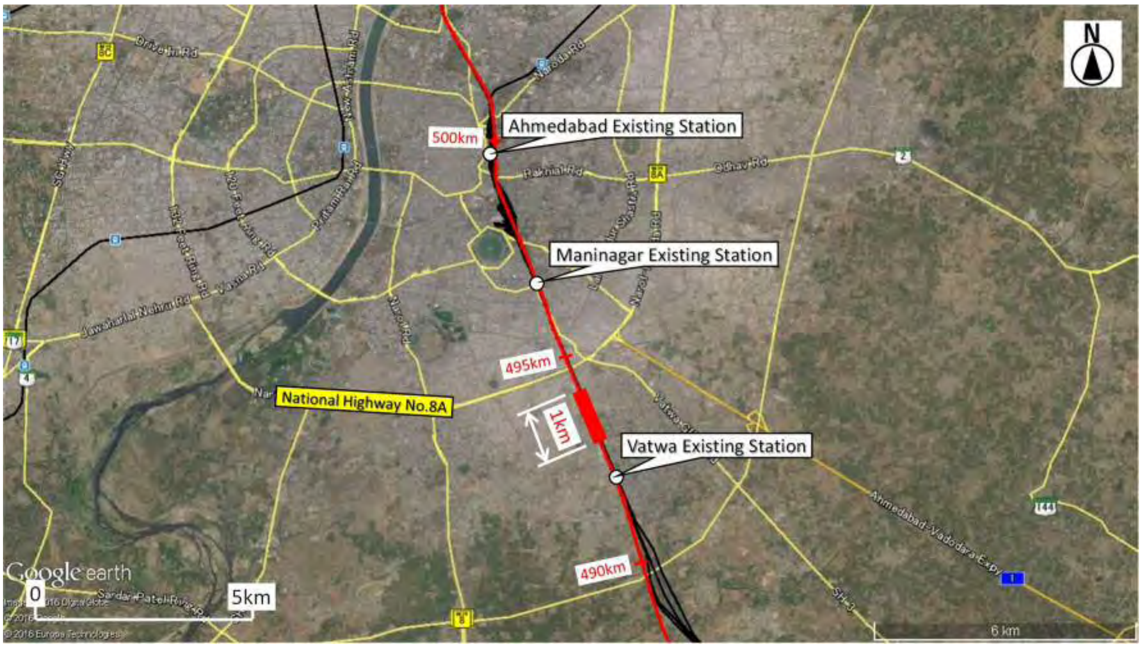
(1) Policy for selection

1) Straight sections of horizontal alignment
2) Passage through land owned by Indian Railways

(2) Candidate locations

1) From Km 493+200 to Km 494+200 (Length: 1km)

(Along the existing railway line between Vatwa station and Maninagar station in Ahmedabad)



Source: Compiled by the Study team based on Google Earth

Figure 8.1.3-1 Location Map of Priority Construction Section

(3) Issues

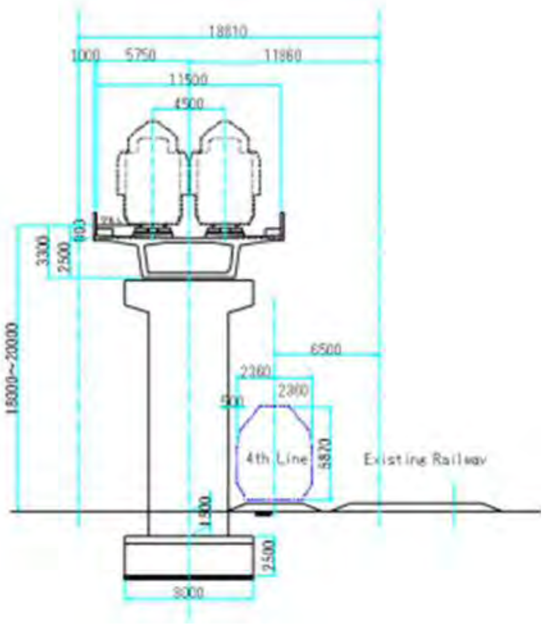
1) The 3rd line is under construction.
2) The 4th line was sanctioned.
3) No data with a coordinate (UTM, WGS84).

(4) Preliminary study

As shown in the above, the 3rd line is under construction and the 4th line was sanctioned along the existing railway line in Ahmedabad. It is necessary to confirm whether the HSR route and these new lines are in conflict or not. In the Joint F/S, a topographic survey in this area was carried out with coordinate (UTM, WGS84). However, drawings of the improvement plan obtained from Western Railways do not have the coordinate. Therefore, the conflict points were checked and the result is as shown in Figure 8.1-8. After all, a cancellation of 4th line has been re-confirmed at the sixth joint committee held in Delhi on 22nd November 2017.

Chainage of HSR (km m)	Distance between Railway Boundary and Existing Railway (m)	
492.400	19	
492.500	20	
492.600	21	
492.700	19	
492.800	20	
492.900	21	
493.000	21	
493.100	24	
493.200	26	
493.300	27	
493.400	28	
493.500	28	
493.600	28	
493.700	28	Length=1.0km
493.800	27	
493.900	28	
494.000	28	
494.100	27	
494.200	26	
494.300	24	
494.400	19	
494.500	17	
494.600	18	
494.700	19	

Standard Cross Section View



Source: The Study team

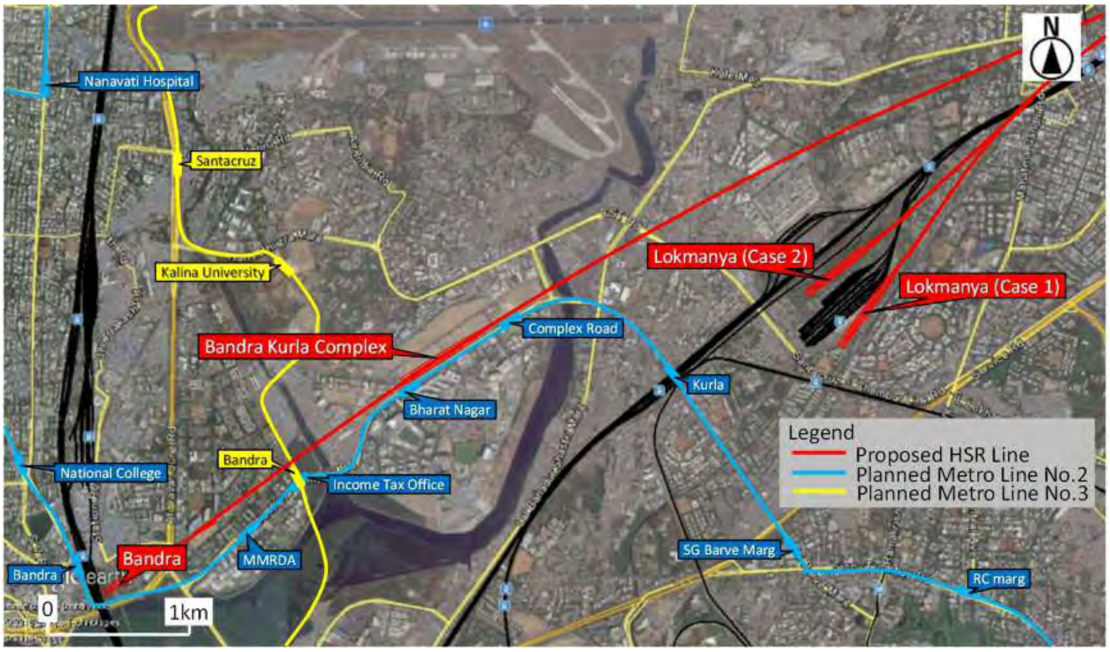
Figure 8.1.3-1 Preliminary study of priority construction section

8.1.4 Discussion of Mumbai station location

In the Joint F/S, Bandra Kurla Complex (BKC) has been agreed to be the starting HSR station between Mumbai and Ahmedabad. However, MMRDA pointed out that the HSR station location at BKC would interfere with their development work. The Study team then carried out an examination of the station location in Mumbai again. With a more detailed appraisal of BKC, the station locations at Bandra and Lokmanya, which were considered as alternative plans in the Joint F/S, were examined again. In addition, a possibility of locating the station at Bandra Reclamation Area (BRA) was considered in 8.1.5 Comparison of station locations at BRA and BKC. After all, at the sixth joint committee held in Delhi on 22nd November 2017, it has been re-confirmed that Mumbai HSR station location was approved at BKC planned in the joint F/S.

(1) Alternatives for station locations

Figure 8.1.4-1 shows the relationship between BKC, Bandra and Lokmanya. The route to Bandra extends almost straight from BKC. Candidate locations at Lokmanya are in vacant space between an existing station and main lines, or the vicinity of a station plaza on the east side of an existing station.

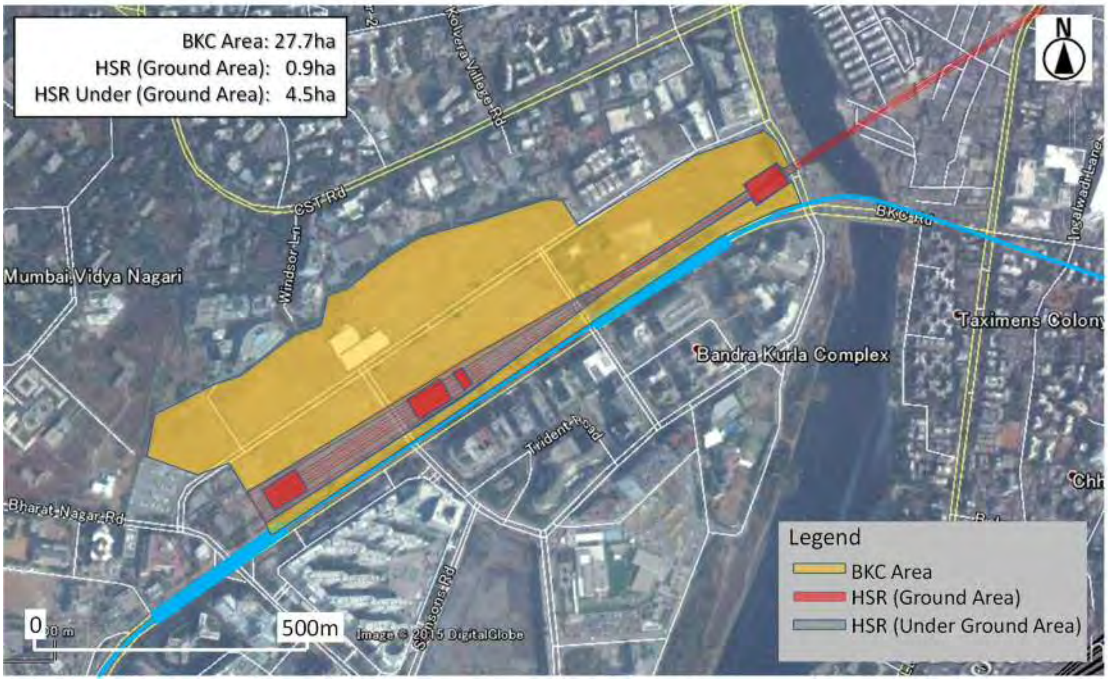


Source: Compiled by the Study team based on Google Earth

Figure 8.1.4-1 Alternatives of Station Locations in Mumbai

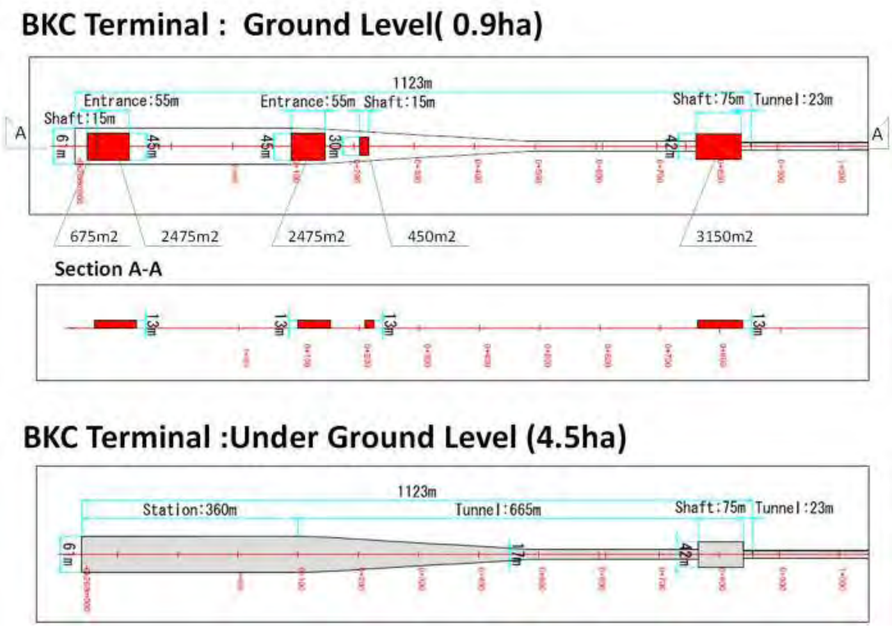
(2) Bandra Kurla Complex (BKC)

Figure 8.1.4-2 shows the required areas in the case of setting the HSR station at BKC. Although an area of approx. 4.5 ha is necessary for the underground portion, an area of approx. 0.9 ha is also necessary for the above ground portion. The facilities above ground are the HSR station entrances and ventilation shafts. The areas and width are shown in Figure 8.1.4-3. In addition, the height of the ventilation above ground is set at 13 m.



Source: Compiled by the Study team based on Google Earth

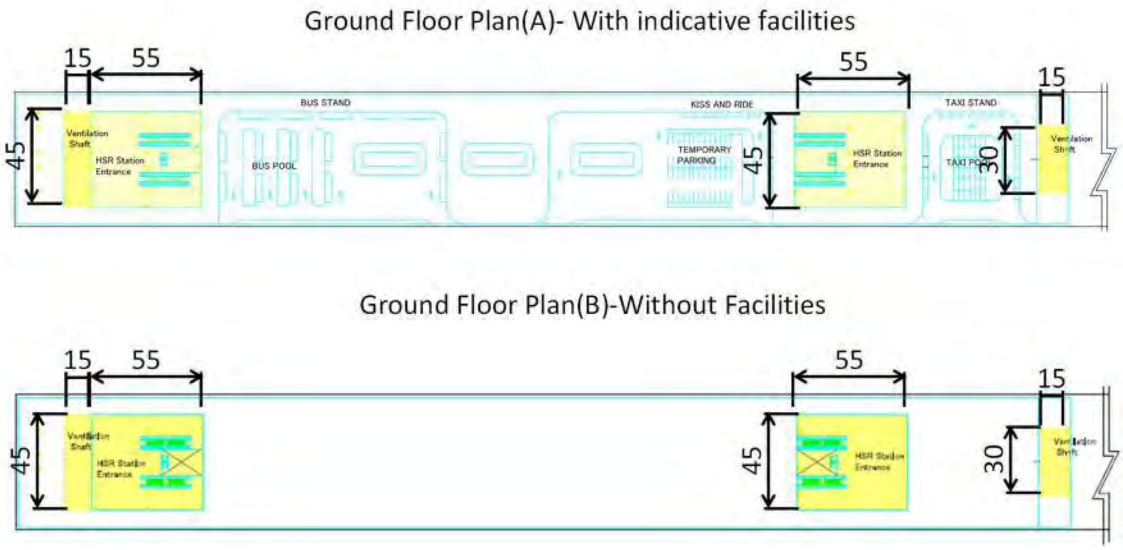
Figure 8.1.4-2 Land Required at BKC



Source: The Study team

Figure 8.1.4-3 Detailed land required at BKC

Figure 8.1.4-4 shows the ground floor plan with - without indicative facilities. The necessary widths for HSR station entrances and ventilation shafts are 55 m x 45 m and 15 m x 45 m (15 m x 30 m), respectively. With case, the facilities are the stand and pool for bus and taxi, and temporary parking for kiss-and-ride.



Source: The Study team

Figure 8.1.4-4 Ground Floor Plan (with-without facilities)

(3) Bandra railway land

The disadvantages in the case of setting the HSR station on Bandra railway land are as follows:

1) Far from the Central Business District
2) Traffic congestion
3) Land is inadequate. Additional land acquisition may be required
4) May require rebuilding of some high rise buildings
5) There are some slums in the vicinity which will be difficult to remove/relocate

Source: Compiled by the Study team based on Google Earth

Figure 8.1.4-5 Station Location on Bandra Railway Land

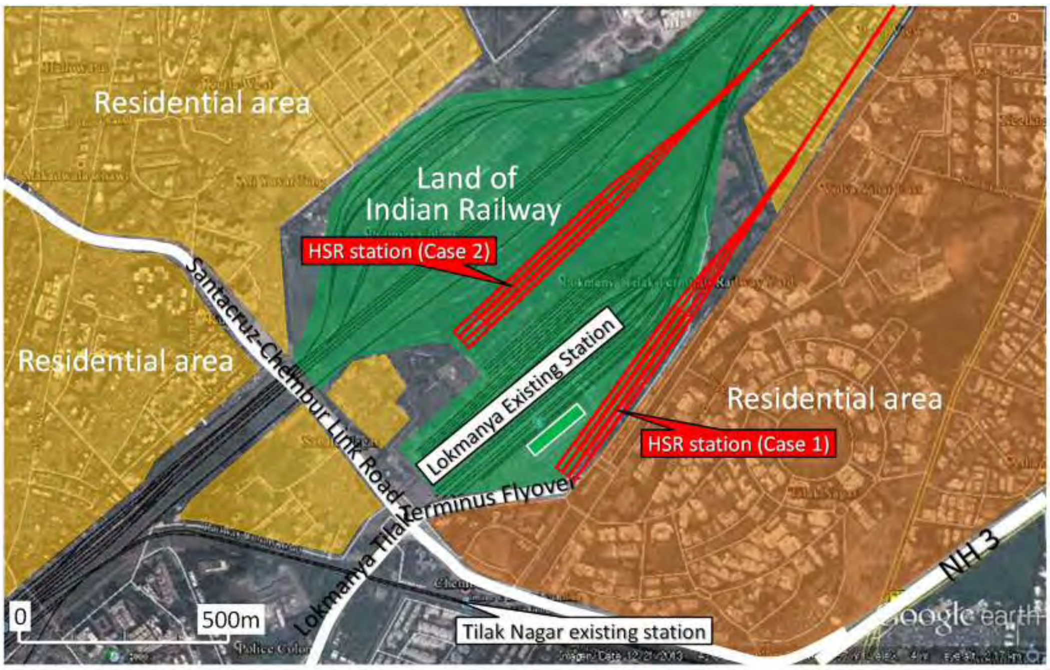
Source: The Study team

Figure 8.1.4-6 Built-up Areas Southeast of Bandra Existing Railway Station

(4) Lokmanya Tilak Terminal

The disadvantages in the case of setting the HSR station at Lokmanya Tilak Terminal are as follows:

1) Far from the Central Business District and western suburbs
2) Expected traffic congestion due to limited road access
3) The area is heavily built-up and has a number of slums nearby.



Source: Compiled by the Study team based on Google Earth

Figure 8.1.4-7 Station Location at Lokmanya Tilak Terminal

(5) Comparison Table

Table 8.1.4-1 summarizes the comparison between BKC, Bandra and Lokmanya.

Table 8.1.4-1 Comparison of Station Location

	BKC	Bandra	Lokmanya (Case 1 or 2)
Passenger demand	Covering CBD area	Far from CBD area	A little far from CBD area
Connectivity with mass transport system	Good connectivity with Metro	Good connectivity with existing railway	Good connectivity with existing railway
Situation around the proposed HSR station	・New development area ・Good road access	・Already built-up area ・Traffic congestion	・Already built-up area ・Traffic congestion
Position of station	Underground	Underground	Underground
Land acquisition	Land of MMRDA	Partial land of Indian railway, private land acquisition might be difficult	(Case 1) Partial land of Indian railway (Case 2) Land of Indian railway
Access to proposed HSR station	Underground	Underground	Underground
Total evaluation	✓✓	✓	✓

CBD: Central Business District, MMRDA: Mumbai Metropolitan Regional Development Authority

Source: The Study team

8.1.5 Comparison of station locations at BRA and BKC

(1) Objective

MOR/NHSRCL has been carrying out discussions with Maharashtra State regarding station location. In this situation, MOR/NHSRCL has requested Japanese side to support the study of the station location in Mumbai again. In the Joint F/S, Bandra Kurla Complex (BKC) had been planned as the starting HSR station for this Project. However, in July 2016, Maharashtra State did not agree about this location for the HSR terminal station. If the location for HSR station in Mumbai is changed, the construction process of long tunnel section, which is critical for the project, will be affected. Maharashtra State suggested that Bandra Reclamation Area (BRA) as an alternative location, which is owned by Maharashtra. Therefore, a technical assessment has been carried out for setting the HSR station at BRA in the Follow-up Study. Some requests from MOR to JICA regarding changing the station location to BRA are as follows:

In reference to your letter regarding HSR terminal location in Mumbai, it would be appreciated if JICA examines the following:

- Underground connectivity similar to BKC for the BRA.
- Possibility of building a multi-story complex at the new proposed terminal.
- Possible existing and new road connectivities from all approach to the new proposed terminal.
- Parking facilities at the new proposed terminal.
- Possibility of locating a multi-modal passenger transport hub at the new proposed terminal to link nearby satellite townships.

Table 8.1.5-1 Flow on Comparison for station location between BKC and BRA

Date	Contents
At joint feasibility study stage	Underground terminal station at BKC was agreed.
2nd June 2016	MOR/NHSRCL carried out the presentation regarding terminal location in Mumbai to Chief Minister of Maharashtra State.
June - July 2016	The Study team carried out the comparison for station location between BKC and BRA based on the existing information.
8th August 2016	MOR/NHSRCL formally requested Japanese side to support the study of station location in Mumbai again.
August - September 2016	The Study team carried out the comparison for station location between BKC and BRA based on site survey and data collection.
	Japanese side reported the result to MOR/NHSRCL.

Source: The Study team

(2) Overview of station planning area

Below is a summary of the population, development progress, land-use situation, catchment area of station and traffic convenience, etc. based on report on current situation and future prospects of the Municipal Corporation of Greater Mumbai and the results of a site survey that also describes the current situation of BRA district.

Source: Greater Mumbai report on draft development plan - 2034

Figure 8.1.5-1 Mass Transit Networks in Greater Mumbai

1) Comparison of catchment areas

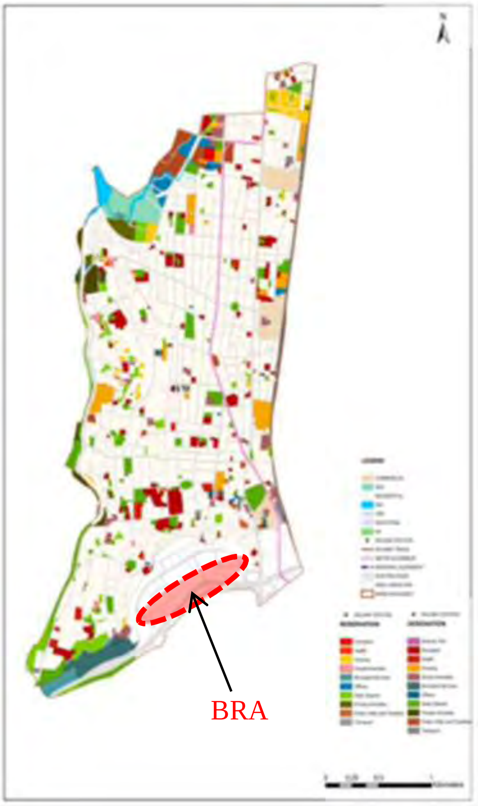
An overview of the catchment area of the station at BRA and BKC is shown in Table 8.1.5-2. The land-use map of H-West ward and H-East ward is shown in Figure 8.1.5-2 and 8.1.5-3.

Table 8.1.5-2 Comparison of Station Catchment Areas

No.	Items	BRA	BKC
1	District name	H-West (H/W) Ward	H-East (H/E) Ward
2	District area (owned by MMRDA)	865 ha (657.9 ha)	1241.9 ha (99 ha)
3	Development ratio (except jurisdiction by MMRDA)	97 %	89 %
4	Population (thousand)	308 (2011), 287 (2034)	563 (2011), 492 (2034)
	Population density	341 pph (2011)	448 pph (2011)
5	Current situation of development, etc.	The area under jurisdiction of MCGM is under progressing as suburban residents. Residential development is under progressing at a part of new development area in reclamation area. Remaining development area is approx. 19 ha.	The area under jurisdiction of MCGM is under progressing as residents/educational institutions/etc. New area under jurisdiction of MCGM is also under progressing as financial areas/commercial areas/others. Remaining development area is approx. 40 ha.
6	Traffic connectivity	Roads around the station location are narrow, but connectivity with expressway is good.	Good connectivity with western expressway and roads around the station location.
		Inconvenient due to 1.5 -2.0 km far from Bandra existing station. Inconvenient connectivity with new metro station.	Convenient due to 1 km from Bandra existing station. Under planning of new metro station nearby.
7	Overview of catchment area of station	Reclamation area is narrow, and room for city development is limited.	CBD has been formulated, a possibility to develop HSR station and city together.

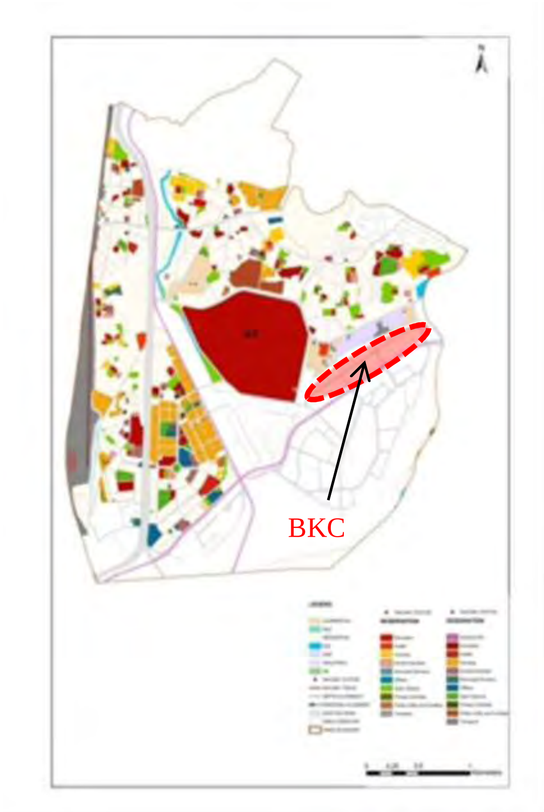
Municipal Corporation of Greater Mumbai consists of 24 districts, with the island city consisting of 9 districts, the western region of 9 districts, and eastern region of 6 districts. Current land use and planning of the H/W district (BRA) and H/E district (BKC) are shown in Figure 8.1.5-2 and 8.1.5-3. The white part shows developing area, and approx. 90 % of the area has been developed.

- H/E district: In the area under the jurisdiction of MCGM on the north side and west side of BKC, there are educational/ medical districts or residential district, where development is under progress. Also in BKC district, a financial/ commercial district is under progress. An area of approx. 30 ha around the planned HSR station is undeveloped.
- H/W district: Except for the undeveloped area around the planned HSR station location at BRA district, all other areas are under development.



Source: Greater Mumbai report on draft development plan - 2034

Figure 8.1.5-2 Land use plan of H/W district



Source: Greater Mumbai report on draft development plan - 2034

Figure 8.1.5-3 Land use plan of H/E district

The Study team compared BRA and BKC from the viewpoint of station catchment area. The results are as follows:

- Areas around BRA and BKC have been developed together.
- Almost all districts under the jurisdiction of MMRDA have been already developed.
- Especially, BKC has been already developed except for the planned location for the HSR station. According to MMRDA, 200,000 jobs have been already created in the developed financial/ commercial district (19 ha) and the district is one of the new central business areas.
- On the other hand, the area for station development at BRA is smaller than that at BKC and is very small as the development of surrounding residential areas has partly proceeded. In addition, the area for development is extremely limited because Mahim Bay and the Western Expressway are located on the south side of the planned HSR station location.

a) BKC district is superior in terms of its connection with transportation facilities such as roads, railway lines, planned Metro lines, etc. BRA district is not bad as it is near the Western Expressway, but roads around the station location are narrow and it does not have good connectivity with railway lines and planned Metro lines. Therefore, some measures would be necessary in the case the station is built there.b) In BRA district, there are some scattered buildings that would interfere with the route plan. Especially, there is a residence of 26-storeys and the expressway on the south side of BRA where the relocation of the property causing hindrance would need to be considered.

c) In the case of setting the HSR station at BRA district, as compared with the BKC district, the route length is approx. 5 km longer, and also arrival time increases a little due to the constraints of the route. In addition, an increase in construction cost for crossing the river, etc. is unavoidable.

2) Access distance to HSR station

The comparison of access distance from each district to the HSR station locations, "BKC" and "BRA" in Mumbai is carried out. The target for this Study is "resident population (excluding slums) "and "employed population", with average access distance calculated from each district to each HSR station location.

Table 8.1.5-3 Average Access Distance

Items	BKC	BRA
Resident population	9.01 km (1.00)	10.68 km (1.19)
Employed population	9.62 km (1.00)	10.60 km (1.10)

Source: The Study team

Access distance to the HSR station from BRA district is approx. 10 - 20 % farther than from BKC district.

Table 8.1.5-4 Basic Ward Data of Greater Mumbai (based on MDDP34)

Zones	Wards	Area (ha)	Population (x1000)				Employees (x1000)	Distance (Km)		Population x(Km) (/1000)		Employees x(Km) (/1000)		Remarks
			2011	2034	Slum(2011)	A-B	2011	from BKC	From BRA	from BKC	From BRA	from BKC	From BRA	
			A		B	C	D	E	F	C x E G	C x F H	D x E I	D x F J	
Island City	A	1,121	185	128	63	122	694	16.10	13.10	1.96	1.60	11.17	9.09	
	B	266	127	83	14	113	117	13.00	10.50	1.47	1.19	1.52	1.23	
	C	191	166	117	0	166	156	13.70	11.10	2.27	1.84	2.14	1.73	
	D	830	347	279	33	314	190	12.60	9.60	3.96	3.01	2.39	1.82	
	E	717	393	280	78	315	221	10.90	8.30	3.43	2.61	2.41	1.83	
	F/N	1,201	529	370	308	221	137	3.70	3.70	0.82	0.82	0.51	0.51	
	F/S	965	361	294	95	266	179	8.00	5.90	2.13	1.57	1.43	1.06	
	G/N	876	599	482	190	409	252	5.70	3.10	2.33	1.27	1.44	0.78	
	G/S	929	378	264	78	300	308	7.80	5.60	2.34	1.68	2.40	1.72	
	Total	7,096	3,085	2,297	859	2,226	2,254							
Western	H/E	1,289	563	493	241	322	216	0.70	3.70	0.23	1.19	0.15	0.80	
	H/W	865	301	217	112	189	164	3.70	1.80	0.70	0.34	0.61	0.30	
	K/E	2,400	824	733	404	420	444	4.60	7.80	1.93	3.28	2.04	3.46	
	K/W	2,442	749	708	109	640	293	6.80	15.10	4.35	9.66	1.99	4.42	
	P/N	4,672	941	990	505	436	295	12.80	15.20	5.58	6.63	3.78	4.48	
	P/S	2,529	464	438	264	200	313	10.20	12.40	2.04	2.48	3.19	3.88	
	R/C	4,803	562	494	104	458	244	17.20	19.60	7.88	8.98	4.20	4.78	
	R/N	1,418	432	535	222	210	91	19.80	22.20	4.16	4.66	1.80	2.02	
	R/S	1,831	691	766	399	292	265	14.80	17.20	4.32	5.02	3.92	4.56	
	Total	22,249	5,527	5,374	2,360	3,167	2,325							
Eastern	L	1,556	902	926	490	412	251	4.30	8.70	1.77	3.58	1.08	2.18	
	M/E	3,389	808	874	245	563	200	7.00	9.40	3.94	5.29	1.40	1.88	
	M/W	1,740	412	358	217	195	173	4.10	6.50	0.80	1.27	0.71	1.12	
	N	2,535	623	556	386	237	233	5.90	9.60	1.40	2.28	1.37	2.24	
	S	2,975	744	709	538	206	275	10.00	13.90	2.06	2.86	2.75	3.82	
	T	4,288	341	306	112	229	102	14.40	18.30	3.30	4.19	1.47	1.87	
	Total	16,483	3,830	3,729	1,988	1,842	1,234							
Greater Mumbai		45,828	12,442	11,400	5,207	7,235	5,813			65.17	77.30	55.88	61.60	
Average access distance										km 9.01	km 10.68	km 9.61	km 10.60	
	Table*1	4	11.3	11.3	5		*2	*3	*3					

Source: *1 - MDD p34, *2 - DP for GM 14-34 Preparatory Studies, *3 - The Study team

3) Current status of Bandra Reclamation Area (BRA)

At the proposed location of the HSR station at BRA district, a fresh concrete plant for PC girders for Mumbai Metro Line-7 was set up in August 2016, and ground improvement of the yard has being carried out by J. Kumar Infraprojects Ltd. The period of the land use is approx. 5 or 6 years according to the site manager. Their structures are not permanent, but it will be necessary to coordinate with starting time of HSR construction.

Figure 8.1.5-4 Current Status at BRA district

Figure 8.1.5-5 Fresh Concrete Plant

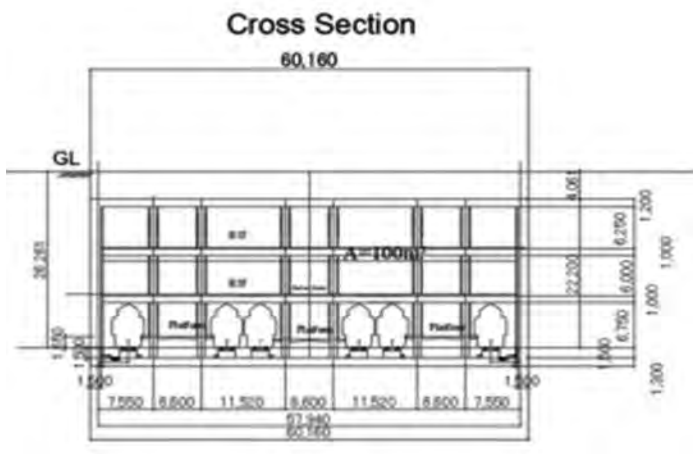
Figure 8.1.5-6 Current Status of Temporary Facilities, etc. of Foundation Work

(3) Station planning

Mumbai station is the starting terminal station for the HSR corridor between Mumbai and Ahmedabad and the number of passengers is estimated at approx. 158 thousand/day in 2053. Mumbai HSR station will be the largest station on this planned route.

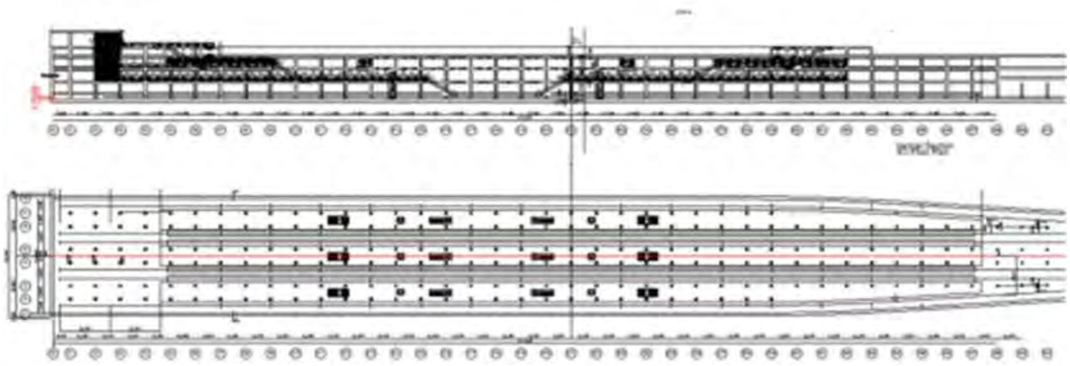
1) Station structure and scale

The station structure is dead-end station that consists of three platforms and six tracks underground. The station width is approx. 60 m and the depth from the ground level to rail level is approx. 26 m. The station has a three-layered underground structure.



Source: The Study team

Figure 8.1.5-7 Cross Section of Mumbai HSR Station



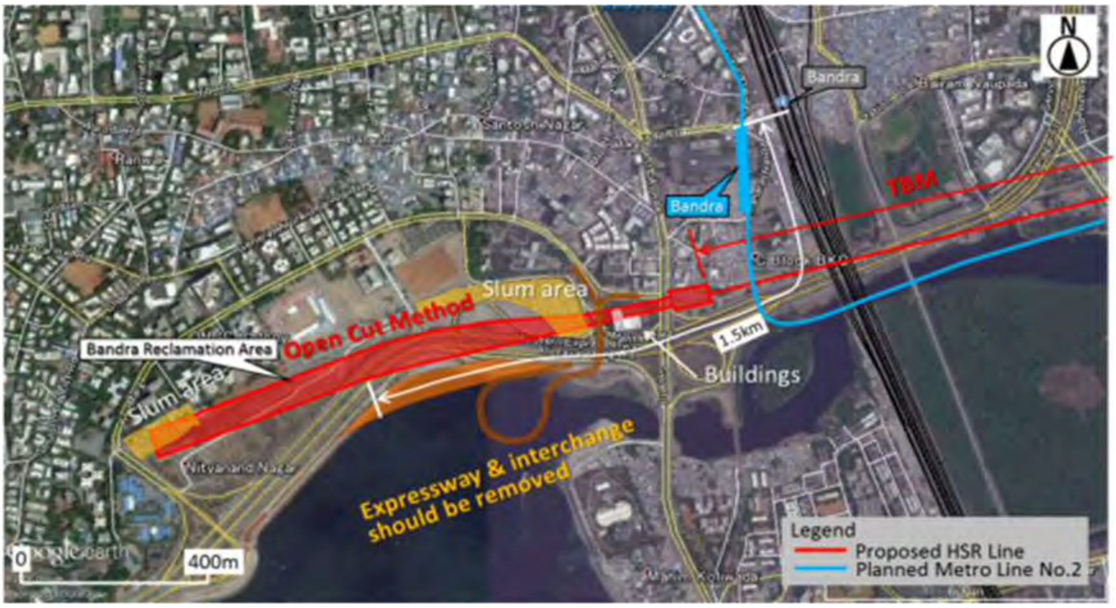
Source: The Study Team

Figure 8.1.5-8 Longitudinal section and Plan view of Mumbai HSR station

2) Station arrangement planning

There are residential areas, various buildings and slums in the vicinity of the proposed location in BRA district, and the Western Expressway is adjacent to the unused land on the southern side. The station length would be approx. 900 m and consist of three platforms and six tracks and a funnel-shaped section but the space available is insufficient and it will be difficult to locate the HSR station and avoid all existing obstacles. Given this, the following three alternatives are proposed:

- Plan A: Setting the HSR station underground after removing the Western Expressway towards seaside
- Plan B: Setting the HSR station underground on the inland side so as not to interfere with the Western Expressway
- Plan C: Setting the HSR station deep underground passing under buildings in order to avoid obstacles.



Source: Compiled by the Study team based on Google Earth

Figure 8.1.5-9 Setting HSR Station Underground after Removing Expressway Seaside (Plan A)

Source: Compiled by the Study team based on Google Earth

Figure 8.1.5-10 Setting HSR Station Underground to Avoid Expressway (Plan B)

Source: Compiled by the Study team based on Google Earth

Figure 8.1.5-11 Setting HSR Station Deep Underground to Passing under Buildings (Plan C)

3) Current site status

In the case of Plan A, site width in the longitudinal direction for the HSR station is insufficient. Furthermore, it is necessary to relocate the Western Expressway and the site width in the cross-sectional direction for HSR station is insufficient because the HSR station is located on the sea side to avoid obstacles such as high-rise buildings.

Source: The Study team

Figure 8.1.5-12 Current Site Status of Plan A

In the case of Plan B and Plan C, the site width in the cross-sectional direction for the HSR station is ensured. However, the HSR station area cannot avoid high-rise buildings because the site width in the longitudinal direction is insufficient.

Source: The Study team

Figure 8.1.5-13 Current Site Status of Plan B and Plan C

4) Obstacles

It is difficult to plan the HSR station to avoid all the nearby obstacles in BRA district. Three alternatives are planned regarding the obstacles and they are as follows:

- Plan A: Main obstacles are the presence of Western Expressway and the Bandra Fire Brigade. It would be necessary to relocate the expressway and issues regarding construction method and construction schedule would need to be considered.

Source: Compiled by the Study team based on Google Earth

Figure 8.1.5-14 Main Obstacles for HSR Station at BRA (Plan A)

- Plan B: Main obstacles are a high-rise building of 26 stories under construction and the Ali Yavar Jung National Institute for the Hearing Handicapped. It is necessary to demolish them for adopting open-cut method for the HSR station, and the issues demolition cost and relocation compensation would need to be considered.

Source: Compiled by the Study team based on Google Earth

Figure 8.1.5-15 Main obstacles for HSR Station at BRA (Plan B)

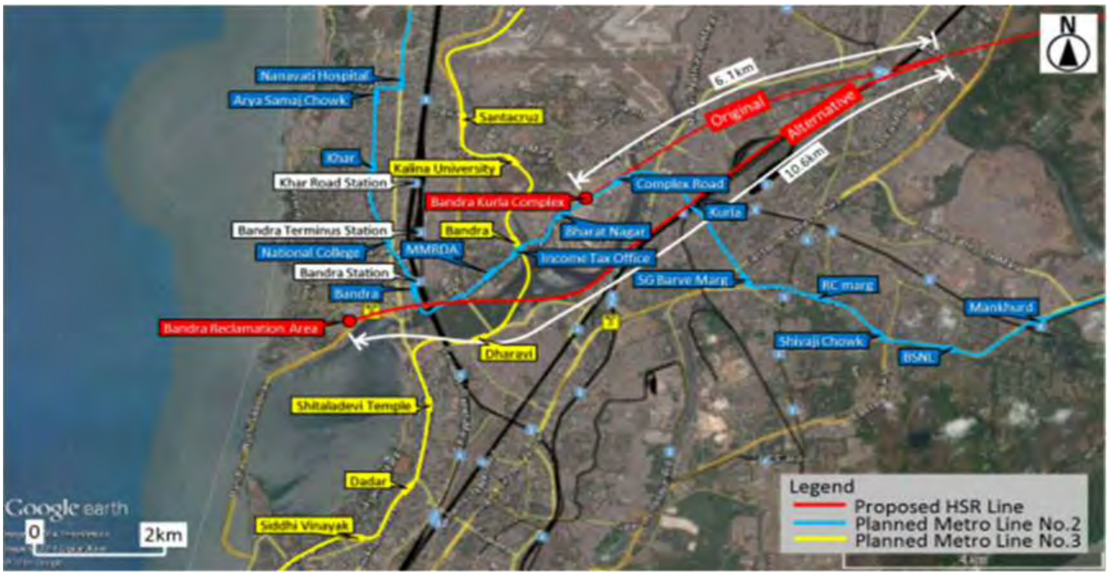
- Plan C: It would be a relatively deep station and pass under high-rise building in order to avoid demolition of a 26-story high-rise building, which is the main obstacle. The issues are risk of passing underground, adhere to planned construction schedule and construction cost.

Source: Compiled by the Study team based on Google Earth

Figure 8.1.5-16 Main Obstacles for HSR Station at BRA (Plan C)

(4) Route planning

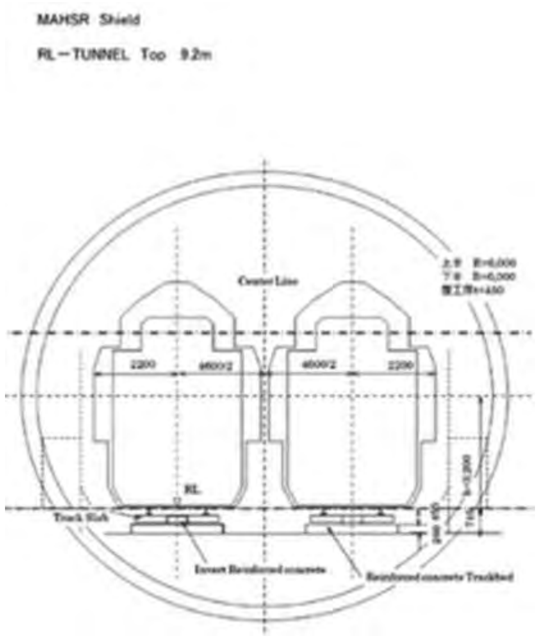
BRA district is located on west side of BKC district. In the case of locating the HSR station at BRA district, the route length would be 4.5 km longer compared to BKC district.



Source: Compiled by the Study team based on Google Earth

Figure 8.1.5-17 Proposed Routes (BKC and BRA)

In the case of BKC route, NATM, which is a standard method of tunneling, has been planned because of the ground surface above tunnel is almost all private land, and because there are no roads and railway lines and an unclear geological and construction environment. However, the route passing through private lands between BRA district and Thane creek, has many uncertainties such as land issues. Therefore, in the case of a route that does not pass through BKC, the route was selected under existing central railway lines with almost no private land and a TBM with double track cross-section was planned because it is safer as compared with NATM.



Source: The Study team

Figure 8.1.5-18 Cross Section of TBM for HSR

Source: The Study team

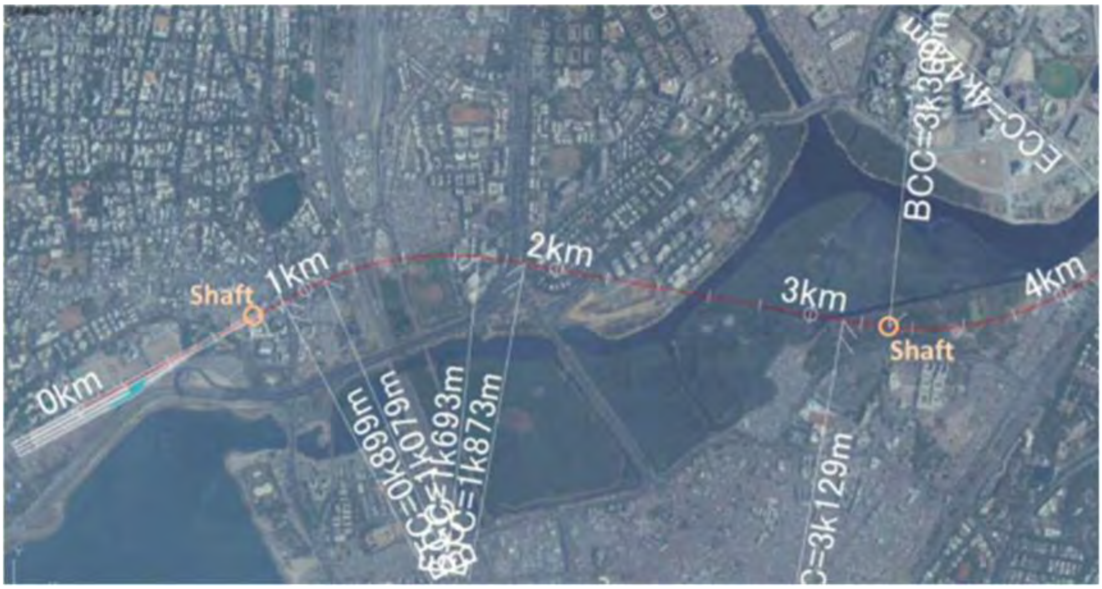
Figure 8.1.5-19 Whole Plan View of Route Alignment (BKC and BRA)

1) Overview of horizontal route planning

There is not a big difference among the three plans for the HSR station location in BRA district. The alignment passes on the western side of Mithi River and passing by tunnel to around 2 km; as the underground portal starting point and crosses Mithi River between 2 km and 3 km and then reaches to Mahim Nature Park located on the eastern side of alignment. At this location, the route passes under Metro Line No.3 (the rail level is approx. 25 m from ground level) and there is a difference of around 2 km between Plan A, B and C.

Source: The Study team

Figure 8.1.5-20 Plan View of Plan A (BRA – Mahim Nature Park)



Source: The Study team

Figure 8.1.5-21 Plan View of Plan B and Plan C (BRA – Mahim Nature Park)

The route from Mahim Nature Park to the connection point of the planned HSR route passes under an existing railway line. The route passes under Lokmanya railway yard from 6.5 km to 8 km. The horizontal alignment of Plan A, Plan B and C is almost same in this section.

