CHAPTER 6 DESIGN REVIEW OF CHENNAI PERIPHERAL RING ROAD (CPRR)

6.1 General

6.1.1 Objectives and Scope of Design Review of CPRR

In order to confirm the reasonability of providing the Japan International Coordination Agency (JICA) Loan to the CPRR Project, the review is undertaken on the design made in the Detailed Project Report (DPR).

Table 6.1.1 shows the volumes of DPRs with the version provided to the JICA Study Team.

Table 6.1.1 Volumes of DPR for Review

Vol.	Report Title	Version/Date	Availability
I	Main Report	Unknown	Provided by JICA
II-A	Design Report (Highways)	Ver.R0, 9 Jan. 2017	Aug. 2017
II-B	Design Report (Structures/Box Culvert)	Unknown (Cover shows Aug. 2016)	Feb. 2018
II-C	Design Report (Structures/Minor Bridge)	Unknown (Cover shows Aug. 2016)	Feb. 2018
II-D	Design Report (Structures/Major Bridge)	Unknown (Cover shows Aug. 2016)	Feb. 2018
II-E	Design Report (Structures/Underpass)	Unknown (Cover shows July. 2016)	Feb. 2018
II-F	Design Report (Structures/Interchange)	Unknown (Cover shows Nov. 2016)	Feb. 2018
II-G	Design Report (Structures/Sec-1 Link Road)	Unknown (Cover shows Sep. 2016)	Feb. 2018
II-H	Design Report (Structures/ROB)	Unknown (Cover shows Aug. 2016)	Feb. 2018
III	EIA & Management Plan	Unknown	Provided by JICA
IV	Social Impact Assessment & RAP	Unknown	Provided by JICA
V	Technical Specifications	-	Not Available
VI	Rate Analysis	Ver.R0, 9 Jan. 2017	Feb. 2018
VII	Bill of Quantities	Ver.R0, 9 Jan. 2017	Nov. 2017
VIII	Cost Estimate	Ver.R0, 9 Jan. 2017	Aug. 2017
IX-A	Drawing (Highways)	Unknown	Aug. 2017
IX-B	Drawing (Structures/ Drainage)	Unknown	Aug. 2017
IX-C	Drawing (Structures/Bridges)	Unknown	Aug. 2017
IX-D	Drawing (Structures/underpass)	Unknown	Aug. 2017
IX-E	Drawing (Structures/Interchange)	Unknown	Aug. 2017

Note: Shaded text is a report not provided at the time of review.
Source: DPR Main Report P1-6 and JICA Study Team

The scope of the design review is set out as shown in Table 6.1.2 considering the objectives of the design review and the provided volumes of DPR at the time of review.

Table 6.1.2 Scope of Design Review

Item	Description in Provided DPR	Scope of Design Review
Traffic Analysis	The traffic survey was carried out in 2013. Future traffic volumes of CPRR (Sec. 2-5) were estimated by the elasticity method stipulated in the Indian Road Congress (IRC).	The traffic survey is carried out in 2017. Future traffic volumes of CPRR (Sec. 1-5) are to be estimated by network analysis using the JICA STRADA software.
Natural Conditions Survey	**Topographic Survey:** Control point survey using GPS, planimetric survey, and route survey (centerline, profile, and cross section) using a total station were carried out. Details of survey methodology and results including calculations are not provided. **Geotechnical Investigation:** CBR tests for subgrade and boring survey at proposed sites for structures were carried out. Results of the boring survey, including N values, are not presented in the provided DPRs. **Hydrological Survey:** No specific surveys were carried out. Standard values recommended in IRC were applied to the rainfall intensity in drainage design.	Survey results are not clearly presented in the provided DPRs; thus, natural conditions survey is not to be reviewed. Contents of surveys to be made in the next design phase of the Project are to be suggested in this Study.

Item	Description in Provided DPR	Scope of Design Review
Design		
Design Conditions	Design conditions such as road classification, technical standards to be applied, design speed and design criteria are presented in the design approach of the DPR report.	Validity of descriptions and consistency within DPR reports are to be reviewed.
Highway Design	**Alignment:** Elements and applied values can be read in the drawings (plan and profile). **Pavement:** Adopted design traffic volume and design CBR as well as deign calculations are presented in the DPR report. **Drainage:** Approach to drainage facilities arrangement as well as typical drainage calculations are illustrated in the DPR report.	**Alignment:** The alignment is to be reviewed based on the applied technical standards **Pavement:** Design results are to be evaluated by comparing with the results of AASHTO and other standards. **Drainage:** Design approach and design calculations are to be reviewed.
Interchange Design	Design reports of DPR (structures/interchanges) were not provided. In the provided reports, applied design criteria and general drawings are available.	The number of lanes for the main road and service road are to be evaluated based on the directional traffic movements that are estimated in this Study. Furthermore, geometric design of interchanges is to be reviewed.
Structure Design	Design reports of DPR (structures/bridges) were not provided. Drawings of structures (General Arrangement Drawings (GADs)) were provided. N values are not presented in boring logs.	Structural design is to be reviewed based on GAD. Foundations including piles could not be reviewed.
ITS Design	Interim results of the Chennai ITS Study are presented in DPR. No original proposals are included.	Updating ITS Design is to be made.
Cost Estimate	Rate analysis was not provided. Design quantities are shown in summarized manner and calculations for quantity take-off are not presented in the DPR report.	Unit rates are to be updated for the year 2017-2018 based on the schedule of rates of Tamil Nadu District. Design quantities are to be preliminarily reviewed for the major items.

Source: JICA Study Team

6.1.2 Natural Conditions Survey

In the DPR, topographic survey including control point survey using GPS, planimetric survey, and route survey (centerline, profile, and cross section) using total station were carried out. However, details of survey methodology and results including calculations are not provided.

Similarly, geotechnical investigation including CBR tests for subgrade and boring survey at proposed sites for structures were carried out, although the results of boring survey including N values are not presented in the provided DPRs.

Since survey results are not clearly presented in the provided DPRs, natural conditions survey is not reviewed in this report. It is suggested that the surveys shown in Table 6.1.3 shall be conducted in the next design phase of the Project.

Table 6.1.3 Natural Conditions Survey to be Conducted in Next Design Phase

Survey Name		Purpose	Note
Document survey		Rough understanding for specific conditions of topography, geology, hydrology, environment, etc. - Topographic map, Geological map, subground map, existing geological survey result, etc. - Aerial photogrammetry - Other information (Construction record, natural disaster record, land use map, weather record, related laws or regulations, etc)	
Site Investigation		Identification of conditions which may be problem in overall view points	Note below specific points. - Terraces, Talus, fault - Location and characteristics of permeable layer - River crossing point - Soft ground etc
Measurement	Reference point survey	Set of reference point	
	Leveling survey	Set of leveling point	
	Topographic survey	Understanding of topography of project area Making of topographic map	
	Route survey	Center line survey：set of main point (IP, etc) Provisional BM survey： set of provisional Bench Mark Profile leveling：understanding of topographical change point Cross leveling：nderstanding of topographical change point ROW survey：set of boundary of ROW	
Geological Survey	Boring test	Understanding of ground condition - Sampling (boring core) - Making hole for in-situ test - Underground water level etc	Boring depth(Normal)：depth which bearing ground (N=over 15) is observed over 5m
	Standard penetration test	Identification of N value	Accurate understanding of ground conditions by overall view points with results of some surveys and tests.
	In-situ test	Holizontal loading test in boring hole In-situ permeable test etc	
	Laboratory test	Physical test： Moisture content test, density test of soil particles, wet density test, particle size test, atterberg test Mechanical test： Uniaxial compression test, triaxial compression test, consolidation test, permeability test etc	
	Geophysical exploration	Elastic wave exploration Electrical prospecting Physical logging with boring hole etc	
Hydrological survey	Weather record survey	Temperature： Monthly average temperature, difference between years, regional characteristics of temperature distribution, etc Rain：Intensity, rain days Wind：direction, velocit etc	Note below points for implementation of hydrological survey - Location where water flow on surface. - Location of many water spring - Condition of underground water level - Location where hinterland is catchment topography - Condition of end of flow
	Topographic and geological survey	Identification of catchment area, discharge coefficient, etc.	
	Boring, soil test	Understanding of - Undergroung water level - Conditions of water spring - Location of permeable layer, permeability, depth of impermeable layer etc.	
Environmental survey	Related natunal condition	Understanding of environmental impact for animals and plants because of change of terrian or underground water level	

Source: JICA Study Team

6.1.3 Road Classification and Design Standards to be Applied

(1) Road Classification

1) Road Classification by Administration

Roads in India are classified by administration into National Highways (NHs), State Highways (SHs), Major District Roads (MDRs), and Other District Roads (ODRs). Since the CPRR Construction Project will be implemented by the Government of Tamil Nadu, CPRR is expected to be an SH once completed. However, CPRR is not currently designated as an SH; the road classification of CPRR by administration is not clarified in the DPR.

2) Terrain Category

The terrain category for road geometric design of CPRR is mostly plain and partially rolling according to the definition of IRC:73-1980 Geometric Design Standards for Rural Highways shown in Table 6.1.4.

Table 6.1.4 Terrain Category and Ground Slope

Terrain Category	Slope of Ground (%)
Plain	0-10
Rolling	10-25
Mountainous	25-60
Steep	60-

Source: IRC:73-1980 Geometric Design Standards for Rural Highways

(2) Design Standards

The road design made in the DPR was conducted in accordance with IRC standards. Table 6.1.5 presents all standards referred to in Vol. II, Design Report-Highways.

Table 6.1.5 Technical Standards Applied in DPR

No	Name of Standard	Title
1	IRC: SP: 87 -2013	Manual of Specifications and Standards for Six Laning of Highways through Public Private Partnership
2	IRC: 73 -1980	Geometric Design Standards for Rural (Non-Urban) Highways
3	IRC: SP: 23 -1993	Vertical Curves for Highways
4	IRC: SP: 23 -1989	Vertical Curves for Highways
5	IRC: 37 -2012	Tentative Guidelines for the Design of Flexible Pavements
6	IRC: 37 -1984	Guidelines for the Design Flexible Pavements
7	IRC: 81 -1997	Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique
8	IRC: 42 -1994	Guidelines on Road Drainage
9	IRC: 08 -1980	Type Designs for Highway Kilometer Stones
10	IRC: 25 -1967	Type Design for Boundary Stones
11	IRC: 26 -1967	Type Desing for 200-Meter Stones
12	IRC: 35 -1997	Code of Practice for Road Markings
13	IRC: 67 -2012	Code of Practice for Road Signs
14	IRC: 79 -1981	Recommended Practice for Road Delineators
15	IRC: SP: 84 -2014	Manual of Specifications and Standards for Four Laning of Highways through Public Private Partnership
16	IRC: SP: 89 -2010	Guidelines for Soil and Granular Material Stabilization Using Cement, Lime and Fly Ash
17	IRC: SP: 42 -2014	Guidelines of Road Drainage
18	IRC: SP: 90 -2010	Manual for Grade Separators and Elevated Structures
19	IRC: 65 -1976	Recommended Practice for Traffic Rotaries

Source: JICA Study Team based on DPR Vol.II, Design Report-Highways

6.1.4 Design Speed and Design Criteria

(1) Design Speed

The DPR Design Report (Vol. II, Design Report-Highways) explains that design speeds of 100 km/h (ruling) and 80 km/h (minimum) are adopted in accordance with IRC:73-1980 Geometric Design Standards for Rural Highways.

Table 6.1.6 Design Speed

Terrain Category	Slope of Ground (%)	Design Speed (km/h)	
		Ruling	Minimum
Plain and Rolling	-25	100	80
Mountainous and Steep	25-	60	40

Source: IRC:73-1980 Geometric Design Standards for Rural Highways

Since the minimum radius of horizontal curves applied to Section 4 is R=200 m, it is desirable to improve those curves in the future to ensure the consistency of the minimum design speed of 80 km/h throughout the route.

(2) Design Criteria

Table 6.1.7 shows the design criteria that is clarified in the DPR Design Report (Vol. II, Design Report-Highways).

Table 6.1.7 Design Criteria

Road Category: SH **Terrain: Mostly Plain, Partially Rolling**		**Ruling / Desirable**	**Minimum**
Design Speed		100 km/h	80 km/h
Cross Section	Right of Way (ROW)	100 m: Section 1 of CPRR, TPP Link Road (Original Alignment) 100 m: North half of TPP Link Road (New Alignment) 45-60 m: South half of TPP Link Road (New Alignment) 60 m: Sections 2 to 5	
	Carriageway	3.5 m Widening 0.9 m (R: 75 m-100 m) 0.6 m (R: 101 m-300 m)	
	Median	5.0 m (0.5 m+4.0 m+0.5 m) (Sec. 1, 2, 3, 5) 1.5 m (0.25 m+1.0 m+0.25 m) (Sec. 4)	
	Shoulder	Paved Shoulder 1.5 m + Earthen Shoulder 2.0 m (Section 1) Paved Shoulder 1.5 m (Sections to 5)	
	Sidewalk	3.0 m (Sections 2, 3, 5) 2.5 m (Section 4) 2.0 m (Section 1)	
Crossfall		2.5% (Earthen Shoulder 3.0%)	
Embankment Slope		2H:1V (H: -3 m) 1.5H:1V Stone Pitching (H: 3 m)	
Maximum Super-elevation		7.0% (R: -400 m) 5.0% (R: 400 m)	
Minimum Horizontal Curve Radius		400 m	250 m
Stop Sight Distance		360 m (V: 100 km/h) 260 m (V: 80 km/h)	180 m (V: 100 km/h) 130 m (V: 80 km/h)
Maximum Gradient		2.5%	3.3%
Clearance	Horizontal	Road Width	
	Vertical	5.5 m (Vehicle Underpass) 4.5 m (Light Vehicle Underpass)	

Source: DPR Vol.II, Design Report-Highways

6.1.5 Number of Lanes

Although there is no clear clarification on the required number of lanes in the DPR, future traffic volumes of Sections 2 to 5 are presented with the limitation of Level of Service (LOS) B as shown in Table 6.1.8.

Table 6.1.8 Future Traffic Volume (L: Main Road, R: Service Road) with Limitation of LOS B in DPR

Year	Sections			
	2	3	4	5
2013	18,014	32,945	42,039	9,606
2014	19,370	35,446	45,282	10,373
2015	20,835	38,149	48,790	11,204
2016	22,415	41,070	52,584	12,106
2017	24,123	44,229	56,691	13,085
2018	25,967	47,646	61,139	14,149
2019	29,059	53,355	68,529	15,896
2020	32,526	59,764	76,832	17,864
2021	36,415	66,960	86,163	20,081
2022	40,780	75,042	96,653	22,580
2023	45,678	84,123	108,449	25,398
2024	48,580	89,573	115,557	27,126
2025	51,678	95,398	123,161	28,980
2026	54,987	101,628	131,297	30,969
2027	58,522	108,291	140,006	33,103
2028	62,300	115,422	149,332	35,394
2029	66,001	122,424	158,457	37,636
2030	69,936	129,876	168,174	40,029
2031	74,121	137,809	178,523	42,583
2032	78,571	146,257	189,549	45,310
2033	83,306	155,256	201,299	48,223
2034	87,755	163,668	212,355	50,979
2035	92,461	172,572	224,065	53,905
2036	97,438	182,000	236,471	57,011
2037	102,705	191,986	249,618	60,310
2038	108,280	202,564	263,553	63,815
2039	113,592	212,652	276,850	67,167
2040	119,186	223,285	290,872	70,708
2041	125,079	234,494	305,661	74,451
2042	131,287	246,314	321,263	78,408
2043	137,830	258,779	337,726	82,591

Year	Sections			
	2	3	4	5
2013	1,655	6,609	7,224	2,317
2014	1,792	7,130	7,809	2,511
2015	1,941	7,695	8,444	2,722
2016	2,102	8,306	9,133	2,951
2017	2,278	8,969	9,882	3,201
2018	2,469	9,688	10,694	3,472
2019	2,779	10,874	12,023	3,911
2020	3,129	12,208	13,520	4,406
2021	3,524	13,708	15,206	4,966
2022	3,969	15,396	17,106	5,596
2023	4,471	17,295	19,246	6,308
2024	4,784	18,468	20,577	6,754
2025	5,120	19,723	22,002	7,232
2026	5,481	21,066	23,528	7,745
2027	5,867	22,504	25,163	8,295
2028	6,281	24,042	26,915	8,884
2029	6,686	25,558	28,636	9,461
2030	7,119	27,171	30,468	10,076
2031	7,579	28,888	32,419	10,732
2032	8,070	30,715	34,498	11,431
2033	8,593	32,660	36,711	12,175
2034	9,080	34,446	38,762	12,871
2035	9,596	36,335	40,931	13,608
2036	10,141	38,331	43,226	14,389
2037	10,719	40,441	45,653	15,215
2038	11,331	42,672	48,222	16,090
2039	11,914	44,794	50,668	16,924
2040	12,527	47,027	53,242	17,803
2041	13,173	49,375	55,952	18,728
2042	13,853	51,845	58,803	19,702
2043	14,570	54,442	61,804	20,728

(green)	**LOC B - 4 Lane with Paved Shoulder**
(red)	**LOC B - 6 Lane with Paved Shoulder**
(blue)	**LOC B - 8 Lane with Paved Shoulder**
(orange)	**LOC B - 10 Lane with Paved Shoulder**

Source: DPR Main Report

According to this information, in 2028, after 10 years from 2018 as of this report, Section 2 needs 8 lanes, Sections 3 and 4 need more than 12 lanes, and Section 5 needs 6 lanes to ensure LOS B. Although the opening year that was assumed in the DPR is not clear, there is a concern that traffic of CPRR will be unstable soon after opening, considering the numbers of lanes that were proposed in the DPR (Section 1: 4-lane, Sections 2 to 4: 6-lane, Section 5: 4-lane).

On the other hand, Table 6.1.9 to Table 6.1.13 show the LOS estimated based on future traffic volumes forecasted in this Study and the numbers of lanes proposed in the DPR (Section 1: 4-lane, Sections 2 to 4: 6-lane, Section 5: 4-lane). It is assumed that the remaining works of Section 4 will be completed in 2021, and construction of Sections 1, 2, 3, and 5 will be completed and the entire stretch will open in 2024. In 2028, after 10 years from 2018 as of this report, the LOS ranges from B to D, which is considered reasonable.