Source: The Study team

Figure 8.1.5-22 Plan View between Mahim Nature Park and Lokmanya Railway Yard

Source: The Study team

Figure 8.1.5-23 Plan View near Lokmanya Railway Yard

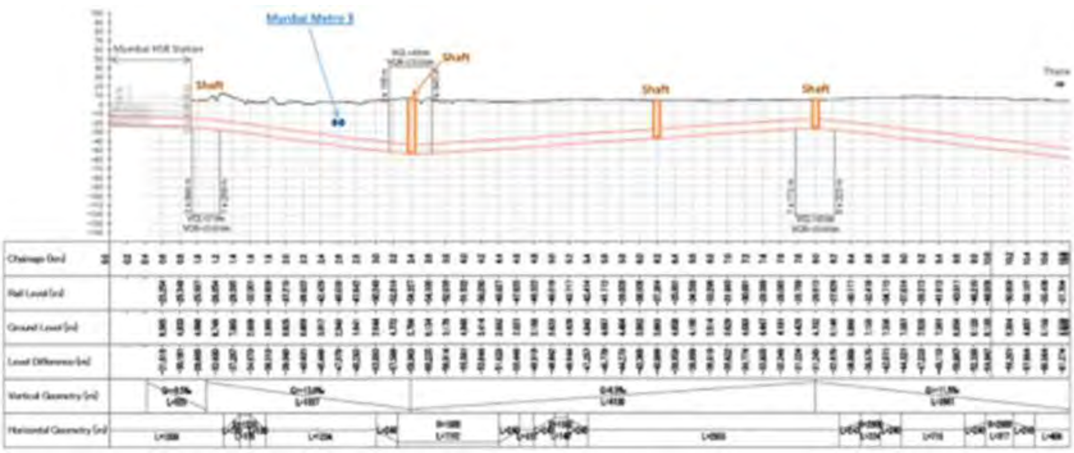
Source: The Study team

Figure 8.1.5-24 Plan View between Lokmanya Railway Yard and a Connection Point of Existing Planned Route

2) Overview of longitudinal route planning

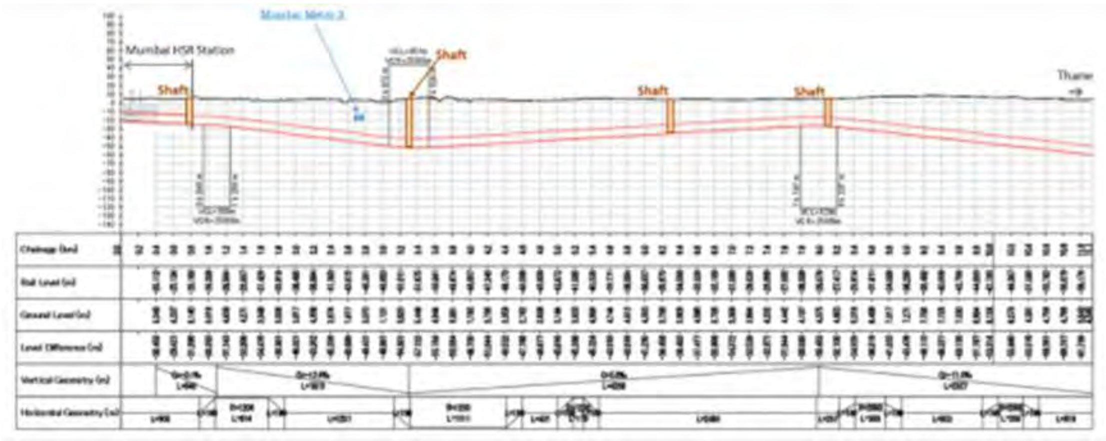
The main points for longitudinal planning are as follows:

- Depth of underground station from GL- approx. 25 m (for plan A and plan B) and- approx. 55 m (for plan C).
- Setting vertical shaft as excavation base every 2 km, the depth of vertical shaft is fixed considering drainage.
- Passing under Metro Line-3 and ensuring a distance as well as diameter of TBM where crossing at approx. 2.5 km from the starting point.



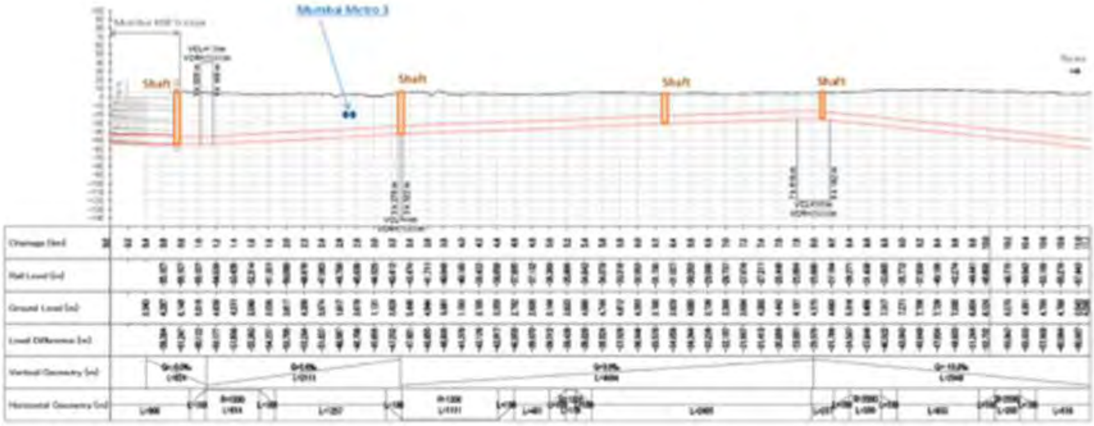
Source: The Study team

Figure 8.1.5-25 Longitudinal Planning of Plan A



Source: The Study team

Figure 8.1.5-26 Longitudinal Planning of Plan B



Source: The Study team

Figure 8.1.5-27 Longitudinal Planning of Plan C

(5) Station facilities

In regards to the HSR station facilities, at BRA district, MOR requested JICA to consider the following:

a) Function of station plaza

- Possible existing and new road connectivity from all approaches to the new proposed terminal.
- Parking facilities at the new proposed terminal.

b) Construction of station terminal building

- Possibility of building multi-story complex at the new proposed terminal.

c) Access to HSR station

- Underground connectivity similar to BKC for BRA.
- Possibility of locating a multi-modal passenger transport hub at the new propose terminal linking nearby satellite townships.

1) Station plaza

The detailed assessment of the station plaza has been carried out. The issues are, how to plan parking lot and how to connect existing roads to the station plaza itself.

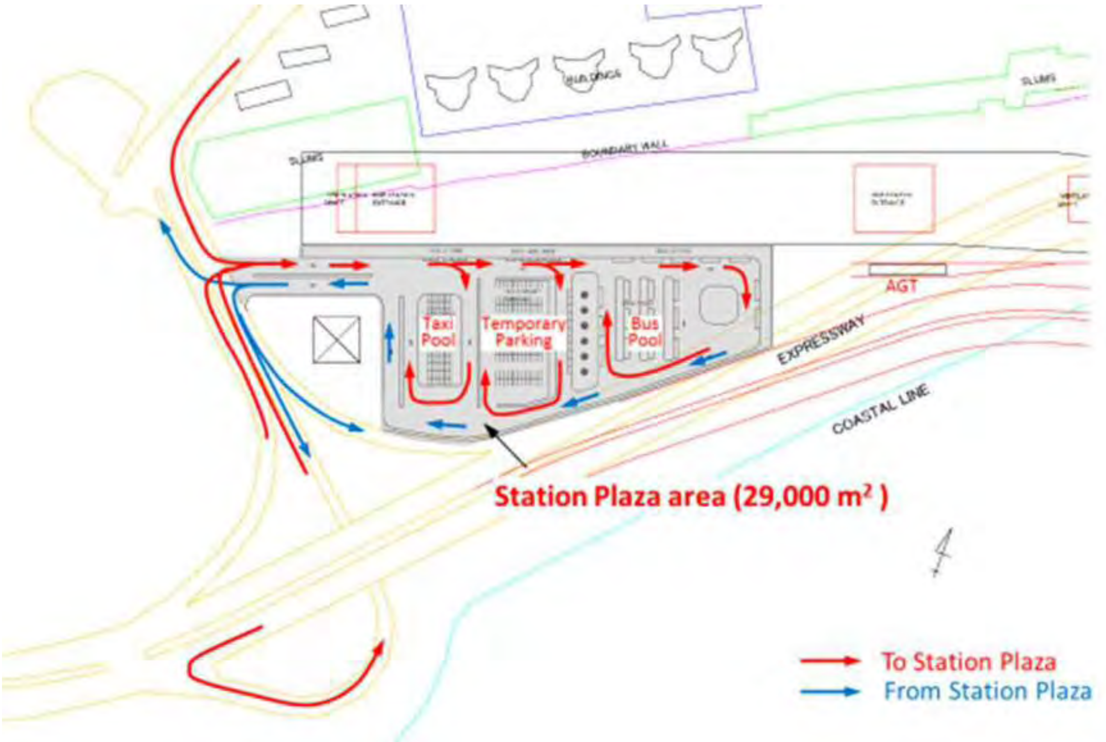
a) How to set the station plaza

The area of the station plaza in Mumbai has been calculated to be 24,000 m^2 using a Japanese formula as reference, and the area of the station plaza at BRA district is 29,000 m^2 considering the local conditions. The setting of bus, taxi and private car has been estimated as follows:

Table 8.1.5-5 Number of Bus, Taxi and Private Cars at BRA Station Plaza

Item	Pool	Stand
Bus	3*3=9	10
Taxi	6*12=72	approx. 5
Private car	12*9=108	Approx. 18 (kiss-and-ride)

Source: The Study team

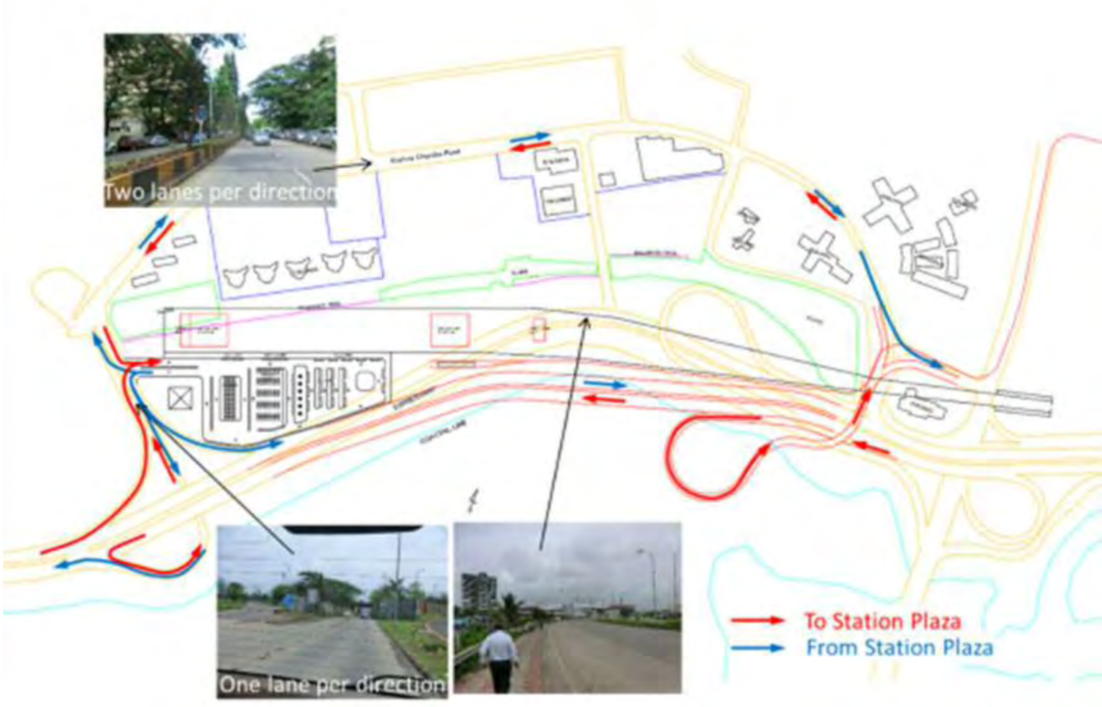


Source: The Study team

Figure 8.1.5-28 Proposed Station Plaza at BRA

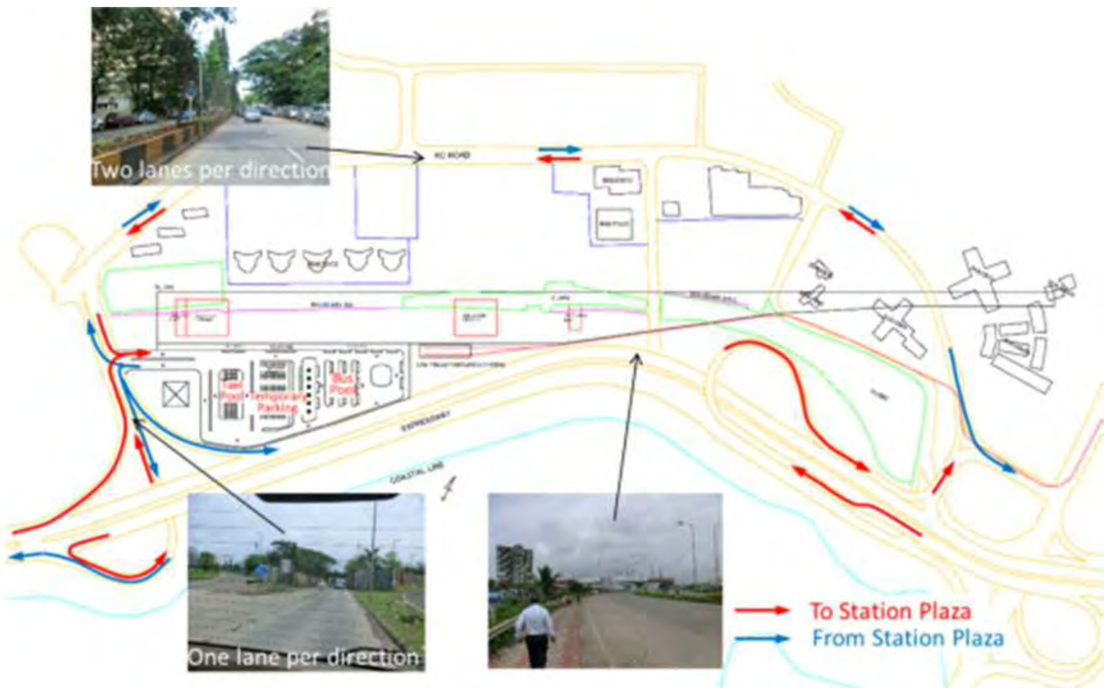
b) How to connect existing roads to the station plaza

Access from the expressway and main roads to the station plaza is to be given by existing roads around HSR station. However, it seems to be insufficient, as the carriageway width of the roads connecting the main transport terminal around HSR station are only two lanes, i.e., one lane per direction.



Source: The Study team

Figure 8.1.5-29 Connectivity Plan to Roads after Removing Expressway (Plan A)

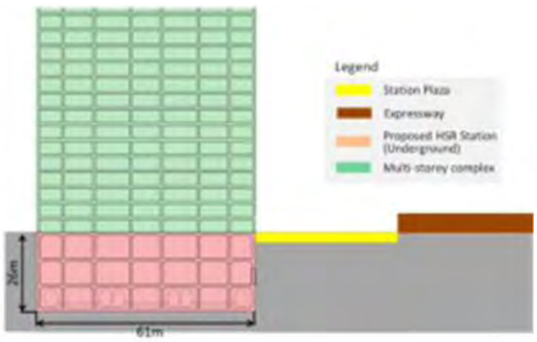


Source: The Study team

Figure 8.1.5-30 Connectivity Plan to Roads and Expressway (Plan B and Plan C)

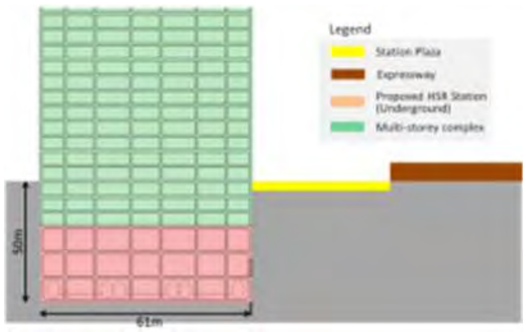
2) Station terminal building

It will be possible to build the same scale station building underground at BRA district because it is possible to construct 3 platforms and 6 tracks as well as the HSR station.



Source: The Study team

Figure 8.1.5-31 Image of station terminal building (Plan A and Plan B)



Source: The Study team

Figure 8.1.5-32 Image of station terminal building (Plan C - deep station)

3) How to access HSR station

The assessment of possible connectivity with an existing railway station, a planned Metro station, and multi-modal passenger transport was requested by MOR. Therefore, the Study team carried out an assessment of not only the accessibility to bus, taxi and private car at the station plaza, but also, how to access existing Bandra railway station, Metro Line No.3, and the AGT to be connected to BRA station.

In the case of locating HSR station at BRA, the distance from the existing Bandra railway station to BRA is approx. 1.5 km. Measures will be necessary, because the distance is too long for the passengers to travel by walking. One option can be a “moving walkway.” However, in practical terms, this is too long and it will be preferable to set up a simple urban transportation system. An underground transportation system was requested by MOR, but this is difficult for the following reasons:

- Regional situation: it will be difficult to set structures deeply underground due to presence of dense buildings around the route.
- Equipment scale: it will be too small space for Metro construction equipment.
- Therefore, the study on a simple “Automated Guideway Transit” above existing roads has been carried out.

a) Overview of AGT route

The AGT route has been planned to pass above the existing roads from “Bandra”, that is, the existing railway station and the planned Metro Line 3 station of Mumbai to the station plaza of “Bandra Reclamation Area”, it would be elevated as there is no space. Also, the AGT station would be elevated on either side as well. The proposed route passes above the existing roads starting at the station and it avoids the interchange of the expressway and then reaches the end of the route. The route length is approx. 1.5 km.

Source: The Study team

Figure 8.1.5-33 AGT route at BRA (Plan B and Plan C)

b) Planning for AGT

The number of passengers in Mumbai HSR station has been estimated to be approx. 79,000/day in 2053. Access transportation system to HSR station, are mainly railway, bus and car (including taxi). If the transport share ratio of railway is estimated approx. 30% - 50%, the passengers of AGT is estimated to be 24,000/day - 40,000/day. In this case, the average traffic volume is estimated 2,000/hour - 3,000/hour.

The facility planning as shown in Table 8.1.5-6 will be possible because the total length between the stations is approx. 1.5 km and it is estimated that the traffic capacity is 3,000 passengers/hour even for single track operation in the case of 5 units per train.

Table 8.1.5-6 Summary of AGT Facilities Plan

Items	Contents	Remarks
Route	Bandra terminal – Bandra Reclamation Area	
Route length	1.48 km	
Facility standard	Single track	Above existing roads
Number of stations	Two stations	
Required time	4 min	Between starting station and terminal station
Operation interval	8 min	
Scheduled speed	25 km/h	
Unit number/train	5 units/train	
Required unit number	20 units	4 sets
Traffic capacity	2,800 passengers/hour	
Number of passengers/day	24,000 – 40,000	

Source: The Study team

Source: The Study team

Figure 8.1.5-34 AGT Route at BRA (Plan A)

Source: The Study team

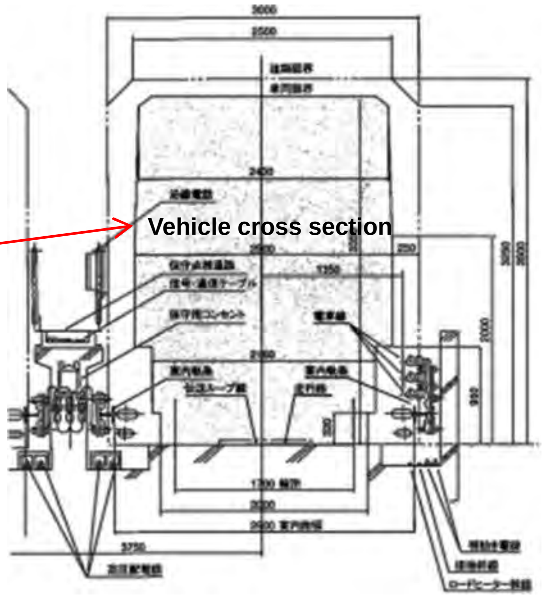
Figure 8.1.5-35 AGT Route at BRA (Plan B and Plan C)

c) Planning of AGT vehicle

The AGT system is capable of running at a steeper gradient due to its rubber tires compared with a steel wheel system, and because it is elevated it has no impact on automobile traffic. However, it is necessary for passengers to move up and down. The configuration of vehicle equipment is that one train set consists of 5 units and a train length is 45 m. The capacity is 240 persons. It is estimated that the number of required trains would be 4 sets and the number of required units is 20 units.

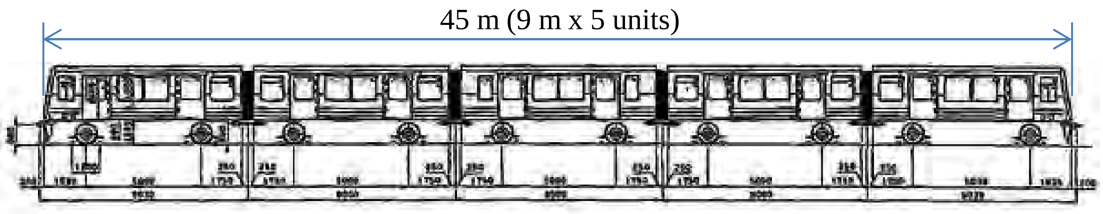
Source: The Study team

Figure 8.1.5-36 Type of AGT Vehicle



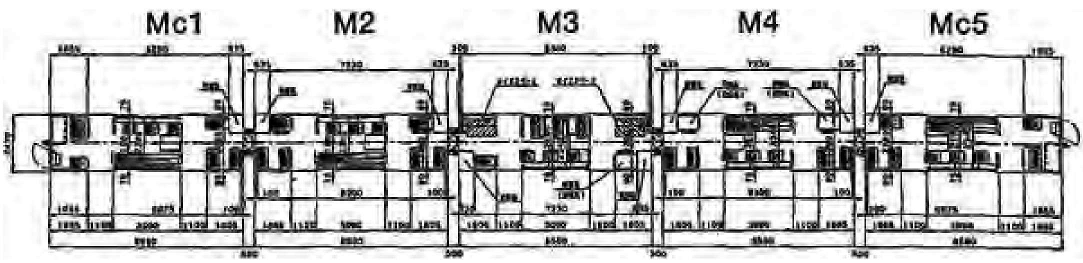
Source: The Study team

Figure 8.1.5-37 Dimensions of AGT Vehicle Gauge



Source: The Study team

Figure 8.1.5-38 Side View of AGT Vehicle



Source: The Study team

Figure 8.1-39 Plan View of AGT Vehicle

Table 8.1.5-7 Specifications of AGT Vehicle (1)

Car type	Guide rail system, four-wheel electric passenger cars
Car body	Light weight stainless steel
Operation system	Automatic operation
Electric system, track gauge	Three-phase AC 600V, 50 Hz, track gauge 1700mm
Train performance	Maximum operation speed 60 km/h, maximum acceleration 0.97 m/s^2

Source: The Study team

Table 8.1.5-8 Specifications of AGT Vehicle (2)

Items		Mc1	M2	M3	M4	Mc5
Type		300-1	300-2	300-3	300-4	300-5
Capacity (persons) <seat>		49 <18>	48 <17>	47 <11>	48 <17>	49 <18>
		241 <81>				
Dead load (ton)		11.8	11.9	11.7	11.8	11.9
Maximum dimension	Length	9030		9000		9030
	Width			2490		
	Height			3340		

Source: The Study team

(6) Summary of this assessment

In the assessment of station location at BRA district in Mumbai, it was understood that the available space is insufficient for the HSR station area and alternatives to either "relocating the expressway" and or "relocating the buildings" were examined.

1) Comparison of alternatives at BRA district

As result of the assessment, it can be seen that it would be necessary to relocate a private high-rise building in the case of Plan B, while in the case of Plan C, the depth of the main terminal station would cause passenger inconvenience. Taking this into account, it will be more realistic to negotiate with the public sector to reclaim some of the bay and to relocate the expressway. However, in any case, there are some issues that the geological survey and buried objects investigation, etc. may not exist, and these have to be carried first before taking a decision, as there are many uncertainties.

Table 8.1.6-1 Comparison of Station Locations at BRA

	Bandra Reclamation Area		
	Plan A	**Plan B**	**Plan C**
Passenger demand	Far from CBD area		
Population around area	308 thousand (2011) (H/E)		
Position of station	Underground (Open cut)		Underground (Open cut + NATM)
Depth of Station	Approx. 25 m		•Approx. 50 m •Additional time by Escalator & Walk from Platform to Ground will be changed from 3 min to 6 min.
Land acquisition	•Not enough vacant space to cover HSR Station Area •Land acquisition might be necessary		
Main obstacles	•Expressway & interchange •Bandra fire Brigade	•26th floors high building •Middle rise buildings •Ali Yavar Jung National Institute for The Hearing Handicapped buildings	•Ali Yavar Jung National Institute for The Hearing Handicapped buildings •Low rise buildings
Connectivity with Mass Transport system	None/Necessary to set AGT		
Road Connectivity	•Narrow road access (KC Road) even near Expressway •Expressway & interchange should be removed	•Narrow road access (KC Road) even near Expressway	
Approach to proposed HSR station	Underground (+4.5 km, +2 min)		
Total evaluation	✓✓	✓	✓

Source: The Study team

2) Comparison between BRA and BKC

From the results of the comparative assessment between BRA and BKC for selecting the station location in Mumbai, it was understood that BKC is almost in the center of the city, has a large site with no obstructing buildings, and has easy access to BKC. In addition, travel time for the HSR would be shorter if the station is at BKC as the route length is shorter and total construction cost would be more than approx. 7,000 Cr. cheaper as compared with BRA. Therefore, BKC is a more desirable location than BRA to be the HSR terminal station in Mumbai.

Table 8.1.6-1 Comparison between BRA and BKC

	Bandra Reclamation Area	**Bandra Kurla Complex**
Passenger demand	Far from CBD area	Covering CBD area
Population around area	308 thousand (2011) (H/E)	563 thousand (2011) (H/W)
Position of station	Underground (Open cut)	Underground (Open cut)
Land acquisition	・Not enough vacant space to cover HSR Station Area ・Land acquisition might be necessary	Land of MMRDA
Connectivity with Mass Transport system	None/Necessary to set AGT	Good connectivity with Planning Metro Line-2
Road Connectivity	・Narrow road access (KC Road) even near Expressway ・Expressway & interchange should be removed	Good road access (BKC Road)
Approach to proposed HSR station	Underground (+ 4.5 km, +2 min)	Underground
Total evaluation	✓	✓✓

Source: The Study team

8.2 Final Alignment Design (FAD)

8.2.1 Objective of design

This design is to carry out the Final Alignment Design (FAD) by using the result of the Final Location Survey (FLS) conducted by the Indian side (NHSRCL). Main content of FAD is the preparation of detailed plan and profile based on Aerial LiDAR Survey. The plan and profile prepared based on Satellite data at joint feasibility study stage was also considered.

(1) Overview of FLS

The Indian side carried out survey of the following items:
1) Extension of DGPS control
2) Aerial LiDAR Survey
3) Staking of Alignment
4) Cadastral Survey
5) Hydrological Survey of Rivers

Out of the aforesaid items, 1), 2) and 5) have been used in FAD.

(2) Overview of FAD

The Japanese side conducted following work using the data provided by the Indian side:
1) Horizontal Alignment Design
2) Vertical Alignment Design
3) Preparation of Plan and Profile

8.2.2 Contents of data used for FAD

The following maps/drawings/data on WGS84 coordinate reference frame provided by NHSRCL, have been used for FAD:
- Three-dimensional topographic survey drawings on a scale of 1:2,500.
- Digital Terrain Model from topographic survey.
- Geological maps at tunnel portal and shaft locations covering (300m×300m) each location. For other locations such data is not required.
- Future development plans of city/district/including industrial plan of local authorities.
- Forest Maps
- High Water Level (HWL) and Low Water Level (LWL) of river crossings.
- River cross sections up to 50 m beyond high banks.
- Detailed plans and L-Sections as per FLS (ground levels in CAD format)

8.2.3 Design contents of FAD

The deliverables of the design are the following items.
- Integration of all the data received from client
- Study and analysis of alignment and other relevant data prepared during feasibility study and supplied by client
- Design of horizontal alignment conforming to SOD of HSR
- Design of vertical alignment conforming to SOD of HSR
- Preparation of plan and profile on 1:2,500 (H) and 1:250 (V)
- Preparation of index plan and profile on an appropriate scale i.e. 1:50,000 (H) and 1:1,000 (V)
- Statement of stations, curves, gradients and coordinates (List of Alignment)
- Cross sections at every 100m based on template provided by client

8.2.4 Basic policy of final alignment design

(1) Horizontal alignment design

1) The Study team carry out the study based on horizontal alignment of Joint FS.
2) Decision/Approval by MOR/NHSRCL is required for horizontal alignment before finalizing vertical alignment.

(2) Vertical alignment design

1) Basically fully elevated, except before and after tunnel (Based on formal letter from MOR on 11th August 2016).
2) Ground level is based on Topographic map by LiDAR survey (Provided by NHSRCL).
3) Setting Minimum Rail Level on Crossings is based on information of following table.

Table 8.2.4-1 Crossing types for vertical alignment design

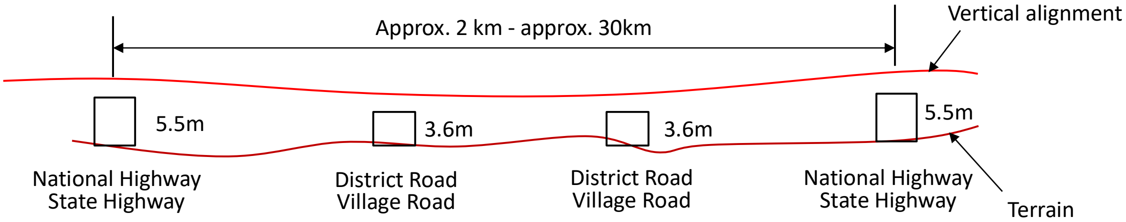
Crossing types	Based on following information
GAD 56+8	Results of negotiation with several counterpart authorities
GAD 60	Girder height as 4.5 m (Due to no negotiation with counterpart authorities)
Remaining crossing points	Tentative structure plan

Note: Remaining crossing points are metaled roads, unmetaled roads, canal, stream, etc. except major crossings mentioned at feasibility study stage.
Source: The Study team

(3) Vertical road clearance on district road and village road, etc.

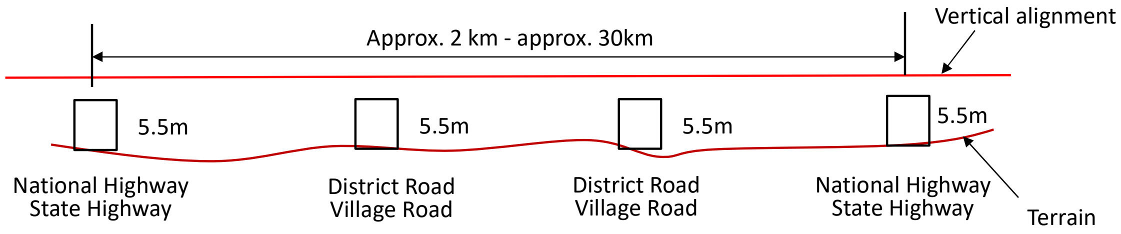
The Study team explained vertical road clearance on district road and village road, etc. to Mr. Khare and Mr. Pervez at NHSRCL office on 24th March 2017 and it was approved that vertical road clearance of 5.5m should be provided for all types of road crossings. The detailed contents are shown in the following.

1) Joint Feasibility Study stage
- Basically embankment section
- Vertical road clearance of district road and village road is provided as 3.6 m



Source: The Study team
Figure 8.2.4-1 Vertical road clearance at joint feasibility stage

2) The Follow-Up Study stage
- Basically fully elevated, except before and after tunnel (Based on formal letter from MOR on 11th August 2016)
- Vertical road clearance of 5.5m should be provided for all roads.



Source: The Study team

Figure 8.2.4-2 Vertical road clearance at the Follow-Up Study stage

(4) Guideline for vertical alignment design other than SOD

The Study team explained guidelines for vertical alignment design other than SOD to Mr. Suthar at NHSRCL office on 18th September 2017 and it was approved. The detailed contents are shown in the following.

1) Minimum distance between gradient changing points

Main line	Recommended 2.0 km Unavoidable 1.5 km

Contents		Distance (km)	Design maximum speed (km/h)
a)	Average distance between gradient changing points on Tohoku Shinkansen in Japan	1.4	260
b)	Recommended distance between gradient changing points on HSR between Mumbai and Ahmedabad in India	2.0	350

Note:
- 1.4 km * 350 km/h / 260 km/h = 1.9 km < 2.0 km
- Even if distance between gradient changing points cannot be secured 2.0 km due to the terrain, it is to be secured 1.5 km over, which is an average distance between gradient changing points on Tohoku Shinkansen in Japan.
- It should be noted that the provision for the maximum speed according to distance between gradient changing points is not specified in Japan.

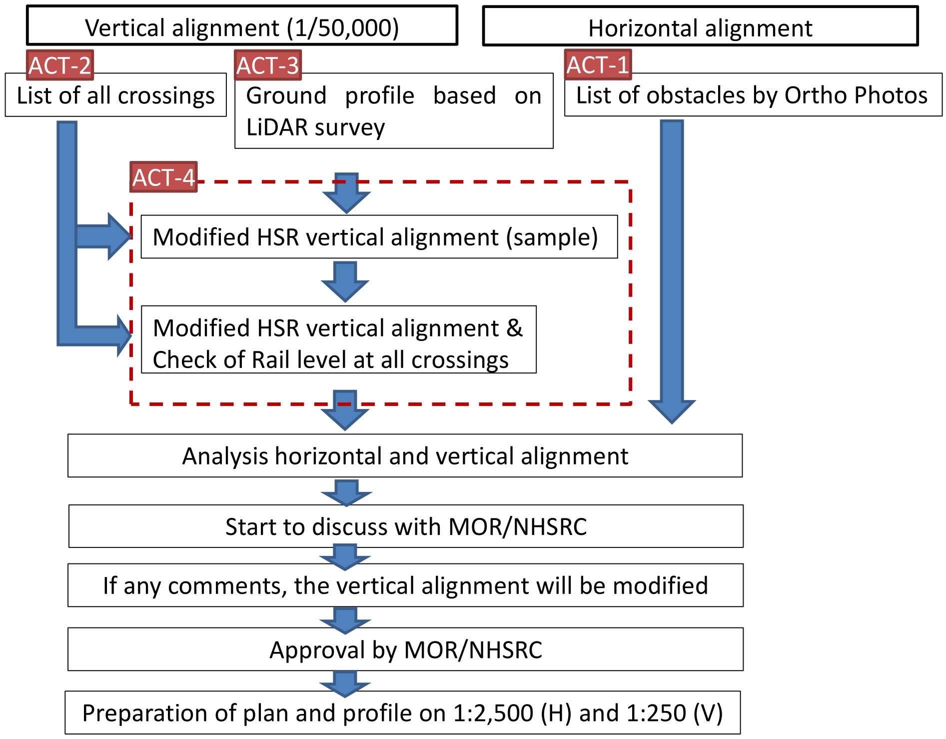
2) Gradient change in circular curve

Gradient change in circular curve shall not be permitted in principle.

Note:
- If gradient change in circular curve is unavoidable on the terrain, it is possible to insert gradient change in circular curve considering cant correction according to the train speed.
- It should be noted that the provision for the gradient change in circular curve is specified in Japan.
- If crest vertical curve in horizontal circular curve is provided, maximum permissible speed should be reduced due to increasing cant, according to maximum permissible cant and maximum permissible cant deficiency established in Schedule of Dimensions.

8.2.5 Basic workflow of final alignment design

Basic workflow of final alignment design is shown in Figure 8.2.5-1. At first, obstacles along the horizontal alignment has been checked by Ortho Photos in order to understand the nature of obstacles. Next, list of all crossings based on the information mentioned in Table 8.2.4-1 has been prepared. And also ground profile without river cross sections based on LiDAR survey has been generated. According to list of all crossings and ground profile by LiDAR survey, draft vertical alignment on 1:50,000 (H) and 1:1,000 (V) has been designed. After analysis of horizontal and vertical alignment, discussion with NHSRCL has been carried out. After NHSRCL almost approved the vertical alignment, The Study team has prepared plan and profile on 1:2,500 (H) and 1:250 (V).



Source: The Study team

Figure 8.2.5-1 Basic workflow of final alignment design

8.2.6 Implementation of final alignment design

(1) Horizontal alignment design

Horizontal alignment has been designed, based on an official letter to NHSRCL on 29th May 2017. At the sixth joint committee held in Delhi on 22nd November 2017, it has been re-confirmed that Mumbai HSR station location was approved at BKC planned in the joint F/S. Horizontal alignment design along the existing railway line in Ahmedabad area up to Sabarmati area has been excluded in this study because the negotiation with Western Railway has not been finalized.

General Consultancy for Mumbai-Ahmedabad HSR Project for Detailed Design
JIC Consortium (Japan International Consultants for Transportation, Nippon Koei & Oriental Consultants Global)

Our Ref. No.: JICC-NHSR-P&E-1705-0052	Your Ref No.:	Date: 29-05-2017
Letter □ Fax □		

Mr. Achal Khare, Managing Director,
National High-Speed Rail Corporation Ltd.
9th Floor, Commercial Tower, Windsor Place
New Delhi 110001, INDIA

Dear sir,

Subject: Horizontal Alignment for Mumbai- Ahmedabad High Speed Rail

In continuation of our discussions and on the request of NHSRC, JICC is submitting the horizontal alignment for the Mumbai- Ahmedabad High Speed Rail. The information for the horizontal alignment is incomplete for the following sections as these sections are yet to be finalized and are under discussion with NHSRC.

Table 1 Horizontal Alignment of Sections yet to be Finalized

No	Section	Chainage	
		From	To
1	Mumbai Area	Km 0+000	Km 4+000
2	Vadodara Area	Km 387+000	Km 407+000
3	Ahmedabad Area to Sabarmati Area	Km 486+000	Km 508+171

We have attached the coordinates of the horizontal intersection angle with the direction and the associated curve radius.

This is for your information and further action. We are awaiting the crossing list information and finalization of pending sections from Table 1 in order to proceed further for finalization of the vertical alignment, etc.

Sincerely,

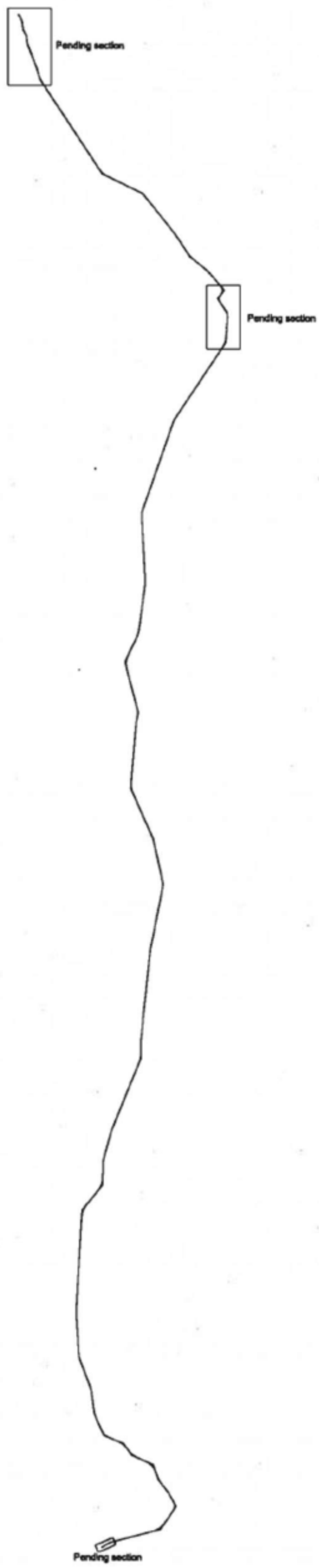
for Kimiaki Mitani

Toshiji Takatsu
Project Director

Cc: 1) Anjum Pervez (Officer on Special Duty, NHSRC)
2) Mr. Akira Sato (Representative, JICA India Office)

Attachment 1: Drawing (Soft Copy)
Attachment 2: Details of Horizontal Geometry

The Masterpiece Building, 2nd Floor, Golf Course Road
Sector 54, Gurgaon -122002, India
TEL : 0124-418-6400 (Ext, 01-19)


Pending section
Pending section
Pending section

General Consultancy for
Mumbai-Ahmedabad HSR Project for Detailed Design

JIC Consortium (Japan International Consultants for Transportation, Nippon Koei & Oriental Consultants Global)

Our Ref. No.: JICC-NHSR-P&E-1705-0052	Your Ref No.:	Date: 29-05-2017
Letter ☐ Fax ☐		

Attachment 2: Details of Horizontal Geometry

Sl. No.	Coordinates of Horizontal Intersection Angle (HIP)		Direction	Radius (m)	Transition Length (m)		Pending Section
	Easting (m)	Northing (m)			In	Out	
0	275335.230000	2109672.276000	-	-	-	-	Mumbai Area
1	277668.966000	2111157.668000	Right	6000	300	300	
2	292526.802000	2115021.141000	Left	6000	620	620	
3	297098.489000	2121677.034000	Left	2000	370	370	
4	294693.918000	2126019.742000	Left	6000	620	620	
5	292065.729000	2129249.692000	Right	6000	620	620	
6	290439.660000	2133889.702000	Left	6000	620	620	
7	284348.401000	2136533.673000	Right	6000	620	620	
8	281941.922000	2139934.484000	Left	6000	620	620	
9	276060.161000	2142306.255000	Right	4000	530	530	
10	273285.003000	2148635.763000	Right	6000	620	620	
11	272460.034000	2155536.123000	Left	6000	620	620	
12	268938.000000	2165107.000000	Right	6000	620	620	
13	268113.000000	2178311.000000	Right	8000	620	620	
14	269894.320000	2207961.635000	Right	6000	620	620	
15	275858.256000	2215200.610000	Left	6000	620	620	
16	275953.212000	2221985.849000	Right	6000	620	620	
17	278429.970000	2230834.501000	Right	8000	620	620	
18	287186.719000	2252233.802000	Left	6000	620	620	
19	287076.034000	2256495.176000	Right	6000	620	620	
20	289893.786000	2283664.452000	Right	8000	620	620	
21	293711.787000	2302901.071000	Left	6000	620	620	
22	290789.282000	2316110.292000	Left	6000	620	620	
23	284309.951000	2330799.586000	Right	6000	620	620	
24	285836.515000	2349677.537000	Right	6000	620	620	
25	286538.369000	2352794.229000	Left	6000	620	620	
26	282665.254000	2367592.573000	Right	6000	620	620	
27	286581.723000	2375823.458000	Left	6000	620	620	
28	288640.488000	2390589.863000	Left	6000	620	620	
29	287536.700000	2410859.037000	Right	6000	620	620	
30	296943.443000	2437836.828000	Right	6000	620	620	
31	312020.750000	2460539.311000	Left	6000	620	620	Vadodara Area
32	312319.467000	2464969.153000	Left	8000	50	50	

The Masterpiece Building, 2nd Floor, Golf Course Road
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General Consultancy for
Mumbai-Ahmedabad HSR Project for Detailed Design
JIC Consortium (Japan International Consultants for Transportation, Nippon Koei & Oriental Consultants Global)

Our Ref. No.: JICC-NHSR-P&E-1705-0052	Your Ref No.:	Date: 29-05-2017
Letter □ Fax □		

Sl. No.	Coordinates of Horizontal Intersection Angle (HIP)		Direction	Radius (m)	Transition Length (m)		Pending Section
	Easting (m)	Northing (m)			In	Out	
33	312341.225000	2465432.620000	Right	8000	50	50	
34	312553.573000	2467843.510000	Left	1400	30	30	
35	312476.102000	2469107.438000	Left	1200	50	50	
36	311975.459000	2469914.250000	Left	8000	100	100	
37	309697.285000	2473364.594000	Right	1500	350	350	
38	311647.891000	2475760.930000	Left	1600	350	350	
39	306739.020000	2481430.760000	Left	6000	620	620	
40	301644.526000	2485588.993000	Right	6000	620	620	
41	297610.828000	2491737.972000	Left	8000	620	620	
42	287848.049000	2503960.627000	Left	6000	620	620	
43	276022.425000	2509619.521000	Right	6000	620	620	
44	257999.544000	2537174.602000	Right	6000	620	620	Ahmedabad Area to Sabarmati Area
45	257086.683000	2540490.878000	Left	5000	410	410	
46	255527.828000	2544423.368000	Right	4000	203	203	
47	255373.683000	2544947.311000	Left	4000	203	203	
48	254860.015000	2546286.601000	Left	8000	30	30	
49	254287.362000	2547708.855000	Right	1000	120	120	
50	254297.022000	2548665.148000	Left	1200	40	40	
51	254217.237000	2549574.296000	Left	600	160	160	
52	253138.946000	2551496.822000	Right	1550	340	340	
53	252900.301000	2553983.849000	Left	1200	60	60	
54	252653.819000	2554551.183000	Left	800	60	60	
55	251747.500000	2555959.012000	-	-	-	-	

The Masterpiece Building, 2nd Floor, Golf Course Road
Sector 54, Gurgaon -122002, India
TEL : 0124-418-6400 (Ext, 01-19)

(2) Vertical alignment design

1) Basic data for vertical alignment design

Vertical alignment has been designed based on the following information. Basic data for vertical alignment design is as shown in Table 8.2.6-1, Table 8.2.6-2 and Table 8.2.6-3. In Table 8.2.6-1, a) to d) are based on preliminary design according to achievements in Japan, e) is based on achievements in Japan and vertical clearance is based on each SOD in India. The girder depth shown in following table is expected as maximum for vertical alignment design. The final girder depth will be provided in detailed design study.