Table 6.1.9 Future Traffic Volume and LOS (Section 1)

Case 2	Section				
	1	2	3	4	5
2021	-	-	-	○	-
2026	○	○	○	○	○
2036	○	○	○	○	○

K	0.09		c_j	2,200	pcu/hour/lane
D	0.50		N	2	lane/direction

Resource	JICA Study Result ： A														
Made by	JICA Consultant														
Case	Case 2														
PCU factor	0.5	1	1	3	1.5	3	4.5								
Year	Unit: PCU/hour/direction														
	Two Wheeler	Car/Jeep	Auto Rickshaw	Bus	LCV	Truck	MAV	Sum	E_T	f_{HV}	f_W	f_P	c	q/c	LOS
2024	6	4	1	4	2	416	358	791	1.7	0.83	1.0	1.0	3,652	0.22	B
2025	12	8	2	7	4	832	717	1,582	1.7	0.83	1.0	1.0	3,652	0.43	B
2026	18	12	3	11	5	1,248	1,075	2,373	1.7	0.83	1.0	1.0	3,652	0.65	C
2027	22	16	5	13	12	1,301	1,038	2,407	1.7	0.83	1.0	1.0	3,652	0.66	C
2028	25	20	7	15	18	1,354	1,000	2,441	1.7	0.83	1.0	1.0	3,652	0.67	C
2029	29	25	9	18	25	1,407	963	2,475	1.7	0.83	1.0	1.0	3,652	0.68	C
2030	33	29	10	20	31	1,460	926	2,509	1.7	0.83	1.0	1.0	3,652	0.69	C
2031	36	33	12	22	38	1,513	888	2,543	1.7	0.83	1.0	1.0	3,652	0.70	D
2032	40	38	14	25	44	1,566	851	2,578	1.7	0.83	1.0	1.0	3,652	0.71	D
2033	44	42	16	27	51	1,619	813	2,612	1.7	0.83	1.0	1.0	3,652	0.72	D
2034	47	46	17	29	57	1,672	776	2,646	1.7	0.83	1.0	1.0	3,652	0.72	D
2035	51	50	19	32	64	1,725	739	2,680	1.7	0.83	1.0	1.0	3,652	0.73	D
2036	55	55	21	34	70	1,778	701	2,714	1.7	0.83	1.0	1.0	3,652	0.74	D
2037	55	55	21	34	70	1,778	701	2,714	1.7	0.83	1.0	1.0	3,652	0.74	D
2038	55	55	21	34	70	1,778	701	2,714	1.7	0.83	1.0	1.0	3,652	0.74	D
2039	55	55	21	34	70	1,778	701	2,714	1.7	0.83	1.0	1.0	3,652	0.74	D
2040	55	55	21	34	70	1,778	701	2,714	1.7	0.83	1.0	1.0	3,652	0.74	D
2041	55	55	21	34	70	1,778	701	2,714	1.7	0.83	1.0	1.0	3,652	0.74	D
2042	55	55	21	34	70	1,778	701	2,714	1.7	0.83	1.0	1.0	3,652	0.74	D
2043	55	55	21	34	70	1,778	701	2,714	1.7	0.83	1.0	1.0	3,652	0.74	D

Source: JICA Study Team

Table 6.1.10 Future Traffic Volume and LOS (Section 2)

Case 2	Section				
	1	2	3	4	5
2021	-	-	-	○	-
2026	○	○	○	○	○
2036	○	○	○	○	○

K	0.09	c_j	2,200 pcu/hour/lane
D	0.50	N	3 lane/direction

Resource	JICA Study Result ： A						
Made by	JICA Consultant						
Case	Case 2						
	0.5	1	1	3	1.5	3	4.5

Year	Unit: PCU/hour/direction														
	Two Wheeler	Car/Jeep	Auto Rickshaw	Bus	LCV	Truck	MAV	Sum	E_T	f_{HV}	f_W	f_P	c	q/c	LOS
2024	51	68	38	34	51	239	249	730	1.7	0.83	1.0	1.0	5,478	0.13	B
2025	102	137	76	67	101	477	498	1,459	1.7	0.83	1.0	1.0	5,478	0.27	B
2026	154	205	114	101	152	716	747	2,189	1.7	0.83	1.0	1.0	5,478	0.40	B
2027	174	228	126	119	202	649	675	2,173	1.7	0.83	1.0	1.0	5,478	0.40	B
2028	195	251	138	137	252	581	602	2,157	1.7	0.83	1.0	1.0	5,478	0.39	B
2029	216	275	151	155	303	514	529	2,141	1.7	0.83	1.0	1.0	5,478	0.39	B
2030	236	298	163	172	353	447	456	2,126	1.7	0.83	1.0	1.0	5,478	0.39	B
2031	257	321	175	190	404	379	384	2,110	1.7	0.85	1.0	1.0	5,610	0.38	B
2032	278	344	187	208	454	312	311	2,094	1.7	0.88	1.0	1.0	5,808	0.36	B
2033	299	367	199	226	505	245	238	2,078	1.7	0.89	1.0	1.0	5,874	0.35	B
2034	319	390	211	243	555	177	166	2,062	1.7	0.91	1.0	1.0	6,006	0.34	B
2035	340	414	223	261	605	110	93	2,047	1.7	0.93	1.0	1.0	6,138	0.33	B
2036	361	437	236	279	656	43	20	2,031	1.7	0.94	1.0	1.0	6,204	0.33	B
2037	361	437	236	279	656	43	20	2,031	1.7	0.94	1.0	1.0	6,204	0.33	B
2038	361	437	236	279	656	43	20	2,031	1.7	0.94	1.0	1.0	6,204	0.33	B
2039	361	437	236	279	656	43	20	2,031	1.7	0.94	1.0	1.0	6,204	0.33	B
2040	361	437	236	279	656	43	20	2,031	1.7	0.94	1.0	1.0	6,204	0.33	B
2041	361	437	236	279	656	43	20	2,031	1.7	0.94	1.0	1.0	6,204	0.33	B
2042	361	437	236	279	656	43	20	2,031	1.7	0.94	1.0	1.0	6,204	0.33	B
2043	361	437	236	279	656	43	20	2,031	1.7	0.94	1.0	1.0	6,204	0.33	B

Source: JICA Study Team

Table 6.1.11 Future Traffic Volume and LOS (Section 3)

Case 2	Section				
	1	2	3	4	5
2021	-	-	-	○	-
2026	○	○	○	○	○
2036	○	○	○	○	○

K	0.09	c_j	2,200	pcu/hour/lane	
D	0.50	N	3	lane/direction	

	Two Wheeler	Car/Jeep	Auto Rickshaw	Bus	LCV	Truck	MAV	Sum
	0.5	1	1	3	1.5	3	4.5	
Resource	JICA Study Result : A							
Made by	JICA Consultant							
Case	Case 2							
Year	Unit: PCU/hour/direction							
	Two Wheeler	Car/Jeep	Auto Rickshaw	Bus	LCV	Truck	MAV	Sum
2024	42	65	67	32	49	268	253	776
2025	83	131	133	64	99	535	506	1,552
2026	125	196	200	97	148	803	759	2,327
2027	165	230	218	125	194	832	736	2,499
2028	204	264	235	152	240	861	713	2,670
2029	244	298	252	180	286	890	690	2,841
2030	284	333	270	208	332	919	667	3,013
2031	324	367	287	236	378	948	645	3,184
2032	363	401	305	264	424	977	622	3,355
2033	403	435	322	292	470	1,005	599	3,527
2034	443	469	340	320	515	1,034	576	3,698
2035	483	503	357	348	561	1,063	553	3,869
2036	522	538	375	376	607	1,092	530	4,040
2037	522	538	375	376	607	1,092	530	4,040
2038	522	538	375	376	607	1,092	530	4,040
2039	522	538	375	376	607	1,092	530	4,040
2040	522	538	375	376	607	1,092	530	4,040
2041	522	538	375	376	607	1,092	530	4,040
2042	522	538	375	376	607	1,092	530	4,040
2043	522	538	375	376	607	1,092	530	4,040

Year	E_T	f_{HV}	f_W	f_P	c	q/c	LOS
2024	1.7	0.83	1.0	1.0	5,478	0.14	B
2025	1.7	0.83	1.0	1.0	5,478	0.28	B
2026	1.7	0.83	1.0	1.0	5,478	0.42	B
2027	1.7	0.83	1.0	1.0	5,478	0.46	B
2028	1.7	0.83	1.0	1.0	5,478	0.49	B
2029	1.7	0.83	1.0	1.0	5,478	0.52	C
2030	1.7	0.83	1.0	1.0	5,478	0.55	C
2031	1.7	0.83	1.0	1.0	5,478	0.58	C
2032	1.7	0.83	1.0	1.0	5,478	0.61	C
2033	1.7	0.83	1.0	1.0	5,478	0.64	C
2034	1.7	0.83	1.0	1.0	5,478	0.68	C
2035	1.7	0.83	1.0	1.0	5,478	0.71	D
2036	1.7	0.83	1.0	1.0	5,478	0.74	D
2037	1.7	0.83	1.0	1.0	5,478	0.74	D
2038	1.7	0.83	1.0	1.0	5,478	0.74	D
2039	1.7	0.83	1.0	1.0	5,478	0.74	D
2040	1.7	0.83	1.0	1.0	5,478	0.74	D
2041	1.7	0.83	1.0	1.0	5,478	0.74	D
2042	1.7	0.83	1.0	1.0	5,478	0.74	D
2043	1.7	0.83	1.0	1.0	5,478	0.74	D

Source: JICA Study Team

Table 6.1.12 Future Traffic Volume and LOS (Section 4)

Case 2	Section				
	1	2	3	4	5
2021	-	-	-	○	-
2026	○	○	○	○	○
2036	○	○	○	○	○

K	0.09	c_j	2,200 pcu/hour/lane
D	0.50	N	3 lane/direction

Resource	JICA Study Result : A							
Made by	JICA Consultant							
Case	Case 2							
Year	Unit: PCU/hour/direction							
	0.5	1	1	3	1.5	3	4.5	
	Two Wheeler	Car/Jeep	Auto Rickshaw	Bus	LCV	Truck	MAV	Sum
2021	429	490	58	252	124	587	297	2,236
2022	428	481	64	263	142	721	443	2,542
2023	427	472	71	274	160	856	589	2,848
2024	425	462	77	285	177	991	736	3,153
2025	424	453	83	296	195	1,125	882	3,459
2026	423	444	90	307	213	1,260	1,028	3,764
2027	512	492	106	338	263	1,246	1,008	3,965
2028	601	540	123	368	313	1,233	988	4,165
2029	689	588	140	399	364	1,219	968	4,366
2030	778	636	157	429	414	1,205	947	4,567
2031	867	684	173	460	464	1,192	927	4,767
2032	956	732	190	490	515	1,178	907	4,968
2033	1,045	780	207	521	565	1,164	887	5,168
2034	1,134	828	224	552	615	1,150	867	5,369
2035	1,223	876	240	582	666	1,137	846	5,569
2036	1,312	924	257	613	716	1,123	826	5,770
2037	1,312	924	257	613	716	1,123	826	5,770
2038	1,312	924	257	613	716	1,123	826	5,770
2039	1,312	924	257	613	716	1,123	826	5,770
2040	1,312	924	257	613	716	1,123	826	5,770

Year	E_T	f_{HV}	f_W	f_P	c	q/c	LOS
2021	1.7	0.83	1.0	1.0	5,478	0.41	B
2022	1.7	0.83	1.0	1.0	5,478	0.46	B
2023	1.7	0.83	1.0	1.0	5,478	0.52	C
2024	1.7	0.83	1.0	1.0	5,478	0.58	C
2025	1.7	0.83	1.0	1.0	5,478	0.63	C
2026	1.7	0.83	1.0	1.0	5,478	0.69	C
2027	1.7	0.83	1.0	1.0	5,478	0.72	D
2028	1.7	0.83	1.0	1.0	5,478	0.76	D
2029	1.7	0.83	1.0	1.0	5,478	0.80	D
2030	1.7	0.83	1.0	1.0	5,478	0.83	D
2031	1.7	0.83	1.0	1.0	5,478	0.87	E
2032	1.7	0.83	1.0	1.0	5,478	0.91	E
2033	1.7	0.85	1.0	1.0	5,610	0.92	E
2034	1.7	0.86	1.0	1.0	5,676	0.95	E
2035	1.7	0.86	1.0	1.0	5,676	0.98	E
2036	1.7	0.86	1.0	1.0	5,676	1.02	F
2037	1.7	0.86	1.0	1.0	5,676	1.02	F
2038	1.7	0.86	1.0	1.0	5,676	1.02	F
2039	1.7	0.86	1.0	1.0	5,676	1.02	F
2040	1.7	0.86	1.0	1.0	5,676	1.02	F

Source: JICA Study Team

Table 6.1.13 Future Traffic Volume and LOS (Section 5)

Case 2	Section				
	1	2	3	4	5
2021	-	-	-	○	-
2026	○	○	○	○	○
2036	○	○	○	○	○

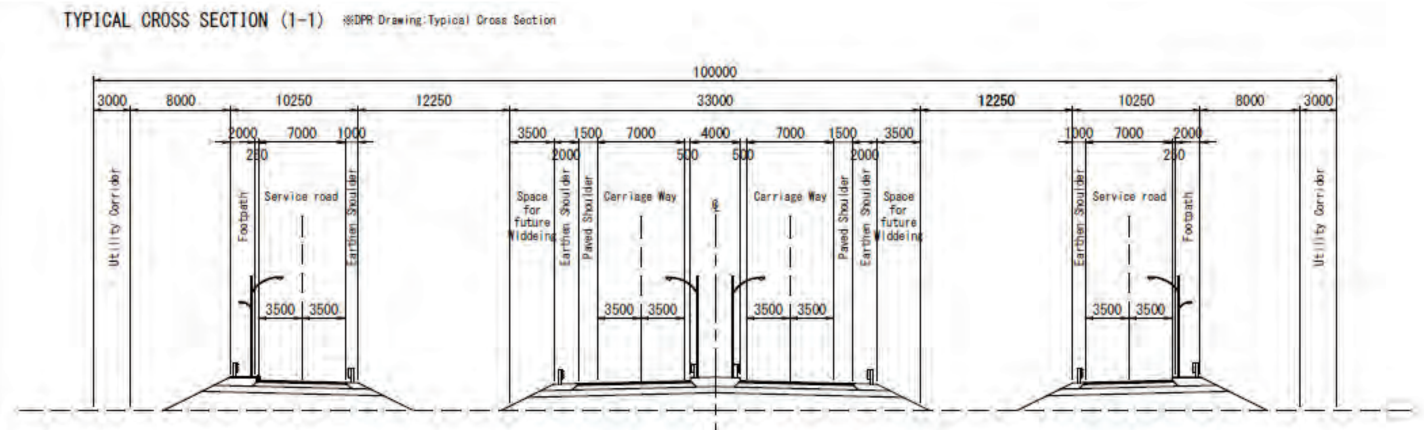
K	0.09		
D	0.50		
c_j	2,200	pcu/hour/lane	
N	2	lane/direction	

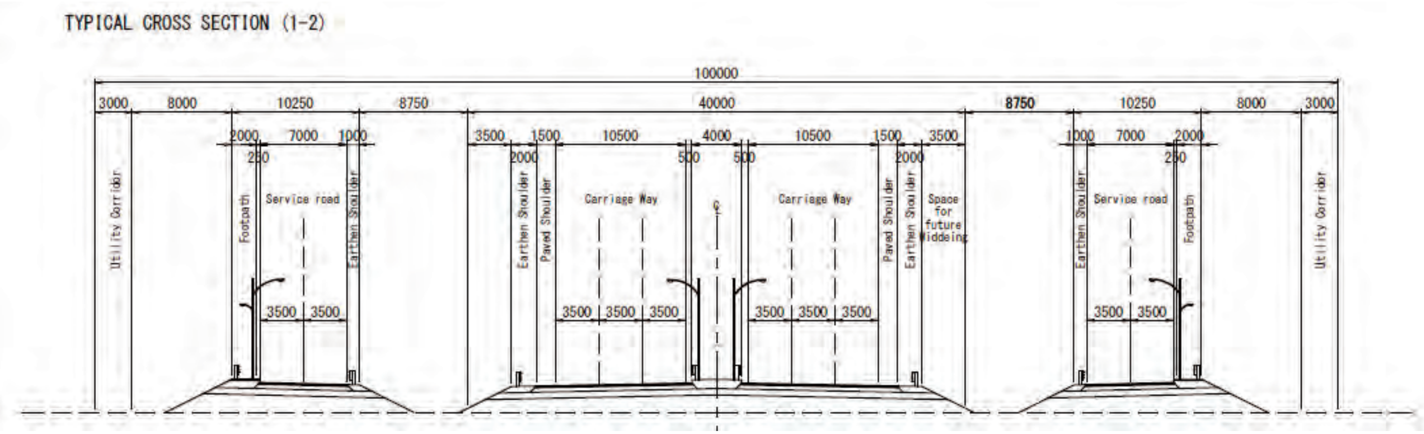
Resource	JICA Study Result : A															
Made by	JICA Consultant															
Case	Case 2															
	0.5	1	1	3	1.5	3	4.5									
Year	Unit: PCU/hour/direction															
	Two Wheeler	Car/Jeep	Auto Rickshaw	Bus	LCV	Truck	MAV	Sum	E_T	f_{HV}	f_W	f_P	c	q/c	LOS	
2024	77	79	42	55	98	115	61	527	1.7	0.85	1.0	1.0	3,740	0.14	B	
2025	153	158	83	110	197	231	121	1,053	1.7	0.85	1.0	1.0	3,740	0.28	B	
2026	230	237	125	165	295	346	182	1,580	1.7	0.85	1.0	1.0	3,740	0.42	B	
2027	256	275	133	206	331	345	180	1,726	1.7	0.86	1.0	1.0	3,784	0.46	B	
2028	282	314	142	246	367	344	178	1,873	1.7	0.86	1.0	1.0	3,784	0.49	C	
2029	308	352	150	286	403	344	176	2,019	1.7	0.86	1.0	1.0	3,784	0.53	C	
2030	334	390	159	327	439	343	175	2,165	1.7	0.88	1.0	1.0	3,872	0.56	C	
2031	360	428	167	367	475	342	173	2,312	1.7	0.88	1.0	1.0	3,872	0.60	C	
2032	386	467	176	407	511	341	171	2,458	1.7	0.88	1.0	1.0	3,872	0.63	C	
2033	412	505	184	447	547	340	169	2,605	1.7	0.88	1.0	1.0	3,872	0.67	C	
2034	438	543	193	488	582	339	168	2,751	1.7	0.88	1.0	1.0	3,872	0.71	D	
2035	464	582	201	528	618	338	166	2,898	1.7	0.88	1.0	1.0	3,872	0.75	D	
2036	490	620	210	568	654	337	164	3,044	1.7	0.88	1.0	1.0	3,872	0.79	D	
2037	490	620	210	568	654	337	164	3,044	1.7	0.88	1.0	1.0	3,872	0.79	D	
2038	490	620	210	568	654	337	164	3,044	1.7	0.88	1.0	1.0	3,872	0.79	D	
2039	490	620	210	568	654	337	164	3,044	1.7	0.88	1.0	1.0	3,872	0.79	D	
2040	490	620	210	568	654	337	164	3,044	1.7	0.88	1.0	1.0	3,872	0.79	D	
2041	490	620	210	568	654	337	164	3,044	1.7	0.88	1.0	1.0	3,872	0.79	D	
2042	490	620	210	568	654	337	164	3,044	1.7	0.88	1.0	1.0	3,872	0.79	D	
2043	490	620	210	568	654	337	164	3,044	1.7	0.88	1.0	1.0	3,872	0.79	D	

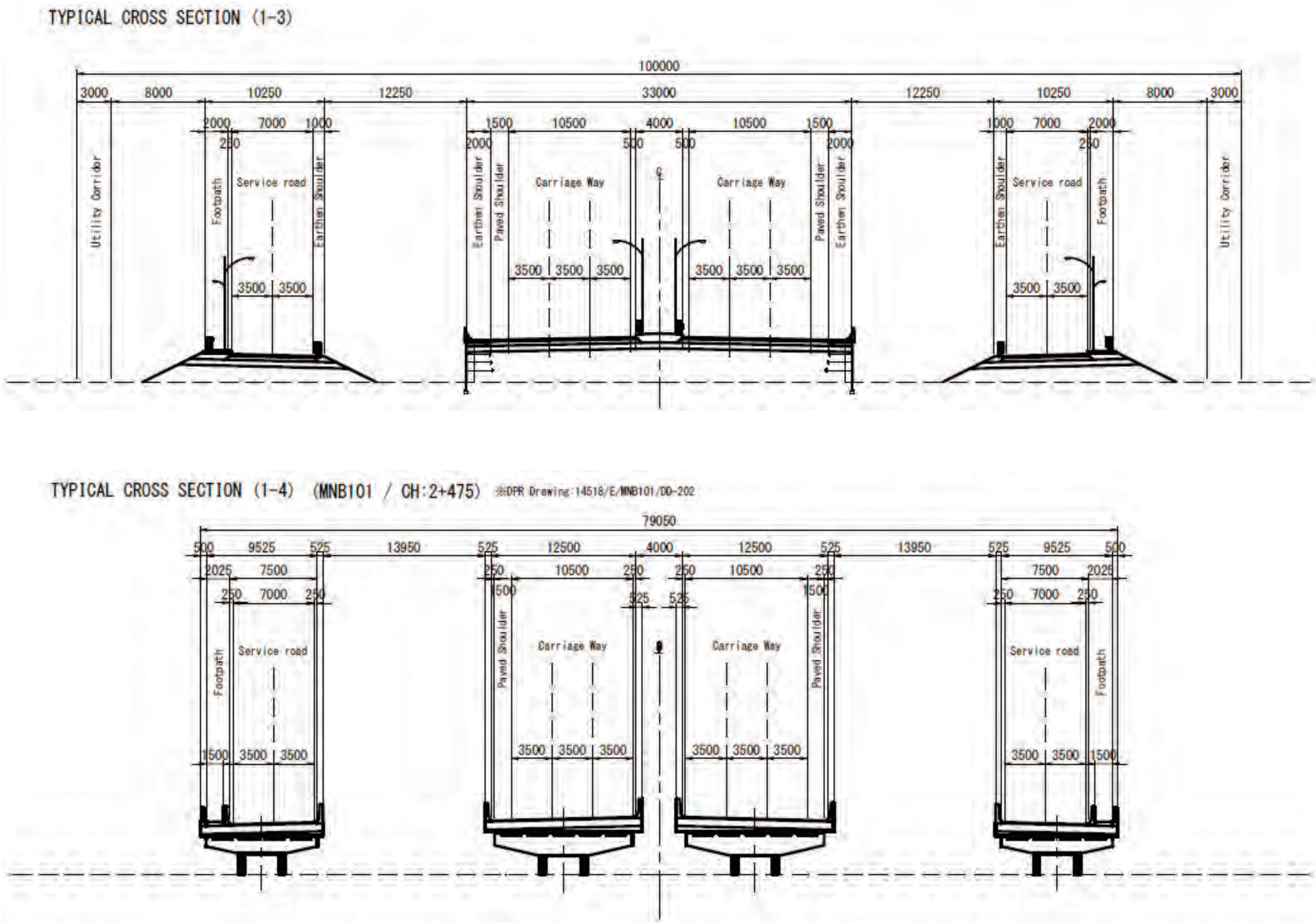
Source: JICA Study Team

6.1.6 Typical Cross Sections

Typical cross sections proposed in the DPR were designed in accordance with the number of lanes stated above and the requirements of the applied design standards. They are shown in Figure 6.1.1 to Figure 6.1.6.

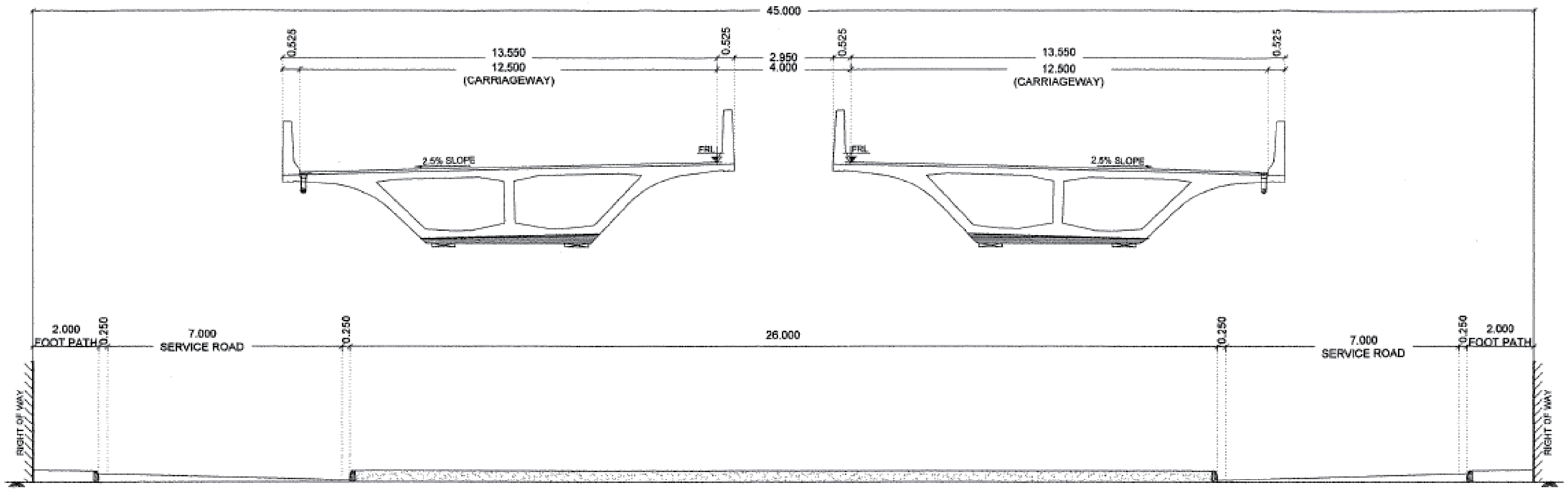




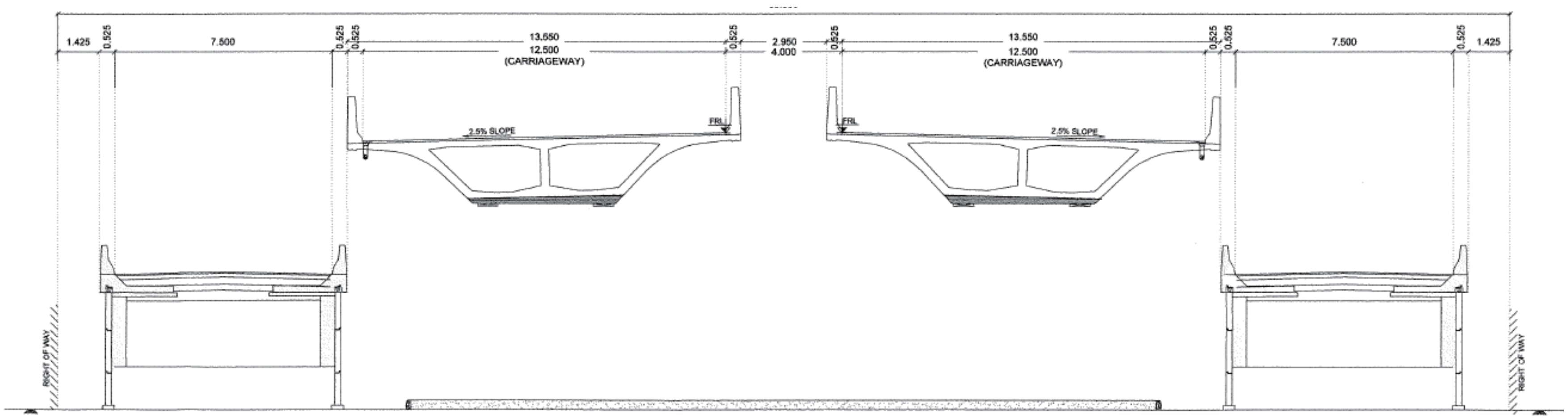


Source: JICA Study Team based on DPR

Figure 6.1.1 Typical Cross Sections (Section 1)



Flyover Section (ROW 45 m)

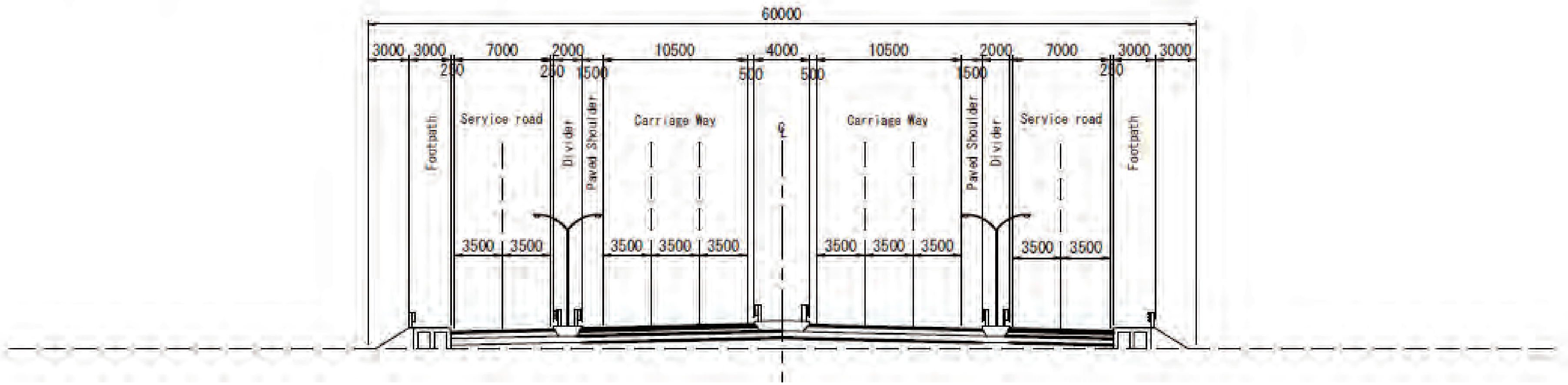


Approach Section (ROW 60 m)

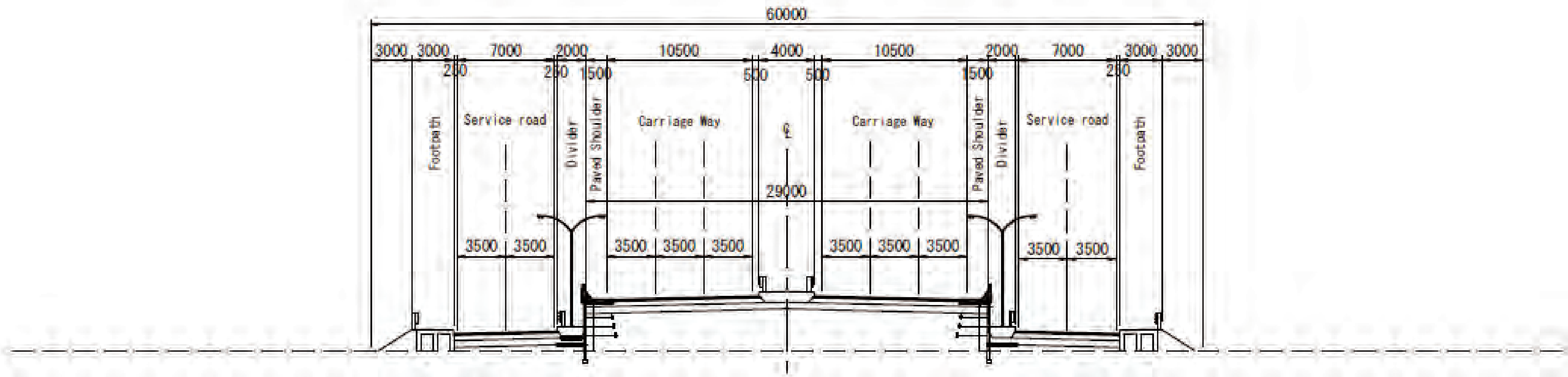
Source: STUP

Figure 6.1.2 Typical Cross Sections TPP Link Road (New Alignment)

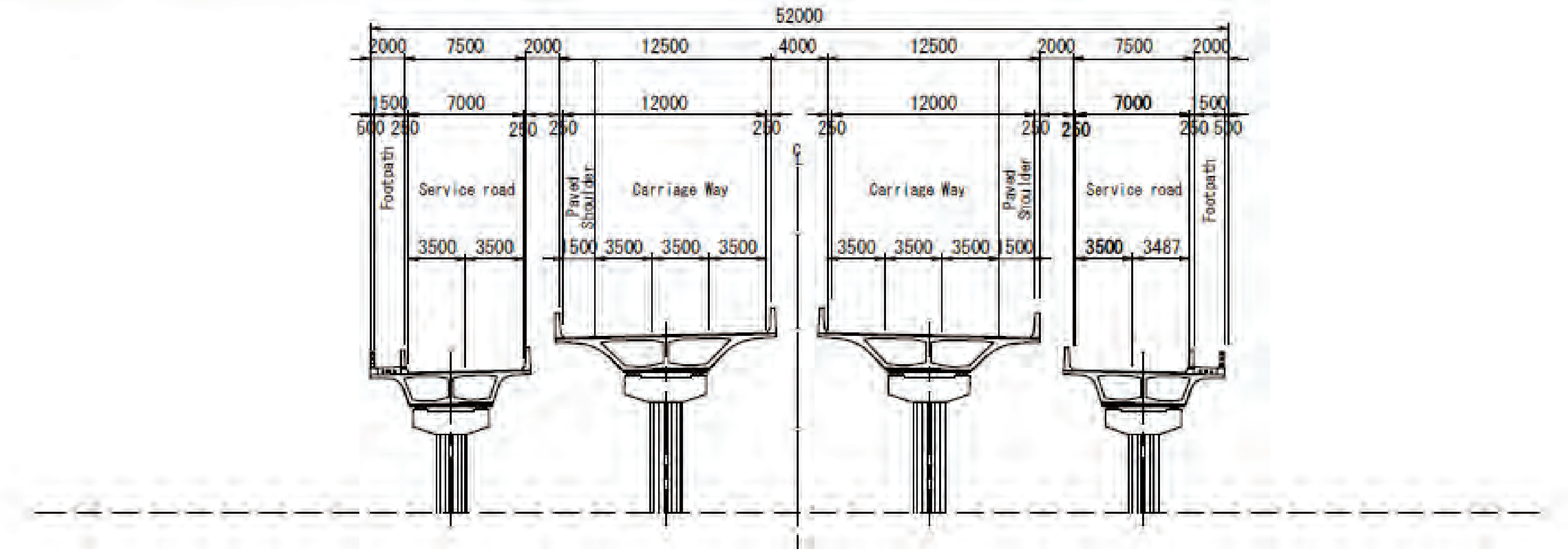
TYPICAL CROSS SECTION (2-1) ※DPR Drawing:Typical Cross Section



TYPICAL CROSS SECTION (2-2)



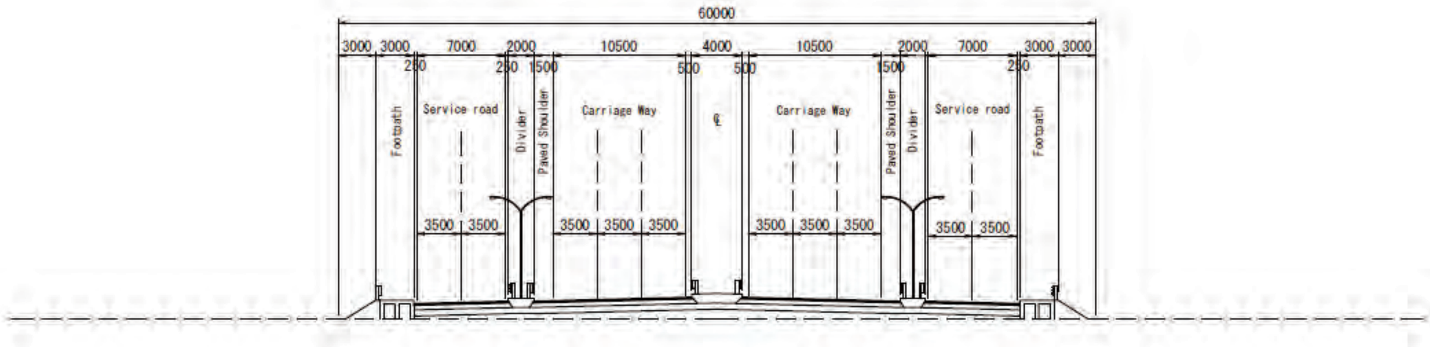
TYPICAL CROSS SECTION (2-3) (MJB AT CH:36+886) ※DPR Drawing:14518/E/MJB201/DD-001



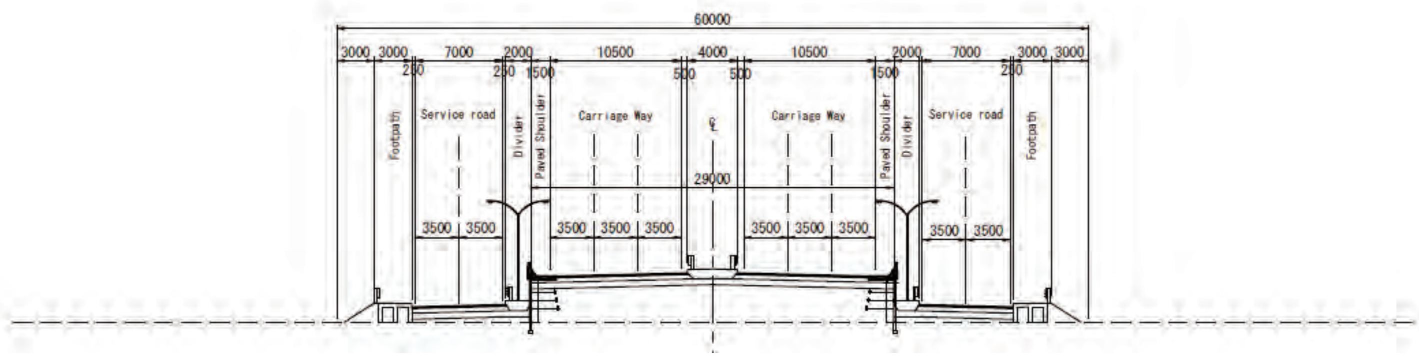
Source: JICA Study Team based on DPR

Figure 6.1.3 Typical Cross Sections (Section 2)

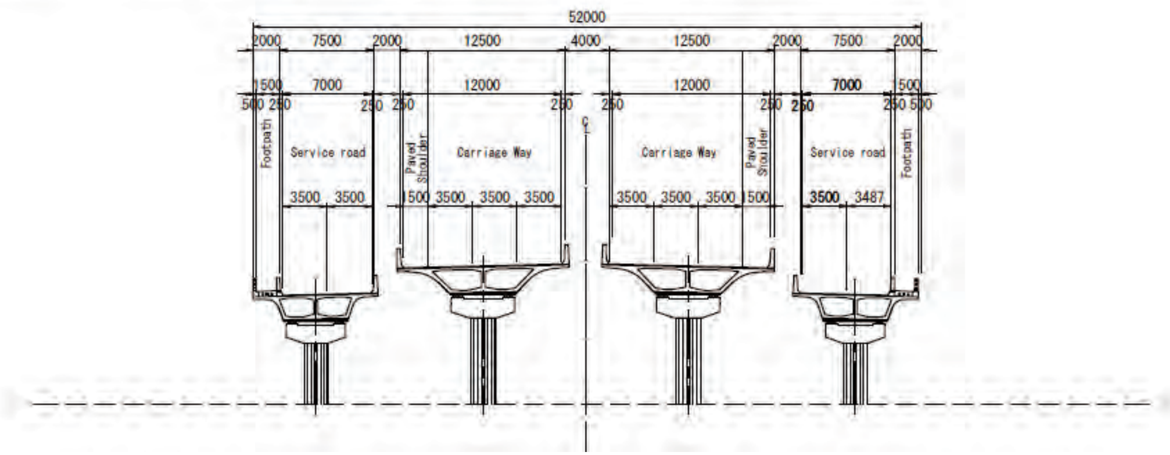
TYPICAL CROSS SECTION (3-1) ※DPR Drawing Typical Cross Section



TYPICAL CROSS SECTION (3-2)



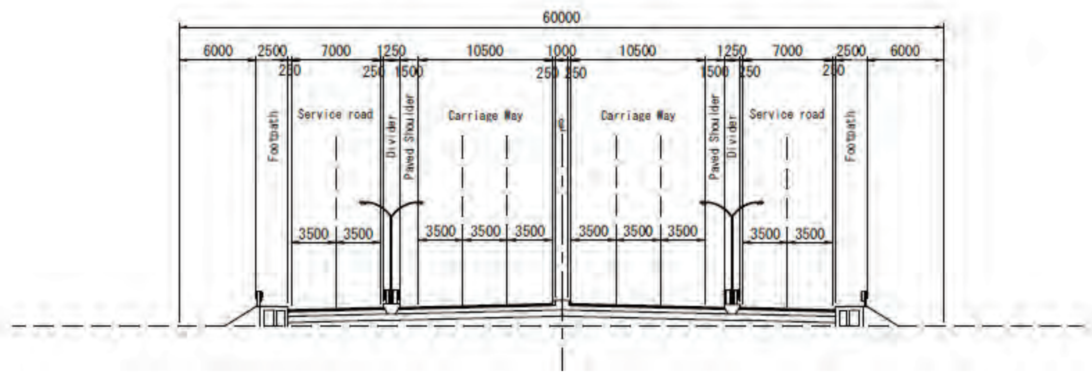
TYPICAL CROSS SECTION (3-3) (MJB AT CH:57+532) ※DPR Drawing:14518/E/MJB301/DD-001