Table 8.2.6-1 Basic data of span configuration, girder depth and vertical clearance

Span configuration & Girder Depth

a) PSC-Box Girder

Span(L)	Simply supported	2 span continuous	3 span continuous
L≦30m	2.5m	-	-
30m<L≦35m	3.0m	-	-
35m<L≦40m	3.0m	-	-
40m<L≦45m	3.5m	-	-
50m	~~6.1m~~	4.0m	3.5m
60m	-	-	4.5m

b) PSC-Box Girder(Cantilever)

Span(L)	Height of Girder		Application
	Fulcrum point	Centre point	
60m	5.0m	2.5m	
70m	6.0m	3.0m	(GAD11)
80m	6.5m	3.5m	(GAD53)

c) Truss Girder

Span(L)	Depth	remark
L≦80m	3.0m	
100m<L	3.0m	

d) Portal

Beam Span(L)	Depth(Beam)
L≦25m	3.5m
30m	4.0m
35m	5.0m

e) Bearing

Beam Span(L)	Depth
PSC	0.5m
Truss	1.0m

Vertical clearance

	Depth	remark
Road	5.500	
Railway	6.525	
DFC	8.705	

Source: The Study team

Table 8.2.6-2 Crossing list of GAD 56 + 8 for vertical alignment design

Sl.No.	GAD No.	Chainage		Name	Existing or Planned (E/P)	Span (m)	Type of girder	Road Level Rail Level HFL (m)	HFL at FLS (m) * 31.07.2017	Level Difference of HFL between FS and FLS (m)	Necessary Clearance as Maximum (m)	Extra below (m)	Girder Height (m)	RL-SL (m)	Min. RL (m)	Min. RL based on vertical alignment (m)	Level Difference (m)	Possibility of control point for vertical alignment	OK or NG	Remarks
		km	m																	
1	1	26	35	Railway	E	1x80+1x50	Truss+Single	16.838			6.525	1.200	3.000	0.800	28.363	28.603	0.240	High	OK	
2	57	28	130	Railway	E	1x70	Truss	6.071			6.525	1.200	3.000	0.800	17.596	22.462	4.866	Low	OK	
3	2	46	578	Railway	E	2x100	Truss+Single	12.887			6.525	1.200	3.000	0.800	24.412	30.308	5.896	Low	OK	
		46	650	DFC-1	P			12.991			8.705	1.200		0.800	26.696	31.288	4.592	Low	OK	
4	3	48	200	Chinchoti Anjur Phata RD-1	E	1x60+2x80+1x60	Truss+Portal	19.423			5.500	1.200	9.000	0.800	35.923	36.800	0.877	High	OK	
5	4	53	490	NH8-1	E	2x50	PC-Box-girder(Continuous-2span)	5.315			5.500	1.200	7.000	0.800	19.815	21.326	1.511	High	OK	
6	5	55	800	Expressway-1	P	4X70	Truss+Single	5.685			5.500	1.200	6.500	0.800	19.685	25.200	5.515	Low	OK	
7	6	62	900	DFC-2	P	2x70	Truss+Portal	18.478			8.705	1.200	9.000	0.800	38.183	39.801	1.618	High	OK	
8	58	71	335	Railway	E	1x40	Truss	4.146			6.525	1.200	3.000	0.800	15.671	15.900	0.229	High	OK	
9	7	72	400	Vaitarna River	E	33x60	PC-Box-girder(Continuous-3span)	1.600	Not yet received	Not yet received	8.000	0.000	4.500	0.800	14.900	15.900	1.000	High	OK	
10	8	85	600	Railway	E	5x80	Truss+Portal	9.667			6.525	1.200	9.000	0.800	27.192	32.638	5.446	Low	OK	
		85	600	DFC-3	P			13.733			8.705	1.200	8.000	0.800	32.438	32.638	0.200	High	OK	
11	9	210	380	NH8-3	E	2x50	PC-Box-girder(Continuous-2span)	20.661			5.500	1.200	7.000	0.800	35.161	35.351	0.190	High	OK	
12	59	221	137	Railway	E	1x40	Truss	12.834			6.525	1.200	3.000	0.800	24.359	29.800	5.441	Low	OK	
13	10	235	384	NH8-4	E	2x50	PC-Box-girder(Continuous-2span)	20.042			5.500	1.200	7.000	0.800	34.542	34.958	0.416	High	OK	
14	11	241	640	NH8-5	E	1x30+2x65+1x30	PC-Box-girder(Cantilever-4span)	16.425			5.500	1.200	9.000	0.800	32.925	33.927	1.002	High	OK	
15	60	262	699	Railway	E	1x40	Truss	21.097			6.525	1.200	3.000	0.800	32.622	34.800	2.178	Medium	OK	
16	12	285	934	DFC-4, Railway	P,E	1x80+1x60+1x80	Truss+Single	25.202			8.705	1.200	3.000	0.800	38.907	39.241	0.334	High	OK	
17	61	317	382	DFC-5	P	1x40+1x80	Truss	12.932			8.705	1.200	3.000	0.800	26.637	27.336	0.699	High	OK	
18	13	320	951	Narmanda River	E	21x60	PC-Box-girder(Continuous-3span)	13.400	8.121	5.279	8.000	0.000	4.500	0.800	21.421	21.924	0.503	High	OK	
19	14	326	938	NH64, Railway	E	3x60	Truss+Single	17.022			6.525	1.200	6.000	0.800	31.547	31.848	0.301	High	OK	
20	15	333	428	DFC-6	P	3x80	Truss+Single	19.010			8.705	1.200	3.000	0.800	32.715	33.500	0.785	High	OK	
21	62	385	0	DFC-7	P	1x70	Truss	30.599			8.705	1.200	3.000	0.800	44.304	44.768	0.464	High	OK	
22	16	391	463	Ring Road(F.O)	E	1x45	PC-Box-girder(Simply supported)	41.147			5.500	1.200	3.500	0.800	52.147	52.430	0.283	High	OK	
23	17	393	410	Manjalpur Main Road	E	1x40	PC-Box-girder(Simply supported)	32.381			5.500	1.200	3.500	0.800	43.381	55.500	12.119	Low	OK	
24	18	394	80	Railway	E	1x40	Truss or PC	30.580			6.525	1.200	3.500	0.800	42.605	55.500	12.895	Low	OK	
25	19	394	268	Vishwamitri Flyover(F.O)	E	1x45	PC-Box-girder(Simply supported)	42.717			5.500	1.200	3.500	0.800	53.717	55.500	1.783	High	OK	
26	20	395	655	Shankheshwar Parshwanath Marg(F.O)	E	1x45	PC-Box-girder(Simply supported)	44.100			5.500	1.200	3.500	0.800	55.100	55.500	0.400	High	OK	
27	21	396	602	Jetalpur RD(F.O)	E	1x45	PC-Box-girder(Simply supported)	42.943			5.500	1.200	3.500	0.800	53.943	55.500	1.557	High	OK	
28	22	396	924	RC Dutt RD	E	1x45	PC-Box-girder (Rigid Frame)	31.331			5.500	1.200	3.500	0.800	42.331	55.500	13.169	Low	OK	
29	23	397	550	Railway	E	Long span		34.978			6.525	1.200	3.500	0.800	47.003	55.500	8.497	Low	OK	
30	24	398	371	SH11	E	1x45	PC-Box-girder(Simply supported)	42.900			5.500	1.200	3.500	0.800	53.900	55.500	1.600	High	OK	
31	25	400	907	Railway	E	2x40+1x50	Truss+Portal	37.035			6.525	1.200	7.500	0.800	53.060	57.741	4.681	Low	OK	
32	26	401	304	Chhani Bridge(F.O)	E	1x40	PC-Box-girder(Simply supported)	46.186			5.500	1.200	3.000	0.800	56.686	58.477	1.791	High	OK	
33	27	401	720	Railway	E	4x40	Truss+Portal	37.317			6.525	1.200	8.000	0.800	53.842	59.080	5.238	Low	OK	
34	28	402	933	Railway	E	1x50	Truss+Single	39.900			6.525	1.200	3.000	0.800	51.425	61.187	9.762	Low	OK	
35	29	404	535	SH188-1	E	1x45	PC-Box-girder(Simply supported)	51.816			5.500	1.200	3.500	0.800	62.816	63.880	1.064	High	OK	
36	30	405	144	NH8-6	E	3x40	PC-Box-girder(Continuous-3span)	51.970			5.500	1.200	3.500	0.800	62.970	63.616	0.646	High	OK	
37	63	434	756	Railway	E	1x40	Truss	43.675			6.525	1.200	3.000	0.800	55.200	56.000	0.800	High	OK	
38	31	446	670	Railway	E	1x70+1x40	Truss+Single	37.050			6.525	1.200	6.500	0.800	52.075	56.000	3.925	Medium	OK	
39	32	449	589	NH8-7	E	4x50	Truss+Portal	39.417			5.500	1.200	9.000	0.800	55.917	56.000	0.083	High	OK	
40	64	455	180	Railway	E	1x40	Truss	32.262			6.525	1.200	3.000	0.800	43.787	45.600	1.813	High	OK	
41	33	459	453	NH8-8	E	2x50	PC-Box-girder(Continuous-2span)	34.195			5.500	1.200	7.000	0.800	48.695	49.210	0.515	High	OK	
42	34	489	730	Sardar Patel Ring Road(F.O)	E	1x45	PC-Box-girder(Simply supported)	50.911			5.500	1.200	3.500	0.800	61.911	62.575	0.664	High	OK	
43	35	491	480	Vinzol Rail Crossing Road	E	1x40	PC-Box-girder(Simply supported)	44.154			5.500	1.200	3.000	0.800	54.654	65.699	11.045	Low	OK	
44	36	492	435	Narol-Vatwa Rd(F.O)	E	1x45	PC-Box-girder(Simply supported)	54.293			5.500	1.200	3.500	0.800	65.293	66.719	1.426	High	OK	
45	37	494	753	NH8A	E	1x45	PC-Box-girder(Simply supported)	56.698			5.500	1.200	3.500	0.800	67.698	69.210	1.512	High	OK	
46	38	495	515	Lal Bahadur Shastri Rd(F.O)	E	1x45	PC-Box-girder(Simply supported)	56.600			5.500	1.200	3.500	0.800	67.600	69.500	1.900	High	OK	
47	39	496	69	Railway	E	4x80	Truss+Portal	48.378			6.525	1.200	7.000	0.800	63.903	69.500	5.597	Low	OK	
48	40	496	379	Ramkrishna Paramhans Marg	E	1x45	PC-Box-girder(Simply supported)	48.490			5.500	1.200	3.500	0.800	59.490	69.500	10.010	Low	OK	
49	41	496	997	Nathalal Jhagadia Bridge(F.O)	E	1x45	PC-Box-girder(Simply supported)	56.330			5.500	1.200	3.500	0.800	67.330	69.500	2.170	Medium	OK	
50	42	497	865	Anupam Bridge(F.O)	E	1x45	PC-Box-girder(Simply supported)	54.600			5.500	1.200	3.500	0.800	65.600	69.500	3.900	Medium	OK	
51	43	499	250	Railway	E	80+160+80+80+40	Truss+Single	50.160			6.525	1.200	5.500	0.800	64.185	69.500	5.315	Low	OK	
52	44	499	428	Rakhial Rd(F.O)	E	80+160+80+80+40	Truss+Single	58.100			5.500	1.200	3.000	0.800	68.600	69.500	0.900	High	OK	
53	45	499	651	Railway	E		Truss	50.121			6.525	1.200	3.500	0.800	62.146	69.500	7.354	Low	OK	
54	46	500	620	Railway	E	50+140+140	Truss+Portal	50.791			6.525	1.200	8.000	0.800	67.316	69.500	2.184	Medium	OK	
55	47	500	813	Kalupur Bridge(F.O)	E	50+140+140	Truss+Portal	57.800			5.500	1.200	3.000	0.800	68.300	69.500	1.200	High	OK	
56	48	501	174	Railway	E	48+80+48	Truss	51.237			6.555	2.000	5.500	0.800	66.092	69.500	3.408	Medium	OK	
57	49	501	521	Amarsinh Chaudhary Bridge(F.O)	E	1x45	PC-Box-girder(Simply supported)	56.770			5.500	1.200	3.500	0.800	67.770	69.500	1.730	High	OK	
58	50	502	154	Babu Jagjvanram Bridge(F.O)	E	1x45	PC-Box-girder(Simply supported)	58.500			5.500	1.200	3.500	0.800	69.500	69.500	0.000	High	OK	
59	51	502	862	Shahibaug Bridge(F.O)	E	1x45	PC-Box-girder(Simply supported)	57.400			5.500	1.200	3.500	0.800	68.400	70.504	2.104	Medium	OK	
60	52	503	462	Shahibaug Bridge Underpass	E	1x45	Truss+Portal	45.496			6.555	1.200	7.000	0.800	61.051	72.330	11.279	Low	OK	
61	53	504	455	Sabarmati River	E	53+4x76+53	PC-Box-girder(Continuous)	47.600	46.191	1.409	8.000	0.000	6.500	0.800	61.491	74.826	13.335	Low	OK	
62	54	505	80	Railway	E	1x45	Truss	53.772			6.555	1.200	3.500	0.800	65.827	76.500	10.673	Low	OK	
63	55	505	175	NH228-2(F.O) + Metro	E,P	1x80	Truss	66.371			4.203	1.500	3.000	0.800	75.874	76.500	0.626	High	OK	
64	56	505	339	Railway	E	2x40	Truss+Portal	53.662			6.555	1.200	7.000	0.800	69.217	76.500	7.283	Low	OK	

Source: The Study team (Note: As of 25th September 2017)

Table 8.2.6-3 Crossing list of remaining major crossings for vertical alignment design

No.	Chainage km	Chainage m	Name	Existing or Planned (E/P)	FS stage (from Annex-13 of Drawing Report): Span (m)	FS stage (from Annex-13 of Drawing Report): Type of girder	Study for Final Vertical Alignment: Road Level Rail Level HFL at FS (m)	HFL at FLS (m) * 31.07.2017	Level Difference of HFL between FS and FLS (m)	Necessary Clearance as Maximum (m)	Extra below (m)	Girder Height as Maximum (m)	RL-SL (m)	Min. RL (m)	Min. RL based on vertical alignment (m)	Level Difference (m)	Possibility of control point for vertical alignment	OK or NG	Remarks
1	21	344	NH4	E	1x30+1x45	PSC-Box-girder (simply support)	20.125			5.500	1.200	4.500	0.800	32.125	32.190	0.065	High	OK	
2	28	800	Ulhas River	E	12x50	PSC-Box-girder	5.700	Not yet received	Not yet received	8.000	0.000	4.500	0.800	19.000	20.000	1.000	High	OK	
3	33	11	NH3	E	1x40	PSC-Box-girder (simply support)	6.120			5.500	1.200	4.500	0.800	18.120	20.000	1.880	High	OK	
4	35	500	SH35	E	1x45	PSC-Box-girder (simply support)	3.515			5.500	1.200	4.500	0.800	15.515	20.000	4.485	Low	OK	
5	38	380	Ulhas River	E	4x50	PSC-Box-girder	3.640	Not yet received	Not yet received	8.000	0.000	4.500	0.800	16.940	20.000	3.060	Medium	OK	
6	50	481	Chinchoti Anjur Phata RD-2	E	1x50	PSC-Box-girder (simply support)	16.634			5.500	1.200	4.500	0.800	28.634	30.251	1.617	High	OK	
7	61	344	Gokhivare Rd	E	1x50	PSC-Box-girder (simply support)	6.859			5.500	1.200	4.500	0.800	18.859	20.171	1.312	High	OK	
8	104	5	Boisar Rd	E	1x30	PSC-I-girder (simply support)	14.468			5.500	1.200	4.500	0.800	26.468	27.000	0.532	High	OK	
9	116	263	SH74	E	1x35	PSC-I-girder (simply support)	17.237			5.500	1.200	4.500	0.800	29.237	34.672	5.435	Low	OK	
10	144	637	SH73	E	1x35	PSC-I-girder (simply support)	49.313			5.500	1.200	4.500	0.800	61.313	61.413	0.099	High	OK	
11	151	380	NH8-2	E	2x45	PSC-Box-girder (simply support)	54.341			5.500	1.200	4.500	0.800	66.341	66.624	0.283	High	OK	
12	162	369	SH185-1	E	1x45	PSC-Box-girder (simply support)	29.167			5.500	1.200	4.500	0.800	41.167	41.947	0.780	High	OK	
13	166	700	Daman Ganga River	E	8x50	PSC-Box-girder	23.150	17.887	5.263	8.000	0.000	4.500	0.800	31.187	44.250	13.063	Low	OK	
14	168	204	SH185-2	E	1x45	PSC-Box-girder (simply support)	33.858			5.500	1.200	4.500	0.800	45.858	46.000	0.142	High	OK	
15	170	834	SH5	E	1x30	PSC-I-girder (simply support)	32.745			5.500	1.200	4.500	0.800	44.745	46.000	1.255	High	OK	
16	175	526	Kolak River	E	4x40	PSC-Box-girder	17.300	15.874	1.426	8.000	0.000	4.500	0.800	29.174	38.065	8.891	Low	OK	
17	188	453	SH186	E	1x30	PSC-I-girder (simply support)	27.315			5.500	1.200	4.500	0.800	39.315	40.079	0.764	High	OK	
18	190	95	Par River	E	7x30+8x50	PSC-Box-girder + PSC-I-girder	19.240	Not yet received	Not yet received	8.000	0.000	4.500	0.800	32.540	32.874	0.334	High	OK	
19	198	200	Aurange River	E	4x50	PSC-Box-girder	14.870	8.200		8.000	0.000	4.500	0.800	21.500	34.515	13.015	Low	OK	
20	201	152	SH67	E	1x45	PSC-Box-girder (simply support)	20.229			5.500	1.200	4.500	0.800	32.229	35.858	3.629	Medium	OK	
21	212	550	Kaveri River (S)	E	4x50	PSC-Box-girder	11.400	Not yet received	Not yet received	8.000	0.000	4.500	0.800	24.700	30.159	5.459	Low	OK	
22	214	400	Kaveri River (N)	E	4x50	PSC-Box-girder	11.320	Not yet received	Not yet received	8.000	0.000	4.500	0.800	24.620	29.800	5.180	Low	OK	
23	216	841	NH360	E	1x35	PSC-I-girder (simply support)	13.026			5.500	1.200	4.500	0.800	25.026	29.800	4.774	Low	OK	
24	223	948	SH703	E	1x30	PSC-I-girder (simply support)	14.445			5.500	1.200	4.500	0.800	26.445	29.800	3.355	Medium	OK	
25	228	550	Ambica River	E	5x50	PSC-Box-girder	17.200	12.380	4.820	8.000	0.000	4.500	0.800	25.680	31.800	6.120	Low	OK	
26	236	600	SH170-1	E	1x30	PSC-I-girder (simply support)	17.364			5.500	1.200	4.500	0.800	29.364	32.645	3.281	Medium	OK	
27	238	100	SH88	E	1x30	PSC-I-girder (simply support)	14.673			5.500	1.200	4.500	0.800	26.673	29.705	3.032	Medium	OK	
28	240	0	Purna River	E	9x50	PSC-Box-girder	11.700	9.115	2.585	8.000	0.000	4.500	0.800	22.415	27.917	5.502	Low	OK	
29	248	580	SH196	E	1x35	PSC-I-girder (simply support)	16.325			5.500	1.200	4.500	0.800	28.325	28.500	0.175	High	OK	
30	250	335	Mindhola River	E	2x40	PSC-Box-girder	11.000	3.112	7.888	8.000	0.000	4.500	0.800	16.412	25.914	9.502	Low	OK	
31	254	620	SH168	E	1x50	PSC-Box-girder (simply support)	16.784			5.500	1.200	4.500	0.800	28.784	29.072	0.288	High	OK	
32	255	741	SH170-2	E	1x40	PSC-Box-girder (simply support)	15.133			5.500	1.200	4.500	0.800	27.133	28.442	1.309	High	OK	
33	264	845	NH6	E	1x50	PSC-Box-girder (simply support)	18.132			5.500	1.200	4.500	0.800	30.132	34.800	4.668	Low	OK	
34	273	338	SH167	E	3x40	PSC-Box-girder (simply support)	21.280			5.500	1.200	4.500	0.800	33.280	34.800	1.520	High	OK	
35	276	300	Tapi River	E	15x50	PSC-Box-girder	21.460	17.568	3.892	8.000	0.000	4.500	0.800	30.868	34.800	3.932	Medium	OK	
36	279	852	SH605	E	1x45	PSC-Box-girder (simply support)	21.555			5.500	1.200	4.500	0.800	33.555	37.584	4.029	Low	OK	
37	290	435	SH65	E	1x35	PSC-I-girder (simply support)	15.446			5.500	1.200	4.500	0.800	27.446	32.215	4.769	Low	OK	
38	293	285	Kim River	E	2x40	PSC-Box-girder	6.600	16.463	-9.863	8.000	0.000	4.500	0.800	29.763	30.000	0.237	High	OK	
39	297	157	Expressway-2	P	2x45	PSC-Box-girder (simply support)	28.931			5.500	1.200	4.500	0.800	40.931	42.000	1.069	High	OK	
40	298	400	SH166	E	1x40	PSC-Box-girder (simply support)	29.946			5.500	1.200	4.500	0.800	41.946	42.000	0.054	High	OK	
41	316	20	NH228-1	E	1x35	PSC-I-girder (simply support)	11.446			5.500	1.200	4.500	0.800	23.446	24.633	1.187	High	OK	
42	322	840	SH6	E	1x45	PSC-Box-girder (simply support)	17.145			5.500	1.200	4.500	0.800	29.145	29.400	0.255	High	OK	
43	359	140	SH161	E	1x35	PSC-I-girder (simply support)	20.631			5.500	1.200	4.500	0.800	32.631	34.200	1.569	High	OK	
44	371	903	SH160	E	1x30	PSC-I-girder (simply support)	21.143			5.500	1.200	4.500	0.800	33.143	34.200	1.057	High	OK	
45	373	93	Dhadhar River	E	1x30+2x50	PSC-Box-girder	19.200	20.746	-1.546	8.000	0.000	4.500	0.800	34.046	34.200	0.154	High	OK	
]	416	188	Expressway-3 (ROB)	P	2x40	PSC-Box-girder (simply support)	39.570			5.500	1.200	3.500	0.800	50.570	50.571	0.001	High	OK	
47	417	120	Mahi River	E	13x50	PSC-Box-girder (simply support)	30.900	26.255	4.645	8.000	0.000	4.500	0.800	39.555	43.697	4.142	Low	OK	
48	420	855	SH188-2	E	1x45	PSC-Box-girder (simply support)	42.201			5.500	1.200	4.500	0.800	54.201	55.889	1.688	High	OK	
49	432	404	SH83	E	1x40	PSC-Box-girder (simply support)	41.721			5.500	1.200	4.500	0.800	53.721	56.000	2.279	Medium	OK	
50	436	170	SH60-1	E	1x40	PSC-Box-girder (simply support)	40.016			5.500	1.200	4.500	0.800	52.016	56.000	3.984	Medium	OK	
51	440	452	SH75	E	1x30	PSC-I-girder (simply support)	37.462			5.500	1.200	4.500	0.800	49.462	56.000	6.538	Low	OK	
52	447	122	SH150	E	1x35	PSC-I-girder (simply support)	36.275			5.500	1.200	4.500	0.800	48.275	56.000	7.725	Low	OK	
53	451	183	SH89	E	1x30	PSC-I-girder (simply support)	36.161			5.500	1.200	4.500	0.800	48.161	49.240	1.079	High	OK	
54	463	950	Mohar River	E	4x40	PSC-Box-girder (simply support)	25.900	29.433	-3.533	8.000	0.000	4.500	0.800	42.733	42.849	0.116	High	OK	
55	471	143	SH60-2	E	1x35	PSC-I-girder (simply support)	30.496			5.500	1.200	4.500	0.800	42.496	45.142	2.646	Medium	OK	
56	473	500	Vatrak River	E	1x30+4x50+1x30	PSC-I-girder(30m) & PSC-Box-girder(50m)	30.000	32.463	-2.463	8.000	0.000	4.500	0.800	45.763	45.854	0.091	High	OK	
57	476	600	Meshwa River	E	4x50	PSC-Box-girder	30.000	29.583	0.417	8.000	0.000	4.500	0.800	42.883	46.843	3.960	Medium	OK	
58	483	43	SH144	E	1x30	PSC-I-girder (simply support)	35.006			5.500	1.200	4.500	0.800	47.006	48.905	1.899	High	OK	
59																			
60																			

Source: The Study team (Note: As of 25th September 2017)

2) Main points for vertical alignment design

Main points for vertical alignment design at the Follow-Up Study stage compared with vertical alignment design at FS stage are as follows. The Study team explained main points for final vertical alignment design to Mr. Suthar at NHSRCL office on 18th September 2017 and it was approved.

a) Smoothing of vertical alignment

- Basically embankment section at FS stage (planned vertical alignment along the ground profile for reducing embankment volume and land acquisition).
- Basically fully elevated except before and after tunnel based on formal letter from MOR on 11th August, 2016
- Vertical road clearance of 5.5 m should be provided for final vertical alignment design for all roads except unavoidable cases on the terrain.
- Attempt to make one vertical gradient length longer avoiding frequent vertical gradient changes.

b) Providing height of girder as 4.5 m for major crossings except GAD 56 + 8 under negotiation, because remaining major crossings have not been negotiated yet.

c) Necessary clearance from HFL to bottom of girder at major river crossings is fixed as 8.0 m referring to the maximum necessary clearance from HFL to bottom of girder at Narmada River & Sabarmati River and it is mentioned in an official letter from Inland Waterways Authority of India (Letter No: IWAI/PR/NNWs/Nav. Clearance/2016) in the Study. Final necessary clearance at major river crossings will be considered in the detailed design study.

d) Gradient change in transition curve shall not be permitted in SOD.

e) Gradient change in circular curve shall not be permitted in principle, except if unavoidable due to the terrain, based on regulations in Japan. In addition, if crest vertical curve in horizontal circular curve is provided, maximum permissible speed should be reduced due to increasing cant. This overlap should be avoided as far as possible.

f) Standard design for viaduct is available up to approx. 25 m in height from RL to GL

The details of each section are shown in Table 8.2.6-4.

Table 8.2.6-4 Main points for vertical alignment design

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
1	-0/257.5	21/150	- Tunnel method changed from NATM to TBM due to environmental issue such as vibration and noise - Vertical alignment has lifted up approx. 10 m to 20 m from FS alignment (with allowance for reasonable overburden for TBM drive) **Judging the above points comprehensively, the vertical alignment has been designed**	- Pending section between Km -0/257.5 and Km 6/770 because the location & Rail Level of Mumbai station is not fixed
2	21/400	26/000	- Maximum gradient 3‰ (0.3%) for considering extension to Pune (from Km 22/300 to Km 23/800) - Securing minimum Rail level at crossings **Judging the above points comprehensively, the vertical alignment has been designed**	
3	29/000	42/750	- Setting the approach section to Thane Depot as Level - Securing minimum Rail level at all crossings - Gradient changing points is minimized as possible, and the distance between gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	-Km 28/800 Ulhas River (HFL at FS only) -Km 38/380 Ulhas River (HFL at FS only)
4	47/000	58/900	- Securing minimum Rail level at all crossings - Securing minimum vertical gradient 2‰ (0.2%) or more in tunnel section - Gradient changing points is minimized as possible, and the distance between gradient changing points is secured for 2.0 km or more - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been**	- Km 46/650 DFC-1 - Km 55/800 Expressway-1

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
			designed	
5	62/900	71/250	- Securing minimum Rail level at crossings except unavoidable case on the terrain - Maximum gradient 3‰ (0.3%) for station yard in SOD - Considering the water drainage from mountain slope near Km 65/500 - Distance between gradient changing points is set as 1.5 km for securing tunnel overburden as much as possible - Overlap between vertical curve and expansion joint after turnout should not be permitted. **Judging the above points comprehensively, the vertical alignment has been designed**	-Tunnel MT-3 and Tunel MT-4 have been replaced with one tunnel. - Km62/900 DFC-2
6	74/200	82/000	- Securing minimum Rail level at all crossings - Setting as elevated section for village near Km 74/600 - Securing minimum vertical gradient 2‰ (0.2%) or more in tunnel section - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	Km 72/600 Vaitarna River (HFL at FS only)
7	82/000	85/600	- Securing minimum Rail level at all crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 85/600 DFC-3
8	87/850	97/950	- Securing minimum Rail level at all crossings considering up and down of terrain - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case.	

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
			Judging the above points comprehensively, the vertical alignment has been designed	
9	97/950	102/750	- Securing minimum Rail level at all crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more **Judging the above points comprehensively, the vertical alignment has been designed**	
10	107/000	112/850	-Securing minimum Rail level at crossings except unavoidable case on the terrain - Setting as elevated section for village near Km 110/200 - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more **Judging the above points comprehensively, the vertical alignment has been designed**	
11	119/500	124/000	- Securing minimum Rail level at crossings except unavoidable case on the terrain - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more **Judging the above points comprehensively, the vertical alignment has been designed**	
12	124/000	129/000	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Gradient change in transition curve shall not be permitted in SOD - Securing minimum vertical gradient 2‰ (0.2%) or more in tunnel section **Judging the above points comprehensively, the vertical alignment has been designed**	
13	129/000	131/600	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more	

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
			- Gradient change in transition curve shall not be permitted in SOD - Securing minimum vertical gradient 2‰ (0.2%) or more in tunnel section **Judging the above points comprehensively, the vertical alignment has been designed**	
14	131/600	135/450	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Gradient change in transition curve shall not be permitted in SOD **Judging the above points comprehensively, the vertical alignment has been designed**	
15	137/500	144/700	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Gradient change in transition curve shall not be permitted in SOD **Judging the above points comprehensively, the vertical alignment has been designed**	
16	144/700	151/400	- Securing minimum Rail level at crossings except unavoidable case on the terrain - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Gradient change in transition curve shall not be permitted in SOD **Judging the above points comprehensively, the vertical alignment has been designed**	- Distance between vertical curve and transition curve is unavoidable case on the terrain
17	153/500	158/000	- Securing minimum Rail level at crossings except unavoidable case on the terrain - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Securing minimum vertical gradient 2‰ (0.2%) or more in tunnel section **Judging the above points comprehensively, the vertical alignment has been designed**	

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
18	167/000	176/800	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 166/700 Daman Ganga River - Km 175/526 Kolak River
19	181/500	188/250	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - - Standard design is available up to approx. 25 m in height from RL to GL **Judging the above points comprehensively, the vertical alignment has been designed**	
20	190/500	197/250	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 190/095 Par River (HFL at FS only) - Km 198/200 Aurange River
21	210/500	232/450	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Station section should be level in principle. **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 212/550 Kaveri River (S) (HFL at FS only) - Km 214/400 Kaveri River (N) (HFL at FS only) - Km 228/550 Ambica River
22	232/450	244/000	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance	- Km 240/000 Purna River

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
			between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	
23	247/500	254/600	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Gradient change in transition curve shall not be permitted in SOD **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 250/335 Mindhola River
24	257/800	262/500	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL **Judging the above points comprehensively, the vertical alignment has been designed**	
25	262/500	279/000	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 276/300 Tapi River
26	285/950	293/600	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance	- Km 285/934 DFC-4, Existing Railway

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
			between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	
27	293/600	296/500	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 293/285 Kim River - Km 297/157 Planning Expressway-2
28	300/000	307/000	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD **Judging the above points comprehensively, the vertical alignment has been designed**	
29	317/400	322/000	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 317/382 DFC-5 - Km 320/951 Narmanda River
30	328/250	335/200	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more	- Km 333/428 DFC-6

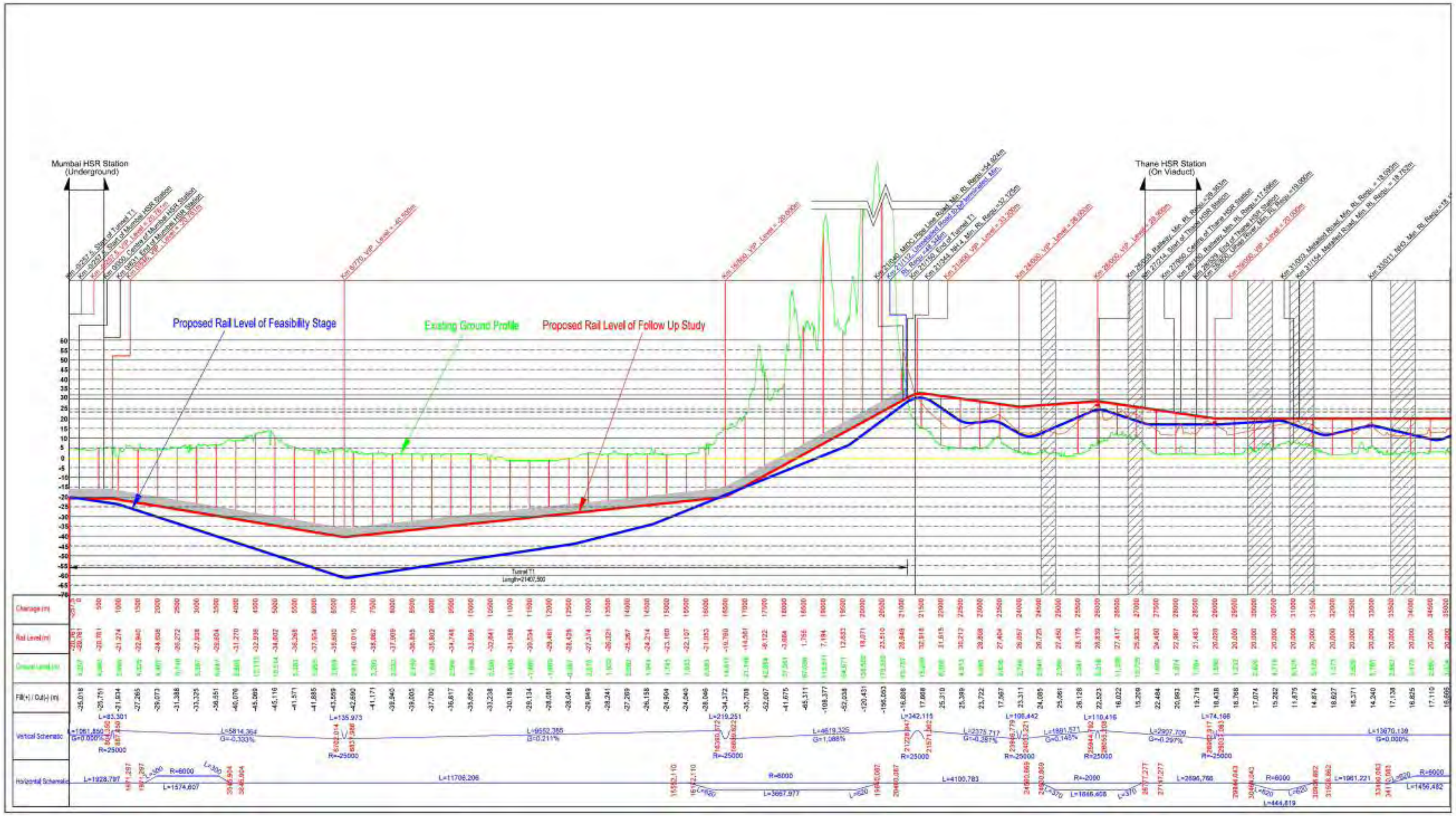
No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
			- Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	
31	343/500	380/200	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible for the almost flat terrain, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL **Judging the above points comprehensively, the vertical alignment has been designed**	- Km373/093 Dhadhar River
32	380/200	385/000	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - New candidate location for Vadodara Maintenance Depot **Judging the above points comprehensively, the vertical alignment has been designed**	-Km 385/000 DFC-7
33	392/250	405/000	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Station section should be level in principle. - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	
34	405/000	407/500	- Securing minimum Rail level at crossings	

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
			- Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Station section should be level in principle. - Gradient change in transition curve shall not be permitted in SOD **Judging the above points comprehensively, the vertical alignment has been designed**	
35	407/500	416/000	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible for the almost flat terrain, and the distance between the gradient changing points is secured for 2.0 km or more - Based on the meeting with NHSRCL in JICC office on 30/08/2017, crossing with planning expressway at Km 416/188 is to be set as ROB (The reason is that pier height of Mahi River Bridge should be lowered as possible). **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 416/188 Planning Expressway-3 (as ROB) - Km 417/120 Mahi River
36	420/850	449/900	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Station section should be level in principle. **Judging the above points comprehensively, the vertical alignment has been designed**	
37	461/500	485/850	- Securing minimum Rail level at crossings - Gradient changing points is minimized as far as possible for the almost flat terrain, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL **Judging the above points comprehensively, the vertical alignment has been designed**	- Km 463/950 Mohar River - Km 473/500 Vatrak River - Km 476/600 Meshwa River
38	485/850	490/250	- Securing minimum Rail level at crossings	

No.	Chainage (Km)		Main points of final vertical alignment design	Remarks
	Start	End		
			- Gradient changing points is minimized as far as possible for the almost flat terrain, and the distance between the gradient changing points is secured for 2.0 km or more - Standard design is available up to approx. 25 m in height from RL to GL - Gradient change in transition curve shall not be permitted in SOD - Gradient change in circular curve shall not be permitted in principle except unavoidable case. **Judging the above points comprehensively, the vertical alignment has been designed**	

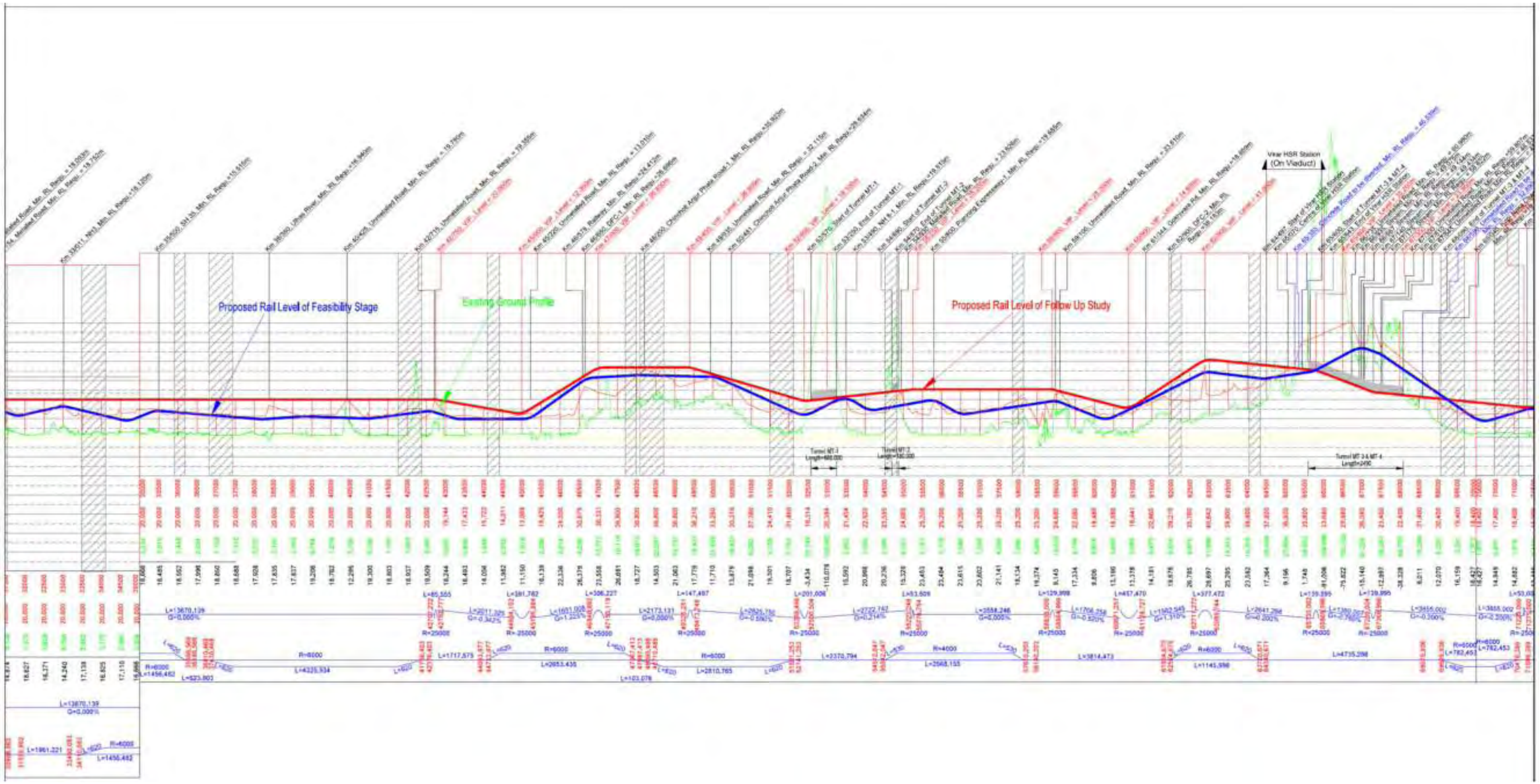
Source: The Study team

The Study vertical alignment design is compared with vertical alignment design at FS stage, which are shown in Figure 8.2.6-1 up to Figure 8.2.6-15. Red line indicates the vertical alignment design in the Study and blue line indicates the vertical alignment design in the joint feasibility study. The Study team explained the vertical alignment design based on the following drawings to Mr. Suthar of NHSRCL and it was approved.



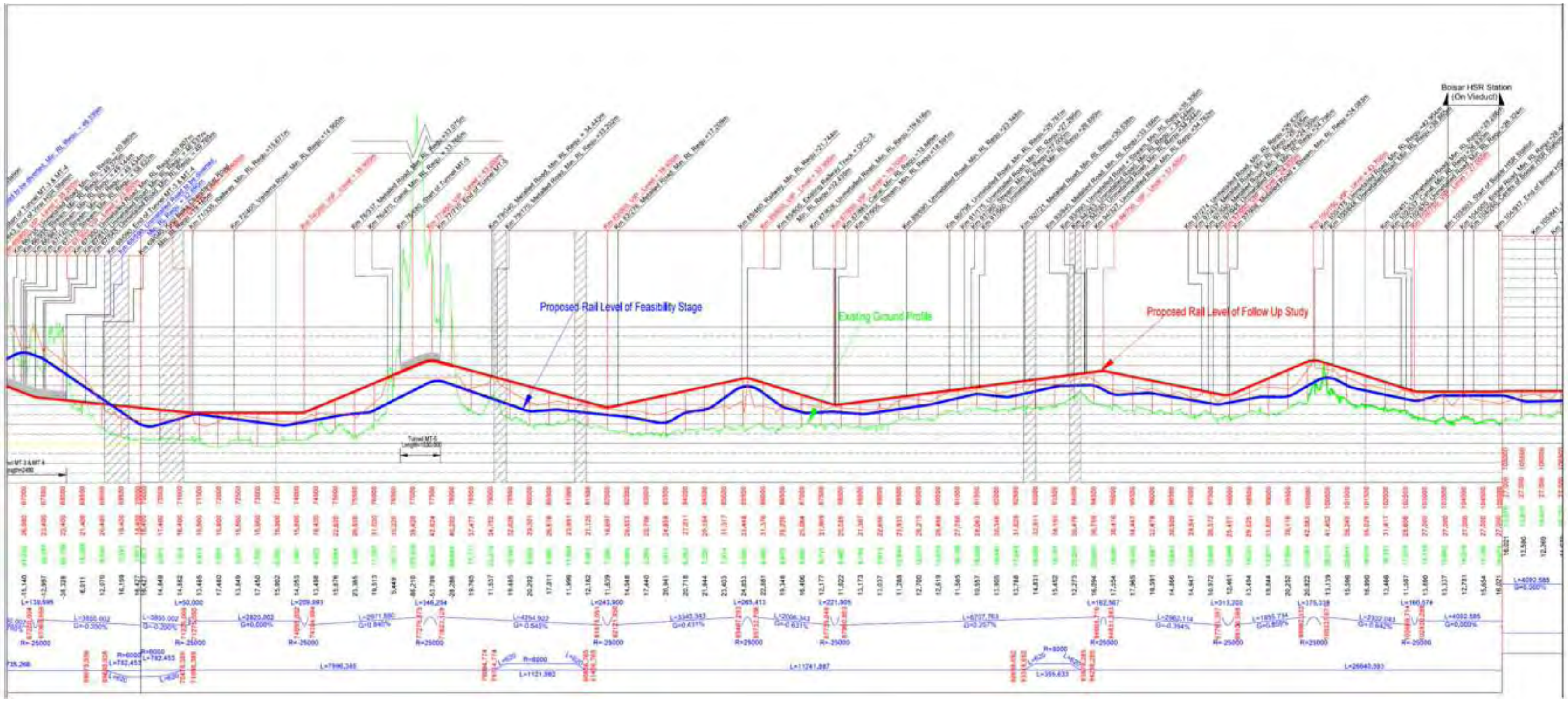
Source: The Study team

Figure 8.2.6-1 Plan & profile from km 0.0 to km 35.0 for discussion with NHSRCL



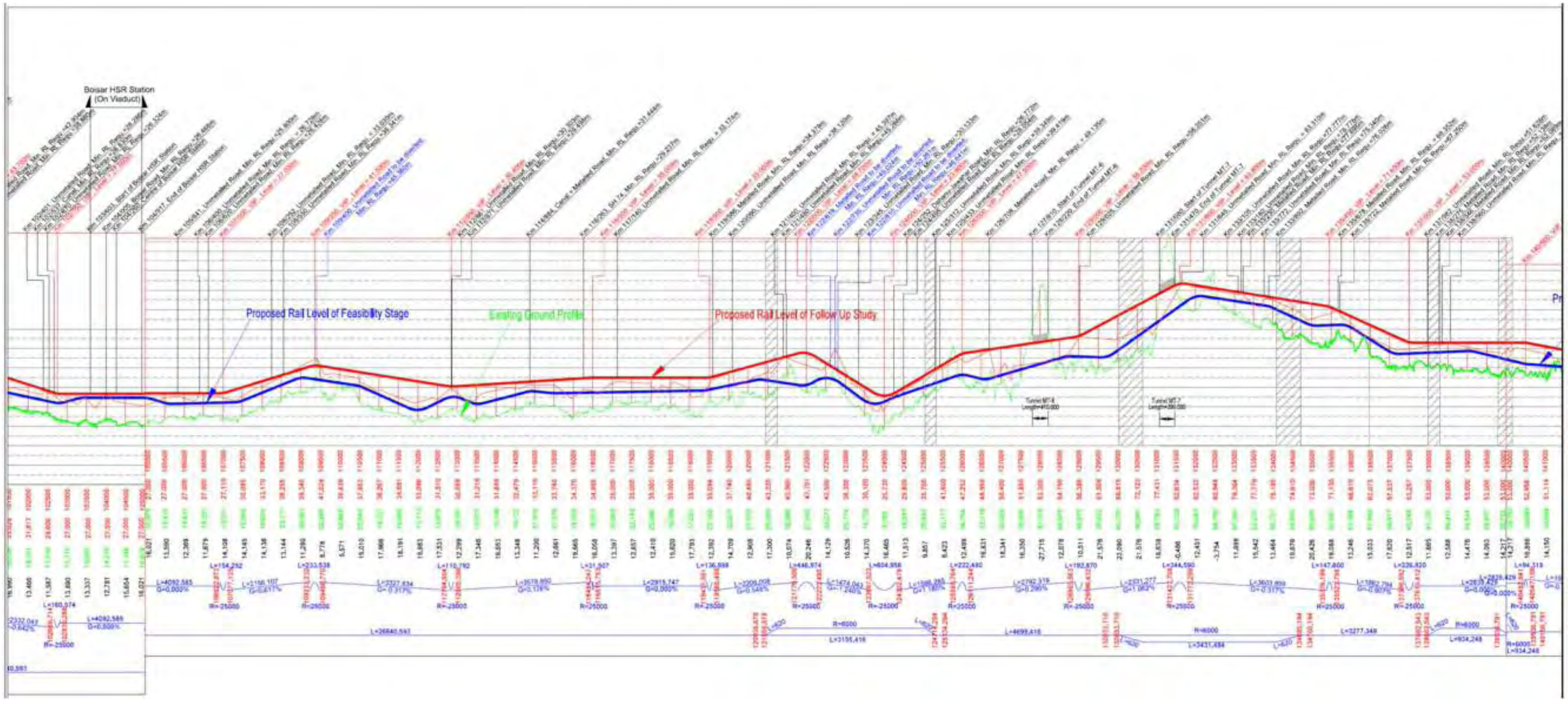
Source: The Study team

Figure 8.2.6-2 Plan & profile from km 35.0 to km 70.0 for discussion with NHSRCL



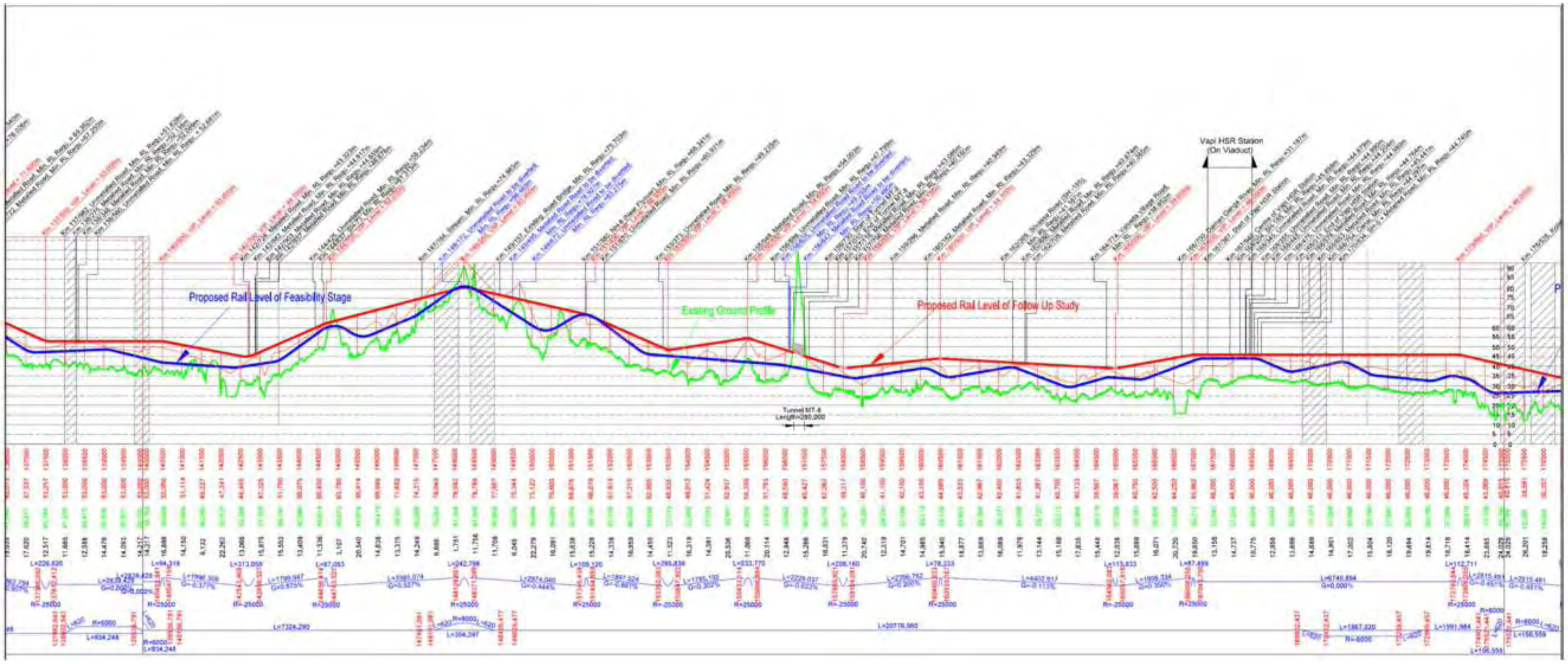
Source: The Study team

Figure 8.2.6-3 Plan & profile from km 70.0 to km 105.0 for discussion with NHSRCL