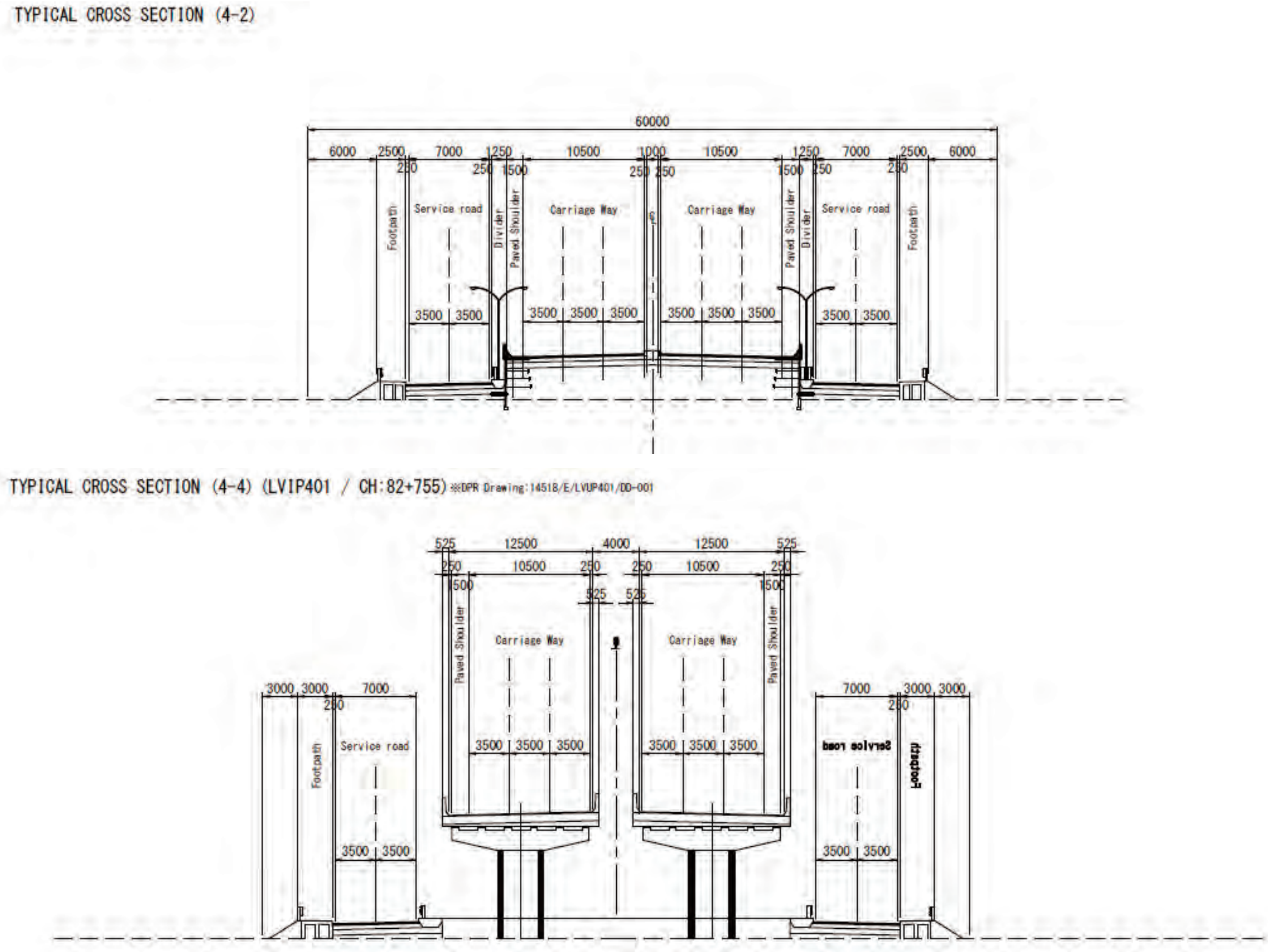


Source: JICA Study Team based on DPR

Figure 6.1.4 Typical Cross Sections (Section 3)

TYPICAL CROSS SECTION (4-1) ※DPR Drawing:Typical Cross Section

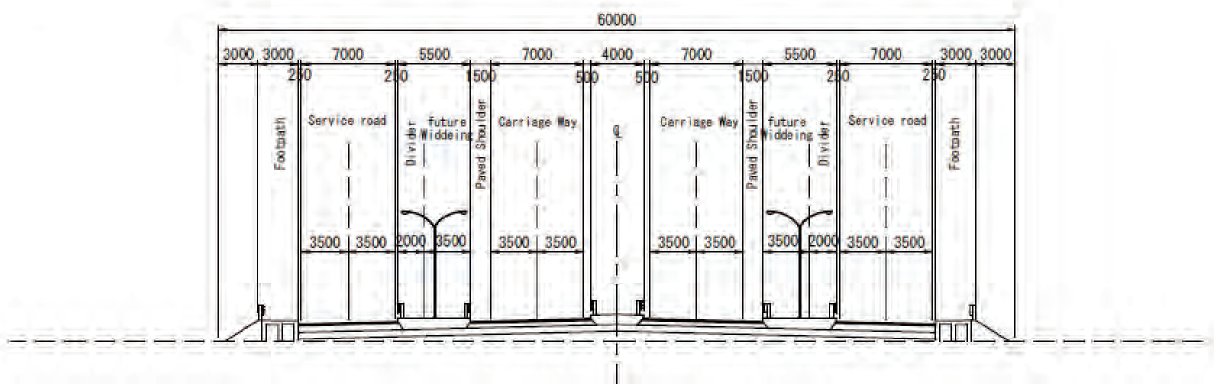




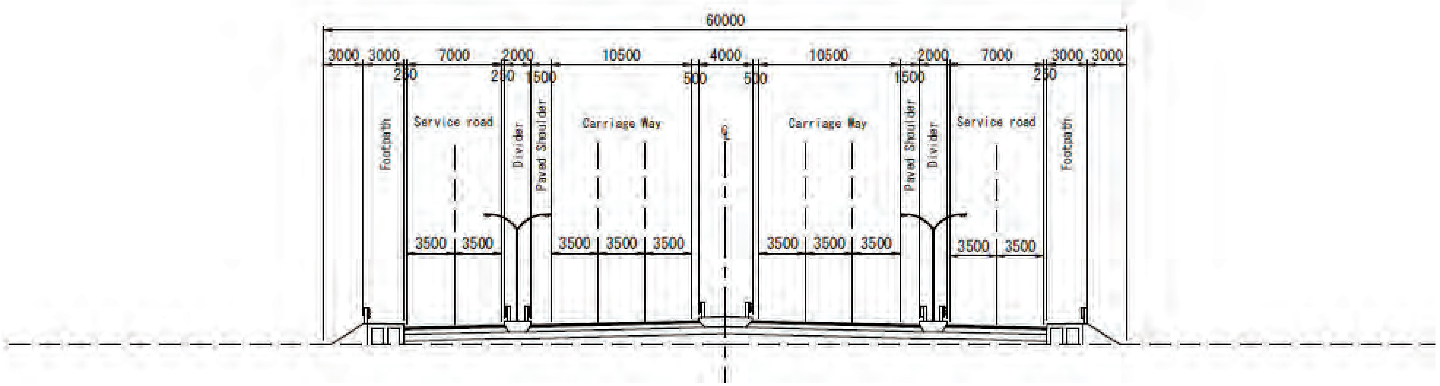
Source: JICA Study Team based on DPR

Figure 6.1.5 Typical Cross Sections (Section 4)

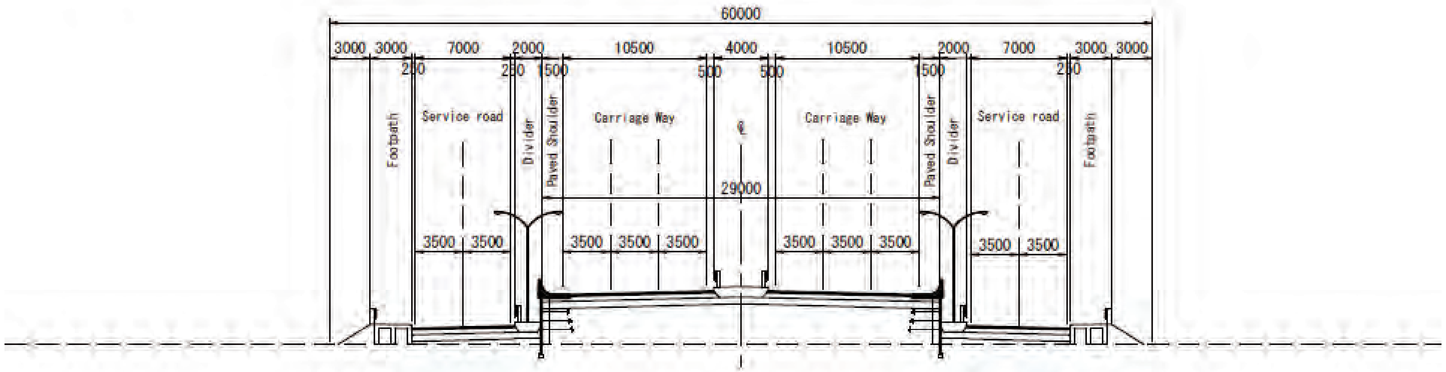
TYPICAL CROSS SECTION (5-1) ※DPR Drawing Typical Cross Section



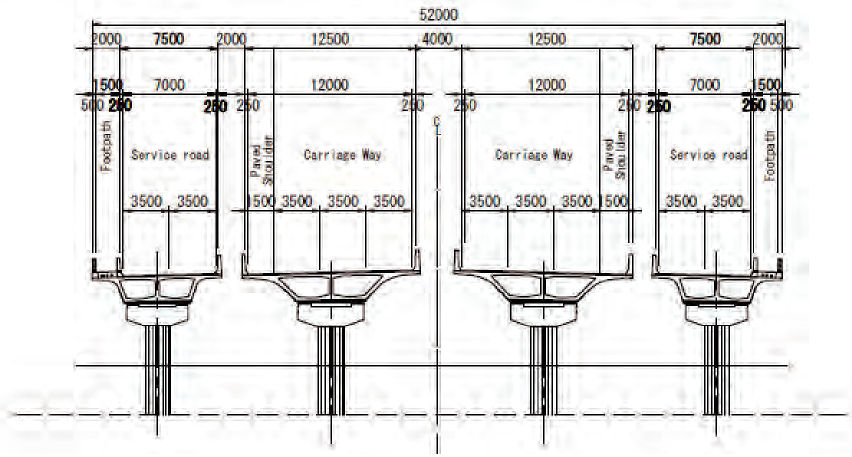
TYPICAL CROSS SECTION (5-2)



TYPICAL CROSS SECTION (5-3)



TYPICAL CROSS SECTION (5-4) (MJB AT CH:102+831) ※DPR Drawing:14518/E/MJB501/DD-001



Source: JICA Study Team based on DPR

Figure 6.1.6 Typical Cross Sections (Section 5)

6.2 Highway Design (All Sections)

6.2.1 Alignment

(1) Horizontal Alignment

In this Study, the alignment is assessed by checking whether the requirements of the design standard are met. The requirements are the design criteria stipulated in IRC:73-1980 (with the minimum values in brackets), and the Japanese Standard (Road Structure Ordinance, with desirable values in brackets) is also presented for reference. Table 6.2.1 shows the assessment results of horizontal elements.

Table 6.2.1 Assessment of Horizontal Elements

No.	Chainage	Curve				Spiral				Super Elevation	Design Speed
		Length	Radius			Length			Parameter		
		Lc	R			Ls			A		
		DPR	DPR	Standard's Criteria (IRC:SP:73-1980)	Ref: Japan 道路構造令	DPR	Standard's Criteria (IRC:73-1980)	Ref: Japan 道路構造令	GAD	DPR	DPR
				Minimum	Minimum		Minimum	Minimum			
		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(%)	(kmph)
SECTION 1											
1	+582.205	76.899	1,000	360 (230)	(700) 460	0	50	85	0	NC	100
2	2+777.809	465.825	4,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
3	4+205.441	415.848	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
4	7+381.771	1070.026	8,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
5	13+765.004	1088.838	3,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
6	16+139.694	957.615	3,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
7	18+135.209	1402.500	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
8	20+051.497	1273.168	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
SECTION 2											
1	21+520.699	946.385	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
2	22+638.640	1074.248	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
3	24+270.774	761.888	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
4	28+951.438	977.561	900	360 (230)	(700) 460	150	55	85	367	4.9	100
5	30+898.976	421.485	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
6	32+546.776	706.656	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
7	33+876.223	835.365	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
8	35+546.315	413.151	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
9	36+518.363	382.233	1,200	360 (230)	(700) 460	40	40	85	219	3.7	100
10	37+410.082	624.697	820	360 (230)	(700) 460	60	60	85	222	5.0	100
11	39+884.917	293.221	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
12	42+508.014	571.494	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
13	44+515.937	1256.456	3,500	360 (230)	(700) 460	0	NR	NR	0	NC	100
14	46+506.400	940.979	900	360 (230)	(700) 460	150	55	85	367	4.9	100

No.	Chainage	Curve Length Lc	Curve Radius R			Spiral Length Ls			Spiral Parameter A	Super Elevation	Design Speed
		DPR	DPR	Standard's Criteria (IRC:SP:73-1980) Minimum	Ref: Japan 道路構造令 Minimum	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japan 道路構造令 Minimum	GAD	DPR	DPR
		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(%)	(kmph)
SECTION 3											
1	47+713.406	614.468	1,100	360 (230)	(700) 460	130	50	85	378	4.0	100
2	51+012.811	2070.974	1,500	360 (230)	(700) 460	105	35	NR	397	3.0	100
3	53+301.377	231.234	1,200	360 (230)	(700) 460	40	40	85	219	3.7	100
4	53+824.176	552.766	525	360 (230)	(700) 460	50	95	85	162	5.0	100
5	55+545.072	947.996	1,500	360 (230)	(700) 460	35	35	NR	229	3.0	100
6	56+949.787	624.172	900	360 (230)	(700) 460	75	55	85	260	4.9	100
7	60+015.968	1072.548	1,000	360 (230)	(700) 460	70	50	85	265	4.4	100
8	62+701.180	954.621	800	360 (230)	(700) 460	165	60	85	363	3.6	100
9	67+753.255	647.369	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
10	69+342.570	294.855	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
11	71+357.817	1465.304	1,500	360 (230)	(700) 460	35	35	NR	229	3.0	100
12	73+189.977	1394.376	1,250	360 (230)	(700) 460	40	50	85	224	3.6	100
13	74+229.450	600.918	1,212	360 (230)	(700) 460	50	50	85	246	3.7	100
14	74+890.596	368.676	1,800	360 (230)	(700) 460	50	30	NR	300	NC	100
15	75+492.018	271.529	685	360 (230)	(700) 460	75	70	85	227	4.2	100
16	76+102.368	318.242	5,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
17	76+536.673	362.733	5,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
18	77+057.860	275.722	650	360 (230)	(700) 460	80	70	85	228	4.4	100
19	77+530.301	56.008	600	360 (230)	(700) 460	80	80	85	219	4.7	100

No.	Chainage	Curve Length Lc DPR	Curve Radius R DPR	Curve Radius R Standard's Criteria (IRC:SP:73-1980) Minimum	Curve Radius R Ref: Japan 道路構造令 Minimum	Spiral Length Ls DPR	Spiral Length Ls Standard's Criteria (IRC:73-1980) Minimum	Spiral Length Ls Ref: Japan 道路構造令 Minimum	Spiral Parameter A GAD	Super Elevation DPR	Design Speed DPR
		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(%)	(kmph)
SECTION 4											
1	78+851.051	100.848	275	360 (230)	(400) 280	50	75	70	117	4.04	80
2	79+114.080	100.67	310	360 (230)	(400) 280	40	75	70	111	3.58	80
3	79+542.904	204.169	1200	360 (230)	(400) 280	0	NR	NR	0	NC	80
4	80+134.297	246.141	1000	360 (230)	(400) 280	0	30	NR	0	NC	80
5	80+828.046	154.699	1000	360 (230)	(400) 280	0	30	NR	0	NC	80
6	81+101.304	145.613	250	360 (230)	(400) 280	50	75	70	112	4.44	80
7	81+355.759	149.478	520	360 (230)	(400) 280	40	45	70	144	3.61	80
8	82+821.692	287.266	2500	360 (230)	(400) 280	0	NR	NR	0	NC	80
9	83+361.641	193.251	645	360 (230)	(400) 280	35	35	70	150	4.41	80
10	83+835.575	39.846	800	360 (230)	(400) 280	30	30	70	155	3.56	80
11	84+035.765	148.451	280	360 (230)	(400) 280	30	75	70	92	3.97	80
12	84+576.445	339.546	560	360 (230)	(400) 280	95	35	70	231	5.08	80
13	84+926.426	74.755	580	360 (230)	(400) 280	0	35	70	0	4.9	80
14	85+006.921	33.755	1200	360 (230)	(400) 280	0	NR	NR	0	NC	80
15	85+099.624	67.961	800	360 (230)	(400) 280	0	30	70	0	3.56	80
16	85+409.959	263.681	580	360 (230)	(400) 280	25	35	70	120	4.9	80
17	85+909.195	177.453	1200	360 (230)	(400) 280	0	NR	NR	0	NC	80
18	86+368.992	111.544	260	360 (230)	(400) 280	30	75	70	88	4.27	80
19	86+754.510	516.202	670	360 (230)	(400) 280	0	35	70	0	4.25	80
20	87+136.501	41.444	1500	360 (230)	(400) 280	0	NR	NR	0	NC	80
21	87+413.601	143.027	1620	360 (230)	(400) 280	30	NR	NR	220	NC	80
22	88+020.902	125.675	1100	360 (230)	(400) 280	40	30	NR	210	4.04	80
23	88+300.961	26.622	1200	360 (230)	(400) 280	0	NR	NR	0	NC	80
24	88+388.390	32.758	1200	360 (230)	(400) 280	0	NR	NR	0	NC	80

No.	Chainage	Curve				Spiral				Super Elevation	Design Speed
		Length	Radius			Length			Parameter		
		Lc	R			Ls			A		
		DPR	DPR	Standard's Criteria (IRC:SP:73-1980) Minimum	Ref: Japan 道路構造令 Minimum	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japan 道路構造令 Minimum	GAD	DPR	DPR
		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(%)	(kmph)
25	88+561.041	22.25	2700	360 (230)	(400) 280	0	NR	NR	0	NC	80
26	88+779.786	25.163	10000	360 (230)	(400) 280	0	NR	NR	0	NC	80
27	89+963.968	186.568	430	360 (230)	(400) 280	35	55	70	123	4.37	80
28	90+402.000	22.343	2000	360 (230)	(400) 280	0	NR	NR	0	NC	80
29	90+483.303	15.261	2000	360 (230)	(400) 280	0	NR	NR	0	NC	80
30	90+788.365	24.324	10000	360 (230)	(400) 280	0	NR	NR	0	NC	80
31	91+154.239	102.041	800	360 (230)	(400) 280	60	30	70	219	3.56	80
32	91+948.435	120.999	620	360 (230)	(400) 280	40	35	70	157	4.59	80
33	92+471.567	98.089	800	360 (230)	(400) 280	30	30	70	155	3.56	80
34	93+444.090	214.851	800	360 (230)	(400) 280	30	30	70	155	3.56	80
35	95+105.829	263.206	600	360 (230)	(400) 280	40	35	70	155	4.74	80
36	95+497.446	271.423	400	360 (230)	(400) 280	35	55	70	118	4.52	80
37	95+893.447	223.592	420	360 (230)	(400) 280	35	55	70	121	4.47	80
38	96+863.854	288.373	2500	360 (230)	(400) 280	0	NR	NR	0	NC	80
39	98+451.421	306.977	700	360 (230)	(400) 280	70	35	70	221	4.06	80
40	100+000.183	442.966	243	360 (230)	(400) 280	35	NA	70	92	4.57	80
41	100+436.217	359.099	500	360 (230)	(400) 280	25	45	70	112	3.76	80
42	100+944.710	70.794	200	360 (230)	(400) 280	60	NA	70	110	3.56	80
43	101+343.802	63.867	200	360 (230)	(400) 280	60	NA	70	110	3.56	80

No.	Chainage	Curve				Spiral				Super Elevation	Design Speed
		Length	Radius			Length			Parameter		
		Lc	R			Ls			A		
		DPR	DPR	Standard's Criteria (IRC:SP:73-1980)	Ref: Japan 道路構造令	DPR	Standard's Criteria (IRC:73-1980)	Ref: Japan 道路構造令	GAD	DPR	DPR
				Minimum	Minimum		Minimum	Minimum			
		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(%)	(kmph)
SECTION 5											
1	103+303.836	646.414	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
2	105+104.402	1216.411	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
3	106+090.478	510.497	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
4	109+045.986	868.657	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
5	110+944.433	970.643	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
6	112+416.511	896.058	1,000	360 (230)	(700) 460	50	50	85	224	4.4	100
7	114+860.019	746.17	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
8	117+553.769	1015.004	5,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
9	119+910.641	1484.83	1,000	360 (230)	(700) 460	50	50	85	224	4.4	100
10	122+943.818	1098.274	2,200	360 (230)	(700) 460	0	NR	NR	0	NC	100
11	124+874.278	356.879	2,500	360 (230)	(700) 460	0	NR	NR	0	NC	100
12	127+318.941	344.582	2,500	360 (230)	(700) 460	0	NR	NR	0	NC	100
13	127+724.555	77.224	5,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
14	128+348.357	55.502	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100
15	128+526.815	189.611	2,000	360 (230)	(700) 460	0	NR	NR	0	NC	100

Legend (red): Does not meet the IRC required value (the minimum value if stipulated)
(orange): Meets the IRC minimum value but does not meet the ruling value
(light orange): Meets the IRC required value but does not meet the Japanese Standard required value (for reference)

Note: GAD: General Arrangement Drawings, DPR: Detailed Project Report, NA: Not Applicable, NR: (Spiral) Not Required, NC: Normal Crown (No Superelevation)
Source: JICA Study Team based on DPR

R200 curves that are adopted at the S-shaped Curve before NH45 IC in Section 4 are the smallest curves throughout the route, and they meet the minimum requirement of IRC. Thus, significant issues are not found for horizontal curve radius. However, the spiral length is not sufficient in some sections; thus, it is desirable to improve those sections.

(2) Vertical Alignment

Similarly, Table 6.2.2 to Table 6.2.6 show the assessment results of vertical elements.

Table 6.2.2 Assessment of Vertical Elements (1/5)

No.	Chainage	VIP	Tangent			Curve					Design Speed	Curve Type
	CH	Level	Slope		Length	Length Lc			Radius R			
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum	(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)	(km/h)	
SECTION 1												
1	+305.51	7.773	0.776%	3.3 (5.0) %	266.715	77.58	60	85	4,500	1,250	100	Sag
2	+553.92	13.983	2.50%	3.3 (5.0) %	160.228	98.8	60	85	4,000	1,800	100	Hog
3	+753.69	14.043	-0.30%	3.3 (5.0) %	99.771	101.2	60	85	4,000	1,800	100	Hog
4	1+021.11	7.358	-2.50%	3.3 (5.0) %	172.818	88	60	85	4,000	1,250	100	Sag
5	1+900.00	4.721	-0.30%	3.3 (5.0) %	780.889	108	60	85	18,000	3,000	100	Sag
6	2+756.00	7.289	0.30%	3.3 (5.0) %	682	240	60	85	40,000	6,500	100	Hog
7	3+466.50	5.157	-0.30%	3.3 (5.0) %	560.5	60	60	85	10,000	3,000	100	Sag
8	4+178.67	7.294	0.30%	3.3 (5.0) %	607.167	150	60	85	25,000	6,500	100	Hog
9	4+761.48	5.546	-0.30%	3.3 (5.0) %	471.209	73.2	60	85	12,000	3,000	100	Sag
10	5+211.64	6.941	0.31%	3.3 (5.0) %	367.814	91.5	60	85	15,000	6,500	100	Hog
11	5+777.17	5.245	-0.30%	3.3 (5.0) %	339.777	360	60	85	60,000	3,000	100	Sag
12	7+026.83	8.993	0.30%	3.3 (5.0) %	1015.667	108	60	85	18,000	6,500	100	Hog
13	7+512.38	7.537	-0.30%	3.3 (5.0) %	375.544	112	60	85	4,000	3,000	100	Sag
14	7+842.97	15.802	2.50%	3.3 (5.0) %	77.545	394.1	60	85	7,882	6,500	100	Hog
15	8+177.97	7.427	-2.50%	3.3 (5.0) %	81.944	112	60	85	4,000	3,000	100	Sag
16	8+727.50	9.075	0.30%	3.3 (5.0) %	457.533	72	60	85	12,000	6,500	100	Hog
17	9+179.55	7.719	-0.30%	3.3 (5.0) %	367.047	98	60	85	3,500	3,000	100	Sag
18	9+607.37	18.415	2.50%	3.3 (5.0) %	285.076	187.5	60	85	7,500	6,500	100	Hog
19	9+900.39	18.415	0.00%	3.3 (5.0) %	104.766	189.005	60	85	8,000	6,500	100	Hog
20	10+315.06	8.618	-2.36%	3.3 (5.0) %	187.037	266.257	60	85	10,000	3,000	100	Sag
21	10+944.27	10.506	0.30%	3.3 (5.0) %	463.077	66	60	85	3,000	3,000	100	Sag
22	11+272.07	18.701	2.50%	3.3 (5.0) %	103.935	381.75	60	85	7,635	6,500	100	Hog
23	11+614.77	10.134	-2.50%	3.3 (5.0) %	95.42	112.8	60	85	4,000	3,000	100	Sag
24	11+966.97	11.261	0.32%	3.3 (5.0) %	246.748	98.1	60	85	4,500	3,000	100	Sag

No.	Chainage	VIP	Tangent			Curve						Design	Curve Type
		Level	Slope		Length	Length			Radius			Speed	
	CH					Lc			R				
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum		(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)		(km/h)	
25	12+310.00	19.836	2.50%	3.3 (5.0) %	56.127	475.7	60	85	9,514	6,500		100	Hog
26	12+649.65	11.345	-2.50%	3.3 (5.0) %	45.807	112	60	85	4,000	3,000		100	Sag
27	13+380.67	13.538	0.30%	3.3 (5.0) %	639.015	72	60	85	12,000	6,500		100	Hog
28	13+762.17	12.393	-0.30%	3.3 (5.0) %	233.507	224	60	85	8,000	3,000		100	Sag
29	14+154.01	22.189	2.50%	3.3 (5.0) %	68.586	422.5	60	85	8,450	6,500		100	Hog
30	14+528.13	12.836	-2.50%	3.3 (5.0) %	106.87	112	60	85	4,000	3,000		100	Sag
31	15+449.17	15.6	0.30%	3.3 (5.0) %	805.038	120	60	85	20,000	6,500		100	Hog
32	16+045.67	13.81	-0.30%	3.3 (5.0) %	512.5	48	60	85	8,000	3,000		100	Sag
33	16+816.81	16.123	0.30%	3.3 (5.0) %	719.639	55	60	85	2,500	3,000		100	Sag
34	17+086.98	22.878	2.50%	3.3 (5.0) %	57.872	369.6	60	85	7,392	6,500		100	Hog
35	17+375.73	15.659	-2.50%	3.3 (5.0) %	54.956	98	60	85	3,500	3,000		100	Sag
36	18+009.90	17.561	0.30%	3.3 (5.0) %	525.162	120	60	85	20,000	6,500		100	Hog
37	18+596.35	15.802	-0.30%	3.3 (5.0) %	442.452	168	60	85	6,000	3,000		100	Sag
38	18+967.99	25.093	2.50%	3.3 (5.0) %	102.841	369.6	60	85	7,392	6,500		100	Hog
39	19+261.37	17.758	-2.50%	3.3 (5.0) %	64.581	88	60	85	4,000	3,000		100	Sag
40	19+594.10	16.76	-0.30%	3.3 (5.0) %	258.729	60	60	85	10,000	3,000		100	Sag
41	20+370.95	19.091	0.30%	3.3 (5.0) %	702.854	88	60	85	4,000	3,000		100	Sag
42	20+617.44	25.253	2.50%	3.3 (5.0) %	99.987	205	60	85	8,200	6,500		100	Hog

Legend (red): Does not meet the IRC required value (the minimum value if stipulated)
(orange): Meets the IRC minimum value but does not meet the ruling value
(light orange): Meets the IRC required value but does not meet the Japanese Standard required value (for reference)

Note: GAD: General Arrangement Drawings, DPR: Detailed Project Report, NA: Not Applicable, NR: (Spiral) Not Required, NC: Normal Crown (No Superelevation)

Source: JICA Study Team based on DPR

Table 6.2.3 Assessment of Vertical Elements (2/5)

No.	Chainage	VIP	Tangent			Curve						Design Speed	Curve Type
			Slope		Length	Length			Radius				
	CH	Level				Lc			R				
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum		(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)		(km/h)	
SECTION 2													
1	21+149.24	25.253	0.00%	3.3 (5.0) %	326.800	205	60	85	8,200	6,500		100	Hog
2	21+365.96	19.835	-2.50%	3.3 (5.0) %	70.215	88	60	85	4,000	3,000		100	Sag
3	22+546.67	16.29	-0.30%	3.3 (5.0) %	897.000	480	60	85	80,000	3,000		100	Sag
4	23+099.14	17.947	0.30%	3.3 (5.0) %	290.470	44	60	85	2,000	3,000		100	Sag
5	23+314.00	23.319	2.50%	3.3 (5.0) %	43.239	299.25	60	85	5,985	6,500		100	Hog
6	23+560.71	17.151	-2.50%	3.3 (5.0) %	41.089	112	60	85	4,000	3,000		100	Sag
7	24+206.11	19.087	0.30%	3.3 (5.0) %	556.394	66	60	85	3,000	3,000		100	Sag
8	24+490.60	26.2	2.50%	3.3 (5.0) %	53.117	396.75	60	85	7,935	6,500		100	Hog
9	24+839.45	17.478	-2.50%	3.3 (5.0) %	94.476	112	60	85	4,000	3,000		100	Sag
10	25+880.00	20.6	0.30%	3.3 (5.0) %	864.550	240	60	85	40,000	6,500		100	Hog
11	26+599.83	18.44	-0.30%	3.3 (5.0) %	563.833	72	60	85	12,000	3,000		100	Sag
12	27+378.96	20.778	0.30%	3.3 (5.0) %	699.126	88	60	85	4,000	3,000		100	Sag
13	27+692.28	28.611	2.50%	3.3 (5.0) %	71.118	396.4	60	85	7,928	6,500		100	Hog
14	28+006.60	20.753	-2.50%	3.3 (5.0) %	60.122	112	60	85	4,000	3,000		100	Sag
15	28+899.14	23.43	0.30%	3.3 (5.0) %	756.537	66	60	85	3,000	3,000		100	Sag
16	29+172.03	30.253	2.50%	3.3 (5.0) %	89.997	364	60	85	7,280	6,500		100	Hog
17	29+419.29	24.071	-2.50%	3.3 (5.0) %	77.185	39.6	60	85	1,800	3,000		100	Sag
18	30+094.83	22.045	-0.30%	3.3 (5.0) %	540.741	150	60	85	25,000	3,000		100	Sag
19	31+053.33	24.92	0.30%	3.3 (5.0) %	763.500	240	60	85	40,000	6,500		100	Hog
20	31+625.00	23.205	-0.30%	3.3 (5.0) %	391.667	120	60	85	20,000	3,000		100	Sag
21	32+473.36	25.75	0.30%	3.3 (5.0) %	733.361	110	60	85	5,000	3,000		100	Sag
22	32+862.00	35.466	2.50%	3.3 (5.0) %	137.385	392.5	60	85	7,850	6,500		100	Hog
23	33+145.22	28.385	-2.50%	3.3 (5.0) %	53.975	66	60	85	3,000	3,000		100	Sag
24	33+796.38	26.432	-0.30%	3.3 (5.0) %	538.153	160	60	85	20,000	3,000		100	Sag

No.	Chainage	VIP	Tangent			Curve						Design	Curve Type
	CH	Level	Slope		Length	Length Lc			Radius R			Speed	
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum		(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)		(km/h)	
25	34+340.00	29.15	0.50%	3.3 (5.0) %	383.625	160	60	85	20,000	6,500		100	Hog
26	35+239.31	26.452	-0.30%	3.3 (5.0) %	763.310	112	60	85	4,000	3,000		100	Sag
27	35+481.93	32.518	2.50%	3.3 (5.0) %	86.622	200	60	85	4,000	6,500		100	Hog
28	35+720.10	26.563	-2.50%	3.3 (5.0) %	89.172	98	60	85	3,500	3,000		100	Sag
29	36+185.17	27.959	0.30%	3.3 (5.0) %	380.062	72	60	85	12,000	6,500		100	Hog
30	36+415.83	27.267	-0.30%	3.3 (5.0) %	173.667	42	60	85	7,000	3,000		100	Sag
31	36+710.33	28.15	0.30%	3.3 (5.0) %	252.500	42	60	85	3,500	3,000		100	Sag
32	37+227.99	35.915	1.50%	3.3 (5.0) %	78.010	837.3	60	85	27,910	6,500		100	Hog
33	37+771.50	27.762	-1.50%	3.3 (5.0) %	93.359	63	60	85	3,500	3,000		100	Sag
34	38+686.54	30.507	0.30%	3.3 (5.0) %	748.536	270	60	85	45,000	6,500		100	Hog
35	39+213.33	28.927	-0.30%	3.3 (5.0) %	361.794	60	60	85	10,000	3,000		100	Sag
36	40+173.83	31.808	0.30%	3.3 (5.0) %	840.500	180	60	85	30,000	6,500		100	Hog
37	40+676.67	30.3	-0.30%	3.3 (5.0) %	376.833	72	60	85	12,000	3,000		100	Sag
38	41+538.36	32.885	0.30%	3.3 (5.0) %	789.690	72	60	85	12,000	6,500		100	Hog
39	41+905.60	31.783	-0.30%	3.3 (5.0) %	275.247	112	60	85	4,000	3,000		100	Sag
40	42+247.93	40.342	2.50%	3.3 (5.0) %	194.377	183.9	60	85	3,678	6,500		100	Hog
41	42+554.31	32.682	-2.50%	3.3 (5.0) %	158.432	112	60	85	4,000	3,000		100	Sag
42	43+475.26	35.445	0.30%	3.3 (5.0) %	684.942	360	60	85	60,000	6,500		100	Hog
43	44+262.42	33.083	-0.30%	3.3 (5.0) %	547.167	120	60	85	20,000	3,000		100	Sag
44	45+284.93	36.151	0.30%	3.3 (5.0) %	887.507	150	60	85	25,000	6,500		100	Hog
45	45+773.26	34.686	-0.30%	3.3 (5.0) %	338.333	150	60	85	25,000	3,000		100	Sag
46	46+639.98	37.286	0.30%	3.3 (5.0) %	731.720	120	60	85	20,000	6,500		100	Hog
47	46+934.93	36.401	-0.30%	3.3 (5.0) %	178.942	112	60	85	4,000	3,000		100	Sag
48	47+272.00	44.828	2.50%	3.3 (5.0) %	176.575	209	60	85	4,180	6,500		100	Hog

Legend (red): Does not meet the IRC required value (the minimum value if stipulated)
(orange): Meets the IRC minimum value but does not meet the ruling value
(light orange): Meets the IRC required value but does not meet the Japanese Standard required value (for reference)

Note: GAD: General Arrangement Drawings, DPR: Detailed Project Report, NA: Not Applicable NR: (Spiral), Not Required, NC: Normal Crown (No Superelevation)
Source: JICA Study Team based on DPR

Table 6.2.4 Assessment of Vertical Elements (3/5)

No.	Chainage	VIP	Tangent			Curve					Design	Curve Type
			Slope		Length	Length			Radius		Speed	
	CH	Level				Lc			R			
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum	(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)	(km/h)	
SECTION 3												
1	47+505.76	38.984	-2.50%	3.3 (5.0) %	74.264	110	60	85	5,000	3,000	100	Sag
2	48+229.70	36.812	-0.30%	3.3 (5.0) %	632.937	72	60	85	12,000	3,000	100	Sag
3	49+267.04	39.924	0.30%	3.3 (5.0) %	821.000	360	60	85	60,000	6,500	100	Hog
4	49+950.54	37.874	-0.30%	3.3 (5.0) %	413.500	180	60	85	30,000	3,000	100	Sag
5	50+565.64	39.719	0.30%	3.3 (5.0) %	494.302	61.6	60	85	2,800	3,000	100	Sag
6	50+908.00	48.278	2.50%	3.3 (5.0) %	109.312	404.5	60	85	8,090	6,500	100	Hog
7	51+264.05	39.377	-2.50%	3.3 (5.0) %	95.202	117.2	60	85	4,000	3,000	100	Sag
8	52+285.21	43.768	0.43%	3.3 (5.0) %	907.809	109.5	60	85	15,000	6,500	100	Hog
9	53+112.05	41.287	-0.30%	3.3 (5.0) %	727.089	90	60	85	15,000	3,000	100	Sag
10	53+724.81	43.125	0.30%	3.3 (5.0) %	523.754	88	60	85	4,000	3,000	100	Sag
11	53+979.31	49.488	2.50%	3.3 (5.0) %	85.503	250	60	85	10,000	6,500	100	Hog
12	54+640.99	49.488	0.00%	3.3 (5.0) %	411.678	250	60	85	10,000	6,500	100	Hog
13	54+943.75	41.919	-2.50%	3.3 (5.0) %	77.767	200	60	85	4,000	3,000	100	Sag
14	55+273.80	50.17	2.50%	3.3 (5.0) %	133.797	192.5	60	85	7,700	6,500	100	Hog
15	55+613.99	50.17	0.00%	3.3 (5.0) %	148.941	190	60	85	7,600	6,500	100	Hog
16	55+835.17	44.641	-2.50%	3.3 (5.0) %	77.180	98	60	85	3,500	3,000	100	Sag
17	56+421.40	46.399	0.30%	3.3 (5.0) %	515.979	42.5	60	85	2,500	3,000	100	Sag
18	56+753.13	53.034	2.00%	3.3 (5.0) %	52.120	516.72	60	85	12,918	6,500	100	Hog
19	57+142.25	45.251	-2.00%	3.3 (5.0) %	60.760	140	60	85	4,000	3,000	100	Sag
20	57+712.02	53.798	1.50%	3.3 (5.0) %	420.267	159	60	85	53,000	6,500	100	Hog
21	58+266.23	45.485	-1.50%	3.3 (5.0) %	432.114	85.2	60	85	4,000	3,000	100	Sag
22	59+031.43	50.305	0.63%	3.3 (5.0) %	691.773	61.65	60	85	4,500	3,000	100	Sag
23	59+450.12	58.679	2.00%	3.3 (5.0) %	224.967	325.8	60	85	8,145	6,500	100	Hog
24	59+707.90	53.524	-2.00%	3.3 (5.0) %	66.130	57.5	60	85	2,500	3,000	100	Sag
25	60+100.26	54.701	0.30%	3.3 (5.0) %	285.604	156	60	85	12,000	6,500	100	Hog
26	60+967.95	46.024	-1.00%	3.3 (5.0) %	627.193	325	60	85	25,000	3,000	100	Sag
27	62+634.97	51.025	0.30%	3.3 (5.0) %	1,488.025	33	60	85	1,500	3,000	100	Sag
28	62+794.02	55.001	2.50%	3.3 (5.0) %	42.518	200.05	60	85	4,001	6,500	100	Hog