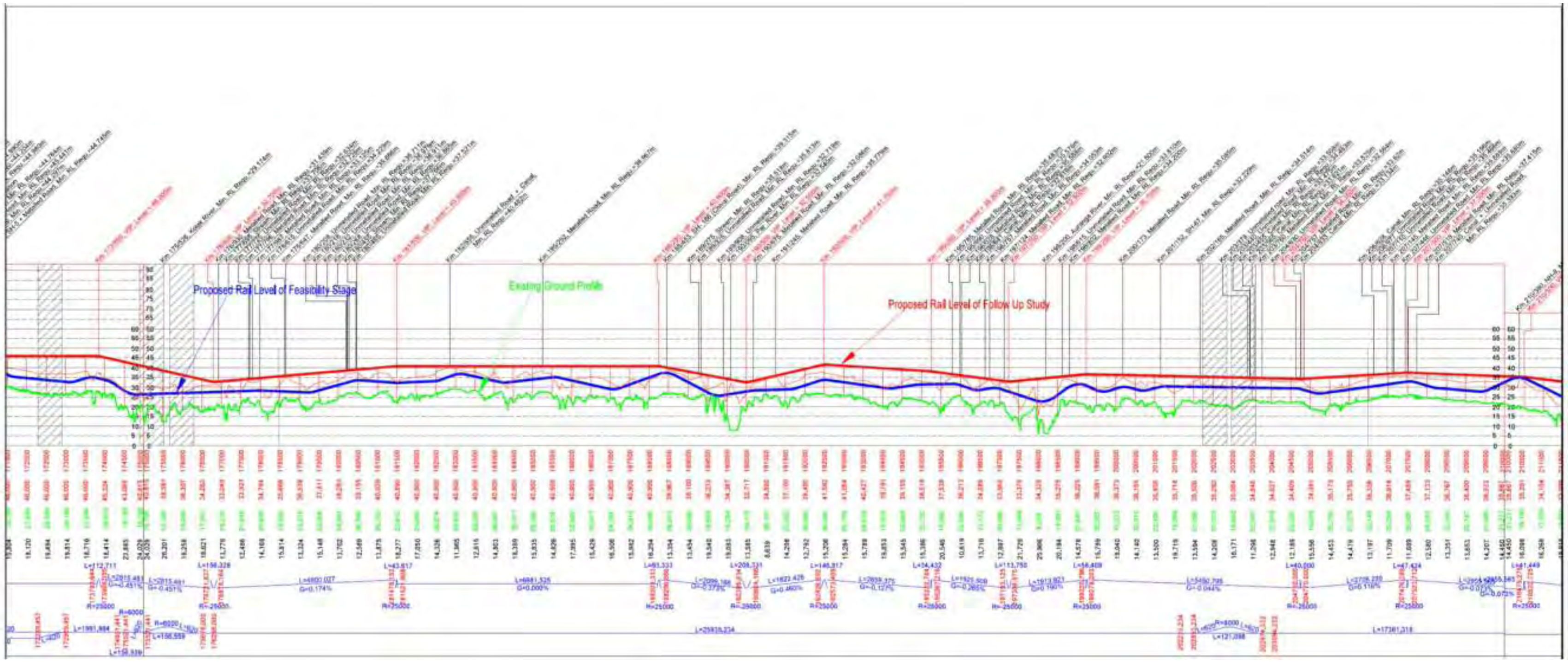
Source: The Study team

Figure 8.2.6-4 Plan & profile from km 105.0 to km 140.0 for discussion with NHSRCL



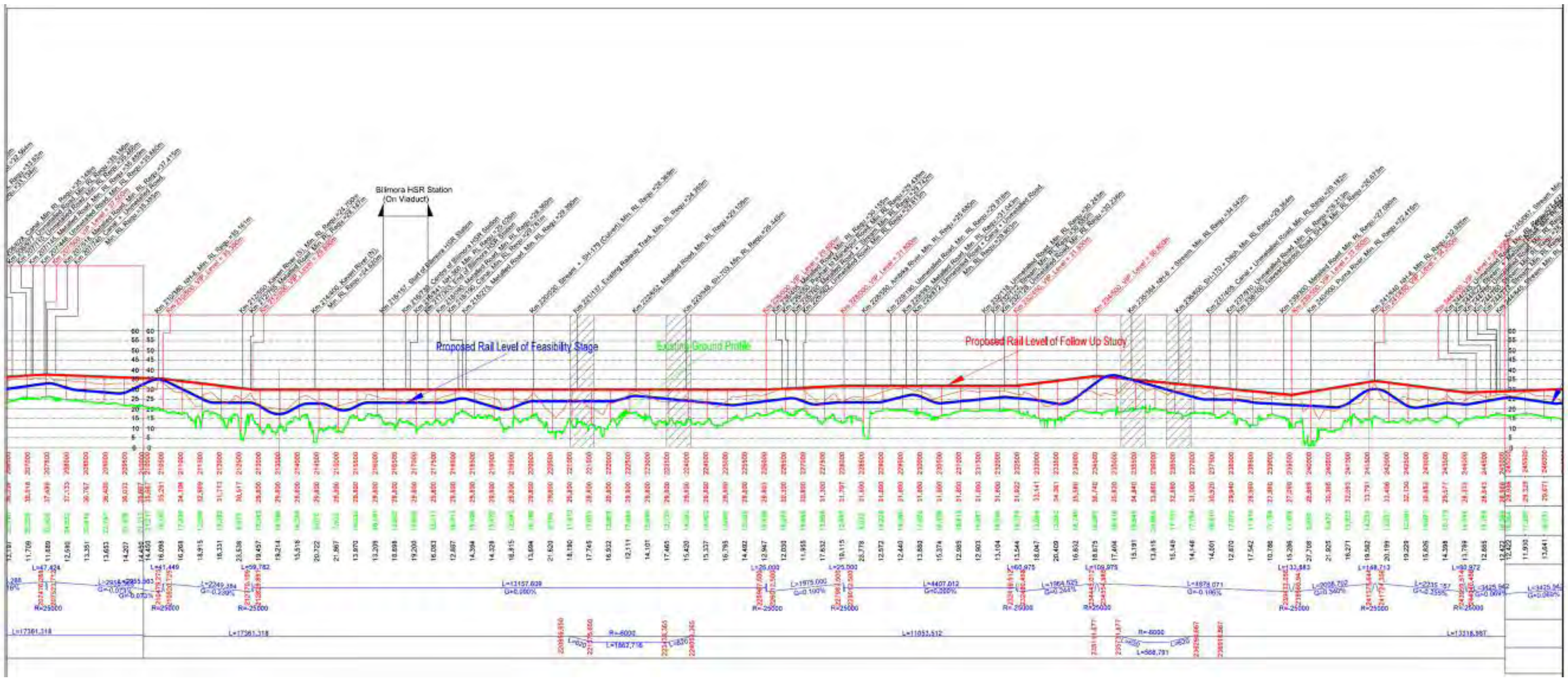
Source: The Study team

Figure 8.2.6-5 Plan & profile from km 140.0 to km 175.0 for discussion with NHSRCL



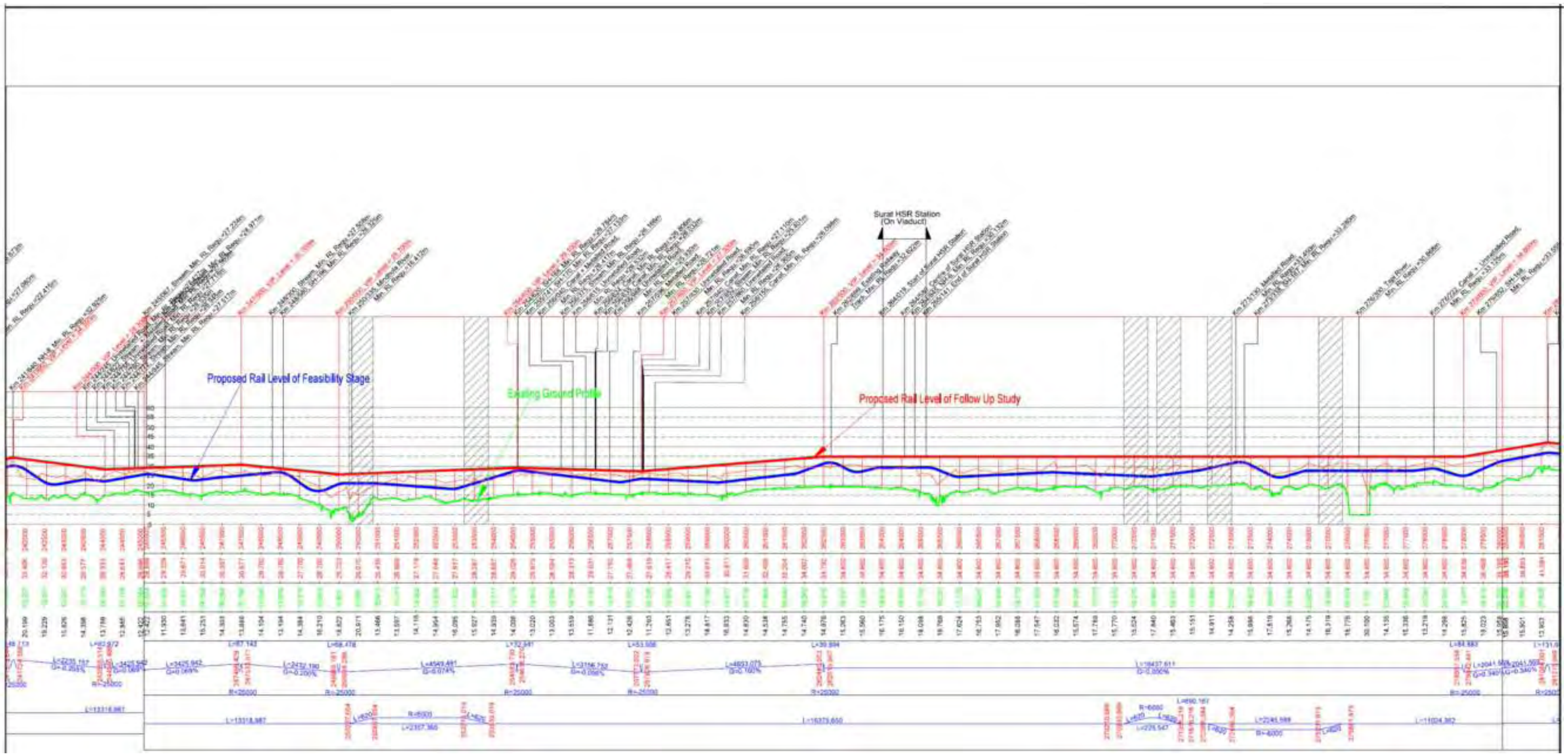
Source: The Study team

Figure 8.2.6-6 Plan & profile from km 175.0 to km 210.0 for discussion with NHSRCL



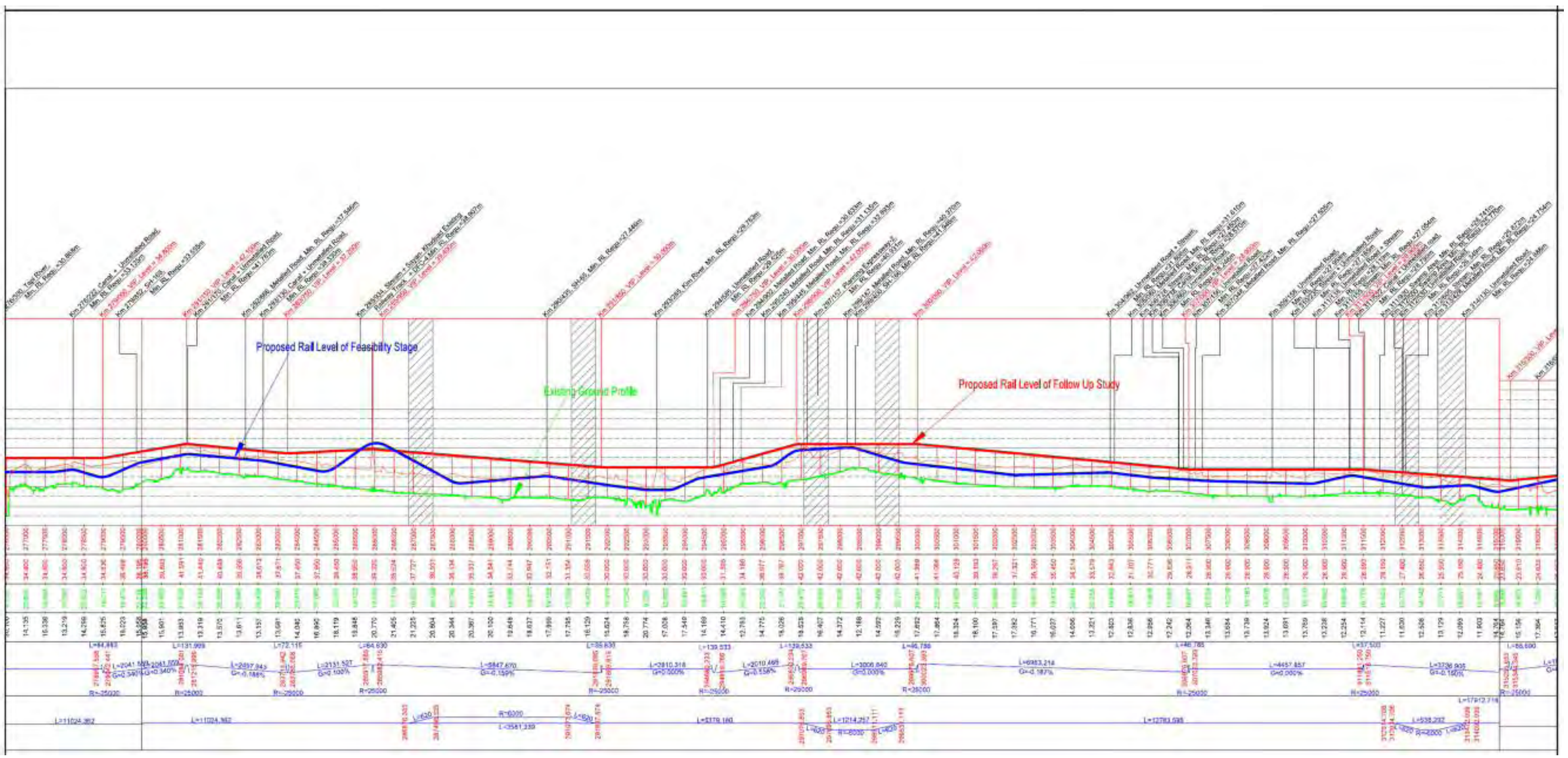
Source: The Study team

Figure 8.2.6-7 Plan & profile from km 210.0 to km 245.0 for discussion with NHSRCL



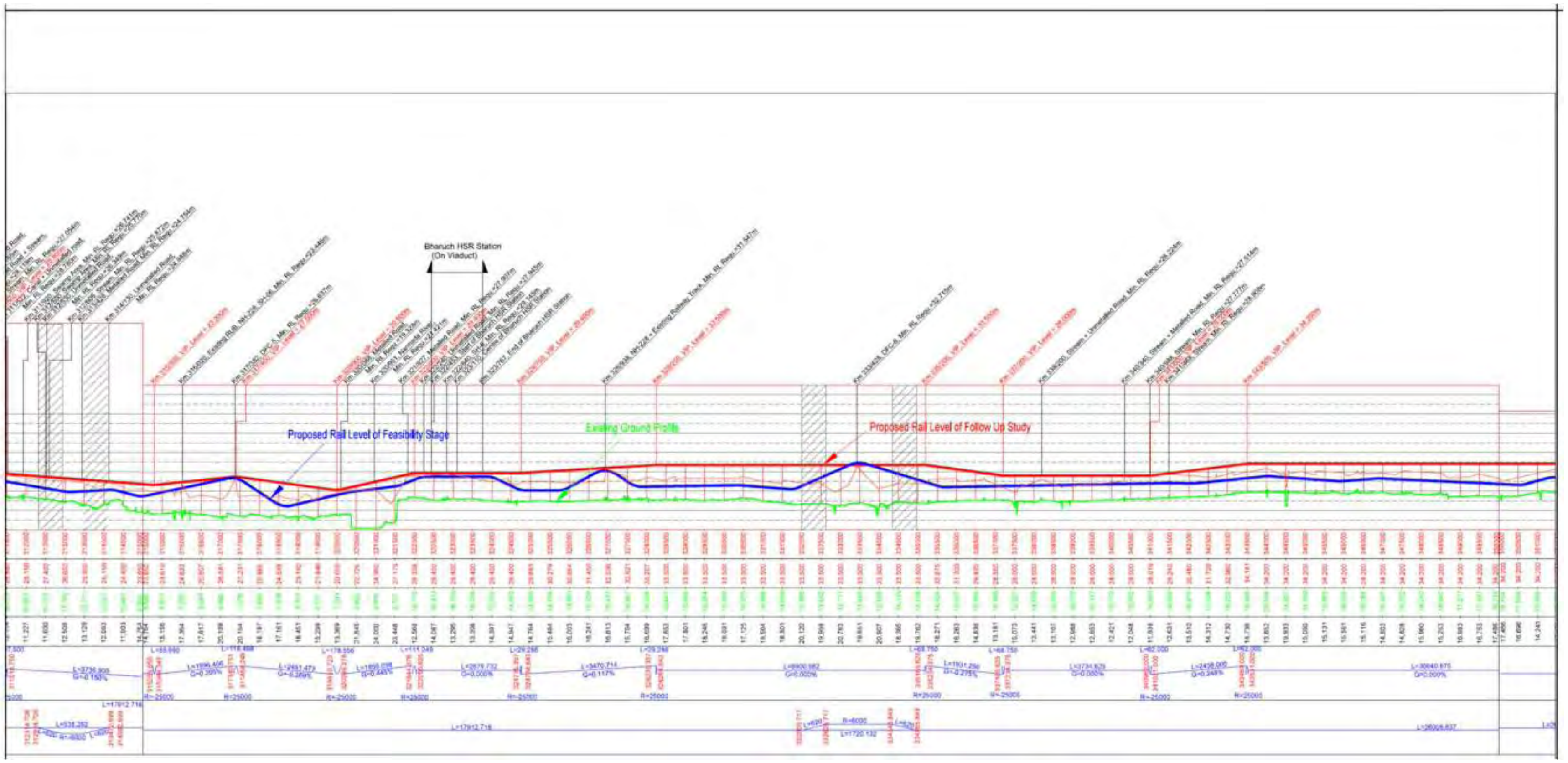
Source: The Study team

Figure 8.2.6-8 Plan & profile from km 245.0 to km 280.0 for discussion with NHSRCL



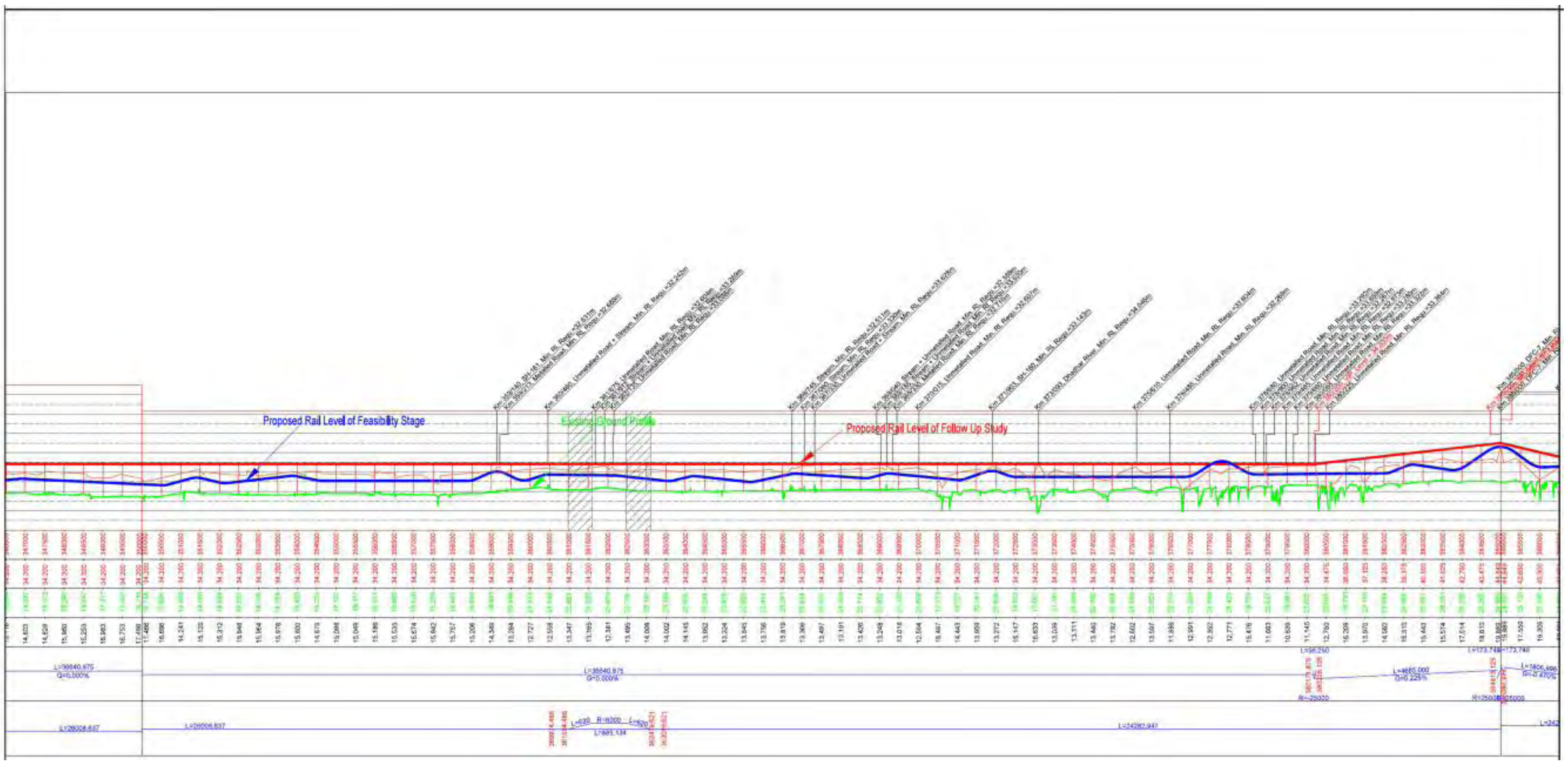
Source: The Study team

Figure 8.2.6-9 Plan & profile from km 280.0 to km 315.0 for discussion with NHSRCL



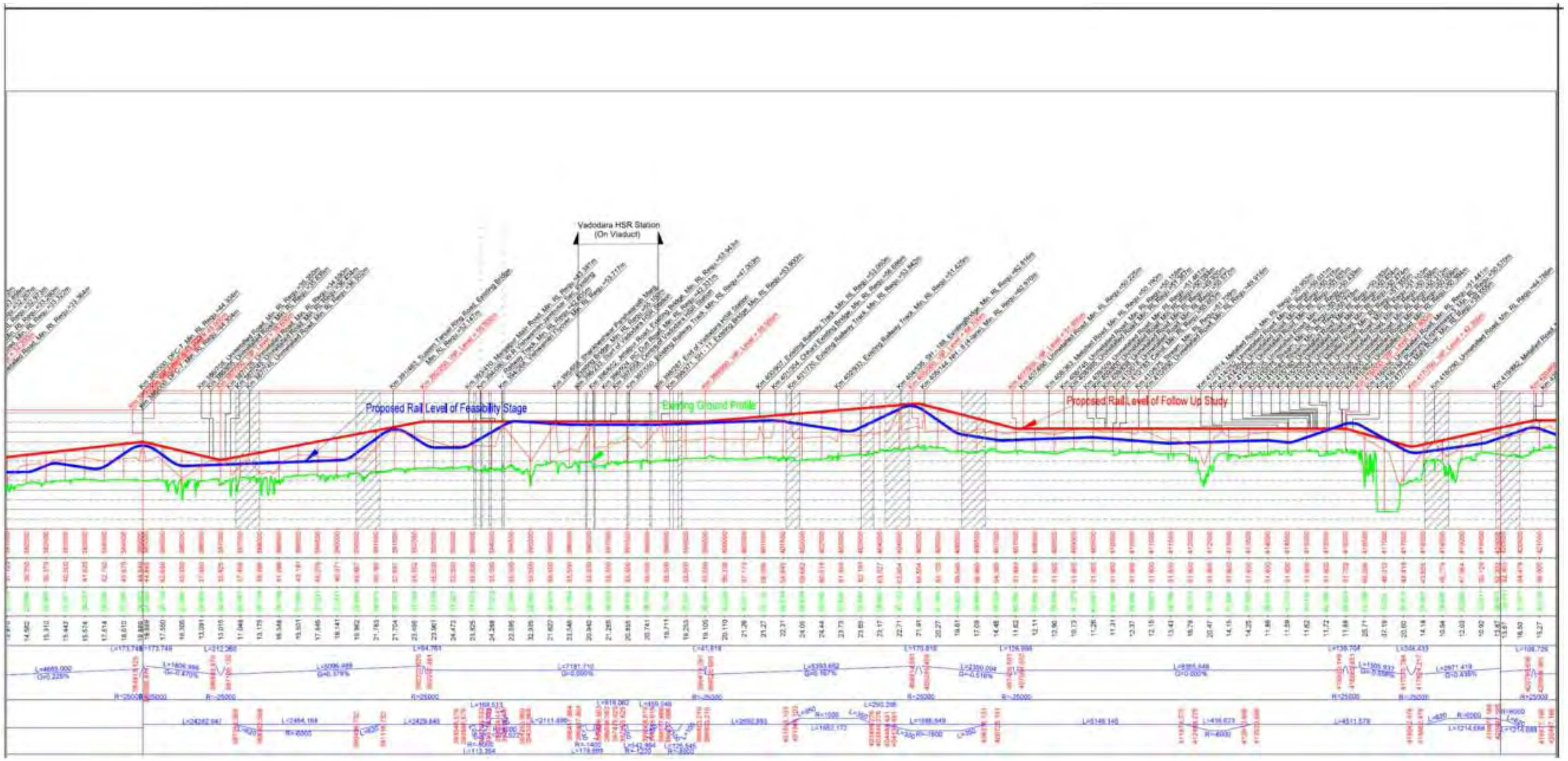
Source: The Study team

Figure 8.2.6-10 Plan & profile from km 315.0 to km 350.0 for discussion with NHSRCL



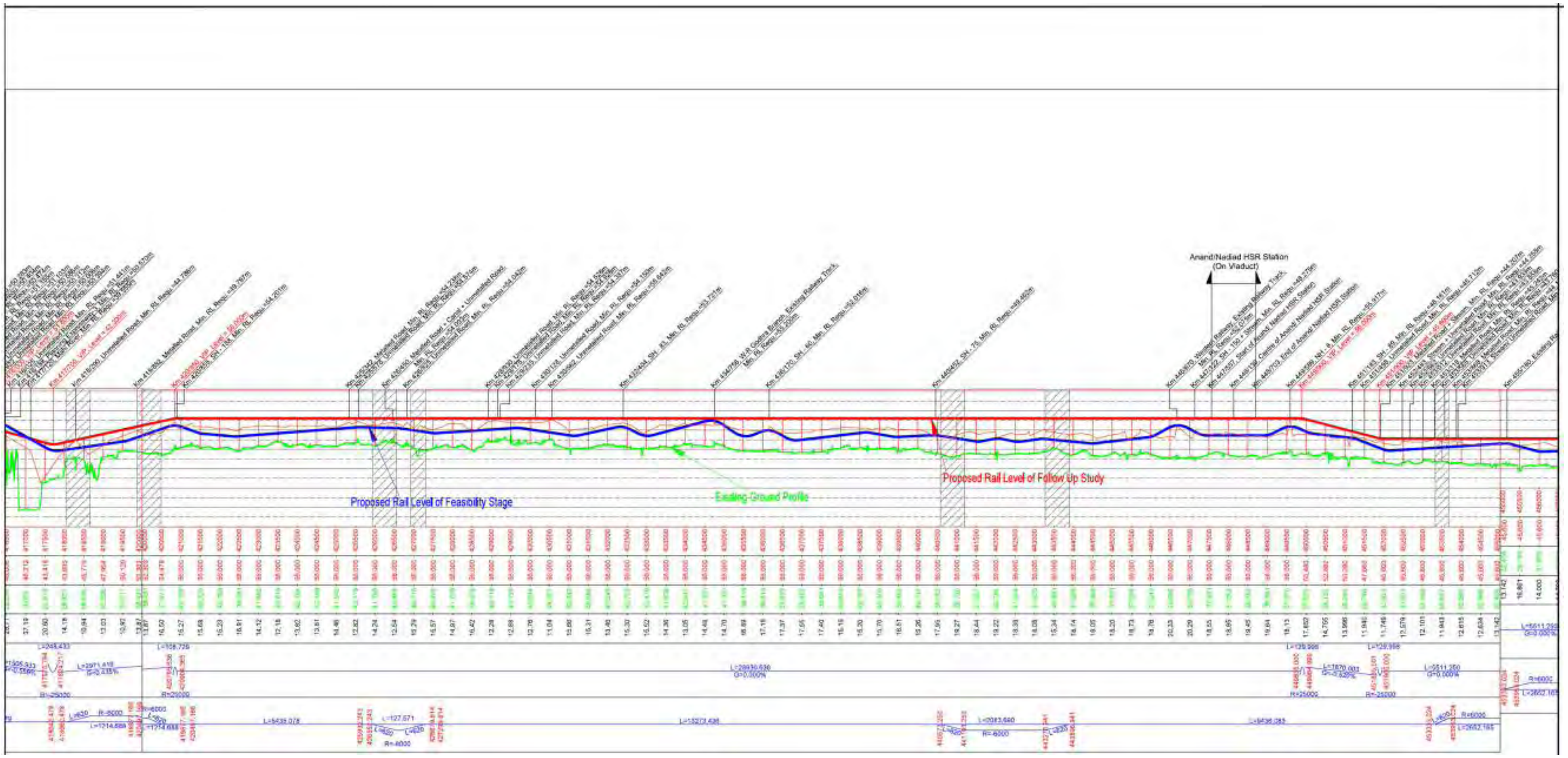
Source: The Study team

Figure 8.2.6-11 Plan & profile from km 350.0 to km 385.0 for discussion with NHSRCL



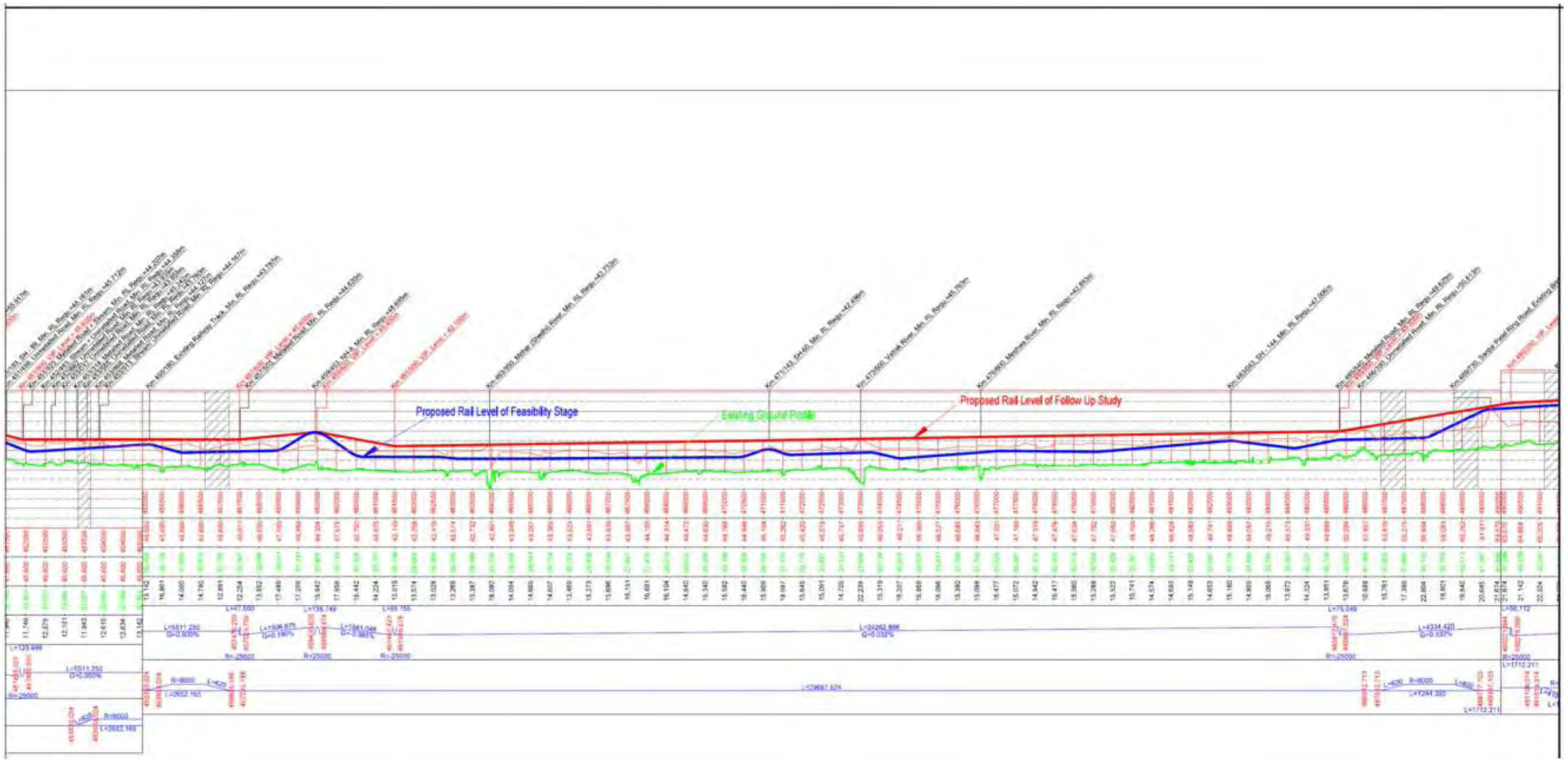
Source: The Study team

Figure 8.2.6-12 Plan & profile from km 385.0 to km 420.0 for discussion with NHSRCL



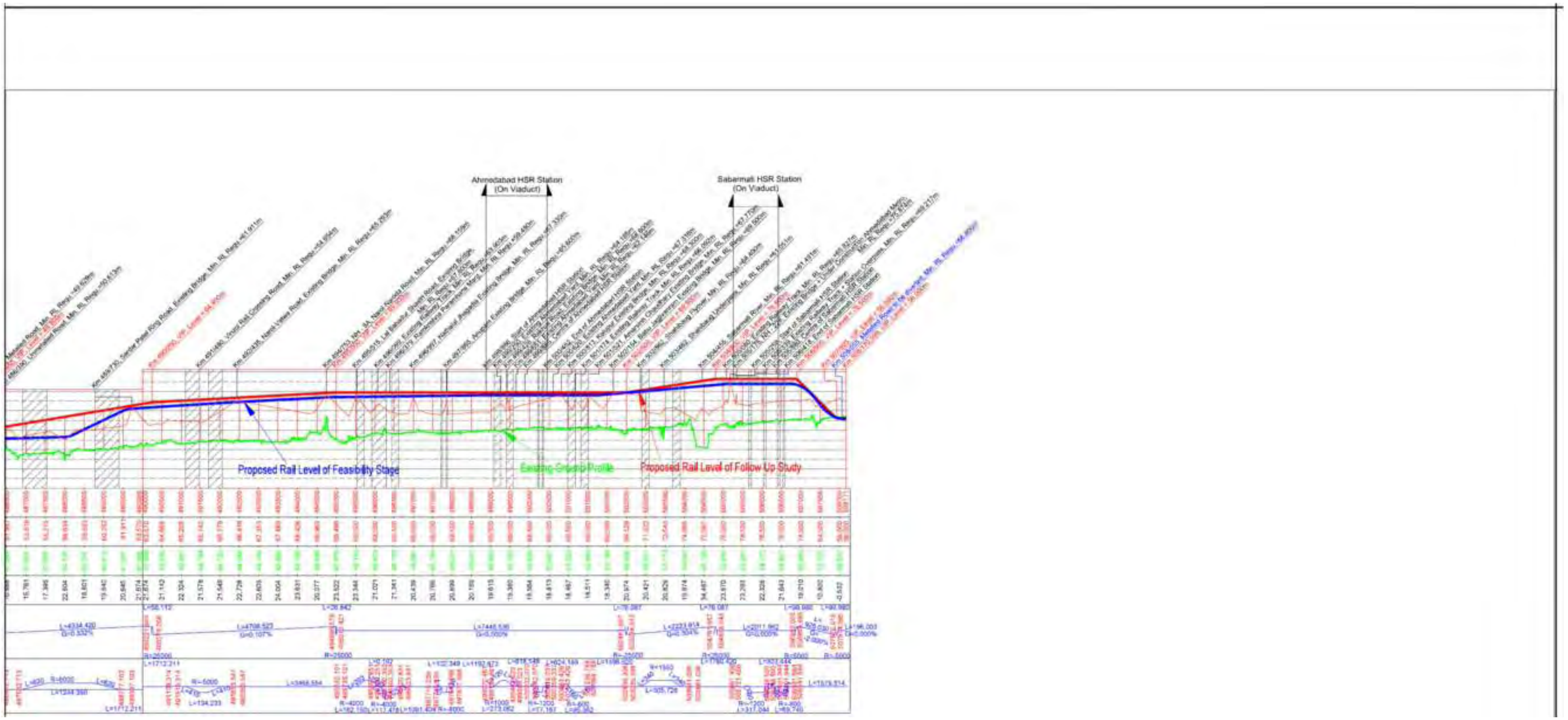
Source: The Study team

Figure 8.2.6-13 Plan & profile from km 420.0 to km 455.0 for discussion with NHSRCL



Source: The Study team

Figure 8.2.6-14 Plan & profile from km 455.0 to km 490.0 for discussion with NHSRCL



Source: The Study team

Figure 8.2.6-15 Plan & profile from km 490.0 to km 508.2 for discussion with NHSRCL

3) Existing roads to be diverted or terminated:

The basic policy for vertical alignment design is described that, vertical road clearance of 5.5 m should be provided for all roads. However, existing roads which have large influence on height of the viaduct, for securing vertical road clearance and can be diverted, should be diverted. Existing roads to be diverted or terminated are shown in Table 8.2.6-5. The Study team explained there were some existing roads to be diverted or terminated to Mr. Suthar of NHSRCL at the some meetings.

Table 8.2.6-5 Existing roads to be diverted or terminated

Section No.	Chainage (km)	Type of crossing	Required Min. Rail Level (m)	Rail Level (m)	Less Clearance (m)	Diverted or Terminated	Remarks
1	21/112	Unmetalled Road	48.346	30.146	-18.200	To be terminated	- Km 21/040 MIDC Pipe line Road (above Tunnel) - Km 21/150 End of Tunnel - Km 21/344 NH-4 (RUB) **Judging the above points comprehensively, this unmetalled road should be terminated.**
2	65/240	Unmetalled Road	37.258	36.320	-0.938	(to be diverted)	- Tunnel No.3 & No.4 have been combined - Securing tunnel overburden as much as possible **Judging the above points comprehensively, these roads should be diverted.**
	65/355	Concrete Road	46.539	36.080	-10.459	To be diverted	
	65/440	Unmetalled Road	49.821	35.920	-13.901	To be diverted	
	68/590	Unmetalled Road	32.890	21.220	-11.670	To be diverted	
3	109/400	Unmetalled Road	45.360	41.252	-4.108	To be diverted	- This unmetalled road is located at hillside. - Km 110/200 village area **Judging the above points comprehensively, these unmetalled roads should be diverted.**
4	122/619	Metalled Road	45.024	41.012	-4.012	To be diverted	- These roads are located at hillside or top of hill. - Maximum gradient of main line for 350km/h is 15‰ (1.5%) - Distance between gradient changing points is secured for 2.0 km - Intense terrain up and down before and after these roads **Judging the above points comprehensively, these roads should be diverted.**
	122/735	Unmetalled Road	50.261	39.524	-10.737	To be diverted	
	122/810	Unmetalled Road	46.641	38.656	-7.985	To be diverted	
5	148/172	Unmetalled Road	96.469	80.444	-16.024	To be diverted	- These roads are located at hillside or top of hill. - Gradient change in transition curve shall not be permitted in SOD. **Judging the above points comprehensively, these roads should be diverted.**
	149/495	Metalled Road	78.927	75.344	-3.582	To be diverted	
	149/672	Unmetalled Road	83.275	74.589	-8.686	To be diverted	
6	156/625	Unmetalled Road	49.255	47.767	-1.487	To be diverted	- Km 156/730 Start of Tunnel - These roads are located at foot of mountain - This area will be used as construction yard for tunnel. **Judging the above points comprehensively, these roads should be diverted if necessary.**
	156/642	Metalled Road	50.490	47.704	-2.785	To be diverted	
7	508/055	Metalled Road	66.800	56.000	-10.800	To be diverted	- Approach section to Sabarmati Depot

Source: The Study team

4) Overlapped sections of crest vertical curve and circular curve
As described in 8.2.4, basic policy of final alignment design, if crest vertical curve is provided in a horizontal circular curve, maximum permissible speed should be reduced due to increasing cant according to maximum permissible cant and maximum permissible cant deficiency established in Schedule of Dimensions. 8 sections shown in Table 8.2.6-6 are overlapped sections of crest vertical curve and horizontal circular curve, because it is unavoidable on the terrain for vertical alignment design.

Table 8.2.6-6 Overlapped sections of crest vertical curve and horizontal circular curve

No.	**Chainage (Km)**	**Horizontal Curve radius (m)**	**Maximum permissible speed (km/h) in SOD**	**Restricted maximum speed (km/h)**
1	Before and after 26/000	2000	210	205
2	Before and after 47/000	6000	350	340
3	Before and after 49/400	6000	350	340
4	Before and after 55/250	4000	300	285
5	Before and after 62/900	6000	350	340
6	Before and after 122/000	6000	350	340
7	Before and after 131/600	6000	350	340
8	Before and after 405/000	1600	185	-

Source: The Study team

5) Station location list
Table 8.2.6-7 shows the station location list in the Study.

Table 8.2.6-7 Station location list

Sl. No.	**Name of Station**	**Type of Station**	**HSR Station chainage (km)**			**Gradient (%)**
			Centre	**Start**	**End**	
1	Mumbai	Underground	0/000	-0/257.5	0/631	Level
2	Thane	Viaduct	27/950	27/214	28/529	-0.297
3	Virar	Viaduct	65/070	64/497	65/643	-0.200
4	Boisar	Viaduct	104/260	103/603	104/917	Level
5	Vapi	Viaduct	167/940	167/367	168/513	Level
6	Bilimora	Viaduct	216/730	216/157	217/303	Level
7	Surat	Viaduct	264/580	264/019	265/141	Level
8	Bharuch	Viaduct	323/110	322/453	323/767	Level
9	Vadodara	Viaduct	397/058	396/233	398/287	Level
10	Anand/Nadiad	Viaduct	448/130	447/557	448/703	Level
11	Ahmedabad	Viaduct	499/885	498/886	500/452	Level
12	Sabarmati	Viaduct	505/880	505/258	506/418	Level

Source: The Study team

6) Station Gradient changing point list

Table 8.2.6-8 shows the gradient changing points of vertical alignment design in the Study.