No.	Chainage CH	VIP Level	Tangent Slope		Tangent Length	Curve Length Lc			Curve Radius R		Design Speed	Curve Type
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum	(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)	(km/h)	
29	63+106.12	47.198	-2.50%	3.3 (5.0) %	166.795	112	60	85	4,000	3,000	100	Sag
30	63+522.41	48.447	0.30%	3.3 (5.0) %	271.804	84.679	60	85	10,000	3,000	100	Sag
31	63+843.35	52.128	1.15%	3.3 (5.0) %	272.996	82.071	60	85	20,000	6,500	100	Hog
32	64+509.46	57.033	0.74%	3.3 (5.0) %	568.252	113.643	60	85	10,000	6,500	100	Hog
33	64+677.42	56.361	-0.40%	3.3 (5.0) %	73.135	76	60	85	4,000	3,000	100	Sag
34	64+962.80	60.642	1.50%	3.3 (5.0) %	88.381	318	60	85	10,600	6,500	100	Hog
35	65+361.59	54.66	-1.50%	3.3 (5.0) %	181.789	116	60	85	4,000	3,000	100	Sag
36	65+853.14	61.542	1.40%	3.3 (5.0) %	331.605	203.895	60	85	30,000	6,500	100	Hog
37	67+422.55	72.847	0.72%	3.3 (5.0) %	1,138.208	658.509	60	85	40,000	6,500	100	Hog
38	68+689.16	61.119	-0.93%	3.3 (5.0) %	863.559	147.592	60	85	10,000	3,000	100	Sag
39	69+291.03	64.43	0.55%	3.3 (5.0) %	499.080	58	60	85	4,000	3,000	100	Sag
40	69+774.61	74.101	2.00%	3.3 (5.0) %	309.477	290.2	60	85	7,255	6,500	100	Hog
41	70+146.31	66.667	-2.00%	3.3 (5.0) %	192.599	68	60	85	4,000	3,000	100	Sag
42	70+516.25	65.557	-0.30%	3.3 (5.0) %	216.803	238.267	60	85	25,000	6,500	100	Hog
43	71+061.47	58.725	-1.25%	3.3 (5.0) %	361.030	130.123	60	85	4,000	3,000	100	Sag
44	71+576.03	69.016	2.00%	3.3 (5.0) %	242.893	413.2	60	85	10,330	6,500	100	Hog
45	72+170.77	57.122	-2.00%	3.3 (5.0) %	333.141	110	60	85	10,000	3,000	100	Sag
46	72+554.83	53.665	-0.90%	3.3 (5.0) %	301.563	55	60	85	10,000	3,000	100	Sag
47	74+661.06	46.293	-0.35%	3.3 (5.0) %	2,050.226	57	60	85	2,000	3,000	100	Sag
48	74+837.34	50.7	2.50%	3.3 (5.0) %	52.232	191.1	60	85	9,800	6,500	100	Hog
49	76+578.18	60.275	0.55%	3.3 (5.0) %	1,549.044	192.5	60	85	35,000	6,500	100	Hog
50	77+352.20	60.275	0.00%	3.3 (5.0) %	584.016	187.5	60	85	7,500	6,500	100	Hog
51	77+832.26	48.273	-2.50%	3.3 (5.0) %	353.412	65.797	60	85	3,500	3,000	100	Sag

Legend : Does not meet the IRC required value (the minimum value if stipulated)
: Meets the IRC minimum value but does not meet the ruling value
: Meets the IRC required value but does not meet the Japanese Standard required value (for reference)

Note: GAD: General Arrangement Drawings, DPR: Detailed Project Report, NA: Not Applicable, NR: (Spiral) Not Required, NC: Normal Crown (No Superelevation)

Source: JICA Study Team based on DPR

Table 6.2.5 Assessment of Vertical Elements (4/5)

No.	Chainage	VIP	Tangent			Curve					Design Speed	Curve Type
	CH	Level	Slope		Length	Length Lc			Radius R			
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum	(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)	(km/h)	
SECTION 4												
1	77+878.68	47.927	2.20%	3.3 (5.0) %	116.727	126.124	50	70	2,600	2,000	80	Sag
2	78+204.00	53.413	2.198	3.3 (5.0) %	116.727	291.054	50	70	6,000	3,000	80	Hog
3	78+620.38	45.147	-2.5	3.3 (5.0) %	222.332	97.032	50	70	4,300	2,000	80	Sag
4	78+874.72	44.446	-0.169	3.3 (5.0) %	175.829	60	50	70	14,815	2,000	80	Sag
5	79+841.39	46.684	0.236	3.3 (5.0) %	906.675	60	50	70	12,713	3,000	80	Hog
6	80+447.60	45.676	-0.236	3.3 (5.0) %	518.982	114.439	50	70	4,300	2,000	80	Sag
7	81+004.01	57.459	2.5	3.3 (5.0) %	363.583	271.215	50	70	5,600	3,000	80	Hog
8	81+286.62	52.534	-2.491	3.3 (5.0) %	99.642	94.721	50	70	3,000	2,000	80	Sag
9	81+400.49	52.811	0.742	3.3 (5.0) %	11.515	110	50	70	7,939	3,000	80	Hog
10	81+996.05	49.192	-0.644	3.3 (5.0) %	510.554	60	50	70	18,563	2,000	80	Sag
11	82+329.76	48.508	-0.32	3.3 (5.0) %	244.759	117.912	50	70	4,300	2,000	80	Sag
12	82+759.00	56.944	2.496	3.3 (5.0) %	224.867	290.834	50	70	6,000	3,000	80	Hog
13	83+201.71	48.144	-2.5	3.3 (5.0) %	239.023	116.54	50	70	4,300	2,000	80	Sag
14	84+061.01	50.119	0.285	3.3 (5.0) %	761.021	80	50	70	10,860	3,000	80	Hog
15	84+903.48	46.848	-0.452	3.3 (5.0) %	739.188	126.57	50	70	4,400	2,000	80	Sag
16	85+333.00	55.744	2.5	3.3 (5.0) %	259.525	213.422	50	70	4,400	3,000	80	Hog
17	85+671.37	49.049	-2.5	3.3 (5.0) %	173.784	115.749	50	70	4,400	2,000	80	Sag
18	86+147.74	49.914	0.206	3.3 (5.0) %	370.772	95.453	50	70	4,300	2,000	80	Sag
19	86+662.00	60.513	2.5	3.3 (5.0) %	311.317	310.424	50	70	6,400	3,000	80	Hog
20	86+908.41	56.705	-2.5	3.3 (5.0) %	43.418	95.573	50	70	3,200	2,000	80	Sag
21	87+370.21	58.798	0.563	3.3 (5.0) %	364.01	100	50	70	8,678	3,000	80	Hog
22	87+767.36	57.116	-0.59	3.3 (5.0) %	279.333	135.627	50	70	4,500	2,000	80	Sag
23	88+264.00	67.6	2.5	3.3 (5.0) %	319.685	218.276	50	70	4,500	3,000	80	Hog
24	88+581.41	61.347	-2.5	3.3 (5.0) %	158.697	99.148	50	70	4,500	2,000	80	Sag
25	89+294.08	59.995	-0.222	3.3 (5.0) %	573.536	119.129	50	70	4,500	2,000	80	Sag
26	89+603.00	66.614	2.5	3.3 (5.0) %	170.213	218.273	50	70	4,500	3,000	80	Hog
27	89+921.25	60.269	-2.5	3.3 (5.0) %	166.023	86.194	50	70	4,500	2,000	80	Sag
28	90+677.06	56.687	-0.51	3.3 (5.0) %	647.701	130	50	70	4,319	2,000	80	Sag
29	90+954.00	61.87	2.5	3.3 (5.0) %	111.944	200	50	70	4,000	3,000	80	Hog

No.	Chainage	VIP	Tangent			Curve					Design	Curve
		Level	Slope		Length	Length			Radius		Speed	Type
	CH					Lc			R			
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum	(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)	(km/h)	
30	91+425.86	51.689	-2.5	3.3 (5.0) %	316.861	110	50	70	4,148	2,000	80	Sag
31	92+321.91	52.981	0.152	3.3 (5.0) %	791.053	100	50	70	4,259	2,000	80	Sag
32	92+648.00	59.59	2.5	3.3 (5.0) %	176.086	200	50	70	4,000	3,000	80	Hog
33	93+123.00	49.141	-2.5	3.3 (5.0) %	335	80	50	70	4,552	2,000	80	Sag
34	93+387.05	47.549	-0.742	3.3 (5.0) %	155.987	136.129	50	70	4,300	2,000	80	Sag
35	93+623.00	51.642	2.5	3.3 (5.0) %	70.859	194.045	50	70	4,000	3,000	80	Hog
36	93+917.35	45.818	-2.5	3.3 (5.0) %	143.148	108.365	50	70	4,300	2,000	80	Sag
37	94+365.12	45.989	0.094	3.3 (5.0) %	363.585	60	50	70	13,907	2,000	80	Sag
38	95+000.15	49.534	0.526	3.3 (5.0) %	558.514	94.998	50	70	5,000	2,000	80	Sag
39	95+444.00	58.664	2.5	3.3 (5.0) %	261.976	266.774	50	70	5,500	3,000	80	Hog
40	95+867.20	50.181	-2.5	3.3 (5.0) %	231.727	116.179	50	70	4,500	2,000	80	Sag
41	96+297.46	50.46	0.156	3.3 (5.0) %	352.172	40	50	70	16,128	3,000	80	Hog
42	97+050.20	49.764	-0.092	3.3 (5.0) %	702.736	60	50	70	24,259	3,000	80	Hog
43	97+284.13	49.064	-0.339	3.3 (5.0) %	174	60	50	70	6,035	2,000	80	Sag
44	97+685.68	51.346	0.655	3.3 (5.0) %	302	140	50	70	8,940	3,000	80	Hog
45	98+141.73	47.589	-0.911	3.3 (5.0) %	346	80	50	70	6,535	2,000	80	Sag
46	98+493.36	48.55	0.313	3.3 (5.0) %	282	60	50	70	24,645	3,000	80	Hog
47	99+183.88	48.916	0.07	3.3 (5.0) %	611	100	50	70	9,223	3,000	80	Hog
48	99+534.87	46.132	-1.014	3.3 (5.0) %	227	147.678	50	70	4,300	2,000	80	Sag
49	99+842.00	51.967	2.5	3.3 (5.0) %	141	184.316	50	70	3,800	3,000	80	Hog
50	100+154.25	45.876	-2.5	3.3 (5.0) %	136	135.603	50	70	4,300	2,000	80	Sag
51	100+358.61	46.464	0.73	3.3 (5.0) %	61	150	50	70	7,864	3,000	80	Hog
52	100+597.23	44.071	-1.177	3.3 (5.0) %	134	60	50	70	7,655	2,000	80	Sag
53	101+165.00	42.431	-0.393	3.3 (5.0) %	468	140	50	70	3,757	2,000	80	Sag
54	101+558.00	54.461	3.333	3.3 (5.0) %	273	100	50	70	3,000	3,000	80	Hog
55	101+920.00	54.565	0	3.3 (5.0) %	262.001	100	50	70	4,000	3,000	80	Hog
56	102+230.08	47.629	-2.5	3.3 (5.0) %	190.075	140	50	70	4,859	2,000	80	Sag

Legend (red): Does not meet the IRC required value (the minimum value if stipulated)
(orange): Meets the IRC minimum value but does not meet the ruling value
(light orange): Meets the IRC required value but does not meet the Japanese Standard required value (for reference)

Note: GAD: General Arrangement Drawings, DPR: Detailed Project Report, NA: Not Applicable, NR: (Spiral) Not Required, NC: Normal Crown (No Superelevation)
Source: JICA Study Team based on DPR

Table 6.2.6 Assessment of Vertical Elements (5/5)

No.	Chainage	VIP	Tangent			Curve					Design Speed	Curve Type
	CH	Level	Slope		Length	Length Lc			Radius R			
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum	(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)	(km/h)	
SECTION 5												
1	103+328.36	52.633	0.30%	3.3 (5.0) %	589.860	77	60	85	3,500	3,000	100	Sag
2	103+583.01	58.999	2.50%	3.3 (5.0) %	101.145	230	60	85	5,750	6,500	100	Hog
3	103+757.58	56.381	-1.50%	3.3 (5.0) %	31.699	55.75	60	85	2,500	3,000	100	Sag
4	103+976.89	57.982	0.73%	3.3 (5.0) %	145.535	91.8	60	85	6,000	6,500	100	Hog
5	104+585.99	53.109	-0.80%	3.3 (5.0) %	404.952	316.5	60	85	15,000	3,000	100	Sag
6	105+309.80	62.591	1.31%	3.3 (5.0) %	448.110	234.9	60	85	9,000	6,500	100	Hog
7	105+744.10	56.945	-1.30%	3.3 (5.0) %	186.850	260	60	85	20,000	3,000	100	Sag
8	106+941.29	56.945	0.00%	3.3 (5.0) %	972.191	190	60	85	7,600	6,500	100	Hog
9	107+121.32	52.444	-2.50%	3.3 (5.0) %	52.026	66	60	85	3,000	3,000	100	Sag
10	108+190.77	49.236	-0.30%	3.3 (5.0) %	994.447	84	60	85	15,000	6,500	100	Hog
11	108+591.49	45.79	-0.86%	3.3 (5.0) %	330.123	57.2	60	85	2,000	3,000	100	Sag
12	108+927.03	52.501	2.00%	3.3 (5.0) %	80.139	453.6	60	85	10,080	6,500	100	Hog
13	109+278.20	43.721	-2.50%	3.3 (5.0) %	102.367	44	60	85	2,000	3,000	100	Sag
14	110+251.00	40.803	-0.30%	3.3 (5.0) %	920.805	60	60	85	20,000	3,000	100	Sag
15	110+796.62	40.803	0.00%	3.3 (5.0) %	470.620	90	60	85	6,000	6,500	100	Hog
16	111+150.65	35.493	-1.50%	3.3 (5.0) %	256.531	105	60	85	3,000	3,000	100	Sag
17	111+501.02	42.5	2.00%	3.3 (5.0) %	89.073	417.6	60	85	9,280	6,500	100	Hog
18	111+891.54	32.737	-2.50%	3.3 (5.0) %	137.713	88	60	85	4,000	3,000	100	Sag
19	112+848.92	29.865	-0.30%	3.3 (5.0) %	802.136	222.5	60	85	25,000	3,000	100	Sag
20	113+575.38	34.151	0.59%	3.3 (5.0) %	563.603	103.2	60	85	6,000	6,500	100	Hog
21	113+825.16	31.329	-1.13%	3.3 (5.0) %	150.994	94.38	60	85	2,600	3,000	100	Sag
22	114+024.02	36.3	2.50%	3.3 (5.0) %	43.665	216	60	85	4,320	6,500	100	Hog
23	114+501.16	24.371	-2.50%	3.3 (5.0) %	325.143	88	60	85	4,000	3,000	100	Sag
24	115+327.05	21.894	-0.30%	3.3 (5.0) %	752.999	57.777	60	85	18,000	3,000	100	Sag
25	116+506.30	22.141	0.02%	3.3 (5.0) %	1,086.164	128.394	60	85	40,000	6,500	100	Hog
26	117+498.58	19.164	-0.30%	3.3 (5.0) %	886.091	84	60	85	3,000	3,000	100	Sag
27	117+796.03	26.6	2.50%	3.3 (5.0) %	51.419	408.05	60	85	8,161	6,500	100	Hog
28	118+116.39	18.591	-2.50%	3.3 (5.0) %	60.343	112	60	85	4,000	3,000	100	Sag
29	118+459.20	19.62	0.30%	3.3 (5.0) %	166.802	240	60	85	40,000	6,500	100	Hog

No.	Chainage	VIP	Tangent			Curve					Design Speed	Curve Type
	CH	Level	Slope		Length	Length Lc			Radius R			
	DPR	DPR	GAD	Standard's Criteria (IRC:SP:73-1980) Maximum	GAD	DPR	Standard's Criteria (IRC:73-1980) Minimum	Ref: Japanese (道路構造令) Minimum	GAD	Ref: Japanese (道路構造令) Minimum	(DPR-DRH)	
	(m)	(m)	(%)	(%)	(m)	(m)	(m)	(m)	(m)	(m)	(km/h)	
30	118+913.33	18.257	-0.30%	3.3 (5.0) %	292.132	84	60	85	3,000	3,000	100	Sag
31	119+263.04	27	2.50%	3.3 (5.0) %	107.713	400	60	85	8,000	6,500	100	Hog
32	119+562.45	19.515	-2.50%	3.3 (5.0) %	64.408	70	60	85	2,500	3,000	100	Sag
33	120+197.27	21.419	0.30%	3.3 (5.0) %	527.283	145.081	60	85	10,000	6,500	100	Hog
34	120+530.40	17.586	-1.15%	3.3 (5.0) %	207.573	106.032	60	85	4,000	3,000	100	Sag
35	120+774.03	21.24	1.50%	3.3 (5.0) %	72.111	237	60	85	7,900	6,500	100	Hog
36	121+165.04	15.375	-1.50%	3.3 (5.0) %	248.514	48	60	85	4,000	3,000	100	Sag
37	122+021.35	12.806	-0.30%	3.3 (5.0) %	776.310	112	60	85	4,000	3,000	100	Sag
38	122+369.12	21.5	2.50%	3.3 (5.0) %	94.166	395.2	60	85	7,904	6,500	100	Hog
39	122+682.04	13.677	-2.50%	3.3 (5.0) %	71.318	88	60	85	4,000	3,000	100	Sag
40	123+759.73	10.444	-0.30%	3.3 (5.0) %	977.688	112	60	85	4,000	3,000	100	Sag
41	124+047.76	17.645	2.50%	3.3 (5.0) %	64.528	335	60	85	6,700	6,500	100	Hog
42	124+344.33	10.23	-2.50%	3.3 (5.0) %	59.079	140	60	85	5,000	3,000	100	Sag
43	125+129.45	12.586	0.30%	3.3 (5.0) %	660.120	110	60	85	5,000	3,000	100	Sag
44	125+482.02	21.4	2.50%	3.3 (5.0) %	101.595	391.95	60	85	7,839	6,500	100	Hog
45	125+756.72	14.532	-2.50%	3.3 (5.0) %	38.719	80	60	85	2,500	3,000	100	Sag
46	126+315.58	18.445	0.70%	3.3 (5.0) %	318.860	400	60	85	40,000	6,500	100	Hog
47	126+789.85	17.022	-0.30%	3.3 (5.0) %	218.269	112	60	85	4,000	3,000	100	Sag
48	127+077.02	24.201	2.50%	3.3 (5.0) %	51.102	360.15	60	85	7,203	6,500	100	Hog
49	127+347.68	17.435	-2.50%	3.3 (5.0) %	60.579	60	60	85	3,000	3,000	100	Sag
50	127+673.71	15.805	-0.50%	3.3 (5.0) %	258.529	75	60	85	3,000	3,000	100	Sag
51	127+871.03	19.751	2.00%	3.3 (5.0) %	44.173	231.3	60	85	5,140	6,500	100	Hog
52	128+225.60	10.887	-2.50%	3.3 (5.0) %	182.922	112	60	85	4,000	3,000	100	Sag
53	128+509.50	11.739	0.30%	3.3 (5.0) %	89.232	66	60	85	12,000	6,500	100	Hog

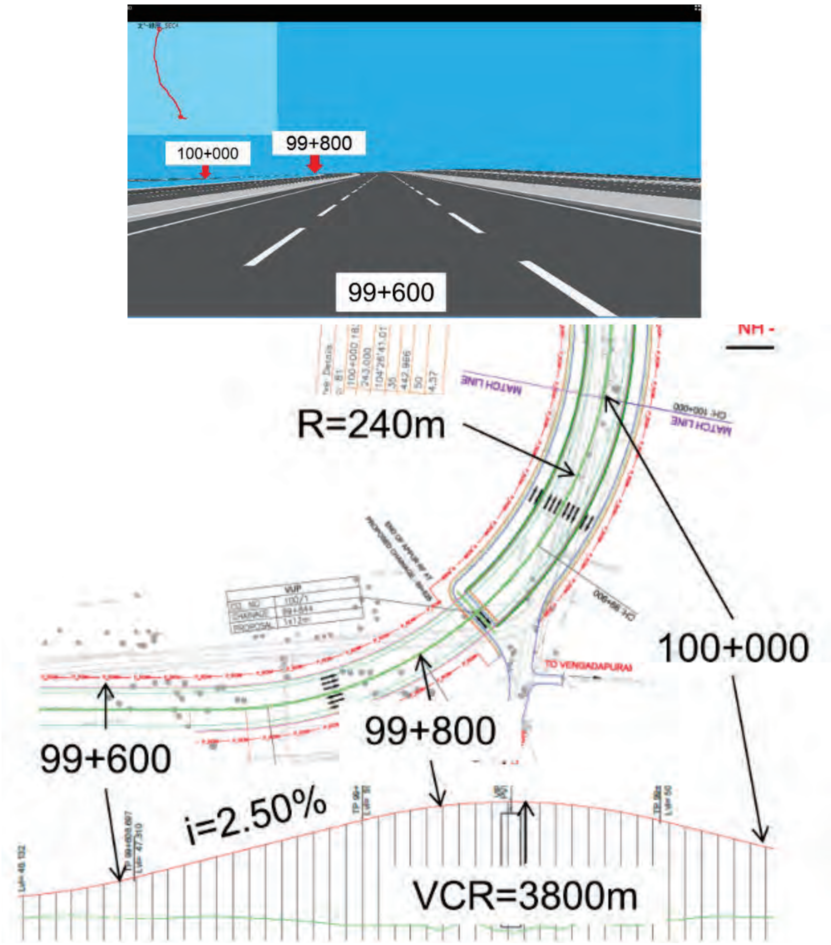
Legend
: Does not meet the IRC required value (the minimum value if stipulated)
: Meets the IRC minimum value but does not meet the ruling value
: Meets the IRC required value but does not meet the Japanese Standard required value (for reference)

Note: GAD: General Arrangement Drawings, DPR: Detailed Project Report, NA: Not Applicable, NR: (Spiral) Not Required, NC: Normal Crown (No Superelevation)
Source: JICA Study Team based on DPR

There is no issue on the gradient since all the applied values meet the IRC requirement throughout the route. On the other hand, the vertical curve length is not sufficient in some sections; thus, it is desirable to improve these sections.

(3) Combination of Horizontal Alignment and Vertical Alignment

In the alignment proposed in the DPR, especially in Section 4 which adhered to the alignment of the existing road, there are some sections where the horizontal and vertical alignments are not well-balanced. It is desirable for these sections to be improved in the detailed design stage of the Project. Figure 6.2.1 shows the alignment around Ch.99+600 where a relatively small curve is situated near the top of the crest curve that creates unfavorable situations in terms of visibility.

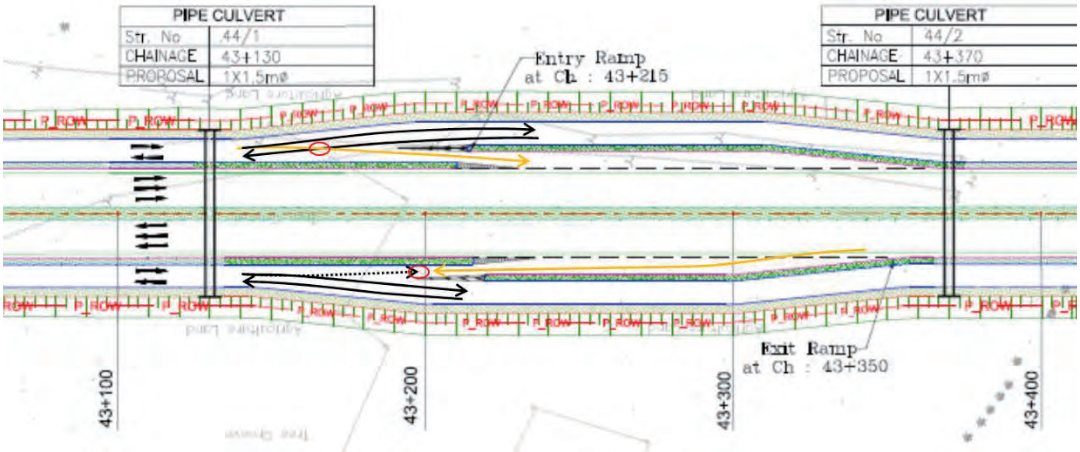


Source: JICA Study Team based on DPR

Figure 6.2.1 Alignment at Ch.99+600 and Drivers' View

6.2.2 Entry/Exit and Service Road

In the design made in the DPR, two-lane service roads that are to be operated as two-way roads are proposed on both sides of the main road. It is planned that the main road and the service road are separated by dividers in the general section, and vehicles may come in and out at entry and exit ramps. However, this system requires crossing at entries to reach the main road. Furthermore, there is a concern of incursions and collisions at exits. Therefore, it is recommended for the service road to have one-way operation at least in the vicinity of entries and exits.



Source: JICA Study Team based on DPR Drawings

Figure 6.2.2 Crossing at Entry and Exit Ramps

6.2.3 Junctions (Intersections/Junctions)

(1) Location and Type of Junction

The project road is an access-controlled highway and is connected with national highways (NH5, NH205, NH4, and NH45) by interchanges. It does not connect directly with state highways (SH51, SH50A, SH50, SH48, and AH57). Basically, a state highway crosses the project road through an underpass and connects to the service road of the project road. However, the project road connects with SH49, SH49B, and TPP Link Road through at-grade intersections (including roundabout) which are located at the beginning point, the end point, and the bifurcating point which are referred to as junctions.

In this section, the design of the junctions in the DPR is reviewed, and the improvement plan is proposed.

The location and the type of junctions are shown in Table 6.2.7.

Additionally, the improvement plan was examined for the connection with SH48.

In this report, it is considered that the intersections where the service road connects to the state highway are different from the junction.

Table 6.2.7 Location and Type of Junction

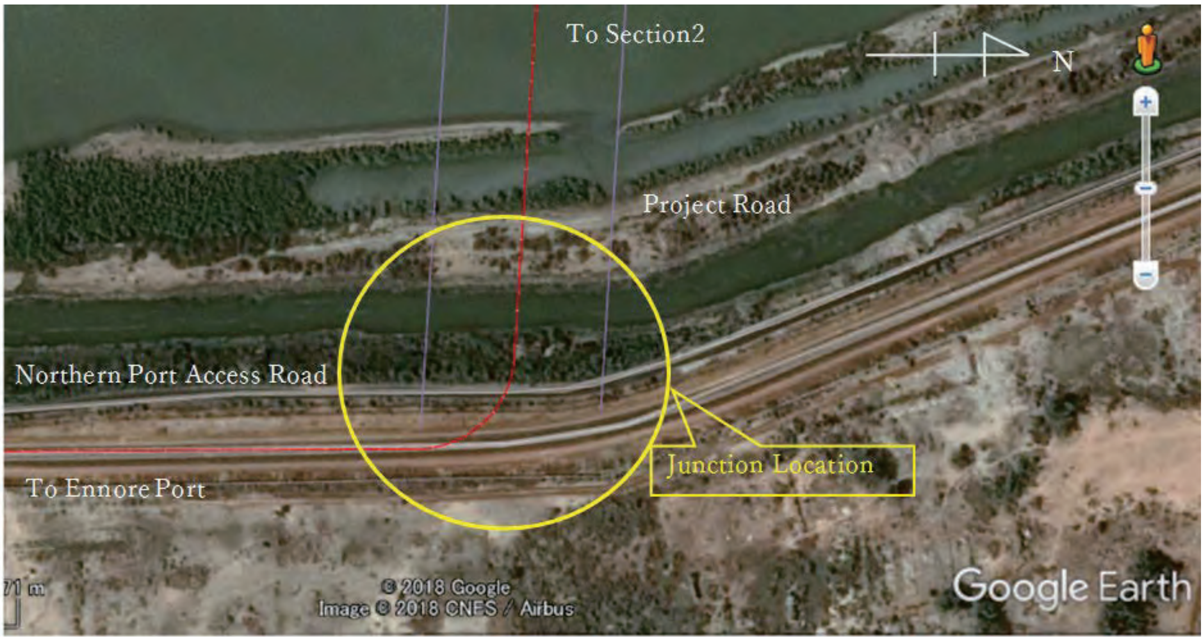
Junction		Connecting Road	Station No. of Main Road	Type of Junction
1	Beginning Point (Ennore Port)	Northern Port Access road	No.0+662 Section.1	At-grade Intersection (3 Legs) Traffic Signalized
2	Bifurcating Point	TPP Link Road	No.6+200 Section.1	At-grade Intersection (3 Legs) Traffic Signalized
3	End Point (Poonjeri Junction in Mamallapuram)	SH49B (OMR) SH49 (ECR)	No.129+200 Section.5	Roundabout (4 Legs)

Source: JICA Study Team

(2) Problem and Improvement Measure of Present Design

1) Beginning Point

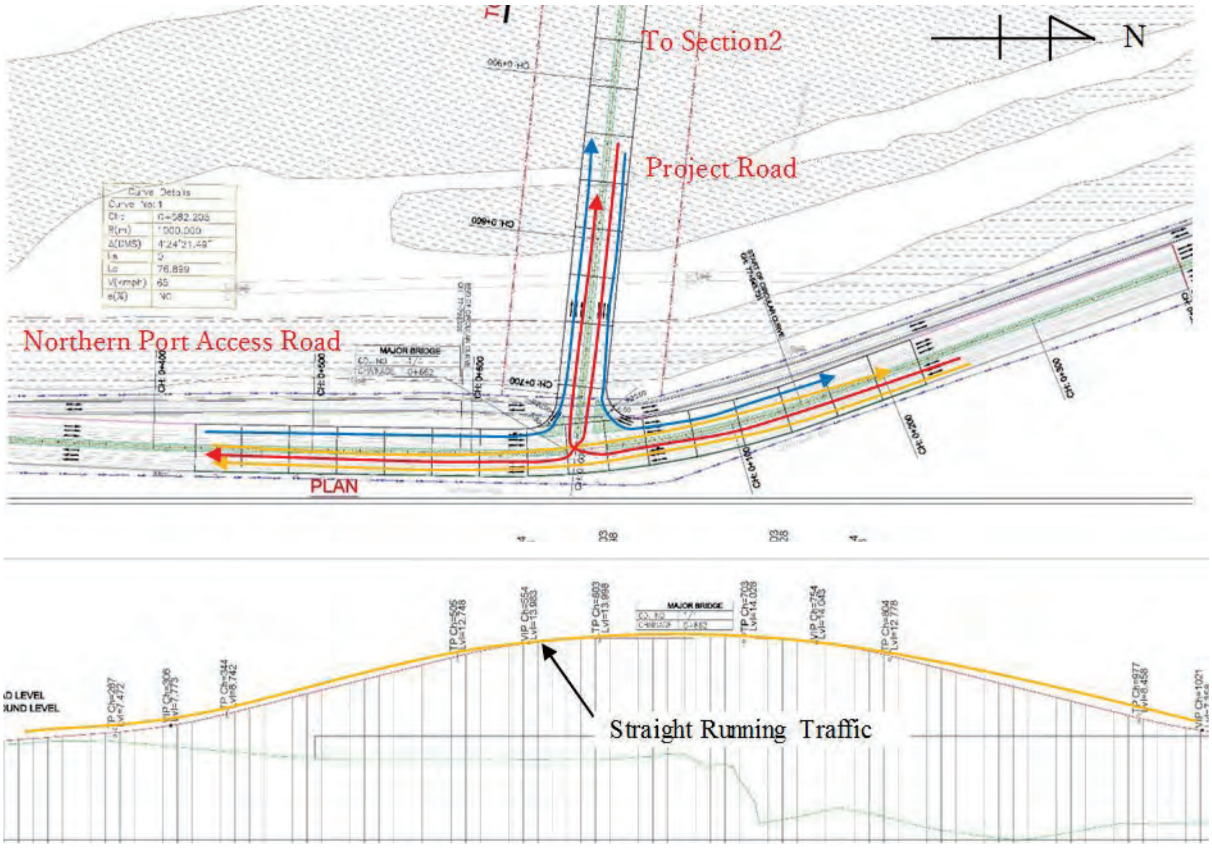
The beginning point of the project road is located near Ennore Port, and it is planned to connect with the Northern Port Access Road (NPAR) by an at-grade intersection (3 legs) on an elevated bridge. The present condition of the beginning point is shown in Figure 6.2.3.



Source: Edited by the JICA Study Team on Google Earth

Figure 6.2.3 Present Condition of Beginning Point

The directions of traffic passing the intersection are straight (south ⇔ north), left turn (south → west, west → north), and right turn (west→south, north→west). Because vehicles going straight intersect with the right-turning vehicles, a traffic signal (three phases) is planned at this at-grade intersection. The plan of the present design is shown in Figure 6.2.4.



Source: JICA Study Team added to DPR

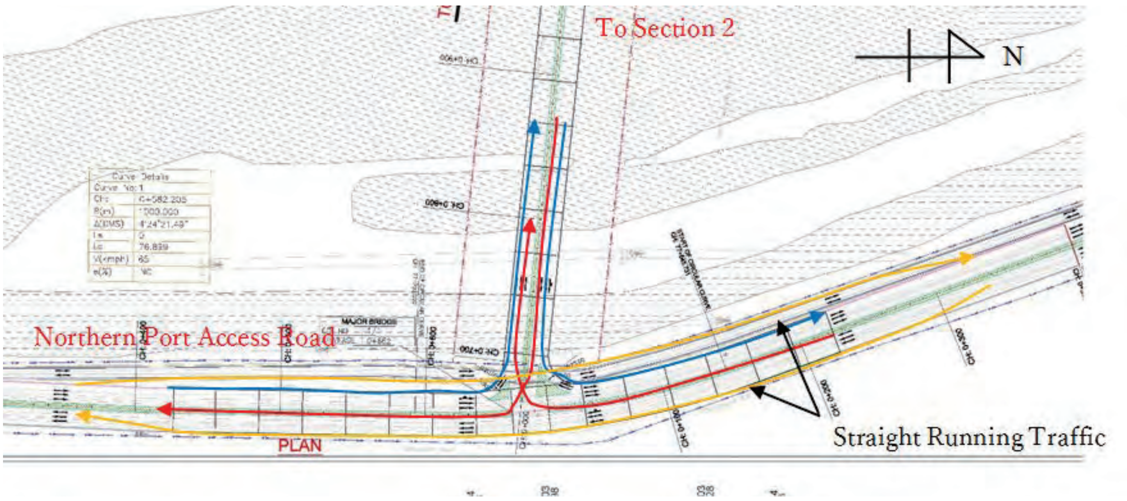
Figure 6.2.4 Plan of the Present Design of Beginning Point

Problem

Traffic jam is expected at the at-grade intersection because of an increase in the future traffic volume (large vehicles such as trailers).

Improvement Plan

Vehicles going straight (south to north) are assigned to the ground level in order to increase the capacity of the intersection, and left turn (south to west and west to north) and right turn (west to south and north to west) are allowed at the intersection. Therefore, the signal becomes two phases. The improvement plan is shown in Figure 6.2.5.

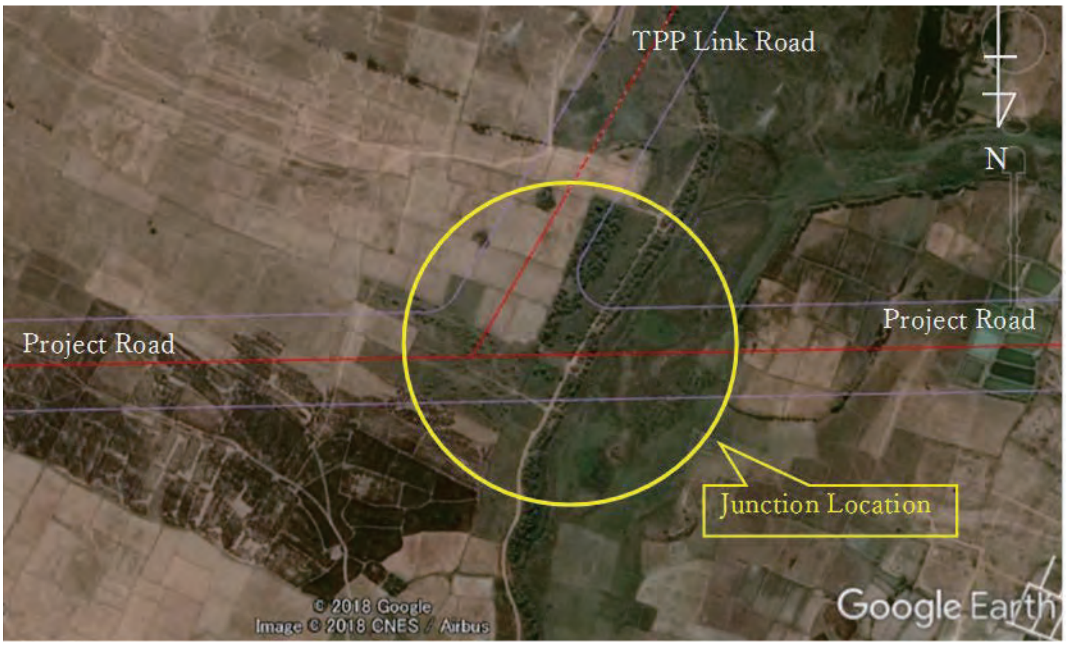


Source: JICA Study Team added to DPRR

Figure 6.2.5 Improvement Plan of Beginning Point

2) Bifurcating Point (Connecting to TPP Link Road)

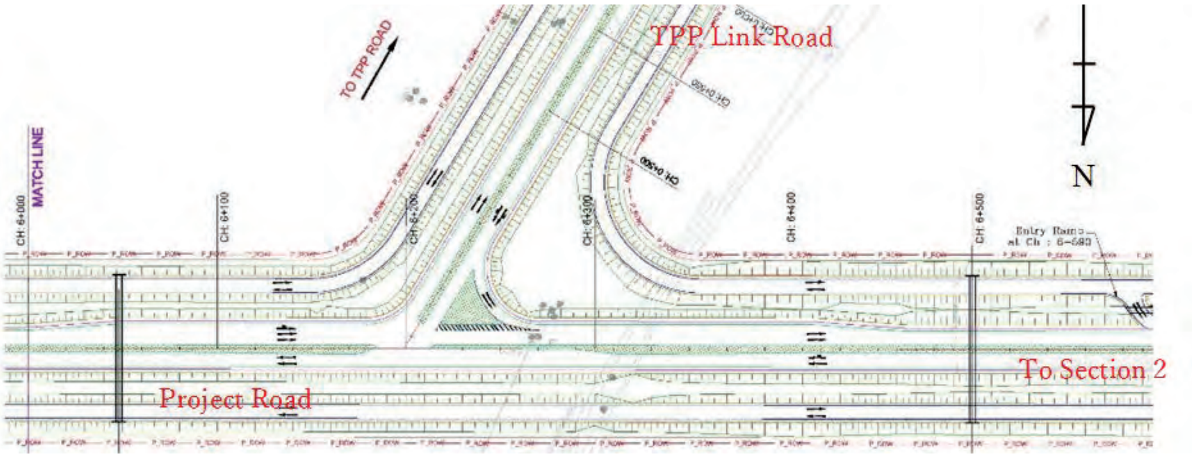
The project road diverges from the TPP Link Road at a point of about 6 km from the beginning point. The present condition of the bifurcation point is shown in Figure 6.2.6.