Table 8.2.6-8 List of gradient changing points

No.	Chainage from (km)	Chainage to (km)	tical Intersection Point Originating	tical Intersection Point Terminating	Gradient (‰)	Rise/Fall	VCL (m)	ymax (m)	Intervals (km)	Remarks
1	-0.2575	0.846	-20.761	-20.761	0.000	Level			1.104	Mumbai.St
2	0.846	6.770	-20.761	-40.500	-3.332	Fall	83.301	-0.035	5.924	Mumbai Tunnel section
3	6.770	16.500	-40.500	-20.000	2.107	Rise	135.973	0.092	9.730	Mumbai Tunnel section
4	16.500	21.400	-20.000	33.300	10.878	Rise	219.267	0.240	4.900	Mumbai Tunnel section
5	21.400	24.000	33.300	26.000	-2.808	Fall	342.131	-0.585	2.600	Mumbai Tunnel section
6	24.000	26.000	26.000	28.900	1.450	Rise	106.442	0.057	2.000	
7	26.000	29.000	28.900	20.000	-2.967	Fall	110.417	-0.061	3.000	Thane.St
8	29.000	42.750	20.000	20.000	0.000	Level	74.167	0.028	13.750	
9	42.750	45.000	20.000	12.300	-3.422	Fall	85.556	-0.037	2.250	
10	45.000	47.000	12.300	36.800	12.250	Rise	391.806	0.768	2.000	
11	47.000	49.400	36.800	36.800	0.000	Level	306.250	-0.469	2.400	
12	49.400	52.400	36.800	19.100	-5.900	Fall	147.500	-0.109	3.000	
13	52.400	55.250	19.100	25.200	2.140	Rise	201.009	0.202	2.850	
14	55.250	58.900	25.200	25.200	0.000	Level	53.509	-0.014	3.650	
15	58.900	60.900	25.200	14.800	-5.200	Fall	130.000	-0.085	2.000	
16	60.900	62.900	14.800	41.000	13.100	Rise	457.500	1.047	2.000	
17	62.900	65.800	41.000	35.200	-2.000	Fall	377.500	-0.713	2.900	Virar.St & Mountain Tunnel No.3 section
18	65.800	67.300	35.200	23.800	-7.600	Fall	140.000	-0.098	1.500	
19	67.300	71.250	23.800	15.900	-2.000	Fall	140.000	0.098	3.950	
20	71.250	74.200	15.900	15.900	0.000	Level	50.000	0.013	2.950	
21	74.200	77.450	15.900	43.200	8.400	Rise	210.000	0.221	3.250	
22	77.450	82.000	43.200	18.400	-5.451	Fall	346.264	-0.599	4.550	
23	82.000	85.600	18.400	33.900	4.306	Rise	243.903	0.297	3.600	
24	85.600	87.850	33.900	19.700	-6.311	Fall	265.417	-0.352	2.250	
25	87.850	94.750	19.700	37.400	2.565	Rise	221.908	0.246	6.900	
26	94.750	97.950	37.400	24.800	-3.938	Fall	162.568	-0.132	3.200	
27	97.950	100.150	24.800	43.700	8.591	Rise	313.210	0.491	2.200	
28	100.150	102.750	43.700	27.000	-6.423	Fall	375.350	-0.704	2.600	
29	102.750	107.000	27.000	27.000	0.000	Level	160.577	0.129	4.250	Boisar.St
30	107.000	109.350	27.000	41.500	6.170	Rise	154.255	0.119	2.350	
31	109.350	112.850	41.500	30.400	-3.171	Fall	233.541	-0.273	3.500	
32	112.850	116.500	30.400	35.000	1.260	Rise	110.793	0.061	3.650	
33	116.500	119.500	35.000	35.000	0.000	Level	31.507	-0.005	3.000	
34	119.500	122.000	35.000	48.700	5.480	Rise	137.000	0.094	2.500	
35	122.000	124.000	48.700	23.900	-12.400	Fall	447.000	-0.999	2.000	
36	124.000	126.000	23.900	47.500	11.800	Rise	605.000	1.830	2.000	
37	126.000	129.000	47.500	56.200	2.900	Rise	222.500	-0.248	3.000	
38	129.000	131.600	56.200	83.800	10.615	Rise	192.885	0.186	2.600	
39	131.600	135.450	83.800	71.600	-3.169	Fall	344.605	-0.594	3.850	
40	135.450	137.500	71.600	53.000	-9.073	Fall	147.608	-0.109	2.050	
41	137.500	140.500	53.000	53.000	0.000	Level	226.829	0.257	3.000	
42	140.500	142.700	53.000	44.700	-3.773	Fall	94.318	-0.044	2.200	
43	142.700	144.700	44.700	62.200	8.750	Rise	313.068	0.490	2.000	
44	144.700	148.250	62.200	80.900	5.268	Rise	87.060	-0.038	3.550	
45	148.250	151.400	80.900	66.900	-4.444	Fall	242.801	-0.295	3.150	
46	151.400	153.500	66.900	48.400	-8.810	Fall	109.127	-0.060	2.100	
47	153.500	155.550	48.400	54.600	3.024	Rise	295.848	0.438	2.050	
48	155.550	158.000	54.600	39.100	-6.327	Fall	233.773	-0.273	2.450	
49	158.000	160.500	39.100	44.100	2.000	Rise	208.163	0.217	2.500	
50	160.500	165.000	44.100	39.000	-1.133	Fall	78.333	-0.031	4.500	
51	165.000	167.000	39.000	46.000	3.500	Rise	115.833	0.067	2.000	
52	167.000	173.850	46.000	46.000	0.000	Level	87.500	-0.038	6.850	Vapi.St
53	173.850	176.800	46.000	32.700	-4.508	Fall	112.712	-0.064	2.950	
54	176.800	181.500	32.700	40.900	1.745	Rise	156.329	0.122	4.700	
55	181.500	188.250	40.900	40.900	0.000	Level	43.617	-0.010	6.750	
56	188.250	190.500	40.900	32.500	-3.733	Fall	93.333	-0.044	2.250	
57	190.500	192.500	32.500	41.700	4.600	Rise	208.333	0.217	2.000	
58	192.500	195.250	41.700	38.200	-1.273	Fall	146.818	-0.108	2.750	
59	195.250	197.250	38.200	32.900	-2.650	Fall	34.432	-0.006	2.000	
60	197.250	199.250	32.900	36.700	1.900	Rise	113.750	0.065	2.000	
61	199.250	204.750	36.700	34.300	-0.436	Fall	58.409	-0.017	5.500	
62	204.750	207.500	34.300	37.500	1.164	Rise	40.000	0.008	2.750	
63	207.500	210.500	37.500	35.300	-0.733	Fall	47.424	-0.011	3.000	
64	210.500	212.800	35.300	29.800	-2.391	Fall	41.449	-0.009	2.300	
65	212.800	226.000	29.800	29.800	0.000	Level	59.783	0.018	13.200	Bilimora.St
66	226.000	228.000	29.800	31.800	1.000	Rise	25.000	0.003	2.000	
67	228.000	232.450	31.800	31.800	0.000	Level	25.000	-0.003	4.450	
68	232.450	234.500	31.800	36.800	2.439	Rise	60.976	0.019	2.050	
69	234.500	239.500	36.800	27.000	-1.960	Fall	109.976	-0.060	5.000	
70	239.500	241.650	27.000	34.300	3.395	Rise	133.884	0.090	2.150	
71	241.650	244.000	34.300	28.300	-2.553	Fall	148.714	-0.111	2.350	
72	244.000	247.500	28.300	30.700	0.686	Rise	80.973	0.033	3.500	
73	247.500	250.000	30.700	25.700	-2.000	Fall	67.143	-0.023	2.500	
74	250.000	254.600	25.700	29.100	0.739	Rise	68.478	0.023	4.600	
75	254.600	257.800	29.100	27.300	-0.562	Fall	32.541	-0.005	3.200	
76	257.800	262.500	27.300	34.800	1.596	Rise	53.956	0.015	4.700	
77	262.500	279.000	34.800	34.800	0.000	Level	39.894	-0.008	16.500	Surat.St
78	279.000	281.150	34.800	42.100	3.395	Rise	84.884	0.036	2.150	
79	281.150	283.750	42.100	37.200	-1.885	Fall	131.999	-0.087	2.600	
80	283.750	285.950	37.200	39.400	1.000	Rise	72.115	0.026	2.200	
81	285.950	291.850	39.400	30.000	-1.593	Fall	64.831	-0.021	5.900	
82	291.850	294.750	30.000	30.000	0.000	Level	39.831	0.008	2.900	
83	294.750	296.900	30.000	42.000	5.581	Rise	139.535	0.097	2.150	
84	296.900	300.000	42.000	42.000	0.000	Level	139.535	-0.097	3.100	
85	300.000	307.000	42.000	28.900	-1.871	Fall	46.786	-0.011	7.000	
86	307.000	311.500	28.900	28.900	0.000	Level	46.786	0.011	4.500	
87	311.500	315.300	28.900	23.200	-1.500	Fall	37.500	-0.007	3.800	
88	315.300	317.400	23.200	27.500	2.048	Rise	88.690	0.039	2.100	
89	317.400	320.000	27.500	20.500	-2.692	Fall	118.498	-0.070	2.600	
90	320.000	322.000	20.500	29.400	4.450	Rise	178.558	0.159	2.000	
91	322.000	324.750	29.400	29.400	0.000	Level	111.250	-0.062	2.750	Bharuch.St
92	324.750	328.250	29.400	33.500	1.171	Rise	29.286	0.004	3.500	
93	328.250	335.200	33.500	33.500	0.000	Level	29.286	-0.004	6.950	
94	335.200	337.200	33.500	28.000	-2.750	Fall	68.750	-0.024	2.000	
95	337.200	341.000	28.000	28.000	0.000	Level	68.750	0.024	3.800	
96	341.000	343.500	28.000	34.200	2.480	Rise	62.000	0.019	2.500	
97	343.500	380.200	34.200	34.200	0.000	Level	62.000	-0.019	36.700	
98	380.200	385.000	34.200	45.000	2.250	Rise	56.250	0.016	4.800	
99	385.000	387.000	45.000	35.600	-4.700	Fall	173.750	-0.151	2.000	
100	387.000	392.250	35.600	55.500	3.790	Rise	212.262	0.225	5.250	
101	392.250	399.500	55.500	55.500	0.000	Level	94.762	-0.045	7.250	Vadodara.St
102	399.500	405.000	55.500	64.700	1.673	Rise	41.818	0.009	5.500	
103	405.000	407.500	64.700	51.800	-5.160	Fall	170.818	-0.146	2.500	
104	407.500	416.000	51.800	51.800	0.000	Level	129.000	0.083	8.500	
105	416.000	417.700	51.800	42.300	-5.588	Fall	139.706	-0.098	1.700	
106	417.700	420.850	42.300	56.000	4.349	Rise	248.436	0.309	3.150	
107	420.850	449.900	56.000	56.000	0.000	Level	108.730	-0.059	29.050	Anand/Nadiad.St
108	449.900	451.900	56.000	45.600	-5.200	Fall	130.000	-0.085	2.000	
109	451.900	457.500	45.600	45.600	0.000	Level	130.000	0.085	5.600	
110	457.500	459.500	45.600	49.400	1.900	Rise	47.500	0.011	2.000	
111	459.500	461.500	49.400	42.100	-3.650	Fall	138.750	-0.096	2.000	
112	461.500	485.850	42.100	49.800	0.316	Rise	99.156	0.049	24.350	
113	485.850	490.250	49.800	64.400	3.318	Rise	75.049	0.028	4.400	
114	490.250	495.000	64.400	69.500	1.074	Rise	56.112	-0.016	4.750	
115	495.000	502.500	69.500	69.500	0.000	Level	26.842	-0.004	7.500	Ahmedabad.St
116	502.500	504.800	69.500	76.500	3.043	Rise	76.087	0.029	2.300	
117	504.800	506.900	76.500	76.500	0.000	Level	76.087	-0.029	2.100	Sabarmati.St
118	506.900	507.925	76.500	56.000	-20.000	Fall	100.000	-0.050	1.025	
119	507.925	508.172	56.000	56.000	0.000	Level	100.000	0.050	0.247	
120	508.172		56.000							

Source: The Study team

7) Important coordinate list

Table 8.2.6-9 shows the important coordinate points of horizontal alignment design in the Study. Coordinates of starting points and ending points of transition curves are based on UTM 43N, WGS84. Software used for this calculation is AutoCAD Civil 3D. ST indicates Straight to Transition, TC indicates Transition to Circular, CT indicates Circular to Transition and TS indicates Transition to Straight.

Table 8.2.6-9 List of important coordinate points

Curve Sl. No.	Important points	Chainage (m)	Northing (m)	Easting (m)	Remarks
1	ST	1671.296639	2110569.677734	276745.159993	Pending section
	TC	1971.296639	2110728.872225	276999.427344	Pending section
	CT	3545.903940	2111355.598536	278439.012318	Pending section
	TS	3845.903940	2111433.250547	278728.779357	Pending section
2	ST	15552.109505	2114379.239294	290058.227668	
	TC	16172.109505	2114544.445320	290655.732099	
	CT	19840.086590	2116618.077876	293612.128661	
	TS	20460.086590	2117123.621700	293970.918317	
3	ST	24560.869391	2120503.843455	296292.667758	
	TC	24930.869391	2120814.346040	296493.613155	
	CT	26777.277025	2122593.818439	296579.247633	
	TS	27147.277025	2122922.181891	296409.046719	
4	ST	29844.043184	2125281.432620	295102.722213	
	TC	30464.043184	2125819.092959	294794.135214	
	CT	30908.862425	2126187.544839	294545.103569	
	TS	31528.862425	2126674.347126	294161.270129	
5	ST	33490.083400	2128195.589286	292923.445422	
	TC	34110.083400	2128682.391572	292539.611982	
	CT	35566.565773	2129950.372189	291830.267476	
	TS	36186.565773	2130532.192737	291616.282837	
6	ST	36810.468317	2131120.986596	291409.942885	
	TC	37430.468317	2131702.807144	291195.958246	
	CT	41756.402758	2134802.313909	288313.246199	
	TS	42376.402758	2135057.852091	287748.441088	
7	ST	44093.977363	2135741.736111	286172.888750	
	TC	44713.977363	2135997.274293	285608.083639	
	CT	47367.412566	2137656.767469	283565.341144	
	TS	47987.412566	2138157.251113	283199.526030	
8	ST	48090.488458	2138241.391899	283139.986399	
	TC	48710.488458	2138741.875543	282774.171285	
	CT	51521.253007	2140469.518528	280589.630664	
	TS	52141.253007	2140710.160493	280018.319872	
9	ST	54512.047246	2141596.792429	277819.559055	
	TC	55042.047246	2141804.599090	277332.115016	
	CT	57610.202506	2143562.639000	275520.693748	

Curve Sl. No.	Important points	Chainage (m)	Northing (m)	Easting (m)	Remarks
	TS	58140.202506	2144043.650936	275298.403810	
10	ST	61954.675301	2147537.091362	273766.713014	
	TC	62574.675301	2148108.596717	273526.533487	
	CT	63720.670982	2149212.578560	273225.630657	
	TS	64340.670982	2149826.915374	273142.595389	
11	ST	69075.936491	2154528.698164	272580.476159	
	TC	69695.936491	2155143.034978	272497.440892	
	CT	70478.389407	2155903.296233	272314.771185	
	TS	71098.389407	2156488.296539	272109.638986	
12	ST	79094.773942	2163992.685784	269348.061957	
	TC	79714.773942	2164577.686089	269142.929759	
	CT	80836.765444	2165674.009023	268912.111983	
	TS	81456.765444	2166292.058861	268863.956259	
13	ST	92698.652313	2177512.066262	268162.918232	
	TC	93318.652313	2178131.220714	268131.388801	
	CT	93678.284953	2178490.822814	268130.958157	
	TS	94298.284953	2179110.051006	268161.004555	
14	ST	120938.877585	2205702.697226	269758.609887	
	TC	121558.877585	2206320.860630	269805.285176	
	CT	124714.293923	2209223.777863	270946.490673	
	TS	125334.293923	2209708.233915	271333.281199	
15	ST	130033.709959	2213335.258396	274321.458652	
	TC	130653.709959	2213819.714447	274708.249178	
	CT	134085.193832	2216997.591926	275873.882179	
	TS	134705.193832	2217617.247939	275892.075630	
16	ST	137982.543031	2220894.276257	275937.935990	
	TC	138602.543031	2221513.932270	275956.129441	
	CT	139536.790605	2222437.649303	276089.558608	
	TS	140156.790605	2223037.123868	276247.466248	
17	ST	147481.080879	2230090.330773	278221.675046	
	TC	148101.080879	2230685.377224	278395.646484	
	CT	148405.477395	2230973.265872	278494.470502	
	TS	149025.477395	2231549.708342	278722.638026	
18	ST	169802.437056	2250778.976064	286591.393687	
	TC	170422.437056	2251356.258631	286817.334861	
	CT	172289.456831	2253185.303313	287152.480732	
	TS	172909.456831	2253805.191463	287145.903704	
19	ST	174901.441273	2255796.504299	287094.181311	
	TC	175521.441273	2256416.392449	287087.604282	
	CT	175677.999911	2256572.829506	287093.659331	
	TS	176297.999911	2257190.354681	287148.131656	

Curve Sl. No.	Important points	Chainage (m)	Northing (m)	Easting (m)	Remarks
20	ST	202233.233993	2282987.224706	289823.550100	
	TC	202853.233993	2283603.096291	289894.603119	
	CT	202974.331700	2283722.839646	289912.655913	
	TS	203594.331700	2284332.284885	290026.334585	
21	ST	220955.649718	2301361.431445	293406.205995	
	TC	221575.649718	2301971.275360	293517.538722	
	CT	223438.365306	2303826.409222	293497.307397	
	TS	224058.365306	2304433.680085	293372.701318	
22	ST	235111.876813	2315226.198400	290984.885357	
	TC	235731.876813	2315829.355857	290841.687391	
	CT	236298.667433	2316367.779851	290665.300356	
	TS	236918.667433	2316938.751600	290423.855046	
23	ST	250237.654108	2329124.909437	285048.637541	
	TC	250857.654108	2329695.881186	284807.192230	
	CT	253215.019295	2332005.385153	284417.009676	
	TS	253835.019295	2332623.985713	284457.480937	
24	ST	270210.669064	2348946.355350	285777.388054	
	TC	270830.669064	2349563.421131	285836.838853	
	CT	271056.216371	2349786.385675	285870.786013	
	TS	271676.216371	2350393.184057	285997.672968	
25	ST	272366.383519	2351066.490169	286149.296095	
	TC	272986.383519	2351673.288551	286276.183051	
	CT	275231.972806	2353905.462653	286237.688556	
	TS	275851.972806	2354507.525115	286089.954442	
26	ST	286876.335256	2365172.653616	283298.610412	
	TC	287496.335256	2365774.716077	283150.876299	
	CT	291077.673959	2369287.526600	283482.300573	
	TS	291697.673959	2369851.334526	283740.031438	
27	ST	297076.853465	2374708.670340	286051.278059	
	TC	297696.853465	2375272.478266	286309.008924	
	CT	298911.110913	2376433.587908	286657.175833	
	TS	299531.110913	2377046.185085	286752.198327	
28	ST	312314.706166	2389707.315562	288517.441275	
	TC	312934.706166	2390322.542113	288593.604693	
	CT	313472.998507	2390860.177971	288616.232745	
	TS	314092.998507	2391479.628551	288592.034494	
29	ST	332005.716666	2409365.845475	287618.013964	
	TC	332625.716666	2409985.296055	287593.815714	
	CT	334345.849139	2411682.639799	287833.960615	
	TS	334965.849139	2412271.064613	288029.052427	
30	ST	360974.486317	2436829.589113	296592.234209	

Curve Sl. No.	Important points	Chainage (m)	Northing (m)	Easting (m)	Remarks
	TC	361594.486317	2437411.744634	296805.305853	
	CT	362479.620605	2438203.809751	297198.594198	
	TS	363099.620605	2438725.427970	297533.585257	
31	ST	387382.567525	2458953.750730	310967.738355	Pending section
	TC	388002.567525	2459475.368949	311302.729414	Pending section
	CT	390496.731617	2461820.567935	312097.606477	Pending section
	TS	391116.731617	2462438.372804	312148.809205	Pending section
32	ST	393546.579360	2464862.714823	312312.289567	Pending section
	TC	393596.579360	2464912.604612	312315.607212	Pending section
	CT	393709.933339	2465025.772766	312322.078568	Pending section
	TS	393759.933339	2465075.715535	312324.469703	Pending section
33	ST	393928.446805	2465244.043610	312332.372061	Pending section
	TC	393978.446805	2465293.986380	312334.763196	Pending section
	CT	394255.968917	2465570.864828	312353.448063	Pending section
	TS	394305.968917	2465620.676035	312357.788727	Pending section
34	ST	396417.864477	2467724.427065	312543.084333	Pending section
	TC	396447.864477	2467754.319445	312545.621267	Pending section
	CT	396626.562841	2467932.880688	312547.999371	Pending section
	TS	396656.562841	2467962.830028	312546.259417	Pending section
35	ST	397475.625205	2468780.358132	312496.149981	Pending section
	TC	397525.625205	2468830.243560	312492.782007	Pending section
	CT	398068.619224	2469343.234022	312329.421340	Pending section
	TS	398118.619224	2469385.880892	312303.322611	Pending section
36	ST	398577.665690	2469775.934851	312061.286319	Pending section
	TC	398677.665690	2469860.807035	312008.402710	Pending section
	CT	398803.210468	2469966.538267	311940.711689	Pending section
	TS	398903.210468	2470050.090783	311885.766801	Pending section
37	ST	401596.103366	2472297.320938	310401.978138	Pending section
	TC	401946.103366	2472595.710707	310219.473185	Pending section
	CT	403498.275702	2474077.711508	310293.376803	Pending section
	TS	403848.275702	2474356.463944	310504.662373	Pending section
38	ST	404138.481377	2474581.531842	310687.866562	Pending section
	TC	404488.481377	2474859.849098	310899.769613	Pending section
	CT	406375.130708	2476638.876730	310872.751051	Pending section
	TS	406725.130708	2476910.630655	310652.493924	Pending section
39	ST	411874.275416	2480803.475424	307282.115483	
	TC	412494.275416	2481265.861153	306869.194167	
	CT	412910.898495	2481556.092153	306570.411593	
	TS	413530.898495	2481955.415996	306096.233310	
40	ST	418042.477814	2484808.211347	302601.107183	
	TC	418662.477814	2485207.535191	302126.928901	

Curve Sl. No.	Important points	Chainage (m)	Northing (m)	Easting (m)	Remarks
	CT	419877.165696	2486108.381618	301315.196254	
	TS	420497.165696	2486621.444329	300967.243339	
41	ST	425932.243402	2491165.961688	297986.063767	
	TC	426552.243402	2491680.384017	297640.063756	
	CT	426679.813943	2491783.667743	297565.188059	
	TS	427299.813943	2492272.494325	297183.881209	
42	ST	440573.250433	2502643.655312	288899.972951	
	TC	441193.250433	2503122.031383	288505.687635	
	CT	443276.940843	2504412.034744	286882.667090	
	TS	443896.940843	2504688.182118	286327.647087	
43	ST	453333.023704	2508761.283374	277815.919535	
	TC	453953.023704	2509037.430749	277260.899532	
	CT	456605.188255	2510769.937529	275281.351429	
	TS	457225.188255	2511283.469045	274934.090780	
44	ST	486912.712646	2536128.506502	258683.760993	Pending section
	TC	487532.712646	2536652.460932	258352.435878	Pending section
	CT	488777.102742	2537784.669311	257841.487527	Pending section
	TS	489397.102742	2538379.764390	257667.802690	Pending section
45	ST	491109.314002	2540030.575025	257213.389171	Pending section
	TC	491519.314002	2540424.485799	257099.775655	Pending section
	CT	491653.547222	2540551.773294	257057.168510	Pending section
	TS	492063.547222	2540934.702872	256910.749019	Pending section
46	ST	495532.101488	2544159.157404	255632.562153	Pending section
	TC	495735.101488	2544348.424634	255559.183344	Pending section
	CT	495897.251489	2544501.721885	255506.372596	Pending section
	TS	496100.251489	2544696.025007	255447.611804	Pending section
47	ST	496100.353337	2544696.122714	255447.583058	Pending section
	TC	496303.353337	2544890.425836	255388.822267	Pending section
	CT	496420.831191	2545001.705403	255351.180374	Pending section
	TS	496623.831191	2545191.780310	255279.919841	Pending section
48	ST	497715.238948	2546210.808499	254889.084270	Pending section
	TC	497745.238948	2546238.812971	254878.325589	Pending section
	CT	497847.587674	2546334.067086	254840.885336	Pending section
	TS	497877.587674	2546361.902242	254829.695885	Pending section
49	ST	499070.460572	2547468.447626	254384.159059	Pending section
	TC	499190.460572	2547580.526089	254341.338548	Pending section
	CT	499463.522595	2547848.028295	254290.907547	Pending section
	TS	499583.522595	2547968.004615	254289.979802	Pending section
50	ST	500202.070210	2548586.520675	254296.227746	Pending section
	TC	500242.070210	2548626.519629	254296.433557	Pending section
	CT	500319.236799	2548703.615106	254293.447214	Pending section

Curve Sl. No.	Important points	Chainage (m)	Northing (m)	Easting (m)	Remarks
	TS	500359.236799	2548743.478286	254290.147892	Pending section
51	ST	500983.425999	2549365.277695	254235.580026	Pending section
	TC	501143.425999	2549523.855393	254215.316070	Pending section
	CT	501238.788482	2549614.881274	254187.223997	Pending section
	TS	501398.788482	2549757.298569	254114.595984	Pending section
52	ST	502895.308345	2551062.535654	253382.525051	Pending section
	TC	503235.308345	2551364.166445	253226.034660	Pending section
	CT	503541.036067	2551655.457007	253134.839236	Pending section
	TS	503881.036067	2551992.476453	253091.385014	Pending section
53	ST	505661.456200	2553764.756112	252921.324263	Pending section
	TC	505721.456200	2553824.435794	252915.149609	Pending section
	CT	506038.500193	2554130.514114	252836.095115	Pending section
	TS	506098.500193	2554185.719471	252812.597042	Pending section
54	ST	506401.944255	2554464.032101	252691.682283	Pending section
	TC	506461.944255	2554518.789312	252667.163368	Pending section
	CT	506531.684372	2554580.273667	252634.295777	Pending section
	TS	506591.684372	2554631.079036	252602.384276	Pending section

Source: The Study team

8.3 GAD (General Arrangement Drawing)

(1) Background of GAD Preparation

Although preparation of the General Arrangement Drawings (GADs), for the features such as road, river, railway lines etc. crossing the HSR alignment have been confirmed to be the undertaking of the Indian side, the Indian side strongly indicated that the GAD preparation requires the knowledge of HSR technology and engineering, which the Indian side does not possess and therefore requested the Japanese side to carry out the GAD preparation. As the result of several discussions carried out between the two governments, which also included JCC members, it was agreed that the GAD preparation is to be undertaken by the Japan side. It should be noted that for the undertaking by Japan side, it is agreed that the Indian side will provide topographic and geological data necessary for these drawings. Also Indian side will undertake necessary negotiations with third parties such as other relevant ministries, authorities, zonal railways, local government, road administration, etc.

(2) Scope of GAD Preparation

The GAD prepration scope included in the Study is fundamentally the following, however the final scope for it will be discussed with JICA in the course of the Study.

- The number of GADs, such as the structures crossing existing railways, long-span river bridges and special bridges, necessary to be immediately prepared in consideration of the overall Project implementation schedule is totals 56 at this moment.

In case relocation of conventional line track at an HSR structure crossing or adjacent to an existing line is required, the Study team will assist the Indian side in discussions or negotiations with zonal railways, including an initial examination for relocation if necessary.

Further, the Indian side requested the Japan side to consider bridge erection methods, taking into consideration Indian construction conditions, structure type with the application of steel or composite structures for long-span bridges and locations crossing or adjacent to conventional lines.

(3) Specification for GAD Preparation

Scale of specification for GAD preparation: 1/100 to 1/500.

(4) Structural Configuration at the existing railway crossing; Adoption of Steel Structure

In order for GAD to be finalized, the Indian side undertakes necessary negotiations with third parties.

Western Railway has issuesd the letter wherein they request to change PSC to the Steel super structure. As a result, MOR on 23rd December 2016 issued a letter to JICA wherein it is suggested that option of using steel structure at railway crossings on HSRC may be explored to facilitate the timely completion of the project. Under the detailed design project for HSR, crossing location where steel super structure is to be applied, is categorised as particular bridge package. Following this principal 8 more bridges crossing railway line was included on 14th February 2017. This means that GAD of additional 8 bridges should be speeded up to start the detailed design of the particular bridge package.

(5) MOR Request to review the location of 3 satations, Vadodara, Ahmedabad and Sabarmati

In terms of HSR structures to be located in an existing railway area, MOR issued to JICA a request letter indicating that the location of three HSR stations should be reviewed from the viewpoint of constructability because of the difficulty in shifting existing running lines as mentioned in the Joint F/S. The detailed procedure to review is to examine the option of taking these stations underground or of shifting them by a few hundred meters. From now, the JICA Study team will examine the options to shift station location, to take the stations underground, etc. and will discuss this with the Indian Side. Detail is mentioned in Section 8.4-Review of HSR Stations Located in Existing Station Area.

(6) NHSRCL Request to review the Coexistence of WR the 4th line with HSR alignment and structure in Ahmedabad and Sabarmati

On the basis of NHSRCL request, HSR alignment studied in F/S will be reexamined and studied again taking into consideration of the 4 line which Western Railway plans. Thus, the influence of the 4th line on HSR is examined, of which the alignment, structure, construction methodology etc. are compared. To shift HSR alignment will result in change of structures already studied. Detail is mentioned in Section 8.4 Review of HSR Stations Located in Existing Station Area.

8.3.1 Scope of GAD work

The Scope of the GAD work is to prepare GADs for a total of 56 crossing locations where two crossings at 46k578m and 46k659m (special bridge) are counted as one location. In addition, 8 GADs where HSR crosses the existing railway line is added to the aforesaid scope of the work.

(1) Special Bridge

As of F/S stage, span configuration is mentioned below.

Table 8.3.1-1 PSC-Box-Continuous (Cantilever Method, Total Length: 1,736m)

Nos.	Chainnage	Span	Length	Crossing
1	26K035M	1x48+1x80+1x48	176M	Railway
2	46K578M 46K650M	1x42+2x70+1x42	224M	Railway DFC
3	53K490M	1x36+1x60+1x36	132M	Road (NH8)
4	210K380M	1x42+1x70+1x42	154M	Road (NH8)
5	235K384M	1x42+1x70+1x42	154M	Road (NH8)
6	241K640M	1x36+2x60+1x36	192M	Road (NH8)
7	285K934M	1x48+1x80+1x48	176M	DFC+ Railway
8	446K670M	1x48+1x80+1x48	176M	Railway
9	459K453M	1x48+1x80+1x48	176M	Road(NH8)
10	501K174M	1x48+1x80+1x48	176M	Railway

Table 8.3.1-2 Composite Girder Bridges (Total Length: 1160m)

Nos.	Chainnage	Span	Length	Crossing
1	48K200M	3x50	150M	Road
2	55K800M	4x50	200M	Expressway
3	62K900M	2x55	110M	DFC
4	85K600M	3x50+1x40+2x50	290M	Railway + DFC
5	326K938M	3x50	150M	Road + Railway
6	333K428M	2x55	110M	DFC
7	449K589M	3x50	150M	Road

Table 8.3.1-3 River (Total Length: 3200m)

Nos.	Chainnage	Span	Length	Crossing
1	72K400M	39x50	1950M	Vaitarna
2	320K951M	25x50	1250M	Narmada

Table 8.3.1-4 Additonal 8 GADs

Nos.	Chainnage	Span	Length	Crossing
1	28K130M	1x40+1x35	65M	Railway
2	71K335M	1x40	40M	Railway
3	221K137M	1x35	35M	Railway
4	262K699M	1x40	40M	Railway
5	317K382M	1x50	50M	Railway
6	385K000M	1x40	40M	Railway

7	434K756M	1x35	35M	Railway
8	455K180M	1x35	35M	Railway

(2) Route alignment around existing station

Table 8.3.1-5 Arround Vadodara Station (Km391.100- Km405.200: Approx. Km15)
(Total Length: 1071m)

Nos.	Chainnage	Span	Length	Crossing
1	391K457M	1x45	45M	Road (RUB)
2	393K423M	1x40	40M	Road (RUB)
3	394K077M	1x40	40M	Railway (RFO)
4	394K268M	1x40	40M	Road (RUB)
5	395K655M	1x45	45M	Road (RUB)
6	396K605M	1x40	40M	Road (RUB)
7	396K924M	1x31	31M	Road (RUB)
8	397K550M	7x40	280M	Railway (RFO)
9	398K392M	1x45	45M	Road (RUB)
10	400K907M	2x40+1x50	130M	Railway (RFO)
11	401K300M	1x40	40M	Road (RUB)
12	401K720M	4x40	160M	Railway (RFO)
13	402K933M	1x45	45M	Railway (RFO)
14	404K535M	1x45	45M	Road (RUB)
15	405K144M	1x45	45M	Road (RUB)

Table 8.3.1-6 Arround Ahmedabad Station (Km489.100- Km508.172: Approx. Km19)
(Total Length: 2200.613m)

Nos.	Chainnage	Span	Length	Crossing
1	489K730M	1x45	45M	Road (RUB)
2	491K480M	1x40	40M	Road (RUB)
3	492K435M	1x45	45M	Road (RUB)
4	494K753M	1x45	45M	Road (RUB)
5	495K510M	1x45	45M	Road (RUB)
6	496K069M	7x40	280M	Railway(RFO)
7	496K379M	1x40	40M	Road (RUB)
8	496K993M	1x35	35M	Road (RUB)
9	497K865M	1x45	45M	Road (RUB)
10	499K250M	4x40	160M	Railway (RFO)
11	499K428M	1x40	40M	Road (RUB)

12	499K651M	2x40+1x42.783+4x40	282.783M	Railway (RFO)
13	500K620M	1x40+4x45+1x42.83	262.83M	Railway (RFO)
14	500K813M	1x45	45M	Road (RUB)
15	501K521M	1x45	45M	Road (RUB)
16	502K155M	1x45	45M	Road (RUB)
17	502K862M	1x40	40M	Road (RUB)
18	503K462M	1x40	40M	Road (RUB)
19	504K455M	1x25+10x38+1x25	430M	Bridge (Major)
20	505K080M	1x45	45M	Railway (RFO)
21	505K174M	1x45	45M	Road (RFO)
22	505K339M	2x35	70M	Railway (RFO)

8.3.2 Subcontracting to local consultants for GAD preparation

The GAD preparation described in 8.3.1 was subcontracted on 6th September 2016 to Rail India Technical and Economic Service (RITES), the local railway consulting firm in India who worked as the local subcontractor in the Joint F/S. After, the GADs, 8 cross points of HSR crossing the existing railway, was additionally subcontracted on 26th May 2017.

(1) Progress of GAD Preparation

Table 8.3.2-1 Status of GADs

Section	GAD No.	Chanage km	Chanage m	Name or Type	Existing or Plan	F/S Proposed Span (m)	F/S Proposed Type of girder	FUS Study Span (m)	FUS Study Type of girder: Type	FUS Study Type of girder: simple or conrtinuous
Normal Section 1	1	26	35	Railway	E	1x48+1x80+1x48	PSC-Box-continuous (Cantilever method)	1x80+1x60	Truss	Simply Supported
	2	46	578	Railway	E	1x42+2x70+1x42	PSC-Box-girder (Cantilever method)	1x60+1x100+1x130+1x60	Truss	Simply Supported & two span continious
		46	650	DFC-1	Plan					
	3	48	200	Chinchoti Anjur Phata RD-1	E	3x50	Composite (Steel+Conc.) with conc. portal at middle	60+2x80+60 (portal 35m)	Truss	Simply Supported
	4	53	490	NH8-1	E	1x36+1x60+1x36	PSC-Box-girder (Cantilever method)	2x50	PSC-Box-girder	Continuous 2 span
	5	55	800	Expressway-1	Plan	4x50	Composite (Steel+Conc) with conc. portal at middle	4x70	Truss	Simply Supported
	6	62	900	DFC-2	Plan	2x55	Composite (Steel+Conc) with conc. portal at middle	2x70 (portal 35m)	Truss	Simply Supported
	7	72	400	Vaitarna River	E	39x50	PSC-Box-girder	33x60	PSC-Box-girder (Continuous 3 span)	Continuous 3 span
	8	85	600	Railway	E	3x50+1x40+2x50	Composite (Steel+Conc.) with conc. portal at middle	5x80 (portal 20~30m)	Truss	Simply Supported
		85	600	DFC-3	Plan					
	9	210	380	NH8-3	E	1x42+1x70+1x42	PSC-Box-girder (Cantilever method)	1x40+2x65+1x40	PSC-Box-girder (Cantilever method)	Continuous 4 span
	10	235	384	NH8-4		1x42+1x70+1x42	PSC-Box-girder (Cantilever method)	1x40+2x65+1x40	PSC-Box-girder (Cantilever method)	Continuous 4 span
	11	241	640	NH8-5	E	1x36+2x60+1x36	PSC-Box-girder (Cantilever method)	1x50+2x80+1x50	PSC-Box-girder (Cantilever method)	Continuous 4 span
	12	285	934	DFC-4, Railway	P, E	1x48 + 1x80 + 1x48	PSC-Box-continuous (Cantilever method)	1x80+1x60+1x80	Truss	Simply Supported
	13	320	951	Narmanda River	E	25x50	PSC-Box-girder	21x60	PSC-Box-girder (Continuous 3 span)	Continuous 3 span
	14	326	938	NH64, Railway	E	3x50	Composite (Steel+Conc) with conc. portal at middle	100+130	Truss	Continuous 2 span
	15	333	428	DFC-6	Plan	2x55	Composite (Steel+Conc) with conc. portal at middle	3x80	Truss	Simply Supported
	16	391	~~457~~ 463	Ring Road (F.O)	E	1x45	PSC-Box-girder	1x45	PSC-Box-girder	simply supported
	17	393	~~423~~ 410	Manjalpur Main Rd	E	1x40	PSC-Box-girder	1x40	PSC-Box-girder	simply supported
Detailed Design at Vadodara Area	18	394	80	Railway	E	1x40	PSC-Box-girder	1x40	PSC-Box	simply supported
	19	394	268	Vishwamitri Flyover (F.O)	E	1x40	PSC-Box-girder	1x45	PSC-Box	simply supported
	20	395	655	Shankheshwar Parshwanath Marg (F.O)	E	1x45	PSC-Box-girder	1x45	PSC-Box	simply supported
	21	396	605	Jetalpur Rd (F.O)	E	1x40	PSC-Box-girder	1x45	PSC-Box	simply supported
	22	396	924	RC Dutt Rd	E	1x31	PSC-Box-girder	1x40	PSC-Box	simply supported
	23	397	550	Railway	E	7x40	PSC-Box-girder	1x120+1x300 +1x180	Truss	Continuous 3 span
	24	398	402	SH11	E	1x45	PSC-Box-girder	1x45	PSC-Box	simply supported
	25	400	907	Railway	E	2x40+1x50	PSC-Box-girder	2×30+1x100	PSC-Box Truss	simply supported
	26	401	304	Chhani Bridge (F.O)	E	1x40	PSC-Box-girder	1x40	PSC-Box	simply supported
	27	401	720	Railway	E	4x40	PSC-Box-girder	2x100	Truss	simply supported
Nomal Section 2	28	402	933	Railway	E	1x45	PSC-Box-girder	1x60	Truss	Simply Supported
	29	404	535	SH188-1	E	1x45	PSC-Box-girder	1x45	PSC-Box-girder	Simply Supported
	30	405	144	NH8-6	E	1x45	PSC-Box-girder	3x40	PSC-Box-girder	Continuous 3 span
	31	446	670	Railway	E	1x48+1x80+1x48	PSC-Box-continuous (Cantilever method)	1x100	Truss	Simply Supported
	32	449	589	NH8-7	E	3x50	Composite (Steel+Conc.) with conc. portal at middle	2x120	Truss	Continuous 2 span
	33	459	453	NH8-8	E	1x48+1x80+1x48	PSC-Box-continuous (Cantilever method)	1x40+2x65+1x40	PSC-Box-girder (Cantilever method)	Continuous 4 span

Area	GAD No.	Chanage km	Chanage m	Name or Type	Existing or Plan	F/S Proposed Span (m)	F/S Proposed Type of girder	FUS Study Span (m)	FUS Study Type of girder: Type	FUS Study Type of girder: simple or conrtinuous
Detailed Design at Ahmedabad&Sabarmati Area	34	489	730	Sarbar Patel Ring Road (F.O)	E	1x45	PSC-Box-girder	1x45	PSC-Box	Simply Supported
	35	491	480	Vinzol Rail Crossing Rd	E	1x40	PSC-Box-girder	1x40	PSC-Box	Simply Supported
	39	496	69	Railway	E	7x40	PSC-Box-girder	2x70+1x78+1x80	Truss	Simply Supported
	36	492	435	Narol -Vatwa Rd (F.O)	E	1x45	PSC-Box-girder	1x45	PSC-Box	Simply Supported
	37	494	753	NH8A	E	1x45	PSC-Box-girder	1x45	PSC-Box	Simply Supported
	38	495	515	Lal Bahadur Shastri Rd (F.O)	E	1x45	PSC-Box-girder	1x45	PSC-Box	Simply Supported
	40	496	379	Ramkrishna Paramhans Marg	E	1x40	PSC-Box-girder	1x40	PSC-Box	Simply Supported
	41	496	997	Nathalal Jhagadia Bridge (F.O)	E	1x35	PSC-I-girder	2x70+1x78+1x80	Truss	Simply Supported
	42	497	865	Anupam Bridge (F.O)	E	1x45	PSC-Box-girder	1x45	PSC-Box	Simply Supported
	43	499	250	Railway	E	4x40	PSC-Box-girder	1x160	Truss	simply supported
	44	499	428	Rakhial Rd (F.O)	E	1x40	PSC-Box-girder	1x80+1x160+2x80+1x40	Truss	Continuous 5 span
	45	499	651	Railway	E	2x40+1x42.783+4x40	PSC-Box-girder	1x75	PSC-Rigid	Continuous 5 span
	46	500	620	Railway	E	1x40+4x45+1x43.83	PSC-Box-girder	2x140	Truss	Continuous 2 span
	47	500	813	Kalupur Bridge (F.O)	E	1x45	PSC-Box-girder			
	48	501	174	Railway	E	1x48+1x80+1x48	PSC-Box-continuous (Cantilever method)	1x80	Truss	simply supported
	49	501	521	Amarsinh Chaudhary Bridge (F.O)	E	1x45	PSC-Box-girder	1x45	PSC-Box	Simply Supported
	50	502	154	Babu Jagjvanram Bridge (F.O)	E	1x45	PSC-Box-girder	1x45	PSC-Box	Simply Supported
	51	502	862	Shahibaug Bridge (F.O)	E	1x40	PSC-Box-girder	1x40	PSC-Box	Simply Supported
	52	503	462	Shahibaug Bridge Underpass	E	1x40	PSC-Box-girder	1x40	PSC-Box	simply supported
	53	504	411	Sabarmati River	E	1x25+10x38+1x25	25 m - PSC-I-girder 38 m - PSC-Box-girder	53+4x76+53	PSC-Box	Continuou 6 spans
	54	505	80	Railway	E	1x45	PSC-Box-girder	1x80	Truss	simply supported
	55	505	183	NH228-2 (F.O)	E	1x45	PSC-Box-girder	1x100	Truss	simply supported
	56	505	339	Railway	E	2x35	PSC-Box-girder	1x60	Truss	simply supported
Additional	57	28	130	Railway	E	1x40+1x35	PSC-Box-girder	1x70	397.55	Truss
	58	71	335	Railway	E	1x40	PSC-Box-girder	1x80	Truss	Truss
	59	221	137	Railway	E	1x35	PSC-I-girder	1x40	Truss	Truss
	60	262	699	Railway	E	1x40	PSC-Box-girder	1x40	Truss	Truss
	61	317	382	DFC-5	Plan	1x50	PSC-Box-girder	1x40+1x80	Truss	Truss
	62	385	0	DFC-7	Plan	1x40	PSC-Box-girder	1x70	Truss	Truss
	63	434	756	Railway	E	1x35	PSC-I-girder	1x40	Truss	Truss
	64	455	180	Railway	E	1x35	PSC-I-girder	1x40	Truss	Truss

(As of 31st October 2017)

(2) Structural configuration at existing railway crossing: Adoption of steel structure

Table 8.3.2-2 HSR located in Existing Railway Area

Date	Contents
Joint Feasibility Study	The PC Box girder structure was adopted taking into consideration of constructability, economic efficiency, and noise issues of railway crossing.
24th Oct. 2016	MOR in the four party meeting attented by MOR, RITES, JICA and JIC, requested that the steel structure to be adopted at existing line crossing.
17th Nov. 2016	Western Railway issued a letter wherein they requested to change PC to the steel structure due to the maintenance issues.
12th -14th Dec. 2016	Because of the request from MOR and Western Railway, The members in Subcommittee Meeting for Steel Structure in the Project, visited the

	workshop of Indian manufacturing company for to verify and understand quality control system.
15th Dec. 2016	MOR mentioned that negotiation with Indian Railway is assumed as too tough to obtain the agreement on the PC girder to be adopted because NHSRCL and IR have different organization. Also, Japanese side requested MOR to issue the letter if the contents of the Feasibility Study are requested to be changed.
16th Dec. 2016	MOR and JIC visited the one of steel structure bridge fabrication workshop approved by Indian Railway near Ambala on December 16, 2016.
23rd Dec. 2016	MOR issues to JICA the letter where it is suggested that option of using steel structure at railway crossings on HSRC may be explored to facilitate the timely completion of the project.
26th Dec. 2016	In the technical Meeting between Indian and Japanese sides, it is determined that structure type and technical specification etc. for steel structure that Japan side recommend is adopted when using the steel structure crossing railway.
9th Jan. 2017	In the Technical Meeting, Indian and Japanese sides discussed the scope of Particular Bridge Package and decide that additional 8 bridge crossing railway line will be included, which means that GAD of additional 8 bridges should be speeded up to start the detailed design of the particular bridge package.
13th Feb. 2017	In the four party meeting, additional 8 bridges which cross excisting railway even though those are not counted up in the GAD 56 are determined to be carried out in the Study

(3) The review of the location of 3 satations, Vadodara, Ahmedabad and Sabarmati

Table 8.3.2-3 HSR located in Existing Railway Area

Date	Contents
23rd Dec. 2016	MOR issues to JICA the letter where the location of three HSR stations, Vadodara, Ahmedabad and Sabarmati Station, is reviewed from the constructability point of view to ensure that the project executed smoothly and in time because of difficulty to shift the existing running lines as mentioned in the Joint Feasibility Study.
9th Jan. 2017	In the technical meeting between Indian and Japanese side, the procedure to review the shifting of existing line is presented from Japan side.
17th Feb. 2017	The JICA Study Team presented the JIC consideration related to the shift of station locations along with the preparatory structural re-examination result. However, MOR responded clearly that the construction of HSR crossings on existing running lines is difficult due to reasons such as non-availability of traffic blocks on existing running lines, non-availability of adequate space, accessibility controraints, and requirement of longer spans for crossing existing running lines of IR and aDFC tracks, of which all factors may delay in completion of project. Thus, MOR suggested that Vadodara Station area should be reviewed by examining the underground and Ahmedabad and Sabarmati Station areas should be reviewed by examining the elevated viaducts

	with different structures from F/S study result.
1st-3rd Mar. 2017 and 22nd-24th Mar. 2017	With Western railway and NHSRCL, the JICA Study Team have carried out the joint site surveys in station areas along with Ahmedabad, Sabarmati and Vadodara Stations.
13th Apr. 2017	The JICA Study Team presentend the policy of station location and structrues. In the presentation, the policies of the rigid fram of HSR Ahmedabad Station and of the long span bridge next to Vadodara station will be adopted.
23rd Jun. 2017	The relocation of conventional line track at an HSR structure crossing or adjacent to an existing line is required, the JICA Study team assisted the Indian side to implement discussions or negotiations with zonal railways, by submitting the presentation materials.
9th Aug. 2017	NHSRCL presented infringement of WR with HSR. As a result, there are impacts on HSR because WR indicates not to accept relocations of WR facilities and stopping the 4th line.

(4) Exaination of Coexistence of the 4th line of WR with HSR

Table 8.3.2-4 Exaimination of Coexistence of the 4th line of WR with HSR

Date	Contents
9th Aug. 2017	NHSRCL had meeting with Western Railway（WR）to discuss about the infringement of WR facility toward HSR
12th Aug. 2017	NHSRCL requested the Study Team that the 4th line is coexisted with HSR and double deck of Sabarmati River bridge is used for HSR and existing railway.
7th Sep. 2017	NHSRCL issued to JICA the letter that NHSRCL requests review of HSR alignment and strucrture taking into consideration of the 4th line.
12th Sep. 2017	JICA issued to NHSRCL the letter that review of HSR alignment and strucrture taking into consideration of the 4th line reqires huge impact toward the implementation plan schedule and so it is necessary to obtain the consensus in the relevant parties.
29th Sep. 2017	JICA amend the contract with JIC.

Span arrangement and type of girder for each GAD are shown in the table 8.3.2-1. RITES has modified the F/S GADs based on the comments regarding Right-of-Way, future development plans, etc. which NHSRCL received from the relevant stake holders/authorities in their negotiations. However, the following reason causes the GAD under the contract of the Study to be drawings which reflect the comments received by NHSRCL from the relevant authorities in their negotiations.

1) The time taken for various approvals whether by Statutory Authorities such as National Highway Authority of India (NHAI), Inland Waterways Authority of India (IWAI), Dedicated Freight Corridor Corporation of India Ltd. (DFCCIL) Indian Railway (IR) etc., require the

time beyond expectation.

2) The request by Ministry of Railways of changing station locations in existing railway area causes additional examination, which delays the start of GAD work.

3) The request by Western Railway of coexistence of the 4th line with HSR in the location around Ahmedabad Station area causes the examination of the HSR alignment and structure, which delayed the time to start to work for GADs.

8.4 Review of HSR Stations Located in Existing Station Area

As per the letter from MOR about HSR stations located in existing station area, the Study team reviewed the station location of Thane, Vadodara, Ahmedabad and Sabarmati station. The Study team, MOR and NHSRCL had meetings as below;

Table 8.4-1 Meetings and Letters

No	Date	Meeting or Letter	Attendees (Indian side)
(1)	23rd December 2016	Letter from MOR to JICA	-
(2)	17th February 2017	Meeting	MOR Mr. Kahre, Mr. Thakur NHSRCL Mr. Pervez
(3)	1st -3rd March 2017	Site Survey	NHSRCL Mr. Pervez
(4)	15th March 2017	Meeting	MOR Mr. Kahre, Mr. Thakur NHSRCL Mr. Pervez
(5)	21st -24th March 2017	Site Survey	NHSRCL Mr. Pervez
(6)	13th April 2017	Meeting	MOR Mr. Kahre, Mr. Thakur NHSRCL Mr. Pervez
(7)	20th April 2017	Letter from JIC to NHSRCL	—
(8)	19th May 2017	Meeting	NHSRCL Mr. Pervez

(1) Letter from MOR to JICA on 23rd December 2016

MOR issued the letter to JICA about reviewing the location of HSR Thane, Vadodara, Ahmedabad and Sabarmati Station on 23rd December 2016.

GOVERNMENT OF INDIA (भारत सरकार)
MINISTRY OF RAILWAYS (रेल मंत्रालय)
RAILWAY BOARD (रेलवे बोर्ड)
*****

Rail Bhavan, New Delhi
Dated: 23.12.2016

No. 2012/Infra/12/38 Pt.VI

Chief Representative,
JICA India Office,
2nd Floor, Dr. Gopal Das Bhawan,
28, Barakhamba Road,
New Delhi – 110001.

Sub:- **Mumbai-Ahmedabad HSR – Stations located in existing railway area.**

As per the Joint Feasibility report, the proposed HSR stations of Vadodara, Ahmedabad, Sabarmati and Thane are located over the existing tracks of Indian Railways. Perusal of drawings submitted along with the Feasibility report indicate that large number of columns are proposed over the existing running yards including the main lines. The construction of these supporting columns within the existing yards at Vadodara, Ahmedabad and Sabarmati will not be possible as the existing running lines cannot be shifted. The location of these three proposed HSR stations is, therefore, required to be reviewed from the constructability point of view to ensure that the project is executed smoothly and in time. It is requested that the option of taking these stations underground or shifting of the proposed station location by few hundred metres may be explored so that the construction of the proposed HSR stations can be undertaken with least disruption to traffic on existing track.

The station location of Thane may also be reviewed as the proposed station is over the 6 existing running main lines. It appears that shifting of this station by few hundred metres towards BKC side may avoid locating the station over these tracks.

23/12/16
(R.C. Thakur)
Executive Director/Infra.(Civil)
Railway Board
Telefax: 011-23382839

Copy to:- OSD, NHSRCL

Cir. : JPN, DS, PO, AJL	D.I.C. : JICA ID
R.D.	REF.
C.R.	
S.R.1	
S.R.2	
File To: MAHR	O.I.C.

Figure 8.4-1 Letter from MOR

(2) Meeting with MOR and NHSRCL on 17th February 2017

1) Thane Station

Thane Station is originally located over the 6 existing lines with 2-span bridge as Figure8.4-2 and 8.4-4. MOR and NHSRCL agreed to examine with the policies below;

- Shift the station location towards Mumbai HSR station as Figure 8.4-3.
- Change the structure of crossing section with the existing lines from 2-span to 1-span bridge as Figure 8.4-5.

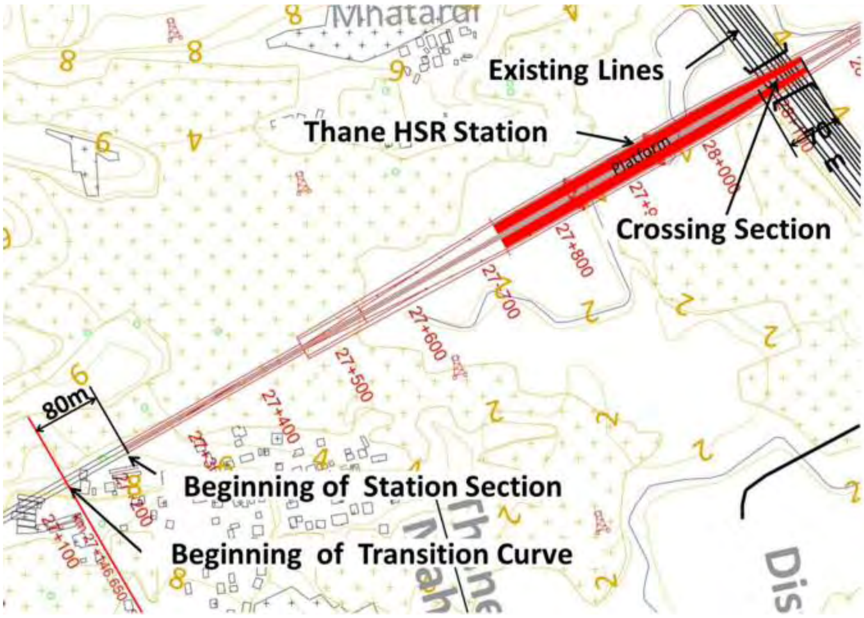


Figure 8.4-2 Station Location of Thane (F/S)

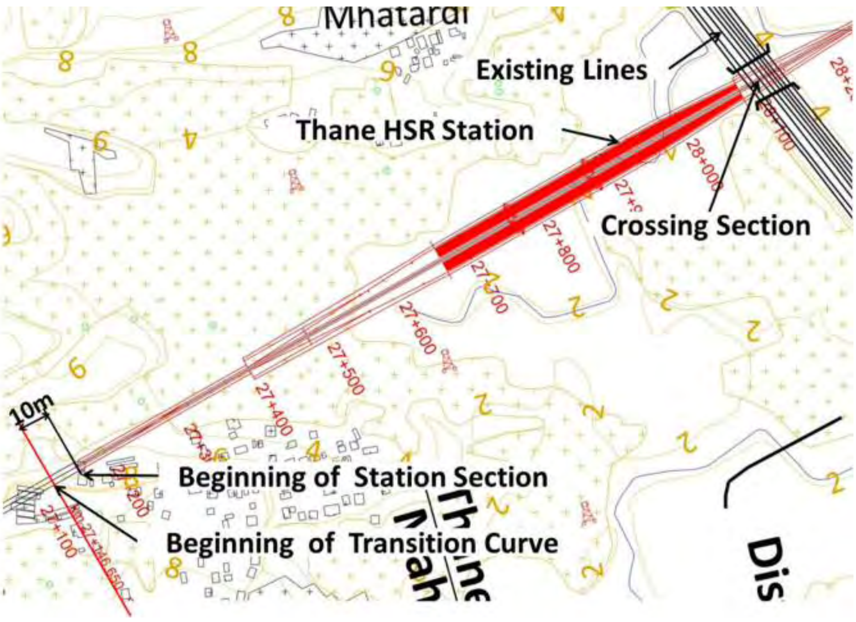


Figure 8.4-3 Station Location of Thane (Alternative)

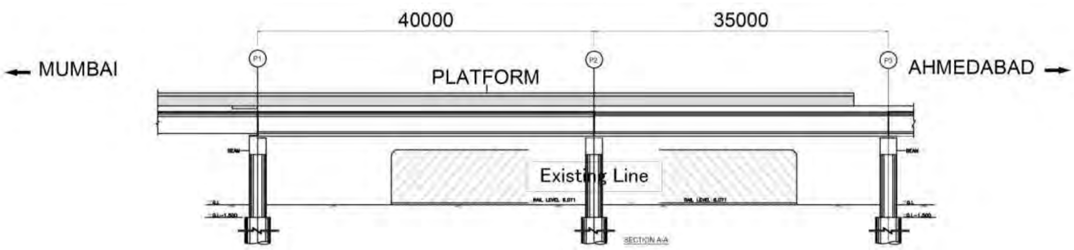


Figure 8.4-4 Structure at Crossing with Existing Lines (F/S)

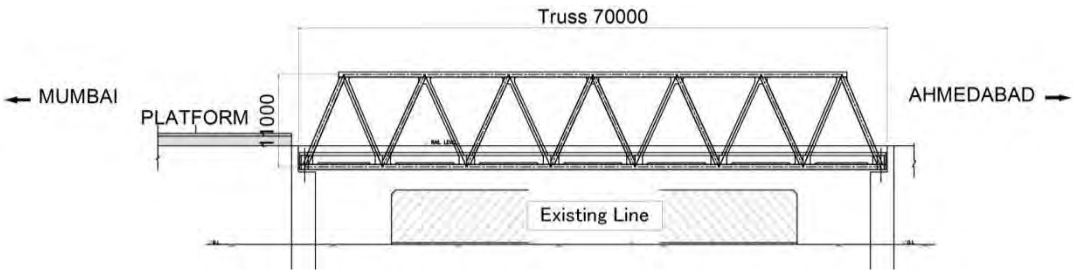


Figure 8.4-5 Structure at Crossing with Existing Lines (Alternative)

2) Vadodara Station

The Study team explained the station location the F/S study team had examined and suggested that HSR cross existing lines with 2-span bridge with dismantling an existing line as Figure 8.4-6. MOR and NHSRCL agreed to examine with the policy below;

- HSR cross the existing lines with underground tunnel. The station location could be changed if it is necessary from the point of view of "feasibility" and "constructability" of HSR.

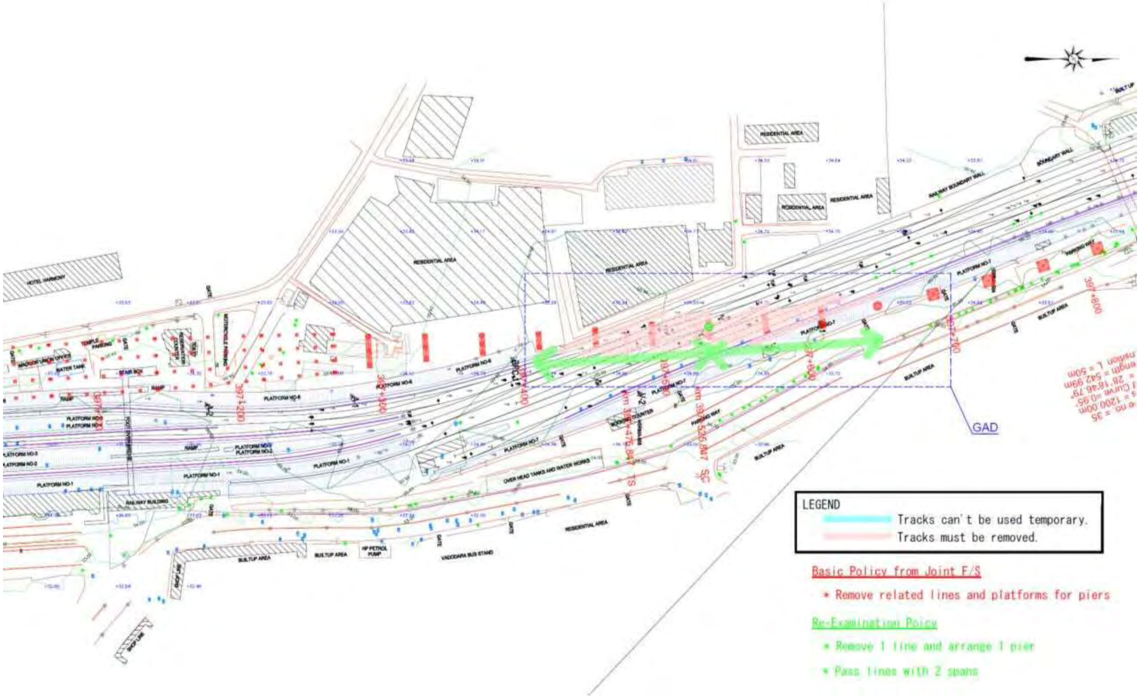


Figure 8.4-6 Image of 2-Span Bridge

3) Ahmedabad Station

The Study team proposed to change the viaduct structure from 4 piers on the tracks and platforms to 2 piers on the 2 platforms. The Study team also proposed to change the type of HSR platforms from 2-island for 4 tracks to 2-island for 2 tracks as Figure 8.4-7 and 8, but in case of 8 trains operation per 1 hour, the stopping time as planned in F/S will not be secured. MOR and NHSRCL agreed to examine with the policies below;

- Plan A: Drop the loop lines and build viaduct with single pier on the platform.
- Plan B: Skip Ahmedabad Station.

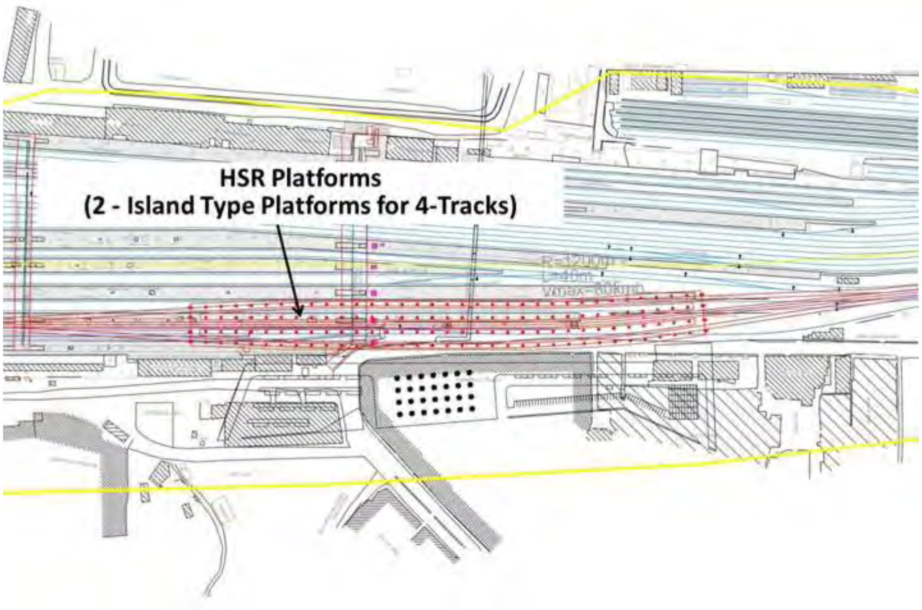


Figure 8.4-7 Structure of Station (F/S)

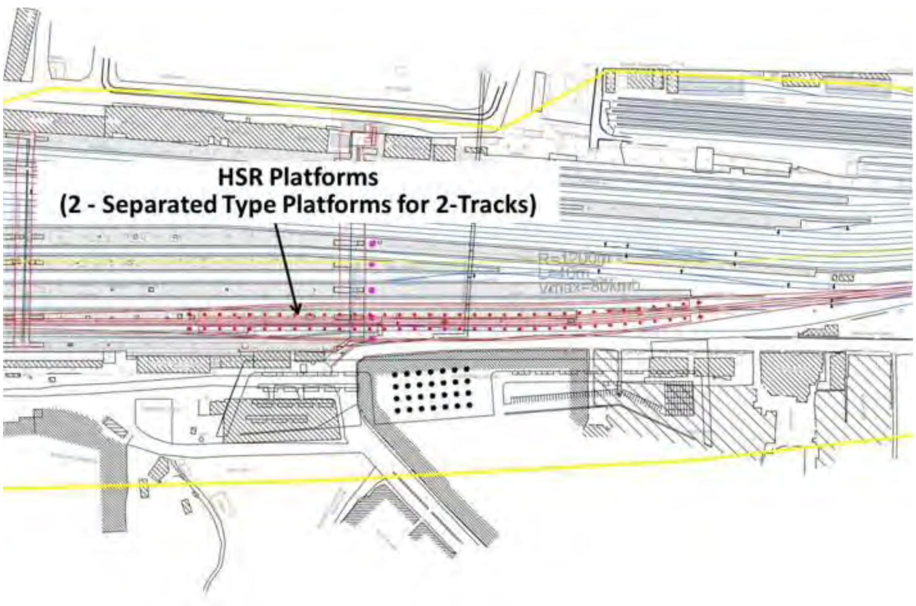


Figure 8.4-8 Structure of Station (Alternative)

4) Sabarmati Station

The Study team explained existing loop lines, etc. should be dismantled as planned in F/S. MOR and NHSRCL agreed to examine with the policy below;

- Examine the plan of F/S at site survey.

(3) Site Survey on 1st -3rd March 2017

The Study team conducted site survey at Ahmedabad and Sabarmati area with NHSRCL and WR. At Sabarmati area, NSHRC agreed to dismantle some of the existing lines and build HSR structure as planned in F/S.

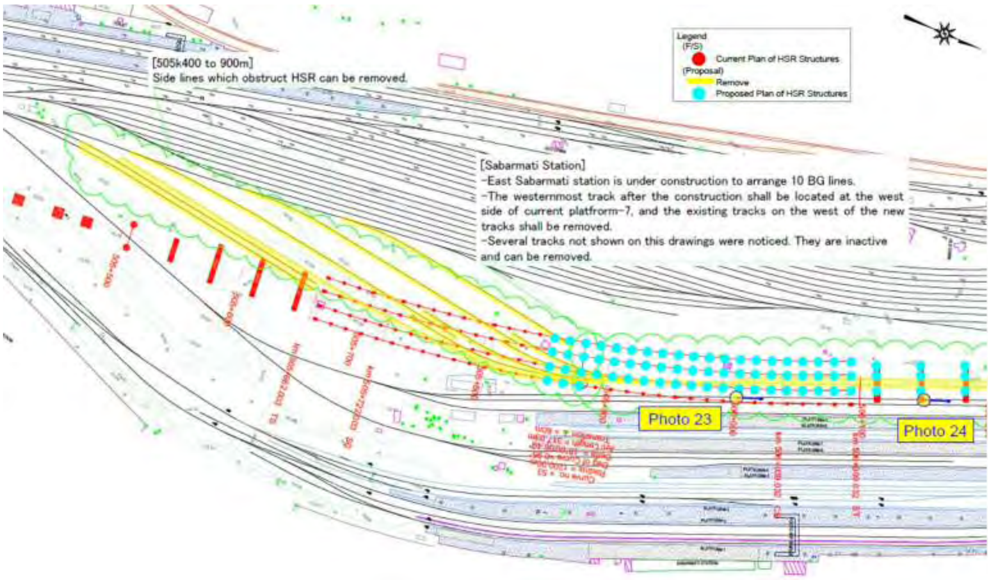


Figure 8.4-9 Sabarmati Station (1)

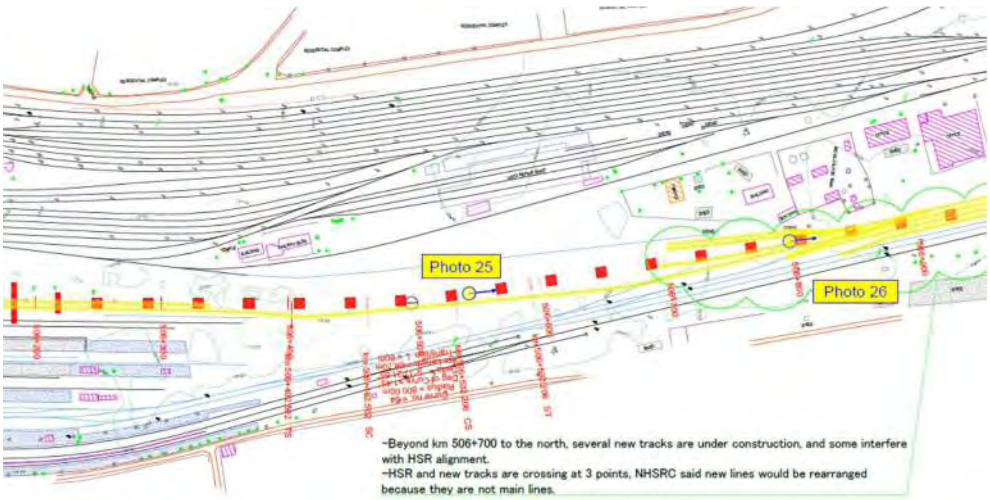


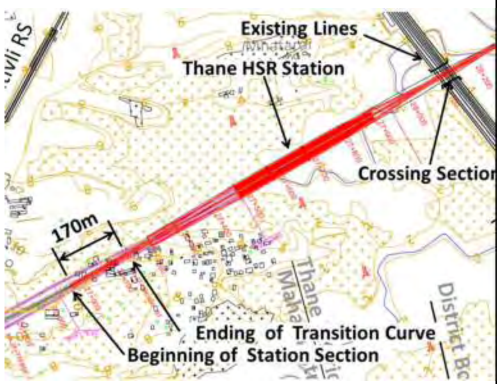
Figure 8.4-10 Sabarmati Station (2)

(4) Meeting with MOR and NSHRC on 15th March 2017

1）Thane Station

The Study team explained conversion plan 1 and plan 2 of the location of Thane Station, both of them is to shift Thane Station towards Mumbai Station. MOR and NHSRCL adopted conversion plan 1 for because the expansion joint and turnout are within straight section.

Table 8.4-2 Conversion Plans for HSR Thane Station

Plan	Conversion Plan 1	Conversion Plan 2
Figure		
Commnets	This plan can be adopted for HSR satation locatoin of Thane Station.	This plan is impossible because the expansion joint and turnaout are within curve section.

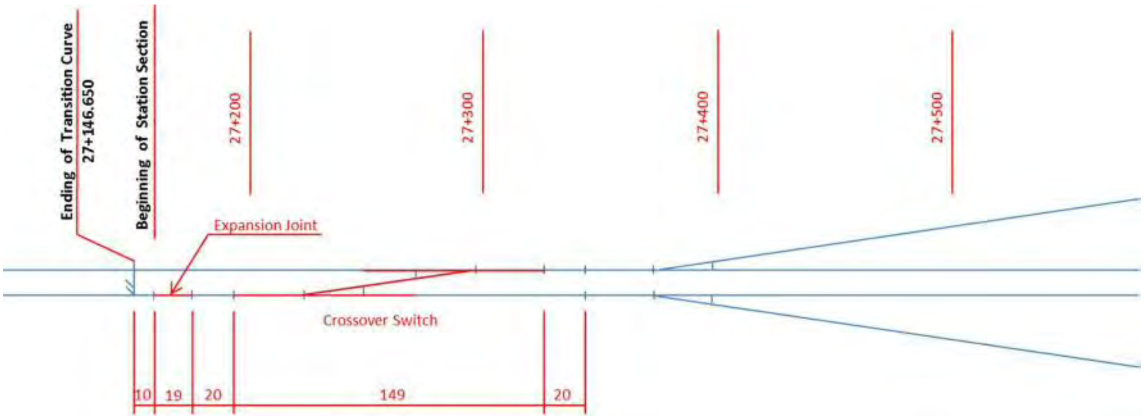


Figure 8.4-11 Enlarged Section View of Conversion Plan 1

2) Vadodara Station

The study team explained F/S plan and 3 alternative plans of Vadodara Station as Table 8.4-3.

Table 8.4-3 F/S and Alternative Plans of Vadodara Station

Alternatives	Original : FS Plan	Alt 1 : Partial Diversion Plan	Alt2 : Underground & Station Relocation Plan	Alt 3 : Shifting Along the Existing Line Plan
Type of Station	Upgraded Station	Upgraded Station	Underground Station	Upgraded Station
Station Location	West side of existing Vadodara Station	(Same as F/S)	2km South of Vadodara station	(Same as F/S)
HSR Alignment	—	(Same as F/S)	Vertical alignment needs modification (13km-length underground tunnel)	Horizontal alignment needs modification
Additional Land Acquisition	—	Small additional L.A. (for construction yard)	Small additional L.A. (for tunnel shaft)	Large additional L.A. (for modification of alignment)
Necessity of IR facilities' diversion	• 4 main lines and some sidings need diversion in station yard • 4 sidings need diversion in freight yard.	• Some sidings in station yard need to be removed for reducing bridge length to less than 200m • 4 sidings need diversion in freight yard.	• No diversion in station yard • No diversion in freight yard	• No diversion in station yard • No diversion in freight yard
Accessibility to IR Vadodara Station	Good accessibility	Good accessibility	2km from Vadodara Station (0.8 km to Vishwamitri St.) *Demand Analysis should be re-examined	Good accessibility
Technical Issue	• Large scale diversion of IR main lines is required for constructing HSR structures	• 300m length steel bridge for HSR is not experienced in Japan • Some sidings in station yard need to be removed for reducing bridge length to less than 200m • Erection method (launching or overhanging) should be carefully examined	• Uncertain buried structure may appear in underground • Detail geological survey is required • Underground continuous wall for open cut tunnel will be constructed on the border of WR and HSR • Underpinning is needed for road flyover structures	• Critically technical issue is not found in Alt 3
Additional Cost	—	Construction Cost : + + Land Acquisition Cost: +	Construction Cost : + + + + Land Acquisition Cost: +	Construction Cost : + Land Acquisition Cost: + + +
Recommendation	—	✓✓✓	✓✓	✓

2-1) Alternative 1: Partial Diversion Plan

Outline of Alternative 1

- The HSR alignment and location of station is the same as F/S.
- HSR cross over the existing lines with 1-span bridge.
- To reduce the span to less than 200m, dismantle some sidings.

Technical issue

- 300m length steel birdie for HSR is not experienced in Japan.
- Some sidings in station yard to be removed for reducing the span less than 200m.
- Erection method (launching or overhanging) should be carefully examined.

Figure 8.4-12 Alternative 1

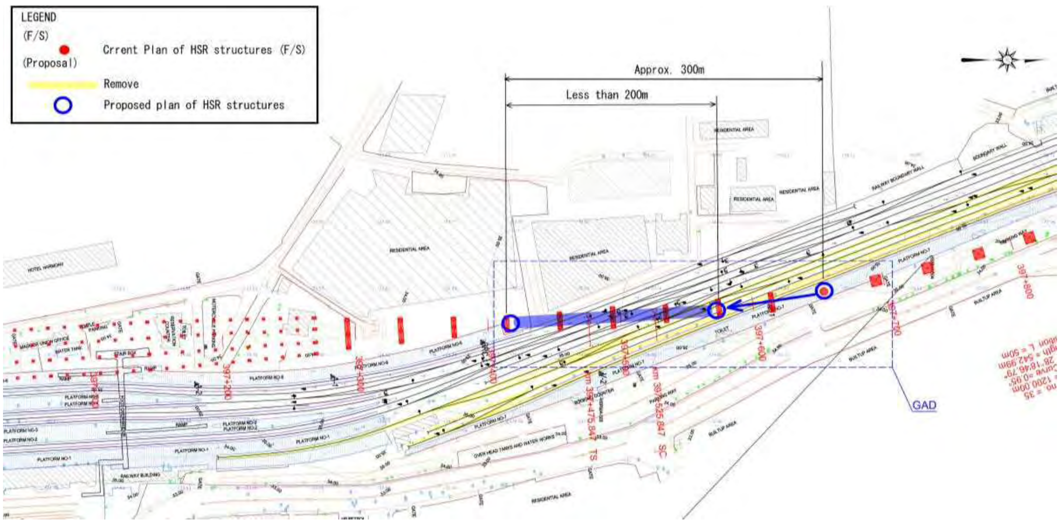


Figure 8.4-13 Long-Span Bridge for Crossing the Existing Lines in Vadodara Station Yard

2-2) Alternative 2

Outline of Alternative 2

- The HSR alignment is the same as F/S.
- Shift the location of HSR station towards 2 km south of existing Vadodara Station.
- HSR cross the existing lines by underground tunnel.
- No diversion of the existing lines.

Technical Issue

- Uncertain buried structure may appear in underground.
- Detail geological survey is required.
- Underground continuous wall should be constructed on the border of WR lines and HSR structure for constructing underground station by open cut tunnel.
- Underpinning may be needed for tunneling under the road flyover structures.
- Construction cost may increase.

Figure 8.4-14 Alternative 2

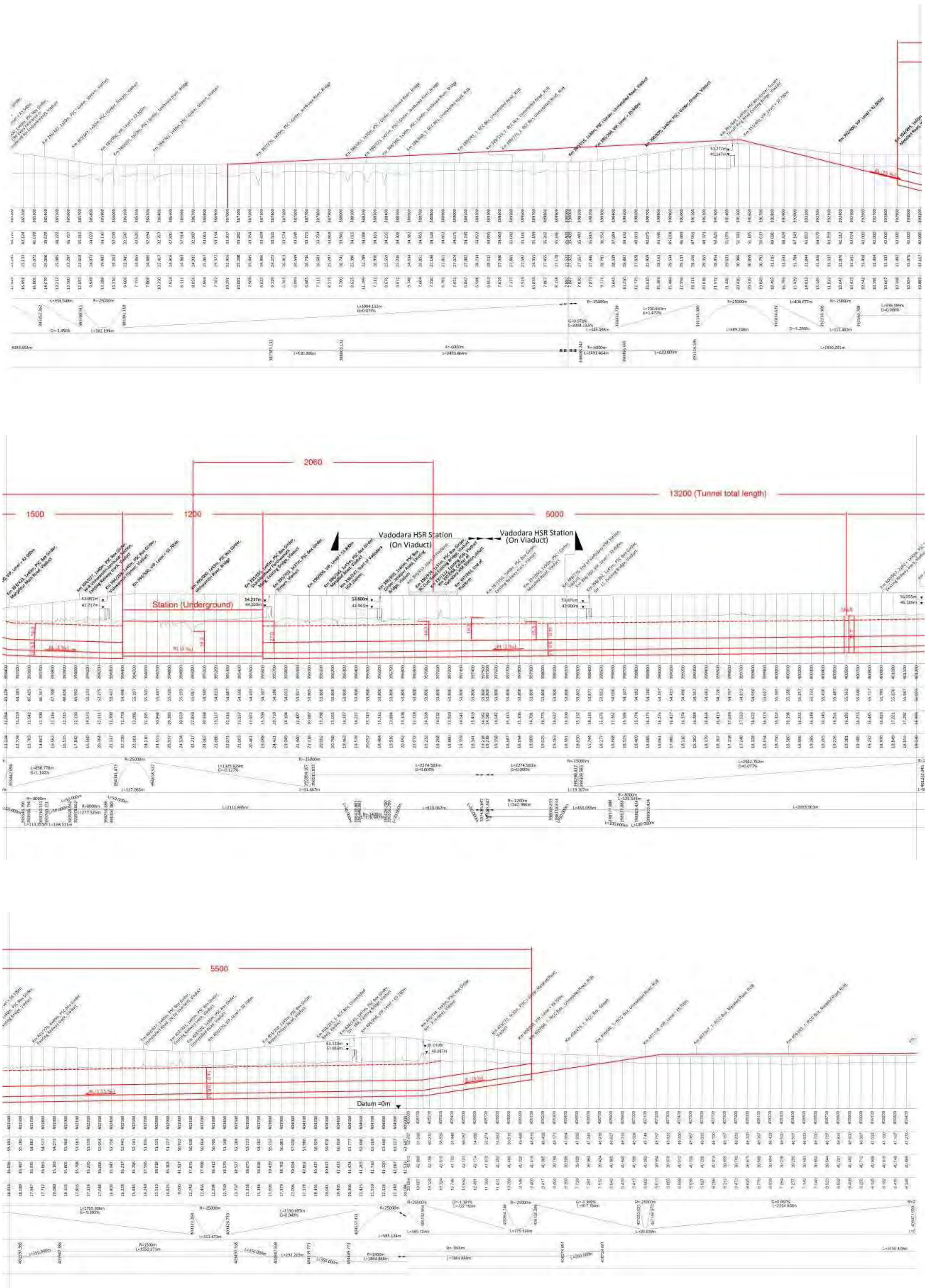


Figure 8.4-15 Rough Vertical Alignment for Underground & Station Relocation Plan

2-3) Alternative 3: Shifting Alignment along the Existing Line Plan

Outline of Alternative 3

- Shift the HSR alignment to the West side.
- HSR do not cross the existing lines in Vadodara station area.
- HSR cross the existing lines at the point where the lines of IR decrease to 2 lines.

Technical Issue

- No critical technical issue.

Other Issue

- Additional large-scale land acquisition and re-settlement is required (Approx. 16m x 5,000m = 80,000m^2)

Figure 8.4-16 Alternative 3

After the Study team explained 3 alternative plans, MOR and NHSRCL agreed to examine 4 plans;

A) Plan A: Examine Alternative 1 further.

B) Plan B: Change the alignment around crossing with the existing lines and reduce the span of bridge.

C) Plan C: Shift the HSR Station towards Vishwamitri Station and cross the existing lines at the same point planned at F/S.

D) Plan D: Shift the HSR Station towards Vishwamitri Station and cross the existing lines at the northern point.

(5) Site Survey on 21st -24th March 2017

The Study team conducted site survey at Vadodara and Ahmedabad area with NHSRCL and WR. At Vadodara area, NSHRC pointed out below;

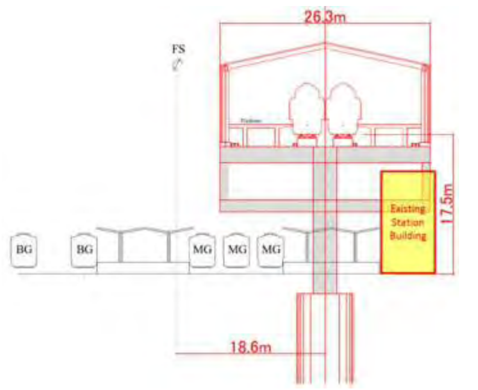
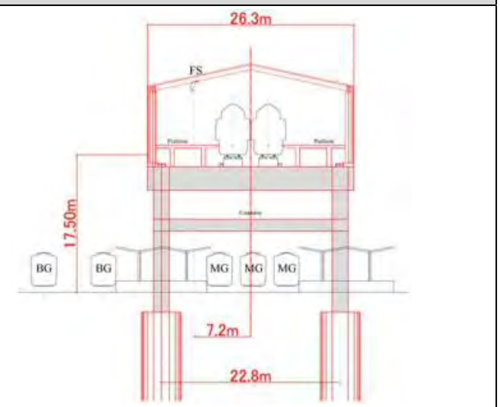
- It is necessary to set "block" for construction over existing tracks. Without block time, main and temporary structures should be fixed strongly. It is impossible to build temporary piers around main lines for construction over existing tracks.
- For main lines, it is impossible to set 2 or 3 hours-block everyday as in Japan, but it is possible to set 2 or 3 hours-block several times a year. With negotiation, it might be also possible to set long-time-block 1 or 2 times a year. It is easier to set block on sidings than main lines.
- WR has a plan to rearrange sidings in Vadodara Station Yard, but construction period is not decided. This plan includes connection of track #1 and #7, so the platform #7 will be in use after rearrangement.
- The blank space between the platform #7 and the eastern road can be used as HSR yard and construction yard, etc.

(6) Meeting with MOR and NHSRCL on 13th April 2017

1) Ahmedabad Station

The Study team suggested 2 alternative structure plans. At alternative Plan 1, single pier is on the platform #12. At alternative Plan 2, two piers are on the platform #10/11 and #12. The Study team also suggested shifting the location of station towards south about 300m. MOR and NHSRCL agreed to alternative Plan 2 and shift of the location of station.

Table 8.4-4 Alternative Structural Plan of Ahmedabad Station

Plan	Alternative Plan 1	Alternative Plan 2
Figure		
Comments	- Less structural stability. - Size of pier and pile becames large. - Lower flexibility with the concourse level of HSR for facilities. - Existing station building should be dismantled. - Shift the HSR alignment about 19 m from F/S. - The HSR alignment overlap with Joythi Fabricare Service.	- More structural stability. - Wider use of the existing platform #12 . - Higher flexibility with the concourse level of HSR for facilities. - Less dismantling of the existing facilities. - Shift the HSR alignment about 7 m from F/S.

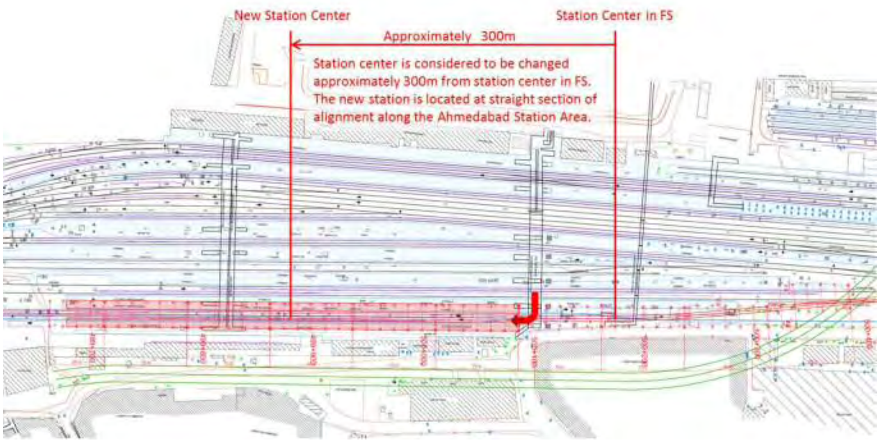
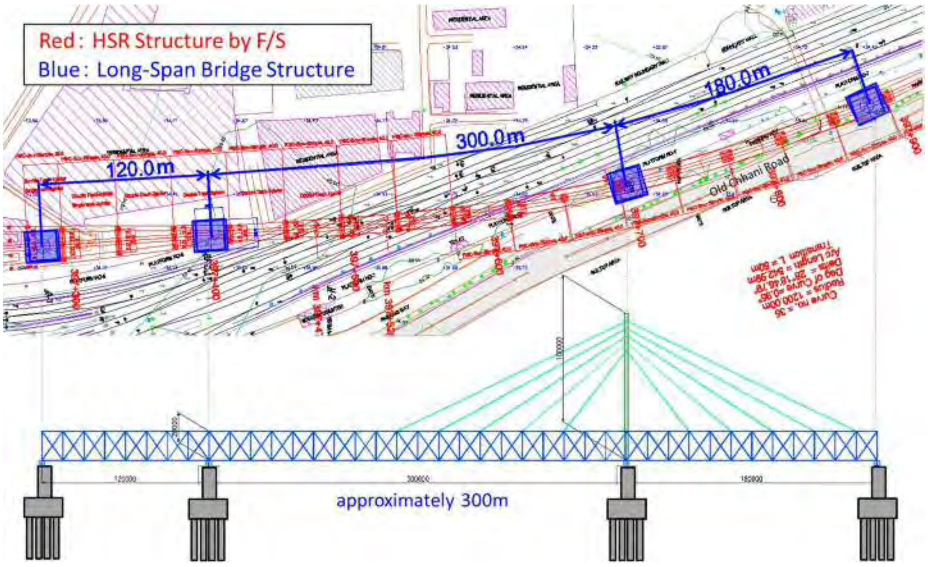


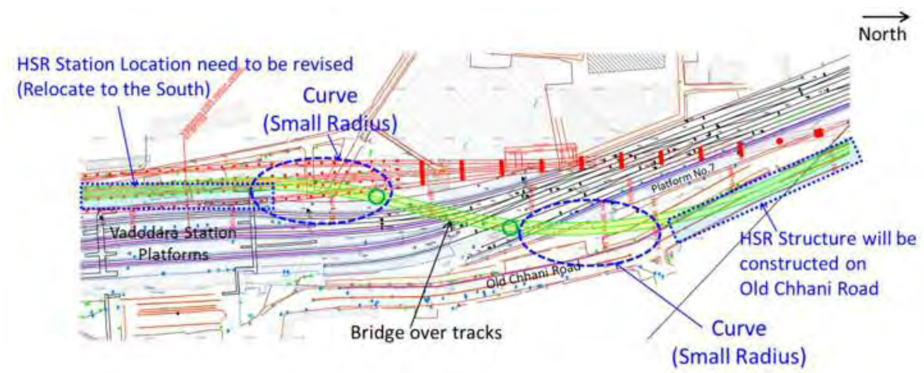
Figure 8.4-17 Re-location of Ahmedabad Station

2) Vadodara Station

The Study team explained 4 plans at crossing with the existing lines. MOR and NHSRCL agreed to Plan 1 due to construction cost, connectivity with the existing lines and land acquisition, etc.

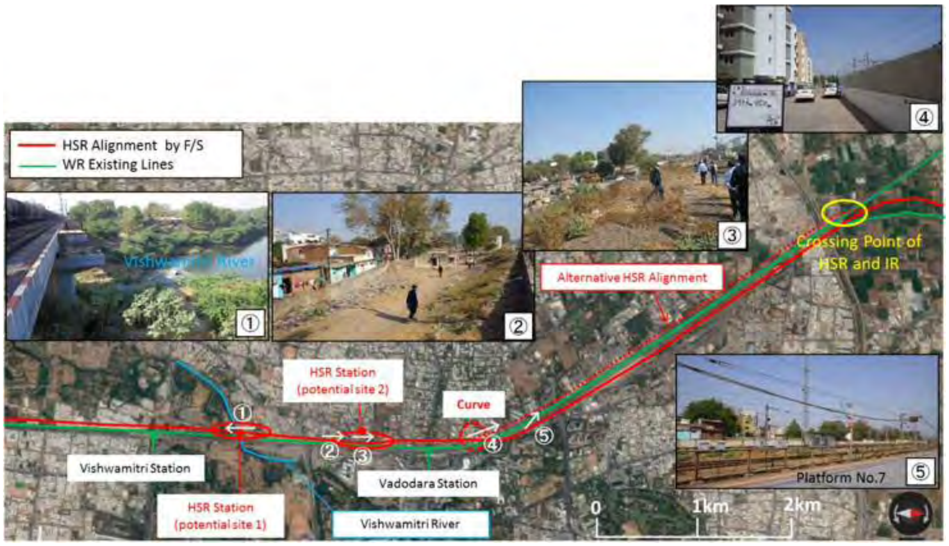
Table 8.4-5 Structural Plans of Crossing with Existing Lines at Vadodara Station

<table>
<tr><th>Plan</th><th>Outline</th></tr>
<tr><td>1-Span Bridge</td><td>


・ Cross the existing lines with 1-span bridge.
・ The alignment and location of station is the same as planned in F/S.
・ Land acquisition area is smaller than that of another plan.
・ Use the railway land between platform #7 and Old Chhani Road as construction yard.
</td></tr>
<tr><td>Change Alignment and Shift Location of Station</td><td>


・ Shift the alignment around the crossing section with existing lines.
・ Shift the location of station towards south because curve section interfere with the HSR station.
・ Connectivity with the existing lines get worse due to the shift of location of station.
・ Maintenance cost increase due to adoption of smaller radius of curve.
</td></tr>
</table>

<table>
<tr>
<td>Change the alignment towards west of existing lines</td>
<td>



- Shift the alignment of HSR towards west of existing lines.
- Additional land acquisition is needed.
- Shift the location of station towards south because curve section interfere with station
- Connectivity with existing lines get worse due to the shift of location of station

</td>
</tr>
<tr>
<td>Underground tunnel and shift of the locatoin of station</td>
<td>

- Change the vertical alignment to underground.
- Construction cost increase.
- Connectivity with existing lines get worse due to the shift of location of station.
- Construction of the underground station under Vishwamitri River is technically hard.

</td>
</tr>
</table>

(7) Letter to NHSRCL on 20th April 2017

The Study team issued the letter to NHSRCL about design philosophy about Thane, Vadodara, Ahmedabad and Sabarmati station.

General Consultancy for
Mumbai-Ahmedabad HSR Project for Detailed Design

JIC Consortium (Japan International Consultants for Transportation, Nippon Koei & Oriental Consultants Global)

Our Ref. No.:JICC-NHSR-CPL-1704-0030	Your Ref No.:	Date: 20-04-2017
Letter ☑ Fax ☐		

Mr. Anjum Pervez, NHSRC
Officer on Special Duty
National High Speed Rail Corporation Ltd.
9th Floor, Commercial Tower, Windsor Place
New Delhi, India

Dear Sir,

Subject: Design Philosophy for Thane, Vadodara, Ahmedabad and Sabarmati Stations

As requested by Ministry of Railway (MOR)'s letter of 23 December 2016 (No. 2012/Infra/12/38 Pt.VI) to JICA, JIC Consortium (JICC) has reconsidered the location and structure for Thane, Vadodara, Ahmedabad and Sabarmati Stations. After the reconsideration and subsequent site-surveys with National High Speed Rail Corporation (NHSRC), JICC met with MOR and NHSRC to finalize the locational and structural plan on 17th February 2017, 15th March 2017 and 13th April 2017. JICC would like to start to design with the design philosophy below:

- Thane Station
  - Station location moved to approximately 70 meters south of location planned in the Joint Feasibility Study (F/S)
- Vadodara Station
  - The current plan is to use a Long-span bridge over existing railway tracks at north of Vadodara Station
- Ahmedabad Station
  - The current plan is to construct with a 2-Column structure (columns on platform No. 10/11 and No. 12)
  - 2 platforms and 2 tracks
  - Station location moved to approximately 300meters south of location planned in F/S
- Sabarmati Station
  - The original location and structure as planned in F/S

JICC request MOR and Western Railway to reconsider 3rd line, 4th line and Gauge Conversion Projects in Ahmedabad and Sabarmati areas to avoid interferences with the HSR alignment.

The Masterpiece Building, 2nd Floor, Golf Course Road
Sector 54, Gurgaon -122002, India
TEL : 0124-418-6400 (Ext, 01-19)

General Consultancy for
Mumbai-Ahmedabad HSR Project for Detailed Design

JIC Consortium (Japan International Consultants for Transportation, Nippon Koei & Oriental Consultants Global)

Our Ref. No.:JICC-NHSR-CPL-1704-0030	Your Ref No.:	Date: 20-04-2017
Letter ☑ Fax ☐		

Sincerely,

Toshiji Takatsu
Project Director

Cc: R.C. Thakur (Executive Director/Infra. (Civil) / MOR), Akira Sato (Representative JICA India Office)

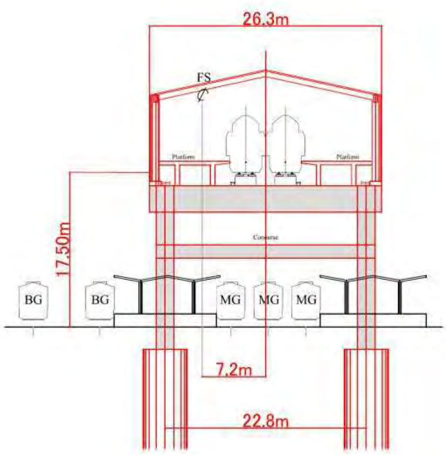
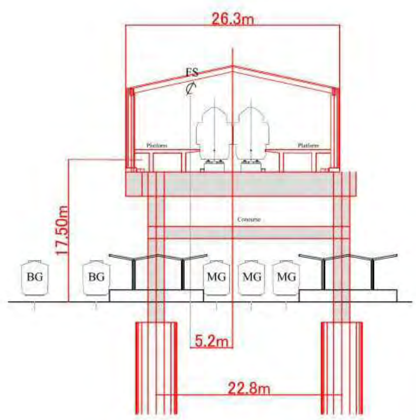
The Masterpiece Building, 2nd Floor, Golf Course Road
Sector 54, Gurgaon -122002, India
TEL : 0124-418-6400 (Ext, 01-19)

Figure 8.4-18 Letter about Design Philosophy

(8) Meeting with NHSRCL on 19th May 2017

The Study team suggested 2 alternative alignments around Ahmedabad Station. NHSRCL said it is not problem to cross with Joythi Fabricare Service. NHSRCL agreed to Plan1 because plan 1 is more structurally balannced than plan 2 and the concourse floor is not on the BG line.

Table 8.4-6 Cross Section of Ahmedabad Station

Plan	Plan 1	Plan 2
Figure		
Comments	- Shift the alignmnet 7.2m east. - No interference with Joythi Fabricare Service. - Center of the structure and center of the alingment is almost the same. ・Concourse floor is not on the BG line.	- Shift the alignmnet 5.2m east. - Interference with Joythi Fabricare Service. - Center of the structure and center of the alingment is not the same - Concourse floor is not on the BG line

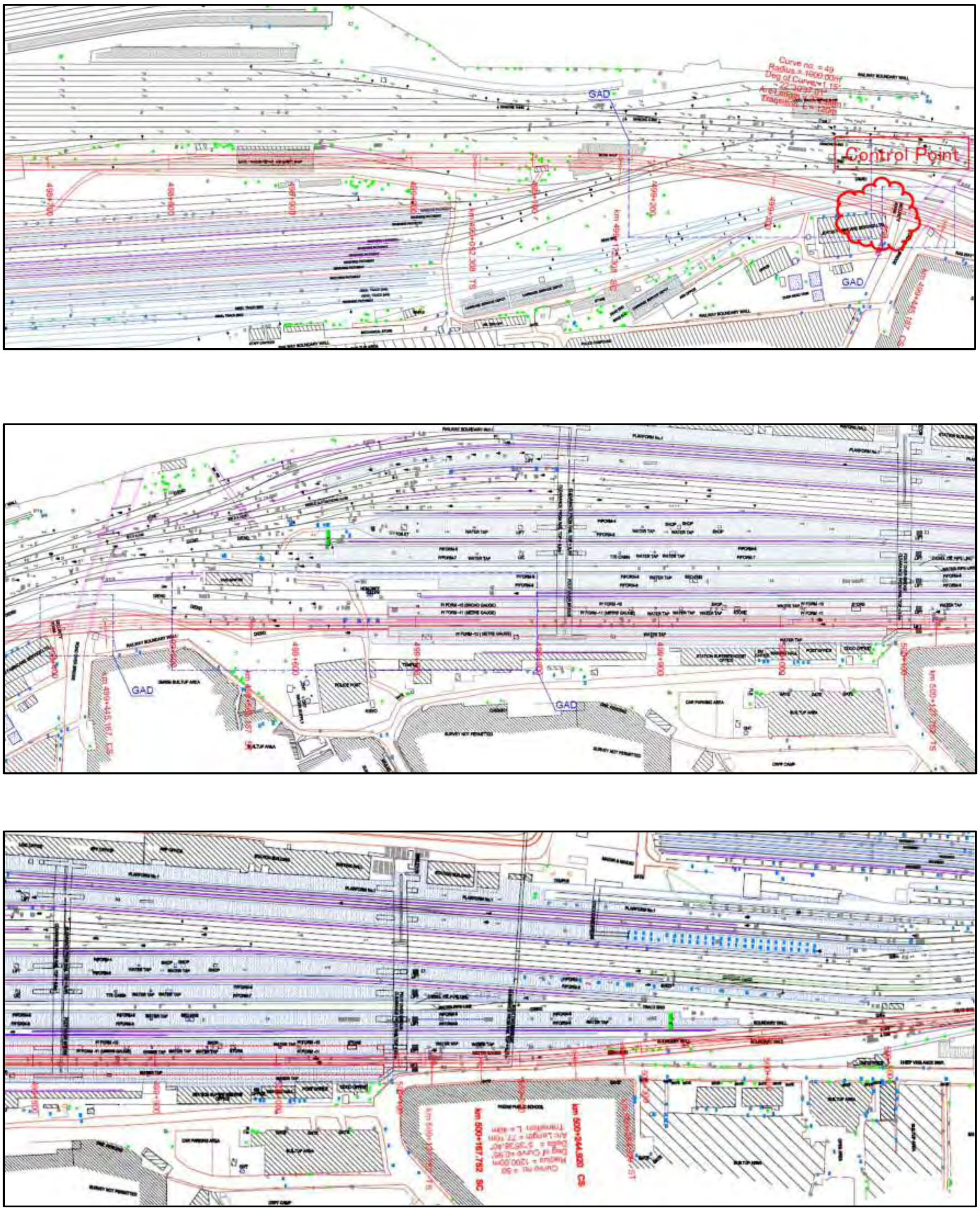


Figure 8.4-19 Alternative Plan 1

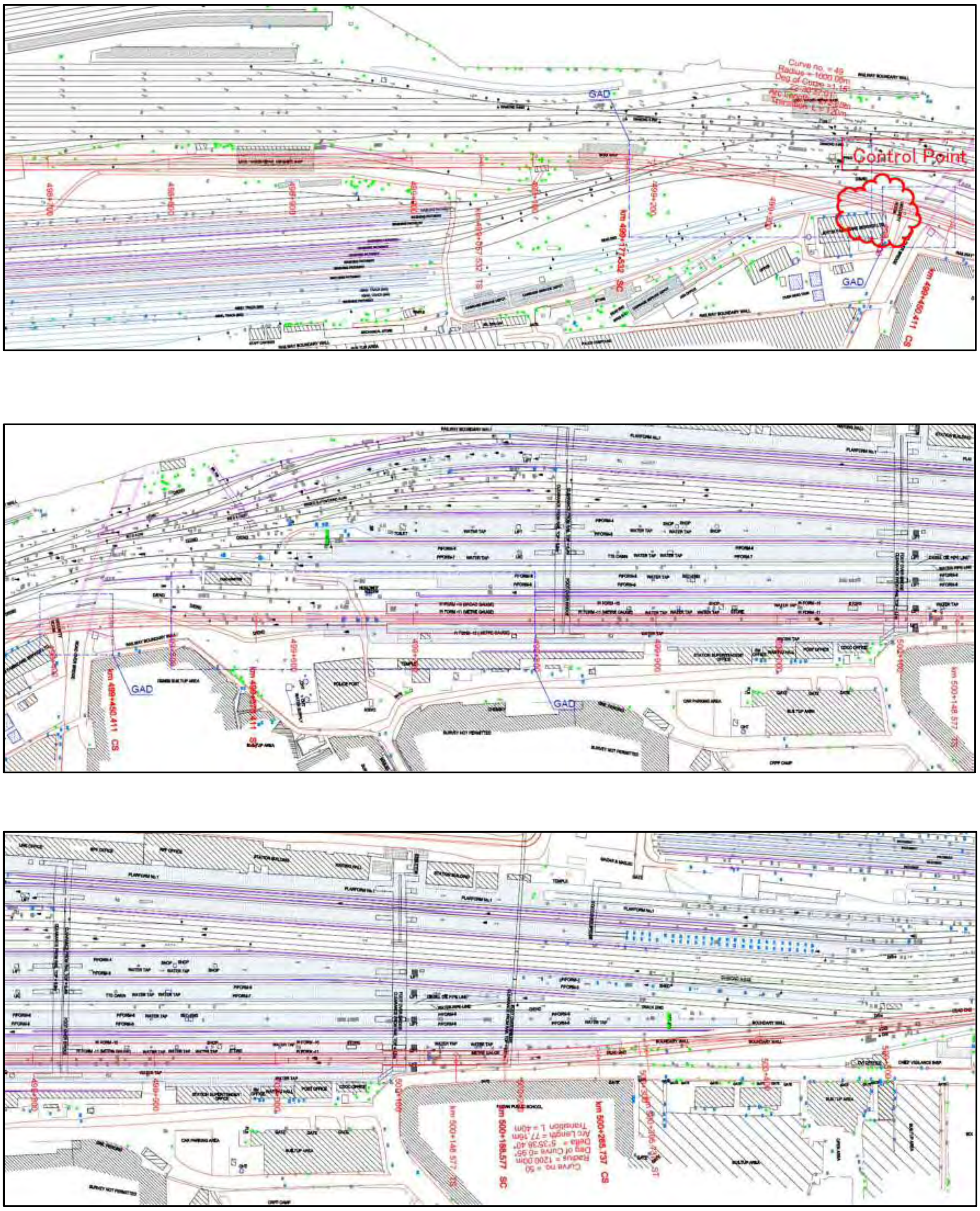


Figure 8.4-20 Alternative Plan 2

(9) Results

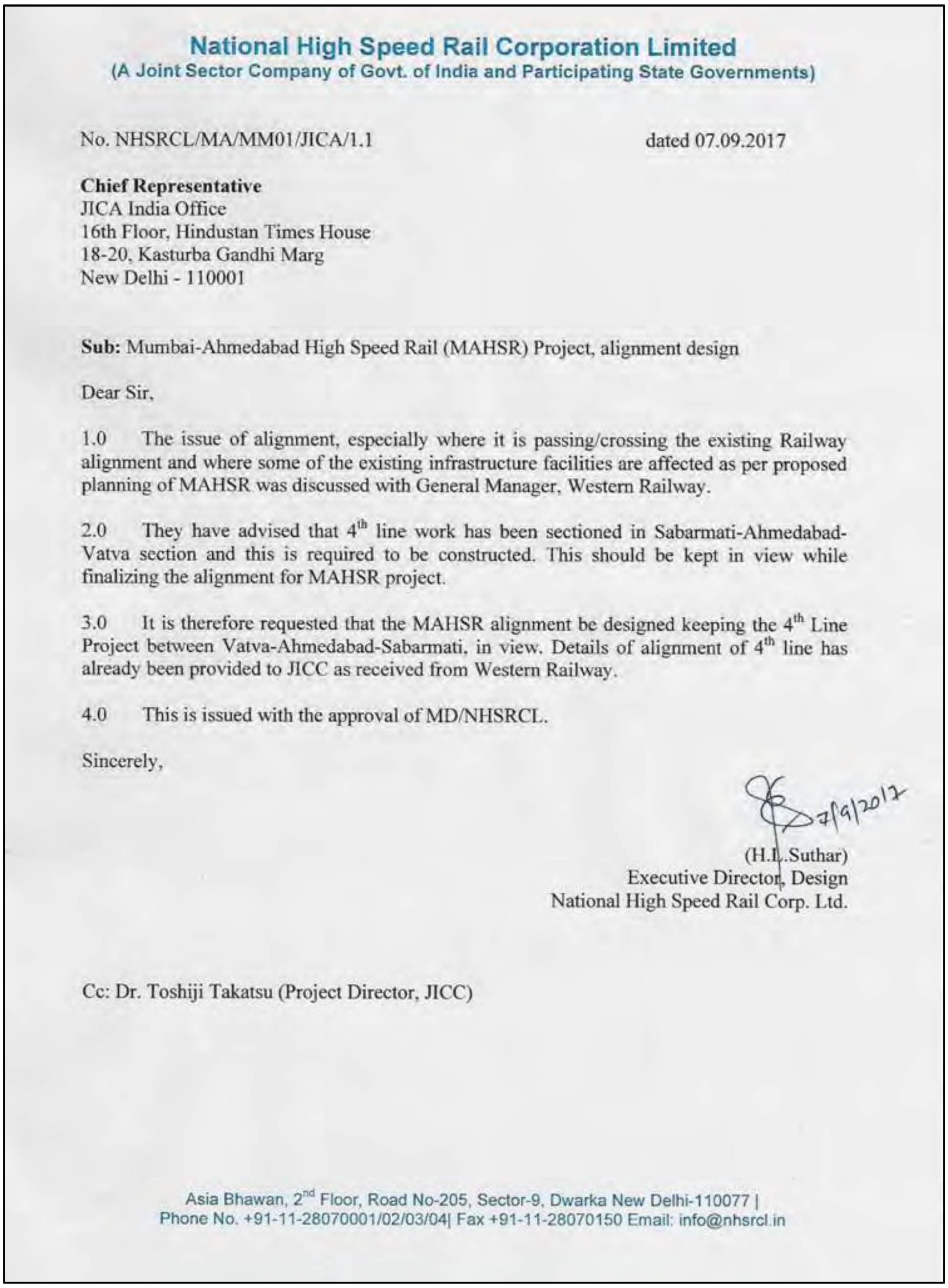
Based on the letter from MOR in Nov. 2016, the Study team re-examined alignment and structure of Thane, Vadodara, Ahmedabad and Sabarmati Station. Policies for each station are;

- Thane Station
  - Shift the station location 70m towards Mumbai HSR station not to cross the existing lines.
  - Change the structure of crossing section with the existing lines from 2-span to 1-span.
- Vadodara Station
  - Change the structure of crossing section with the existing lines from viaduct to 1-span bridge.
  - The alignment and location of station is the same as planned in F/S.
- Ahmedabad Station
  - Shift the alignment 7.2m east.
  - Change the type of HSR platforms from 2-island for 4 tracks to 2-island for 2 tracks.
  - Change the viaduct structure from 4 piers on the tracks and platforms to 2 piers on the 2 platforms.
- Sabarmati Station
  - Dismantle some of the existing lines and build HSR structure as planned in F/S.

8.5 4th line impact on HSR

8.5.1 Background

Based on discussion between NHSRCL and WR, NHSRCL made an oral request to JIC to finalize HSR alignment in consideration of the 4th line project on 11th August 2017, and issued an official letter on 7th September 2017. The 4th line project is the plan to build one more track along existing lines, which WR planned after F/S.



National High Speed Rail Corporation Limited
(A Joint Sector Company of Govt. of India and Participating State Governments)

No. NHSRCL/MA/MM01/JICA/1.1 dated 07.09.2017

Chief Representative
JICA India Office
16th Floor, Hindustan Times House
18-20, Kasturba Gandhi Marg
New Delhi - 110001

Sub: Mumbai-Ahmedabad High Speed Rail (MAHSR) Project, alignment design

Dear Sir,

1.0 The issue of alignment, especially where it is passing/crossing the existing Railway alignment and where some of the existing infrastructure facilities are affected as per proposed planning of MAHSR was discussed with General Manager, Western Railway.

2.0 They have advised that 4th line work has been sectioned in Sabarmati-Ahmedabad-Vatva section and this is required to be constructed. This should be kept in view while finalizing the alignment for MAHSR project.

3.0 It is therefore requested that the MAHSR alignment be designed keeping the 4th Line Project between Vatva-Ahmedabad-Sabarmati, in view. Details of alignment of 4th line has already been provided to JICC as received from Western Railway.

4.0 This is issued with the approval of MD/NHSRCL.

Sincerely,

7/9/2017

(H.L.Suthar)
Executive Director, Design
National High Speed Rail Corp. Ltd.

Cc: Dr. Toshiji Takatsu (Project Director, JICC)

Asia Bhawan, 2nd Floor, Road No-205, Sector-9, Dwarka New Delhi-110077 |
Phone No. +91-11-28070001/02/03/04| Fax +91-11-28070150 Email: info@nhsrcl.in

Figure 8.5.1-1 Letter to Reconsider HSR Alignment from NHSRCL

On 12th September 2017 JICA issued a letter to NHSRCL to request approval from stakeholders, because the commencement of project might delay if the alignment and structure need to be reconsidered. On 29th September JICA and JIC made a contract to change the scope so that JIC made general examination for the impact of 4th line project on HSR.

JICA

Japan International Cooperation Agency

JICA(EI)9-12004
September 12, 2017

Mr. Achal Khare
Managing Director
NHSRCL
New Delhi

Sub: **Re:Mumbai-Ahmedabad High Speed Railway Project (MAHSR), alignment design**

Dear Mr. Khare,

With reference to your letter No. NHSRCL/MA/MM01/JICA1.1 dated on 7th September 2017, regarding the 4th Line Project between Vatwa-Ahmedabad-Sabarmati, we are seriously concerned about the delay of commencement of operations of MAHSR if the alignment and structural design of MAHSR are to be reviewed in line with the alignment of the 4th Line Project.

Thus, we feel that the impact of the 4th Line Project on MAHSR especially from the viewpoint of project implementation schedule should be ascertained jointly at first and a consensus from all related stakeholders should be obtained at your end before starting the design work as you've requested.

Yours sincerely,

Taro OKAWA
Director
Transportation and ICT Group, Infrastructure and
Peacebuilding Department
JICA

CC: Dr. Toshiji Takatsu, Project Director, JICA Study Team
Mr. Takema Sakamoto, Chief Representative, JICA India

Figure 8.5.1-2 Letter to Request Approval to Delay the Commencement of Project

After the letter from JICA to NHSRCL on 12th September 2017, the 4th line project became one of the agenda of the Prime Ministers' meeting of India and Japan held on 14th September 2017 and succeeding series of discussion between Railway Minister of India and the Japanese Ambassador to India in October 2017. According to the discussion, the 4th line project was cancelled, and the design of HSR shall be conducted without consideration to the 4th line project. On 8th November 2017 JICA issued the letter to NHSRCL to request official letter about the decision. At the 6th Joint Committee Meeting on 22nd November 2017, it was officially cocfirmed that the 4th line project was cancelled.

JICA

Japan International Cooperation Agency

JICA (EI) 11-08001-(1)
November 08, 2017

Mr. Achal Khare
Managing Director
National High Speed Rail Corporation Limited
New Delhi

Subject: Mumbai-Ahmedabad High Speed Rail (MAHSR) Project, Alignment Design

Dear Mr. Khare,

This is with reference to your letter No. NHSRCL/MA/MM01/JICA1.1 dated September 07, 2017 regarding the issue of alignment design of MAHSR in Sabarmati-Ahmedabad-Vatra section due to the overlapping with the 4th line plan of Western Railways. According to the discussion in the Prime Minister's meeting of India and Japan held on September 14, 2017 and succeeding series of discussion between Railway Minister of India and the Japanese Ambassador to India in October 2017, we are acknowledged that the 4th line plan of Western Railways has been decided to be cancelled, and the design of MAHSR shall be conducted without consideration to the 4th line plan.

As a formal process, JICA is waiting for the official letter from you on the above decision. However, with consideration to the necessary time for approval procedure in Indian side and MAHSR project schedule, please note that we will order the JICA Study Team to re-start the design of civil structures in Sabarmati-Ahmedabad-Vatra section before the issuance of your official letter.

We kindly request you to respond to JICA within 10 days from the receipt date of this letter, if you have any opinion on the above.

Your kind understanding and cooperation are highly appreciated.

Yours sincerely,

大川太郎

Taro Okawa
Director, Team 3, Transportation and ICT Group
Infrastructure and Peacebuilding Department, JICA HQ

Cc:
Dr. Toshiji Takatsu, Project Director, JICA study Team
Mr. Takema Sakamoto, Chief Representative, JICA India Office
Mr. Kyosuke Inada, Sr. Director, SAD-1, South Asia Department, JICA HQ

Figure 8.5.1-3 Letter to Request Official Letter about the Cancel of the 4th line Project

8.5.2 Examine Impact of the 4th line

The Study team picked up 10 areas where the 4th line project influences HSR and examined each area.

Table 8.5.2-1 Areas Where the 4th line Project Influences HSR

No	Chainage (m)			Length (m)	Number of tracks which cross HSR
1	491650	to	492200	550	1
2	495400	to	495600	200	1
3	496000	to	497100	950	1
4	497950	to	498050	100	1
5	499330	to	499680	350	3
6	500100	to	500250	150	1 to 3
7	500580	to	500700	120	1 to 2
8	500980	to	501330	350	7
9	501500	to	503100	1600	4
10	503440	to	504240	800	4

The Study team examined structure, construction methodology of HSR structures. The Study team supposed 2 situations. One is to shift HSR alignment until the 4th line does not influence HSR. Another is to change structure of HSR and not shift HSR alignment. The Study team conducted site-survey after examination. Offset distances for HSR and the 4th line are shown in below;

Table 8.5.2-2 Offset Distance between HSR and Existing line and 4th line

Offset Distance	Order of Construction	
	4th line > HSR	HSR > 4th line
From Centre of existing line To Surface of pile	Over 3.5m	
From Centre of 4th line To Surface of pier	Over 2.36m	Over 2.36m
From Centre of 4th line To Surface of pile	Over 3.5m	- *Distance from pile of HSR and ground level should be over 1.5m

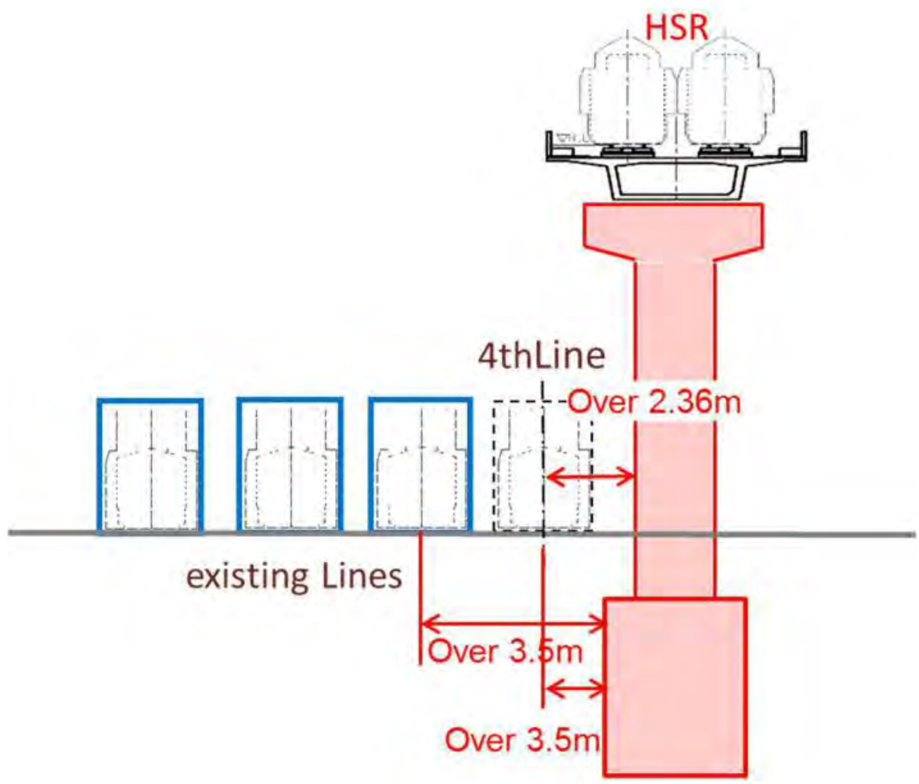


Figure 8.5.2-1 Offset Distance between HSR and Existing line and the 4th line
(Order of Construction: 4th Line>HSR)

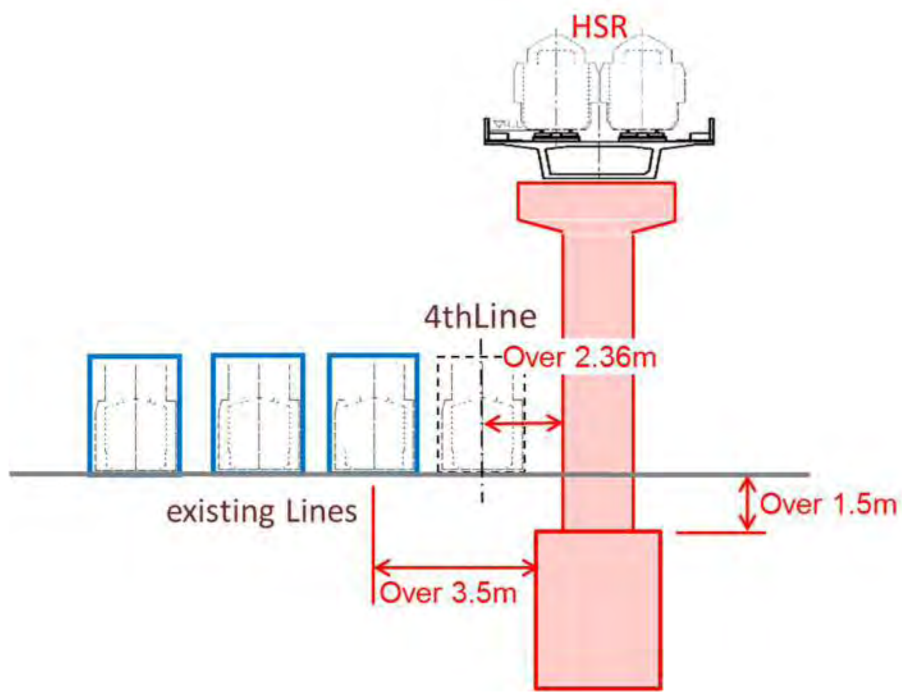


Figure 8.5.2-2 Offset Distance between HSR and Existing line and the 4th line
(Order of Construction: HSR>4th line)

8.5.3 Results

Results for each are shown below;

(1) 491k650m to 492k200m (Sections : 491k772m and 492k052m)

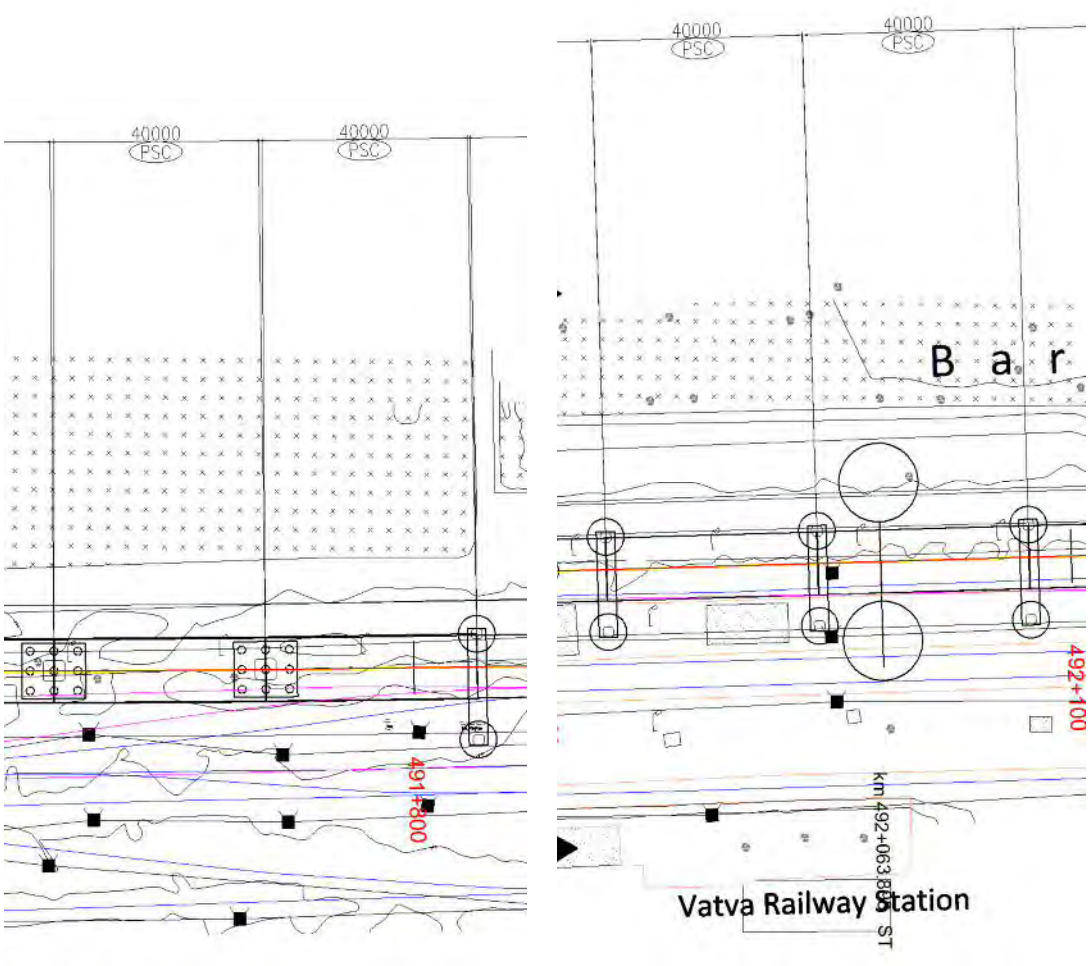
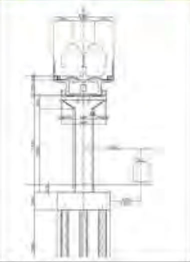
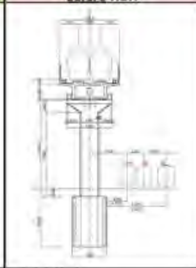
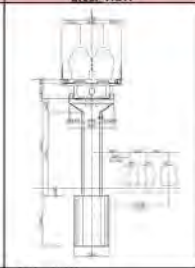
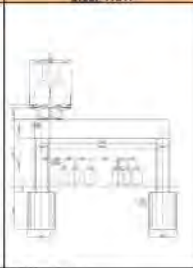


Figure 8.5.3-1 Plan Views at Examined Section

Table 8.5.3-1 Comparison Table for 491k772m

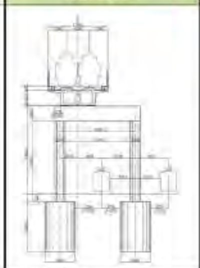
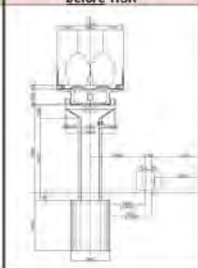
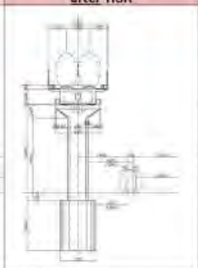
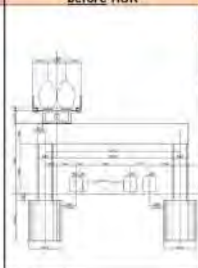
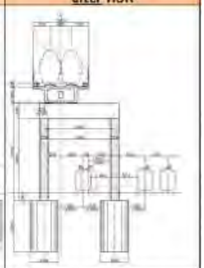
No. of cross section: ①–1 AP58

	HSR without 4th line	HSR with 4th line			
HSR Alignment	NO Alignment Change	Alignment Change		NO Alignment Change	
Construction of 4th line will start	Original Plan	Alternative ① before HSR	Alternative ② after HSR	Alternative ③ before HSR	Alternative ④ after HSR
Image of Sectional View					
Structure Type	PC Box Girder + Single Pier + Pile Foundation	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Portal + Caisson	PC Box Girder + Portal + Caisson
Outline of Sectional View		• Pier location results from clearance between the C/L of 4th line and the edge of caisson. • The structural C/L of pier, which causes alignment change, is shifted 3.9m toward east side from FS alignment.	• Pier location results from clearance between the C/L of 4th line and the edge of pier. • The structural C/L of pier, which causes alignment change, is shifted 3.9m toward east side from FS alignment.	• Single pier is changed to portal, and pier location of portal results from clearance between the C/L of 4th line and the edge of caisson. • The structural C/L of right pier is shifted 3.9m toward east side from FS structural C/L.	• Pier location results from clearance between the the edge of pier and the edge of pcbox Girder. • The structural C/L of right pier is shifted 2.5m toward east side from FS structural C/L.
Construction Methodology	- Substructure : Normal - Superstructure : Span by Span	- Substructure : Normal - Superstructure : Span by Span	- Substructure : Normal - Superstructure : Span by Span	- Substructure : Using large crane - Superstructure : Span by Span	- Substrucure : Using large crane - Superstructure : Span by Span

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is calculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

Table 8.5.3-2 Comparison Table for 492k052m

No. of cross section: ①–2 AP65

	HSR without 4th line	HSR with 4th line			
HSR Alignment	NO Alignment Change	Alignment Change		NO Alignment Change	
Construction of 4th line will start	Original Plan	Alterenative ① before HSR	Alterenative ② after HSR	Alterenative ③ before HSR	Alterenative ④ after HSR
Image of Sectional View					
Structure Type	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Portal + Caisson	PC Box Girder + Portal + Caisson
Outline of Sectional View		• Pier location results from clearance between the C/L of BG line and the edge of caisson. • The structural C/L of pier, which causes alignment change, is shifted 1.6m toward east side from FS alignment.	• Pier location results from clearance between the C/L of BG line and the edge of caisson. • The structural C/L of pier, which causes alignment change, is shifted 1.6m toward east side from FS alignment.	• Single pier is changed to poratal, and pier location of portal results from clearance between the C/L of BG line and the edge of caisson. • The structural C/L is equal to the FS alignment.	• Pier location results from clearance between the C/L of 4th line and the edge of pier. • The structural C/L is equal to the FS alignment.
Construction Methodology	- Substructure : Using large crane - Superstructure : Span by Span	- Substructure : Normal - Superstructure : Span by Span	- Substructure : Normal - Superstructure : Span by Span	- Substructure : Using large crane - Superstructure : Span by Span	- Substructure : Using large crane - Superstructure : Span by Span

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(2) 495k400m to 495k600m (Section : 495k487m)

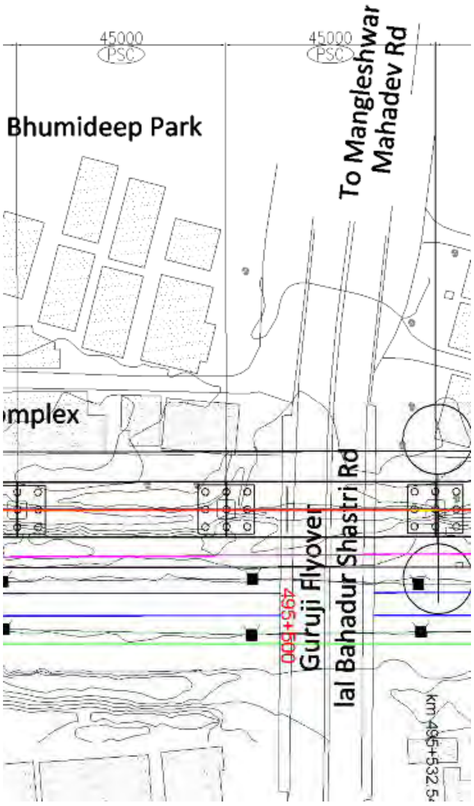
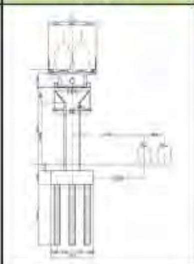
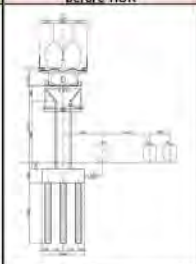
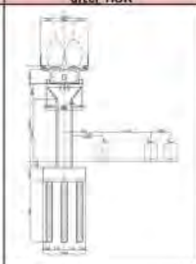
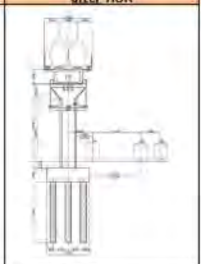


Figure 8.5.3-2 Plan View at Examined Section

Table 8.5.3-3 Comparison Table for 495k487m

No. of cross section: ② AP150

	HSR without 4th line	HSR with 4th line			
HSR Alignment	NO Alignment Change	Alignment Change		NO Alignment Change	
Construction of 4th line will start	Original Plan	Alternative ① before HSR	Alternative ② after HSR	Alternative ③ before HSR	Alternative ④ after HSR
Image of Sectional View					
Structure Type	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Portal + Caisson	PC Box Girder + Single Pier + Caisson
Outline of Sectional View		・Pier location results from clearance between the C/L of 4th line and the edge of pile foundation. ・The structural C/L of pier, which causes alignment change, is shifted 3.5m toward east side from FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L of pier, which causes alignment change, is shifted 3.5m toward east side from FS alignment.	・Single pier is changed to portal, and pier location of portal results from clearance between the C/L of 4th line and the edge of caisson. ・The structural C/L of pier, which causes alignment change, is shifted 1.5m toward east side from FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L is equal to the FS alignment.
Construction Methodology	- Substructure : Normal - Superstructure : Span by Span	- Substructure : Normal - Superstructure : Span by Span	- Substructure : Normal - Superstructure : Span by Span	- Substructure : Using large crane - Superstructure : Span by Span	- Substructure : Using large crane - Superstructure : Span by Span

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(3) 496k000m to 497k100m (Sections : 497k006m and 497k084m)

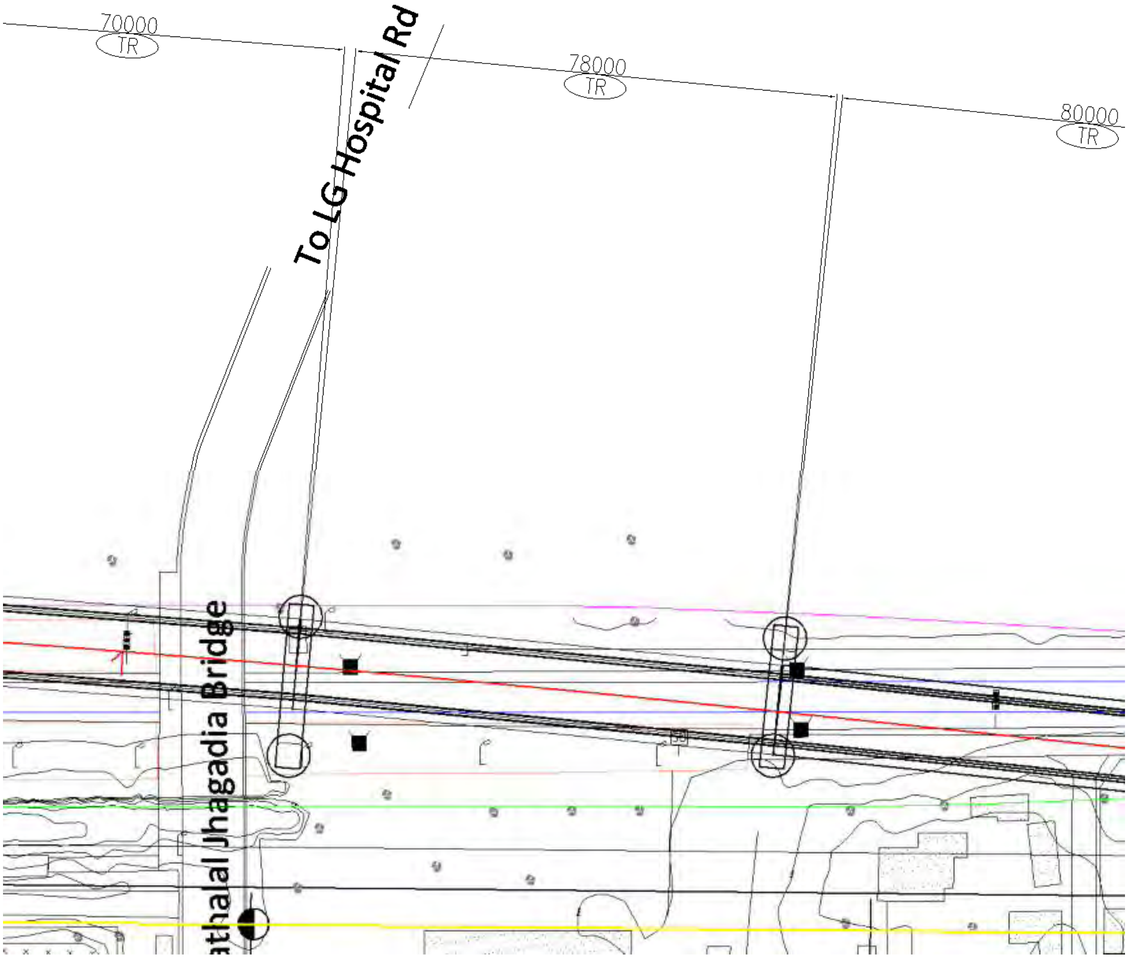
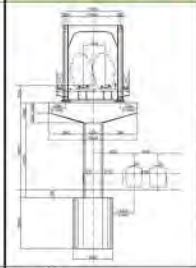
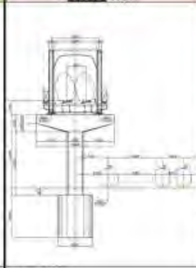
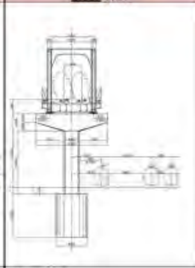
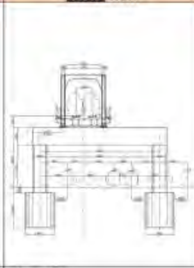
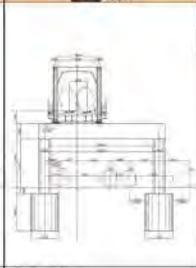


Figure 8.5.3-3 Plan Views at Examined Section

Table 8.5.3-4 Comparison Table for 497k006m

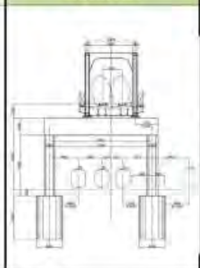
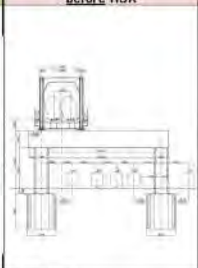
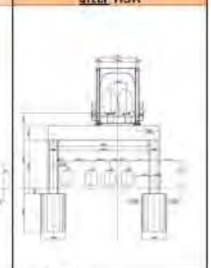
No. of cross section: ③−1 AP186

	HSR without 4th line	HSR with 4th line			
HSR Alignment	**NO Alignment Change**	**Alignment Change**		**NO Alignment Change**	
Construction of 4th line will start	**Original Plan**	**Alterenative ①** **before HSR**	**Alterenative ②** **after HSR**	**Alterenative ③** **before HSR**	**Alterenative ④** **after HSR**
Image of Sectional View					
Structure Type	Truss Girder + Single Pier + Caisson	Truss Girder + Single Pier + Caisson	Truss Girder + Single Pier + Caisson	Truss Girder + Single Pier + Caisson	Truss Girder + Single Pier + Caisson
Outline of Sectional View		・Pier location results from clearance between the C/L of 4th line and the edge of caisson ・The structural C/L of pier, which causes alignment change, is shifted 12.1m toward east side from FS alignment	・Pier location results from clearance between the C/L of 4th line and the edge of caisson ・The structural C/L of pier, which causes alignment change, is shifted 12.1m toward east side from FS alignment	・Single pier is changed to poratal, and pier location of portal results from clearance between the C/L of 4th line and the edge of caisson ・The structural C/L is equal to the FS alignment	・Pier location results from clearance between the C/L of 4th line and the edge of pier ・The structural C/L is equal to the FS alignment
Construction Methodology	− Substructure : Neighboring Work to existing line at Station − Superstructure : Sliding and Launching Method	− Substructure : Neighboring Work to existing line at Station − Superstructure : Sliding and Launching Method	− Substructure : Neighboring Work to existing line at Station − Superstructure : Sliding and Launching Method	− Substructure : Using large crane − Superstructure : Sliding and Launching Method	− Substructure : Using large crane − Superstructure : Sliding and Launching Method

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

Table 8.5.3-5 Comparison Table for 497k084m

No. of cross section: ③−2 AP190

	HSR without 4th line	HSR with 4th line			
HSR Alignment	**NO Alignment Change**	**Alignment Change**		**NO Alignment Change**	
Construction of 4th line will start	**Original Plan**	**Alterenative ①** **before HSR**	**Alterenative ②** **after HSR**	**Alterenative ③** **before HSR**	**Alterenative ④** **after HSR**
Image of Sectional View					
Structure Type	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson
Outline of Sectional View		・Pier location results from clearance between the C/L of 4th line and the edge of caisson ・The structural C/L of pier, which causes alignment change, is shifted 17.5m toward east side from FS alignment	・Pier location results from clearance between the C/L of 4th line and the edge of caisson ・The structural C/L of pier, which causes alignment change, is shifted 17.5m toward east side from FS alignment	・Pier location results from clearance between the C/L of 4th line and the edge of caisson ・The structural C/L is equal to the FS alignment	・Pier location results from clearance between the C/L of 4th line and the edge of pier ・The structural C/L is equal to the FS alignment
Construction Methodology	− Substructure : Neighboring Work to existing line at Station − Superstructure : Sliding and Launching Method	− Substructure : Neighboring Work to existing line at Station − Superstructure : Sliding and Launching Method	− Substructure : Neighboring Work to existing line at Station − Superstructure : Sliding and Launching Method	− Substructure : Neighboring Work to existing line at Station − Superstructure : Sliding and Launching Method	− Substructure : Using large crane − Superstructure : Sliding and Launching Method

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(4) 497k950m to 498k050m (Section : 498k005m)

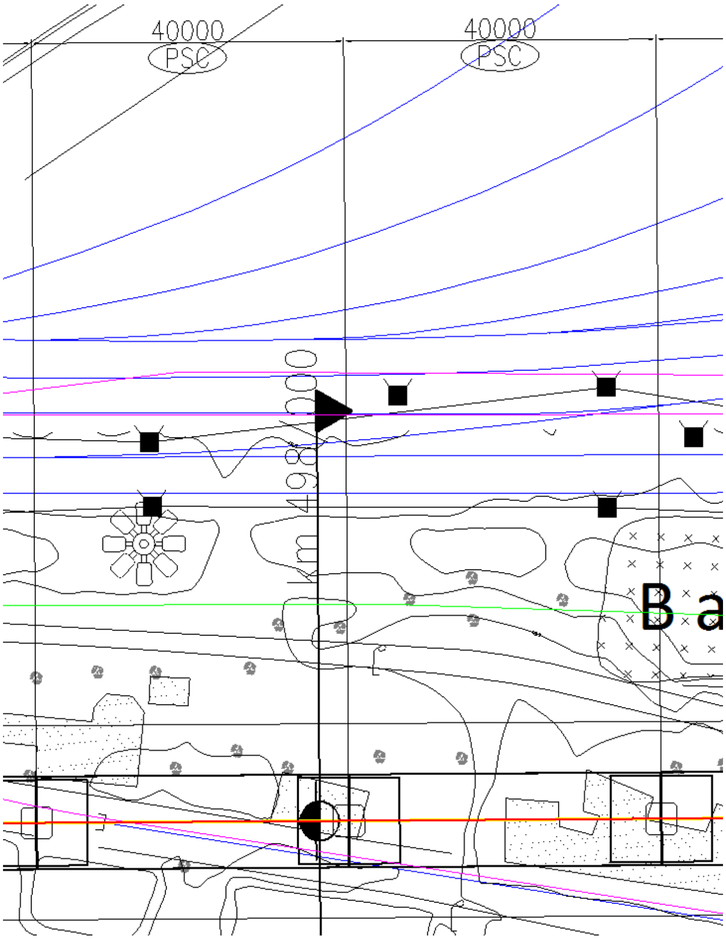
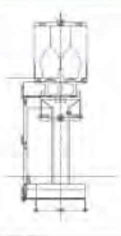
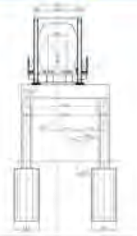


Figure 8.5.3-4 Plan View at Examined Section

Table 8.5.3-6 Comparison Table for 498k005m

No. of cross section: ④ AP213

	HSR without 4th line	HSR with 4th line			
HSR Alignment	NO Alignment Change	Alignment Change		NO Alignment Change	
Construction of 4th line will start	Original Plan	Alternative ① before HSR	Alternative ② after HSR	Alternative ③ before HSR	Alternative ④ after HSR
Image of Sectional view					
Structure Type	PC Box Girder + Single Pier + Spread			Truss Girder + Portal Pier + Caisson	PC Box Girder + Portal Pier + Caisson
Outline of Sectional View				· Single Pier is changed to portal. · Pier location of portal results from width of portal.	· Single Pier is changed to portal. · Pier location of portal results from width of portal.
Construction Methodology	- Substructure : Normal - Superstructure : Sliding and Launching Method			- Substructure : Using large crane - Superstructure : Sliding and Launching Method	- Substructure : Using large crane - Superstructure : Sliding and Launching Method

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(5) 499k330m to 499k680m (Section : 499k485m)

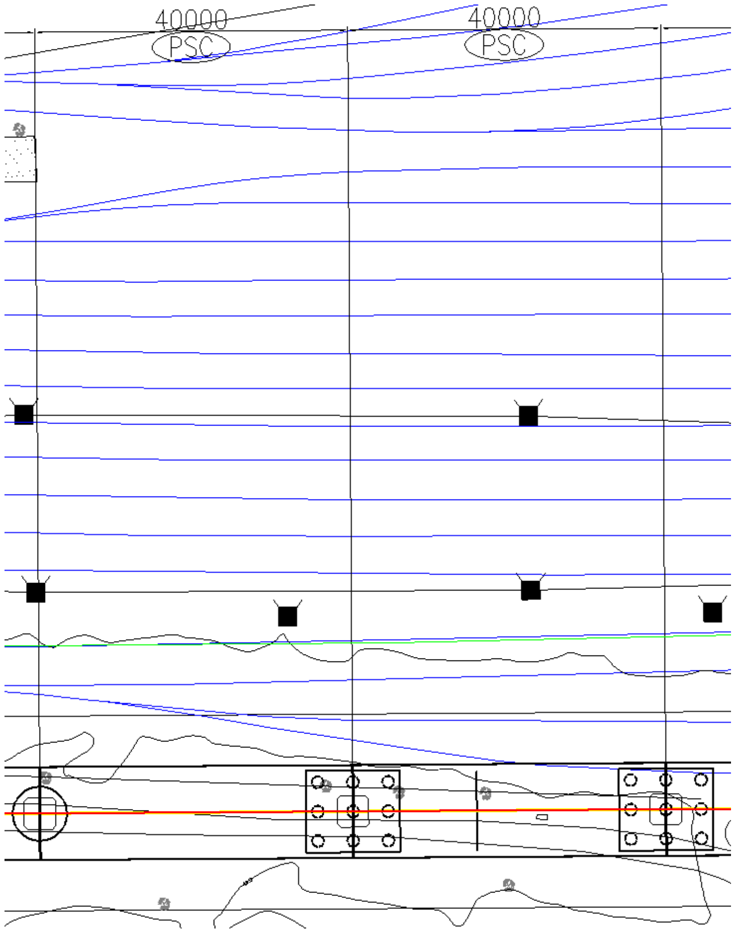
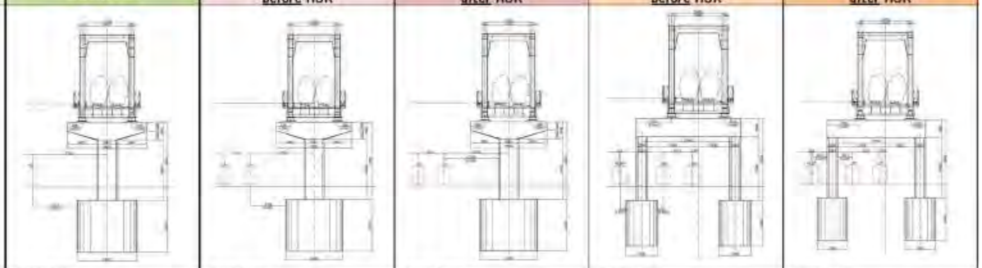


Figure 8.5.3-5 Plan View at Examined Section

Table 8.5.3-7 Comparison Table for 499k485m

No. of cross section: ⑤ Station AP7

	HSR without 4th line	HSR with 4th line			
HSR Alignment	**NO Alignment Change**	**Alignment Change**		**NO Alignment Change**	
Construction of 4th line will start	**Original Plan**	**Alternative ① before HSR**	**Alternative ② after HSR**	**Alternative ③ before HSR**	**Alternative ④ after HSR**
Image of Sectional View					
Structure Type	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson
Outline of Sectional View		+ Pier location results from clearance between the C/L of 4th line and the edge of caisson. + The structural C/L of pier, which causes alignment change, is shifted 14.5m toward west side from FS alignment.	+ Pier location results from clearance between the C/L of 4th line and the edge of caisson. + The structural C/L of pier, which causes alignment change, is shifted 14.5m toward west side from FS alignment.	+ Single pier is changed to poratal, and pier location of portal results from clearance between the C/L of 4th line and the edge of caisson. + The structural C/L is equal to the FS alignment.	+ Single pier is changed to poratal, and pier location of portal results from clearance between the C/L of 4th line and the edge of caisson. + The structural C/L is equal to the FS alignment.
Construction Methodology	- Substructure : Neighboring Work to existing line at Station - Superstructure : Sliding and Launching Method	- Substructure : Neighboring Work to existing line at Station - Superstructure : Sliding and Launching Method	- Substructure : Neighboring Work to existing line at Station - Superstructure : Sliding and Launching Method	- Substructure : Neighboring Work to existing line at Station - Superstructure : Sliding and Launching Method	- Substructure : Neighboring Work to existing line at Station - Superstructure : Sliding and Launching Method

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(6) 500k100m to 500k250m (Section : 500k130m)

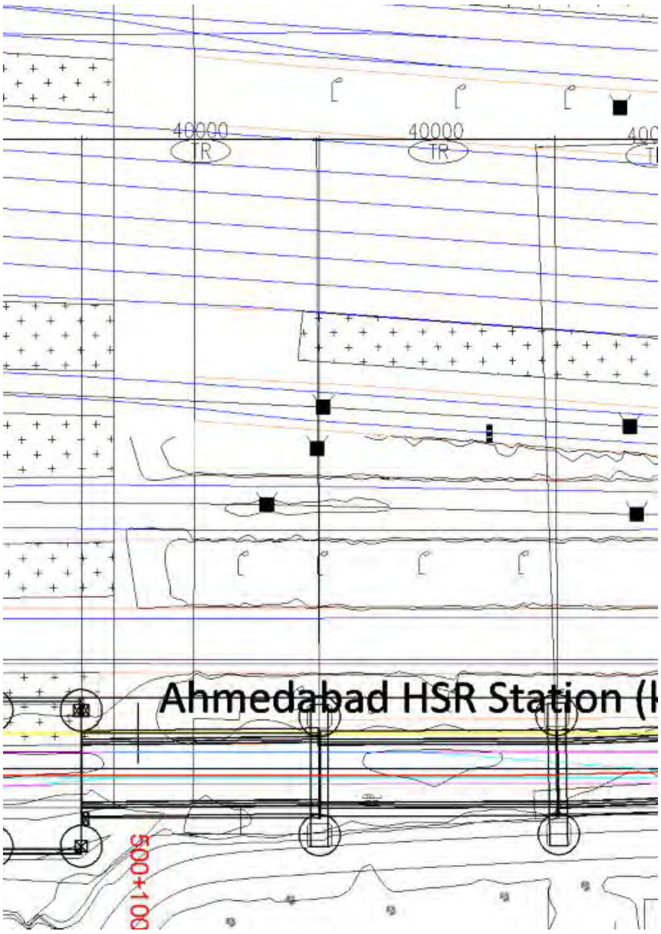
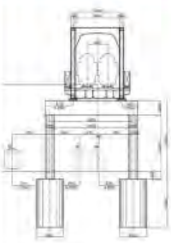
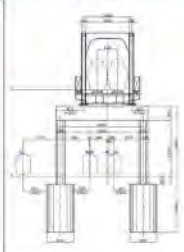
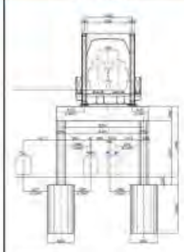


Figure 8.5.3-6 Plan View at Examined Section

Table 8.5.3-8 Comparison Table for 500k130m

No. of cross section: ⑥ Station AP17

	HSR without 4th line	HSR with 4th line			
HSR Alignment	NO Alignment Change	Alignment Change		NO Alignment Change	
Construction of 4th line will start	Original Plan	Alterenative ① before HSR	Alterenative ② after HSR	Alterenative ③ before HSR	Alterenative ④ after HSR
Image of Sectional View					
Structure Type	Truss Girder + Portal + Caisson			Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson
Outline of Sectional View				· Single pier is changed to poratal and pier location of portal results from clearance between the C/L of 4th line and the edge of caisson. · The structural C/L is equal to the FS alignment.	· Single pier is changed to poratal and pier location of portal results from clearance between the C/L of 4th line and the edge of caisson. · The structural C/L is equal to the FS alignment.
Construction Methodology	- Substructure : Neighboring Work to existing line at Station - Superstructure : Using crane			- Substructure : Neighboring Work to existing line at Station - Superstructure : Using crane	- Substructure : Neighboring Work to existing line at Station - Superstructure : Using crane

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(7) 500k580m to 500k700m (Section : 500k580m)

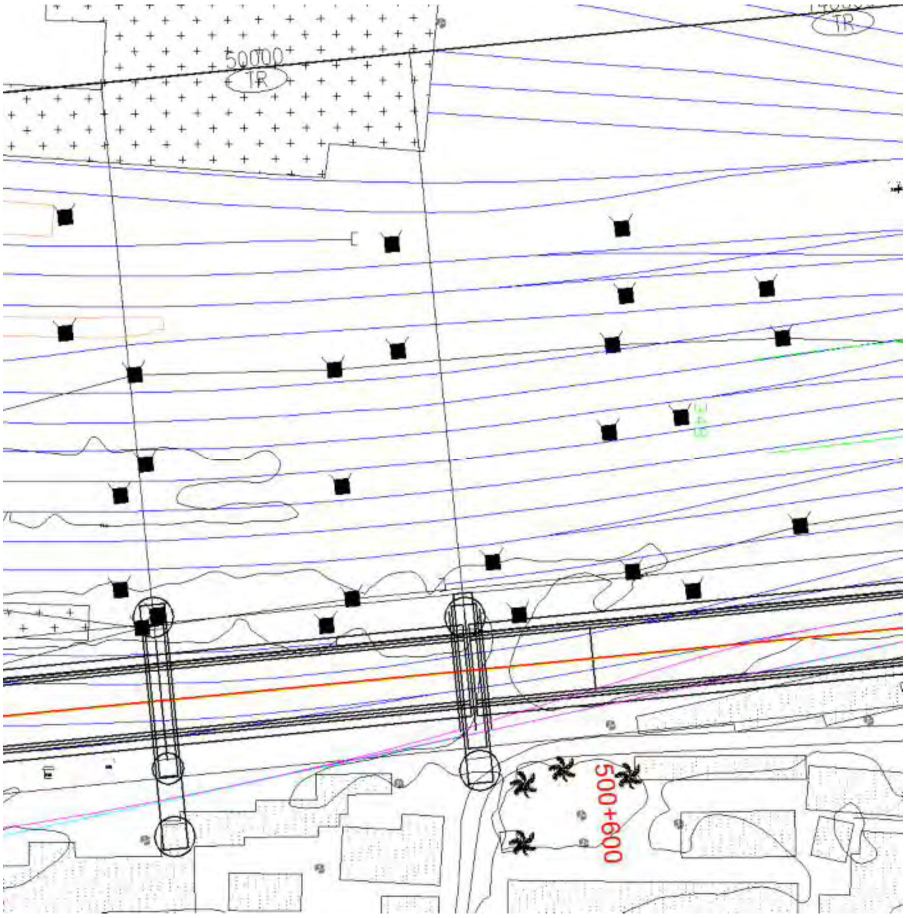
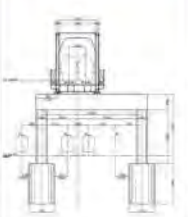
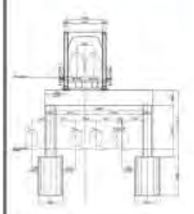
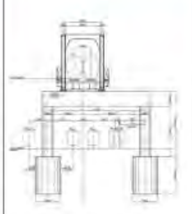
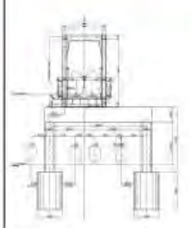
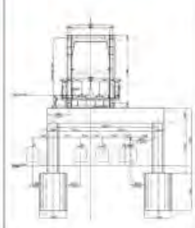


Figure 8.5.3-7 Plan View at Examined Section

Table 8.5.3-9 Comparison Table for 500k580m

No. of cross section: ⑦ Station AP24

	HSR without 4th line	HSR with 4th line			
HSR Alignment	NO Alignment Change	Alignment Change		NO Alignment Change	
Construction of 4th line will start	Original Plan	Alterenative ① before HSR	Alterenative ② after HSR	Alterenative ③ before HSR	Alterenative ④ after HSR
Image of Sectional View					
Structure Type	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson	Truss Girder + Portal + Caisson
Outline of Sectional View		- Pier location results from clearance between the C/L of MG line and the edge of caisson. - The structural C/L is equal to the FS alignment.	- Pier location results from clearance between the C/L of MG line and the edge of caisson. - The structural C/L is equal to the FS alignment.	- Pier location results from clearance between the C/L of MG line and the edge of caisson. - The structural C/L is equal to the FS alignment.	- Pier location results from clearance between the C/L of MG line and the edge of caisson. - The structural C/L is equal to the FS alignment.
Construction Methodology	- Substructure : Neighboring Work to existing line at Station - Superstructure : Launching Method	- Substructure : Neighboring Work to existing line at Station - Superstructure : Launching Method	- Substructure : Neighboring Work to existing line at Station - Superstructure : Launching Method	- Substructure : Neighboring Work to existing line at Station - Superstructure : Launching Method	- Substructure : Neighboring Work to existing line at Station - Superstructure : Launching Method

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is calculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(8) 500k980m to 501k330m (Section : 501k218m)

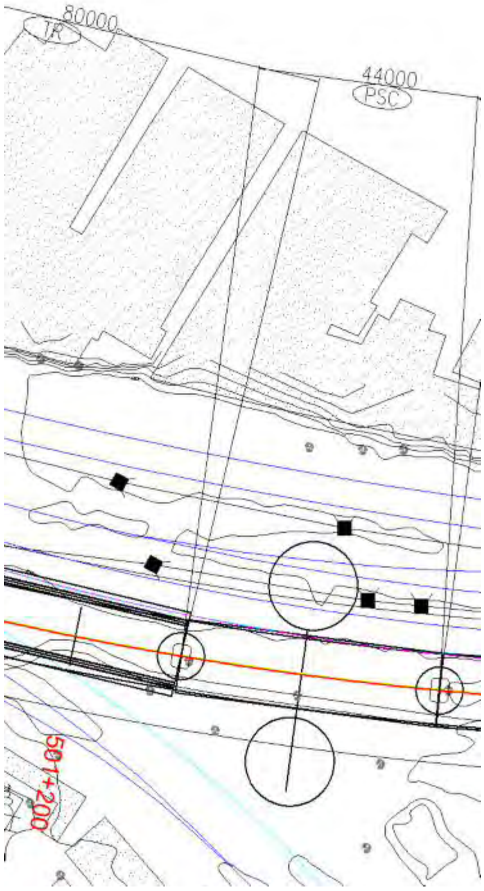
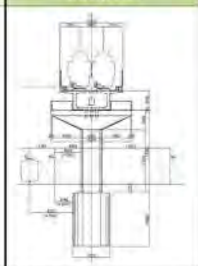
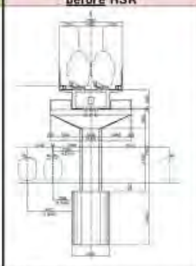
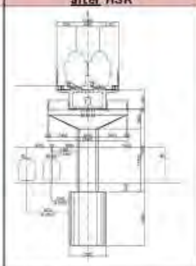
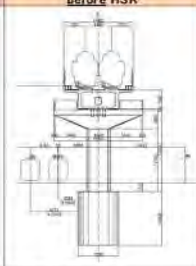
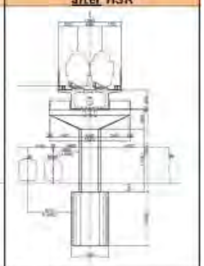


Figure 8.5.3-8 Plan View at Examined Section

Table 8.5.3-10 Comparison Table for 501k218m

No. of cross section: ⑧ AP244

	HSR without 4th line	HSR with 4th line			
HSR Alignment	NO Alignment Change	Alignment Change		NO Alignment Change	
Construction of 4th line will start	Original Plan	Alternative ① **before** HSR	Alternative ② **after** HSR	Alternative ③ **before** HSR	Alternative ④ **after** HSR
Image of Sectional View					
Structure Type	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson
Outline of Sectional View		・Pier location results from clearance between the C/L of 4th line and the edge of caisson. ・The structural C/L of pier, which causes alignment change, is shifted 0.15m toward west side from FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L is equal to the FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L is equal to the FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L is equal to the FS alignment.
Construction Methodology	– Substructure : Normal – Superstructure : Span by Span	– Substructure : Neighboring Work to existing line at Station – Superstructure : Sliding and Launching Method	– Substructure : Neighboring Work to existing line at Station – Superstructure : Sliding and Launching Method	– Substructure : Neighboring Work to existing line at Station – Superstructure : Sliding and Launching Method	– Substructure : Neighboring Work to existing line at Station – Superstructure : Sliding and Launching Method

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(9) 501k500m to 503k100m (Section : 501k897m)

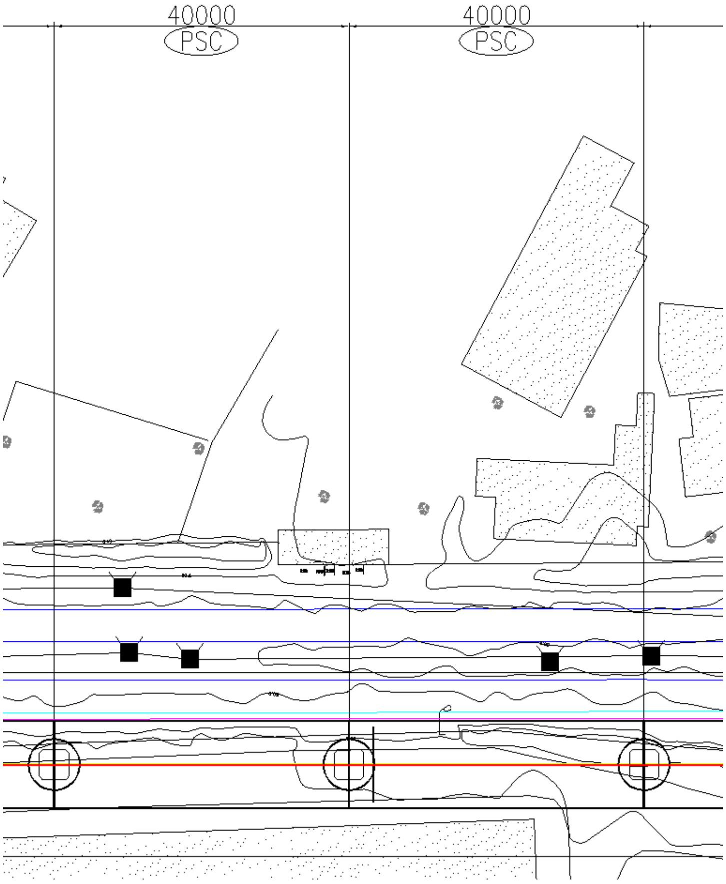
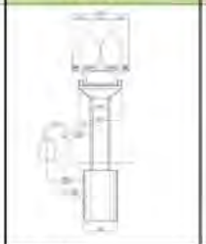
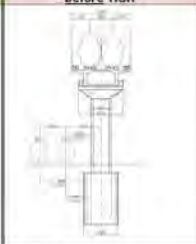
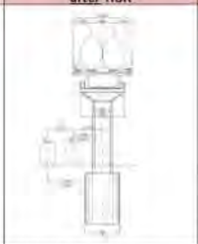
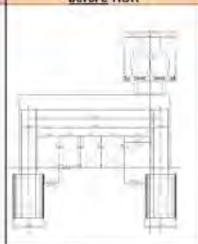


Figure 8.5.3-9 Plan View at Examined Section

Table 8.5.3-11 Comparison Table for 501k897m

No. of cross section: ⑨ AP261

	HSR without 4th line	HSR with 4th line			
HSR Alignment	**NO Alignment Change**	**Alignment Change**		**NO Alignment Change**	
Construction of 4th line will start	**Original Plan**	**Alterenative ① before HSR**	**Alterenative ② after HSR**	**Alterenative ③ before HSR**	**Alterenative ④ after HSR**
Image of Sectional View					
Structure Type	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Portal + Caisson	PC Box Girder + Single Pier + Caisson
Outline of Sectional View		・Pier location results from clearance between the C/L of 4th line and the edge of caisson. ・The structural C/L of pier, which causes alignment change, is shifted 1.3m toward east side from FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L is accordingly equal to the FS alignment taking into consideration of clearance between the C/L of 4th line and the edge of pier.	・Single pier is changed to portal, and pier location of portal results from clearance between the C/L of 4th line and the edge of caisson. ・The structural C/L of right pier is shifted 1.2m toward east side from FS structural C/L.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L is equal to the FS alignment.
Construction Methodology	- Substructure : Neighboring Work to existing line - Superstructure : Span by Span	- Substructure : Neighboring Work to existing line - Superstructure : Span by Span	- Substructure : Neighboring Work to existing line - Superstructure : Span by Span	- Substructure : Neighboring Work to existing line - Superstructure : Span by Span	- Substructure : Neighboring Work to existing line - Superstructure : Span by Span

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is calculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

(10) 503k440m to 504k240m (Section : 503k663m)

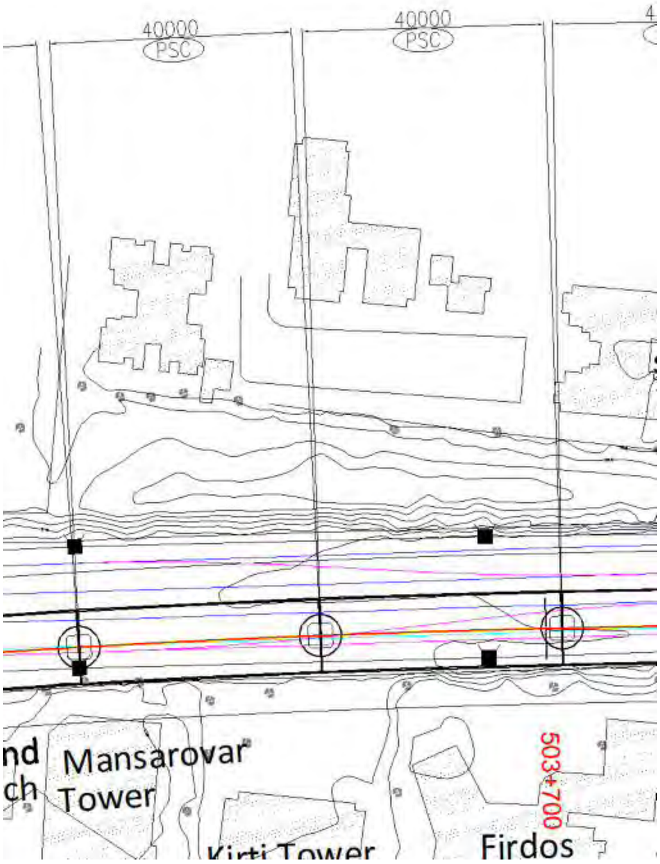
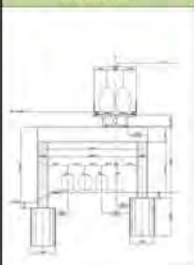
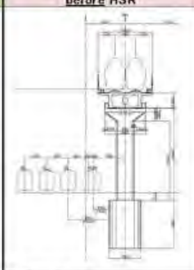
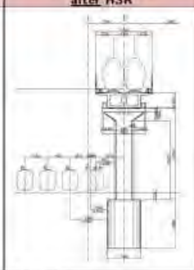
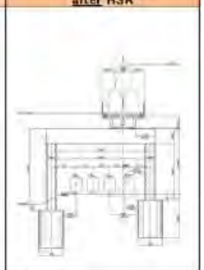


Figure 8.5.3-10 Plan View at Examined Section

Table 8.5.3-12 Comparison Table for 503k663m

No. of cross section: ⑩ AP306

	HSR without 4th line	HSR with 4th line			
HSR Alignment	NO Alignment Change	Alignment Change		NO Alignment Change	
Construction of 4th line will start	Original Plan	Alternative ① **before** HSR	Alternative ② **after** HSR	Alternative ③ **before** HSR	Alternative ④ **after** HSR
Image of Sectional View					
Structure Type	PC Box Girder + Portal Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Single Pier + Caisson	PC Box Girder + Portal + Caisson	PC Box Girder + Portal + Caisson
Outline of Sectional View		・Pier location results from clearance between the C/L of 4th line and the edge of caisson. ・The structural C/L of pier, which causes alignment change, is shifted 8.6m toward west side from FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of caisson. ・The structural C/L of pier, which causes alignment change, is shifted 7.5m toward west side from FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L is equal to the FS alignment.	・Pier location results from clearance between the C/L of 4th line and the edge of pier. ・The structural C/L is equal to the FS alignment.
Construction Methodology	- Substructure : Neighboring Work to underpass - Superstructure : Span by Span	- Substructure : Neighboring Work to underpass - Superstructure : Span by Span	- Substructure : Neighboring Work to underpass - Superstructure : Span by Span	- Substructure : Neighboring Work to underpass - Superstructure : Span by Span	- Substructure : Neighboring Work to underpass - Superstructure : Span by Span

【NOTES】
Detail of structure type, span construction methodology etc. is likely to be modified based on the result of detailed design because the result mentioned above is culculated as the preliminary study.
The construction methodology mentioned above is likely to be changed based on planning construction execution.

Chapter 9 Training Programme in Japan

9.1 Objective of Training

The Ministry of Railways formed a new Special Purpose Vehicle (SPV) in February 2016 named the National High Speed Rail Corporation Limited (NHSRCL) to implement the Project for the Mumbai-Ahmedabad High Speed Railway (MAHSR). The objective of this training was to invite the executive directors of NHSRCL to Japan and develop their understanding of the “Technical & Design Standards” and “Station Area Development” for implementing the first HSR project in India.

9.2 Target Persons for Training

The objective of this training was to train the NHSRCL’s executive officials such as general managers, directors and others concerned for the first HSR project in India. The target number of trainees were 20 (Twenty). The training programme was organized twice. Each training programme was comprised of 10 (Ten) trainees. The trainees were selected by Commission of Railway Safety, MOR and/or NHSRCL.

The number and background of the trainees are shown in Table 9.2-1.

Table 9.2-1 Number & Background of Trainees

Background	Number (person)	
	1st training	2nd training
Civil and Track Engineering/ Maintenance	4	6
Rolling Stock	1	2
Power Supply	2	
Signaling and Telecommunication	1	
Transport Planning	1	1
HR & Administration	1	1[1]
Total	10	10

9.3 Training Programme Execution

9.3.1 General overview of the Training Programmes

The training programme was designed to organize twice. The 1st Training Programme was executed in July 2017, and the 2nd Training Programme was executed in October 2017. The execution plan of both training programmes is highlighted below.

(1) Overview of the Training Programme

The objective of the training programme was to enhance capacity of NHSRCL executive officials through lectures and site visits concerning Shinkansen.

It was essential that the executive officials at NHSRCL understood not only technical area-specific matters but also overall management issues in order to establish an effective high speed railway management structure. Japanese practices on Shinkansen management were considered as good examples. During First Week, lectures and site visits were organized in accordance with

[1] The trainee (HR & Administration) could not participate in the 1st week of the 2nd Training Programme because of health reason.

management aspect(s) of high speed railway. During Second Week, lectures and site visits were conducted in accordance with operational and maintenance aspect(s) as per technical area-specific needs on the ground. Table 9.3.1-1 shows the general information of each programme.

Table 9.3.1-1 General information of each training programme

	The 1st Training Programme	The 2nd Training Programme
Training period (including the travel dates)	2nd July (Sun) – 15th July (Sat) 2017 (14 days)	1st October (Sun) – 14th October (Sat) 2017 (14 days)
Training period	3rd July (Mon) – 14th July (Fri) 2017 (12 days)	2nd October (Mon) – 13th October (Fri) 2017 (12 days)
Cooperating Organizations	• Ministry of Land, Infrastructure, Transport and Tourism (MLIT) • Japan International Cooperation Agency (JICA) • Kotsu Kyoryoku Kai • Japan Railway Construction, Transport and Technology Agency (JRTT) • Railway Technical Research Institute • East Japan Railway Company (JR-East) • Japan Railway Technical Service • JR-East Personnel Service Co., Ltd. • Tekken Corporation • Kawasaki Heavy Industries, Ltd. – Hyogo Works • Hitachi – Mito Works • Totetsu Kogyo Co., Ltd.	• MLIT • JICA • JRTT • JR-East • Japan Railway Technical Service • Kotsu Kyoryoku Kai • JR-East Personnel Service Co., Ltd. • Kawasaki Heavy Industries, Ltd. • Toa Road Corporation
Groups	5 (① HR & Administration, ② Transport Planning, ③ Civil and Track Engineering, ④Rolling Stock & Power Supply, ⑤ Signaling & Telecommunication)	4 (① HR & Administration, ② Transport Planning, ③ Civil and Track Maintenance, ④ Rolling Stock)

(2) Training Curriculum

First Week of the training programme was applicable for all trainees. Second Week of the programme was organized in accordance with the area(s) of specialisation. During the course of the curriculum development, JIC collected feedback from NHSRCL side (from each group) on the draft version of the curriculum. As a result, the final version of the curriculum for each programme was prepared with consideration of the feedback from each group.

9th October 2017 was a Japanese national holiday. Hence, JIC faced some difficulties in finalizing the programme for 9th October 2017. As a result of the discussion with JR East, a site survey of "JR-East General Education Center" was organized.

9.3.2 The 1^{st} Training Programme Itinerary

Table 9.3.2-1 shows the list of the 1^{st} Training Programme participants, which was held in July 2017.

Table 9.3.2-1 The 1^{st} Training Programme Participants

	Area of Specialty	Name	Position, Organization
1	Civil and Track Engineering/ Maintenance	Mr. R. C. Thakur	Executive Director (Infrastructure/Civil), MOR
2		Mr. Ajay Kumar	Director (Track-II) (Research Design & Standard Organization: RDSO), Indian Railways, MOR
3		Mr. U. P. Singh	Chief Project Manager (Engineering/Mumbai), MOR
4		Mr. Amit Singh	Deputy General Manager (Civil), NHSRCL
5	Rolling Stock & Power Supply	Mr. Sushil Chandra	Commissioner (Western Circle), Commission of Railways Safety
6		Mr. Prashant Mishra	General Manager (Electrical), NHSRCL
7		Mr. Neeraj Verma	Director (RDSO), Indian Railways, MOR
8	Signaling & Telecommunication	Mr. Alok Katiyar	General Manager (Signal & Telecommunication), NHSRCL、
9	Transport Planning	Mr. Pankaj Uke	Senior Division Commercial Manager (Traffic), MOR
10	HR & Administration	Mr. Ravindra Kumar	General Manager (Human Resources), NHSRCL

Table 9.3.2-2 shows the itinerary of the 1^{st} Training Programme, which were held in July 2017.

Table 9.3.2-2 The 1^{st} Training Programme Itinerary

Date	Day	Time			Programme	Host organization	Venue
2^{nd} July	Sun	13:00	-		Arrival to Narita, Japan		
		17:00	-	18:00	JICA briefing	JICA	JIC HQ
3^{rd} July	Mon	10:30	-	11:00	Courtesy call on MILT, plus discussion	MILT	MILT
		11:00	-	11:40	Lecture by JRTT	JRTT	MILT
		13:00	-	13:55	Orientation		JR-East HQ
		14:00	-	14:45	Courtesy call on JR-East, plus discussion	JR-East	JR-East HQ
		15:00	-	16:20	Management of JR-East	JR-East	JR-East HQ
		17:00	-	17:30	Courtesy call on JICA HQ	JICA	JICA HQ
		18:00	-	19:00	Welcome Party	JICA	Housou Kaikan
4^{th} July	Tues	10:00	-	11:20	Site visit to Shinkansen Transport Dept.	JR-East	Omiya
		12:02	-	13:37	Transfer from Omiya to Sendai by Shinkansen		
		14:15	-	16:30	Site visit to General Rolling Stock Maintenance Center	JR-East	Shin-Rishi
		17:57	-	19:32	Transfer from Sendai to Tokyo by Shinkansen		
5^{th} July	Wed	09:50	-	10:50	Site visit to Ueno Shinkansen Train Drivers' Dept.	JR-East	Ueno
		11:14	-	12:36	Transfer from Ueno to Shin-Shirakawa		
		13:00	-	16:30	Site visit to JR-East General Education Center	JR-East	Shin-Shirakawa
		17:47	-	19:16	Transfer from Shin-Shirakawa to Tokyo		
6^{th} July	Thur	09:20	-	10:30	Lecture on JR-East electrical facilities and equipment	JR-East	JR-East HQ
		10:40	-	11:50	Lecture on Transport & Rolling Stock Dept.	JR-East	JR-East HQ

		13:00	-	14:10	Lecture on Maintenance of Ground Facilities Dept.	JR-East	JR-East HQ
		14:20	-	15:30	Lecture on Safety Measures	JR-East	JR-East HQ
		15:40	-	16:50	Lecture on Shinkansen – the half century	Kotsu Kyoryoku Kai Foundation	JR-East HQ
		17:00	-	18:10	Lecture on Customer Services	JR-East	JR-East HQ
		23:00	-	05:00 (next day)	<Rolling Stock & Power Supply Group> Site survey of overnight works	JR-East	Tabata
7th July	Fri	10:00	-	12:00	Site visit to Tokyo Station	JR-East	Tokyo
		14:00	-	15:00	Site visit to Omiya Signal & Telecommunication Technology Center	JR-East	Omiya
		15:30	-	17:00	Site visit to Omiya Shinkansen Track Maintenance Technology Center	JR-East	Omiya
		23:00	-	03:00 (next day)	<All participants> Site survey of overnight maintenance works	JR-East	Oyama
10th July	Mon				<HR & Personnel> • Lecture on Maintenance Management of Shinkansen • facilities • Lecture by Transport & Rolling Stock Dept. • Lecture by Admin. Dept.	JR-East	JR-East HQ
					<Transportation Planning> Site visit to Ueno Shinkansen Train Drivers' Depot, lecture and tour of Drivers' Depot	JR-East	Ueno
					<Civil, Track & Facility Maintenance> • Lecture on Maintenance Management of Shinkansen facilities • Site visit to Washinomiya Shinkansen Track Maintenance Depot • Site visit to Omiya Shinkansen Track Maintenance Technology Center	JR-East	JR-East HQ, Omiya
					<Rolling Stock & Power Supply> • Lecture by Electrical & Signal Network System Dept. • Lecture by Shinkansen Transport Dept. • Site visit to Omiya Shinkansen Technical Center • Tour of Shin Omiya Transformer Substation Tour of Washinomiya Maintenance Depot	JR-East	JR-East HQ, Omiya, Washinomiya
					<Signaling & Telecommunication> • Lecture by Electrical & Signal Network System Dept. • Site visit to Omiya Signal & Telecommunication Technology Center	JR-East	JR-East HQ, Omiya
11th July	Tues				<HR & Personnel> • Ride on East-i • Site visit to Honjo Waseda Station	JR-East	Honjo Waseda
					<Transportation Planning> • Ride on East-i • Site visit to Marunouchi Conductors' Depot	JR-East	Tokyo
					<Civil, Track & Facility Maintenance> • Ride on East-i • Lecture by Shinkansen Transport Dept.	JR-East	Omiya
					<Rolling Stock & Power Supply> • Site visit to Railway Technical Research Institute • Site visit to Tokyo Power Distribution Technology Center • Ride on East-i • Site survey of overnight works (tour of Shinkansen compound, overhead crossing)	Railway Technical Research Institute, JR-East	Kunitachi, Tokyo, Kitakami
					<Signaling & Telecommunication> • Site visit to Railway Technical Research Institute • Discussion with JIC technical Signaling & Telecom Team • Ride on East-i	Railway Technical Research Institute, JIC, JR-East	Kunitachi, JIC HQ
12th July	Wed				<HR & Personnel> • Site visit to Omiya Station • Lecture by Personnel Dept.	JR-East	Omiya, JR-East HQ

		• Lecture by Marketing Dept.		
		<Transportation Planning> • Site visit to Omiya Station • Lecture by Shinkansen Transport Dept.	JR-East	Omiya
		<Civil, Track & Facility Maintenance> • Site visit to Tokyo Station (underground) • Lecture by Totetsu Kogyo Co., Ltd. • Site visit to Tekken Corporation	JR-East, Totetsu Kogyo Co., Ltd, Tekken Corporation	Tokyo, Shinano-machi, Narita
		<Rolling Stock & Power Supply> Site visit to Shinkansen Rolling Stock Maintenance Center	JR-East	Sendai
		<Signaling & Telecommunication> • Site visit to Tokyo Shinkansen Rolling Stock Center • Site visit to Hitachi Ltd. • Site visit to Shinkansen Facilities (site survey of overnight works)	JR-East, Hitachi Ltd.	Sendai, Mito, Omiya
13th July	Thur	<HR & Personnel> • Lecture on Planning Section at Shinkansen Transport Dept. • Lecture by Finance Dept. • Lecture by Health & Welfare Dept.	JR-East	Omiya, JR-East HQ
		<Transportation Planning> Lecture by Transport & Rolling Stock Dept.	JR-East	JR-East HQ
		<Civil, Track & Facility Maintenance> Site visit to Railway Overpass Construction Project near Niigata Station on the Shinetsu Line, on-site lecture	JR-East	Niigata
		<Rolling Stock & Power Supply> Site visit to Kawasaki Heavy Industries, Ltd.	Kawasaki Heavy Industries, Ltd.	Kobe
		<Signaling & Telecommunication> Lecture by Shinkansen Transport Dept.	JR-East	Omiya
14th July	Fri	09:30 - 10:30 Case study – Opening of Tohoku Shinkansen	JIC	JIC HQ
		10:30 - 11:30 Training for HSR staff	JIC	JIC HQ
		13:00 - 14:00 Formulation of Regulations and Rules for Operation & Maintenance	JIC	JIC HQ
		14:00 15:00 Group discussion	JIC	JIC HQ
		16:00 - 17:20 Seminar – presentation by Mr. Prashant	JARTS	Hotel Metropolitan Edmont
		17:30 - 18:30 Closing seminar	JARTS	Hotel Metropolitan Edmont

Please see below the photos, which were taken during the 1st Training Programme.

Courtesy call on JICA HQ

Courtesy call on JR-East HQ


Simulator trial at JR-East General Education Center


Tour of JR-East General Education Center


At Monitoring & Control Center of Mechanical Facilities in Tokyo Station (underground)


Last day of the training programme at JIC HQ

9.3.3 The 2nd Training Programme Itinerary

Table 9.3.3-1 shows the list of the 2nd Training Programme participants.

Table 9.3.3-1 The 2nd Training Programme Participants

	Area of Specialty	Name	Position, Organization
1	Civil and Track Engineering/ Maintenance	Mr. Pramod Kumar Acharya	Commissioner (Eastern Circle), Commission of Railway Safety
2		Mr. Anjum Pervez	Officer on Special Duty (Civil Engineering), NHSRCL
3		Mr. Heera Lal Suthar	Executive Director (Engineering), NHSRCL
4		Mr. Pradeep Ahirkar	Chief Project Manager(Engineering), Vadodara, NHSRCL、
5		Mr. Indudhara Sastry	General Manager (Contract), NHSRCL
6		Mr. Manoj Goyal	Deputy Chief Project Manager (Civil), NHSRCL
7	Rolling Stock	Mr. Sandeep Srivastava	General Manager (Electrical Rolling Stock), NHSRCL
8		Mr. Brijesh Dixit	Additional General Manager (Mechanical), NHSRCL
9	Transport Planning	Mr. Abhijit Narendra	Executive Director (Traffic & PPP, Railway Board), MOR
10	HR & Administration	Mr. Sanjay Sehgal	Joint General Manager (Corporate Coordination/Administration), NHSRCL

Table 9.3.3-2 shows the itinerary of the 2nd Training Programme, which were held in October 2017.

Table 9.3.3-2 The 2nd Training Programme Itinerary

Date	Day	Time			Programme	Host organisation	Venue
1st Oct.	Sun	08:45	-		Arrival to Narita, Japan		
		12:00	-	13:30	Welcome Lunch	JIC	Near JIC HQ

2nd Oct.	Mon	09:30	-	10:30	JICA Orientation	JICA	JICA HQ
		10:30	-	11:00	Courtesy call on JICA	JICA	JICA HQ
		11:30	-	12:00	Courtesy call on MILT	MILT	MILT
		13:30	-	14:20	Orientation	JR-East	JR-East HQ
		14:30	-	15:20	Courtesy call on JR-East	JR-East	JR-East HQ
		16:30	-	17:00	Seminar	JARTS	Housou Kaikan
		17:00	-	18:30	Welcome Party	JARTS	Housou Kaikan
3rd Oct.	Tues	10:00	-	12:00	Site visit to Tokyo Station	JR-East	Tokyo
		13:30	-	15:00	Lecture on Management of JR-East	JR-East	JR-East HQ
		15:10	-	15:50	Lecture on Points to be noted before making site visits	JR-East	JR-East HQ
		16:00	-	17:30	Lecture by Transport Safety Dept.	JR-East	JR-East HQ
4th Oct.	Wed	09:30	-	11:00	Lecture by Rolling Stock Dept.	JR-East	JR-East HQ
		11:10	-	12:40	Lecture by Customer Service Dept.	JR-East	JR-East HQ
		15:00	-	16:30	Lecture by JRTT	JRTT	JRTT HQ
		17:20	-	18:05	Site survey of Shin-Yokohama Station	JIC	Yokohama
5th Oct.	Thur	09:30	-	11:00	Lecture by Electrical & Signal Network System Dept.	JR-East	JR-East HQ
					<Transport Planning> Site visit to Takasaki Station & Takasaki Transportation Depot Site visit to Marunouchi Conductors' Depot	JR-East	JR-East HQ
					<Track & Civil Structure> Ride on East-i	JR-East	Sendai
					<Rolling Stock> Ride on East-i	JR-East	Sendai
6th Oct.	Fri	10:00	-	12:00	Site visit to Tokyo Station	JR-East	Tokyo
		14:00	-	15:00	Site visit to Omiya Signal & Telecommunication Technology Center	JR-East	Omiya
		15:30	-	17:00	Site visit to Omiya Shinkansen Track Maintenance Technology Center	JR-East	Omiya
		23:00	-	03:00 (next day)	<All participants> Site survey of overnight maintenance works	JR-East	Oyama
8th Oct.	Sun				<Track & Civil Structure – starting at 23:30> Overnight site survey: Exchange of movable nose crossing works	JR-East	Omiya
9th Oct.	Mon				<All> Site visit to JR-East General Education Center	JR-East	Shin-Shirakawa
					<Track & Civil Structure only – starting at 16:00> Lecture on civil and construction works by JR-East Structural Engineering Center	JR-East	JR-East HQ
10th Oct.	Tues				<HR & Personnel> • Lecture by Personnel Dept. • Site visit to Honjo Waseda Station	JR-East	Honjo Waseda
					<Transportation Planning> • Ride on East-i • Site visit to Marunouchi Conductors' Depot	JR-East	Tokyo
					< Track & Civil Structure> Site visit to tunnel construction work of Hokkaido Shinkansen	JRTT	Hakodate
					<Rolling Stock> • Site visit to Rolling Stock Maintenance Center • Overnight site survey (starting at 22:30): overnight works (e.g., Koriyama Station, Re-wiring of contact wire)	JR-East	Shin-rifu, Koriyama
11th Oct.	Wed				<HR & Personnel> • Lecture by Facility Dept. • Tour of JR-East SHINJUKU Station • Lecture by Administration Dept.	JR-East	Omiya, JR-East HQ
					<Transportation Planning> • Site visit to Omiya Station • Lecture by Shinkansen Transport Dept.	JR-East	Omiya
					<Track & Civil Structure> • Lecture by Facilities Dept. • Site visit to Shinkansen Transport Dept. • Site visit to Omiya Track Maintenance Technology Center • Overnight site survey (starting at 23:00): overnight work in Omiya	JR-East	Tokyo, Omiya
					<Rolling Stock>	JR-East	Sendai

		Site visit to Shinkansen Rolling Stock Maintenance Center					
12th Oct.	Thur	<HR & Personnel> • Lecture by Finance Dept. • Lecture by Marketing Dept. • Ride on East-i				JR-East	JR-East HQ, Sendai
		<Transportation Planning> • Site visit to Ueno Shinkansen Train Drivers' Depot, lecture and tour of Drivers' Depot • Ride on East-i				JR-East	Ueno, Sendai
		<Track & Civil Structure - A> Site visit to Railway Overpass Construction Project near Niigata Station on the Shinetsu Line, on-site lecture				JR-East	Niigata
		<Track & Civil Structure - B> Site visit to Toa Road Corporation				Toa Road Corporation	Tsukuba
		<Rolling Stock> Site visit to Kawasaki Heavy Industries, Ltd.				Kawasaki Heavy Industries, Ltd.	Kobe
13th Oct.	Fri	09:30	-	11:30	Lecture on "SHIKANSEN – the half century"	Kotsu Kyouryoku Kai	JIC HQ
		11:30	-	13:00	Lunch	JIC	Near JIC HQ
		13:10	-	14:00	Case study – Opening of Tohoku Shinkansen	JIC	JIC HQ
		14:00	-	14:10	Break	JIC	JIC HQ
		14:10	-	14:30	Lecture on Shinkansen EMU Development	JIC	JIC HQ
		14:30	-	14:45	Break	JIC	JIC HQ
		14:45	-	17:00	Group discussion	JIC	JIC HQ
		17:00	-	17:20	Travel to Housou Kaikan		
		17:30	-	18:30	Closing seminar	JICA	Hosou Kaikan

Please see below the photos, which were taken during the 2nd Training Programme.

Courtesy call on MILT

Riding East-i during the Training Programme

Site survey at SHIN HAKODATE HOKUTO – tunnel construction site

Site survey at KAWASAKI Heavy Industries, Ltd.

Site survey at JR ODAWARA Station

Lecture at JIC HQ on the last day of the Training Programme

9.3.4 Outputs of the Training Programme

Most of the trainees have had a certain level of understanding on Shinkansen through the consulting service(s) provided by Japanese side in India. After the 1st and the 2nd Training Programmes, the level of understanding and knowledge on SHNKANSEN from technical and management aspects by the trainees has been significantly increased. The main outputs of the two programmes are listed below:

- Deepening the understanding and knowledge on overall Shinkansen system
- Understanding of how to secure safety and punctual operation of Shinkansen
- Understanding of the importance of separating maintenance hours from operation hours, in order to secure appropriate maintenance of Shinkansen
- Understanding of the responsibilities, roles, staffing and functions of each staff at Shinkansen Transport Department
- Understanding of area of responsibilities for JR-East as well as outsourcing work(s)
- Understanding of the importance given to capacity development of staff and contents of training programme(s)

9.3.5 Application of the Outputs

Both Japanese and Indian sides are expected to adopt the outputs of the training programme. Table 9.3.4-1 shows the expected actions from both sides. The table below includes lessons learned from the 1st Training Programme, which JIC shall take into consideration when planning and organizing the 2nd Training Programme.

Table 9.3.5-1 The Expected Application from Both Sides

Japanese Side	Indian Side
• Training purpose: prepare a training guidance, so that Indian side will have better understanding of the training purpose • Training curriculum: allocate more time for Q & A • Utilize the relationships built and/or strengthened between Japanese and Indian sides through the training programme in Japan for more effective and efficient implementation of the projects.	• Training purpose: understand the importance of knowledge enhancement on management issues in addition to area of interest/specialties as executive officials • Disseminate the knowledge and information on Shinkansen operation and maintenance within India • Apply Japanese case studies and/or models introduced to Indian side for organizational development of NHSRCL (e.g., staff training) • Utilize the relationships built and/or strengthened between Japanese and Indian sides through the training programme in Japan for more effective and efficient implementation of the projects.

9.3.6 Remarks

On 21st July 2017, the 12th Technical Meeting on HSR was held in India. During the Meeting, JIC made a brief reporting on the 1st training programme. The followings are the highlight of what was reported and lessons learned.

<Japanese side>

- The 1st training programme was successful due to full cooperation and support by the cooperating organizations as listed in Section 9.3-1.
- If there is any training programme in October 2017, selection process of 10 (Ten) participants for that training programme shall be finalized by the end of August 2017. The selected trainees should be at a director's level and/or above.
- The 2nd training programme is planned in two parts. First Week is applicable to all trainees with the high importance given to "Concept of safety and punctuality". Second Week is as per group. For the 2nd training programme, there are 4 (Four) groups namely 1) HR and Administration, 2) Transportation Planning, 3) Civil Works and Facility Management and 4) Rolling Stock.

<Indian side>

- Expressed appreciation and a high level of satisfaction by all trainees participated in the 1st training programme.
- 10 (Ten) new trainees will be selected for the 2nd training programme. Same curriculum should be prepared for the 2nd training programme. Meanwhile, appointment of new NHSRCL executive officials is finalized within August 2017. Hence, it is recommended to dispatch newly appointed executive officials to Japan.
- It is requested to organize the 2nd training programme during the period avoiding Diwali.
- The time allocated for Q & A was too short at times. Hence, presentation materials may be provided to the concerned trainees in advance.

Chapter 10 Conclusions

The purpose of this Study is to assume the establishment of a high-speed railway in India by institutional support for legal system, technical standards, safety assurance, station / station peripheral development for introduction of the first high-speed railway in India.
Specific results of this Study are listed below.

(1) The draft certification system for MAHSR project, based on Japanese system, are proposed in November 2016.

(2) Developed technical standards necessary for construction and design of a HSR, consulted the Japanese support committee, and sent the approved technical standards to India. Finalization of Technical Standards, SOD for HSR and MSS was shown below Table

Table SOD and MSS

	Submission by the JIC	Review by the support committee(Japan)	Submission by the support committee
SOD	9th February 2017	1st March 2017 (5th committee)	20th March 2017
MSS (General)	24th October 2017	20th November 2017 (7th committee)	15th December 2017
MSS (Rolling Stock)	16th November 2017	20th November 2017 (7th committee)	15th December 2017
MSS (Track)	20th February 2017	1st March 2017 (5th committee)	20th March 2017
MSS (Signalling and Telecommunication)	6th June 2017	9th June 2017 (6th committee)	23rd June 2017
MSS (Power Supply System)	29th December 2017	12th January 2018* *Exceptional treatment	January 2018
MSS (Operation Control Center)	3rd April 2017	9th June 2017 (6th committee)	23rd June 2017
MSS (Viaduct and Bridge)	7th February 2017	1st March 2017 (5th committee)	20th March 2017
MSS (Earth Structure)	23rd May 2017	9th June 2017 (6th committee)	23rd June 2017
MSS (Tunnel)	17th March 2017	1st March 2017** (5th committee) **Conditional approval	8th May 2017
MSS (Station)	20th February 2017	1st March 2017 (5th committee)	20th March 2017

(3) In addition to this, the draft of DBR (Viaduct and Bridge, Track, Earth Structures, Tunnel and Railway Stations) was submitted to the Indian side and it is applied to the design work.

(4) The test embankment work for black cotton soil was completed, measurements were carried out from 2016 to 2017, and the results were summarized

(5) Conducted a test of CAM using Indian material used for slab track

(6) In response to the request from the Indian side, the following work was carried out

1) Provision of GAD at major intersections and technical support of alignment design of the HSR. A part of the work has not been completed due to delay of survey work and pending negotiation to relevant counterparts.

2) Examination of alternatives for location and access route of Mumbai HSR station

3) Modification of alignment design and structural plan of the HSR due to interruption with the conventional railway line or in close proximity

4) Modification of alignment design and structural plan of the HSR due to the plan of the 4th line

(7) Regarding development around the railway station along the HSR. Case studies were conducted at two stations, Ahmedabad (Conventional Line Joint Stations) and Surat (Suburban Station) about station and station periphery development, and utilization of Town Planning Scheme and development through the establishment of fund. We have made a proposal.

(8) Training in Japan was conducted for executives of the NHSRCL

The outcomes of this Study are utilized in the Detail Design Study. We plan to continue working on technical standards, FAD and GAD that have not been completed in the above Follow-Up Study.