Source: Edited by the JICA Study Team on Google Earth

Figure 6.2.6 Present Condition of Bifurcation Point

The directions passing the intersection are straight (west⇔east), left turn (east→south and south→west), and right turn (west→south and south→east). Because vehicles going straight intersect with right-turning vehicles, a traffic signal (three phases) is planned at the at-grade intersection. The plan of the present design is shown in Figure 6.2.7.



Source: JICA Study Team added to DPRR

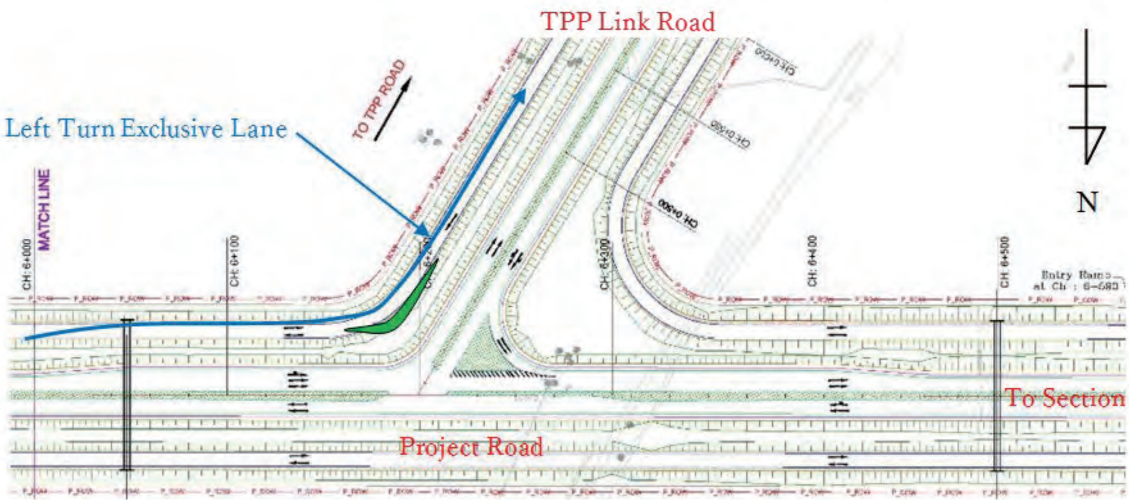
Figure 6.2.7 Plan and Profile of the Present Design of Bifurcation Point

Problem

The traffic jam is expected at the at-grade intersection because of an increase in the future traffic volume (large vehicles such as trailers).

Improvement Plan

To increase the capacity of the intersection, the left turn (east→south) is changed to use the left turn exclusive lane (free the left turn). As a result, not only the road capacity but also safety improves. Improvement plan is shown in Figure 6.2.8.



Source: JICA Study Team added to DPRR

Figure 6.2.8 Improvement Plan of Bifurcation Point

3) End Point

The end point of the project road is located near the town of Mahabalipuram facing the Bay of Bengal, and it connects with SH49 (ECR), SH49A (OMR), and SH49B. A three-leg intersection (T-type) and a four-leg intersection are adjacent to each other. The present condition of the end point is shown in Figure 6.2.9.

Source: Edited by the JICA Study Team on Google Earth

Figure 6.2.9 Present Condition of End Point

The type of intersection is an elliptical roundabout, which is channelized by an island. The project road connects to the roundabout from the west side; SH49 connects from the south side and west side, and SH49A connects from the north side. The length of the island of the roundabout is 80 m, and the minimum radius is about 30 m. The plan of the present design is shown in Figure 6.2.10.

Source: JICA Study Team added to DPRR

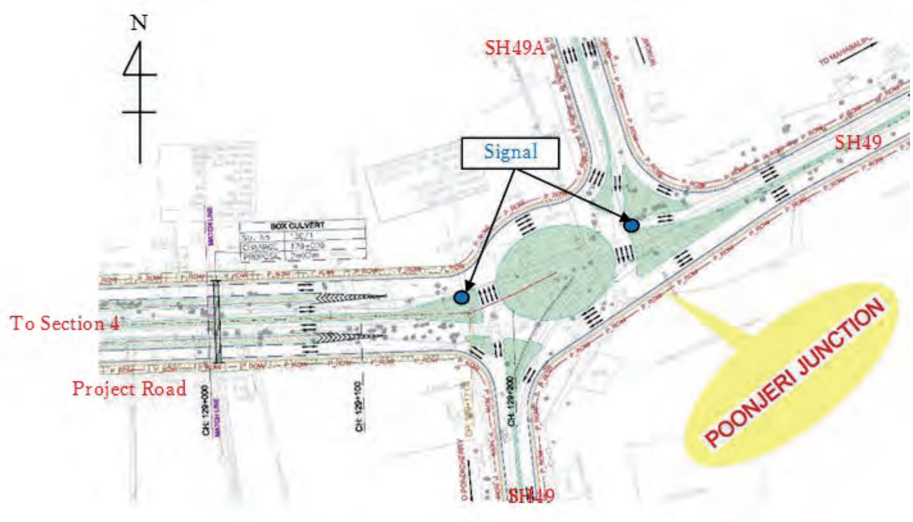
Figure 6.2.10 Plan of the Present Design of End Point

Problem

The traffic of SH49 (north side) crosses from the project road (west side) to SH49 (east side), and from SH49 (south side) to SH49 (east side). Traffic of SH49 (south side) crosses from SH49A (north side) to the project road (west side) and SH49 (east side), and from SH49 (east side) to the project road (west side). Therefore, temporary stop is required at these points.

Improvement Plan

The installation of traffic signals is necessary at the crossing point to improve safety at the intersection. The improvement plan is shown in Figure 6.2.11.



Source: JICA Study Team added to DPRR

Figure 6.2.11 Recommended Plan

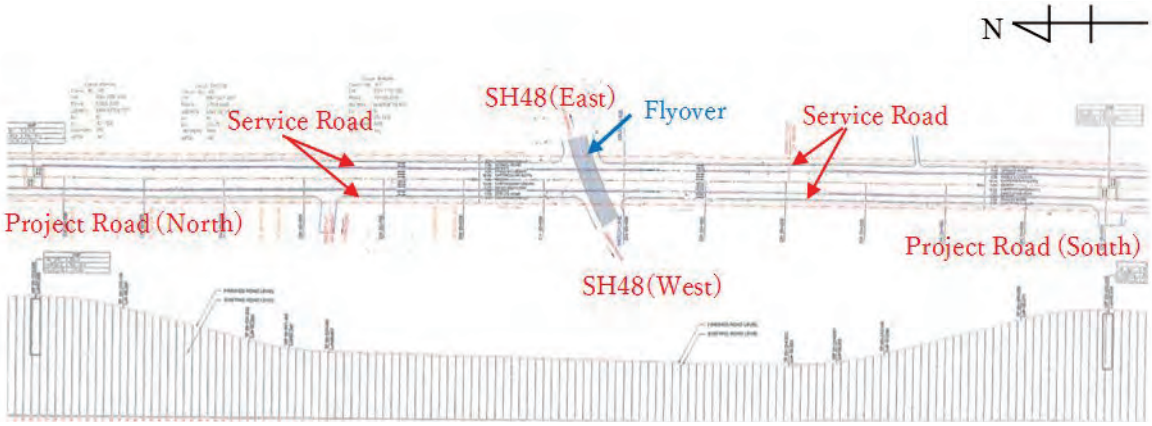
4) Crossing of SH48

The project road crosses SH48 through a flyover at the 88.96 km point of the project road in Section 4. Lots of factories related to cars are in the surrounding area. The present condition of the crossing point with SH48 is shown in Figure 6.2.12.

Source: Edited by the JICA Study Team on Google Earth

Figure 6.2.12 Present Condition of Crossing Point of SH48

The project road is not connected with SH48, and only passes under the flyover of SH48. Therefore, the project road will be connected with SH48 using the opening of the side separator of the project road and passing through the service road installed outside of the project road. The plan of the present design is shown in Figure 6.2.13.



Source: JICA Study Team added to DPRR

Figure 6.2.13 Projected Plan and Profile

Problems

The traffic from the project road (north side) to SH48 (east side) goes out to the service road at the opening of the side separator before this intersection, goes to the intersection on the service road, and turns left on SH48. On the other hand, the traffic to SH48 (west side) goes out to the service road at the opening, goes to the underpass after the intersection, andcrosses the project road, makes a U-turn to the service road, and turns left at the intersection. It becomes similar to the project road (south).

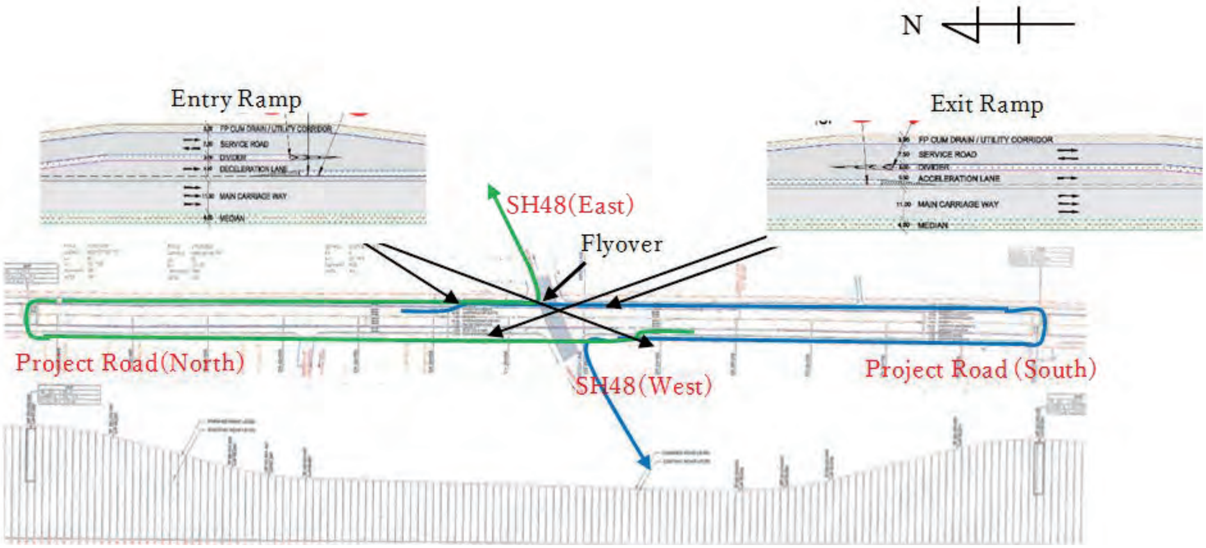
The traffic from SH48 (east side) to the project road (south side) turns left at this intersection from the service road and enters to the project road using the opening of the side separator. On the other hand, the traffic goes to the project road (north side), turns left at the intersection, goes on the service road and up to the underpass of the project road, makes a U-turn to the service road, and enters to the project road from the opening. It becomes similar to SH48 (west side).

As described above, the project road connects with SH48 using the service road. Further, the traffic that turns right has to go to the underpass and cross the project road to make a U-turn. Therefore, it takes a long distance and time. Moreover, there is a problem of capacity shortage and safety for entry and exit at the opening of the side separator (without acceleration lane and deceleration lane).

Improvement Plan

There are a lot of factories surrounding this crossing. It is expected that the traffic volume will increase in the future, and traffic congestion will be a concern at this intersection. Therefore, it is desirable to install the interchange which directly connects the project road and SH48. As for the installation position, the crossing point is desirable. If it is difficult, an interchange connecting with another road parallel to the project road is considerable.

Including these plans, it is desirable to install an acceleration lane and a deceleration lane at the entry and exit of the project road to increase the traffic capacity and safety. It is possible to use the 3 m space between the outside of the sidewalk and ROW. Improvement plans are shown in Figure 6.2.14.



Source: JICA Study Team added to DPRR

Figure 6.2.14 Improvement Plan of Connection with SH48

5) Others

At the VUP in STA.29+172, it is desirable to improve the traffic operation because the service road is currently not planned to connect with straight direction at the intersection.

6.2.4 Pavement

(1) Design Standards Adopted in the DPR

The DPR adopted two types of Indian design standards for the pavement design of CPRR. New pavements shall be designed in accordance with the method prescribed in IRC:37-2012, Tentative Guidelines for the Design of Flexible Pavements, and the strengthening of existing pavements shall be designed in accordance with the method prescribed in IRC:81-1997, Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique. This selection of design standards was consistent with the design condition of CPRR; therefore, the selection seems to be reasonable.

(2) Field Survey and Investigation of DPR

The following seven types of surveys were carried out for the pavement design of CPRR.

Table 6.2.8 Summary of Survey and Investigation Shown on DPR

No.	Survey Name	Interval	Purpose	Remark
1	Road Inventory Survey	every 500 m interval (every 200 m interval only for high embankment locations)	Capturing details of general road conditions ・terrain ・land use ・roadway width ・shoulder soil type ・curve details ・Intersection data ・high embankment location ・RoW ・existing utility services ・general drainage condition, etc.	Target location ・Section 3: KM 39+000 to KM 27+000 of SH-57 i.e. End of Thiruvallur bypass to NH-4 ・Section 4: KM 24+750 to KM 0+000 of SH-57 i.e. NH-4 to NH-45 ・Section 5: KM 11+200 to KM 13+200 of SH-49B

No.	Survey Name	Interval	Purpose	Remark
2	Pavement Condition Survey	every 500 m interval	Capturing soundness of road/pavement condition details ・cracks ・potholes ・raveling ・rut depth ・edge failure, etc.	The rut depth was measured by a straight edge, 3 m long using a graduated wedge. The areas of cracking, pothole, and raveling were recorded by experienced engineers. Results were summarized in the Pavement Condition Index (PCI).
3	Pavement Crust Investigation	every 500 m interval	Pavement composition of the existing road to determine existing pavement thickness and composition; Lab tests were carried out to determine sub-grade properties: ・grain size ・Atterberg limits OMC (optimum moisture content) field CBR, laboratory CBR (Soaked and Unsoaked) ・soil type, etc.	Pavement Crust Investigation by digging up trench pits at interface of pavement and earthen shoulder. Field CBR using DCP (Dynamic Cone Penetrometer)
4	Sub-grade Characteristics and Strength		Determination of pavement crust details, the field tests to identify on the existing sub-grade ・in-situ CBR using DCP ・field density ・field moisture content The sub-grade soil samples were collected, and laboratory tests were carried out to determine: ・grain size distribution ・soil classification ・Atterberg limits ・optimum moisture content ・soaked and unsoaked CBR	For existing road
5	Soil Investigation	1 km interval	Assessment of sub-grade characteristic and strength of natural soil along the widening stretches ・moisture content ・Atterberg limits ・grain size distribution ・swell ・soil classification	For natural ground: for each homogenous section or three soil samples for each soil type
6	Axle Load Survey	No description on DPR	For calculation of vehicle damage factor (VDF) for pavement design	The DPR mentioned that the design consultant of the DPR carried out an axle load survey for pavement design. However, no back-data description, although VDF was shown on DPR.
7	Rebound	every 500 m	Assessment of the residual	The deflection measurements

No.	Survey Name	Interval	Purpose	Remark
	Deflection Survey	interval on outer wheel paths of both travel lanes	strength of the existing pavement and also to design the overlay thickness of pavement layers	were taken by conventional procedure given in IRC:81-1997 "Guidelines for Strengthening of Flexible Road Pavements using Benkelman Beam Deflection Technique".

Source: JICA Study Team based on DPR Volume II, Design Report-Highways

(3) Pavement Design in DPR

1) Parameters for Pavement Design

Design Life

The DPR referred to the description of IRC:37-2012 for the design life of 15 years for national highways (NHs) and state highways (SHs), and 20 years for expressways and urban roads. Also, if stage construction is adopted, the thickness of the granular layer should be provided for the full design period. Hence, the DPR adopted that sub-base and base course have 20 years of design life, and bituminous layers have 15 years design life. The values of design life are generally for pavement designs; therefore, the DPR condition for design life of pavement design is reasonable.

Lane Distribution Factor

DPR used the lane distribution factor shown in Table 6.2.10.

Table 6.2.9 Lane Distribution Factor Shown on DPR of CPRR

	Section 1	Section 2	Section 3	Section 4	Section 5
Calculation Table Table 4.10 – 4.13	0.225	0.225	0.225	0.300	0.375

Source: JICA Study Team based on DPR Volume II, Design Report-Highways

Design Traffic Volume

The DPR used the Average Annual Daily Traffic (AADT) of each section given in Table 6.2.11 below for pavement design. They were calculated from the traffic survey carried out in 2013.

Table 6.2.10 Average Annual Daily Traffic Shown on DPR

Sections	Goods Vehicle				Passenger Vehicle
	LCV	2-Axle	3-Axle	Multi-Axle	Bus
Section 2	830	1957	1544	924	384
Section 3	1563	3181	2077	1137	2337
Section 4	2120	5186	2260	1249	2188
Section 5	602	1031	494	210	516

Source: DPR Volume II, Design Report-Highways

Growth Rates

The traffic forecast in the DPR was made using the growth rates given in Table 6.2.12 below.

Table 6.2.11 Growth Rate for Pavement Design Shown on DPR

Year	LCV	2 & 3 Axle Trucks	MAV	Bus
2013-2018	13.10%	7.33%	6.22%	5.55%
2018-2023	11.79%	6.59%	5.60%	5.00%
2023-2028	10.61%	5.93%	5.04%	4.50%
2028-2033	9.55%	5.35%	4.53%	4.05%
2033-2038	8.59%	4.81%	4.08%	3.64%
2038-2043	7.73%	4.33%	3.67%	3.28%

Source: DPR Volume II, Design Report-Highways

Vehicle Damage Factor (VDF)

The VDF is a multiplier for converting the number of commercial vehicles of different axle loads to the number of standard axle load repetitions as shown in IRC:37-2012. The design of new pavement or the strengthening of existing pavement is based on the cumulative number of 8.16-tonne (18 kips) equivalent standard axles that will pass over the roads during the design period.

The DPR shows that the axle load survey was carried out for commercial vehicles (goods vehicles and passenger vehicle) to determine the VDF in each section of CPRR, and the VDFs were calculated in accordance with the guidelines provided in IRC:37-2012. However, the axle load survey results were not shown in the DPR; therefore, the JICA Study Team could not confirm the validity of the VDFs. The VDFs shown in the DPR are given in Table 6.2.13 below.

Table 6.2.12 VDF for Pavement Design Shown in the DPR

unit/vehicle

Section	LCV	2-Axle	3-Axle	Multi-Axle	Bus
Section 2	0.927	4.64	4.263	3.673	0.227
Section 3	0.078	2.613	4.048	5.725	0.453
Section 4	0.128	2.888	5.528	6.063	0.25
Section 5	0.085	5.88	6.69	4.75	0.59

Source: DPR Volume II, Design Report-Highways

Calculation of Design Traffic

The design traffic is considered in terms of the cumulative number of standard axles (18 kips) to be carried during the design life. The following equation is used to compute the design traffic in terms of the cumulative number of standard axles in the DPR:

$$N = \frac{365 \times \{(1+r)^n - 1\} \times A \times LD \times VDF}{r}$$

Where

N	:	Cumulative standard axles for the design life (MSA: million standard axles)
r	:	Annual growth rate of commercial vehicles
n	:	Design life in years
A	:	Initial traffic in terms of number of commercial vehicles per day
LD	:	Lane distribution factor
VDF	:	Vehicle damage factor

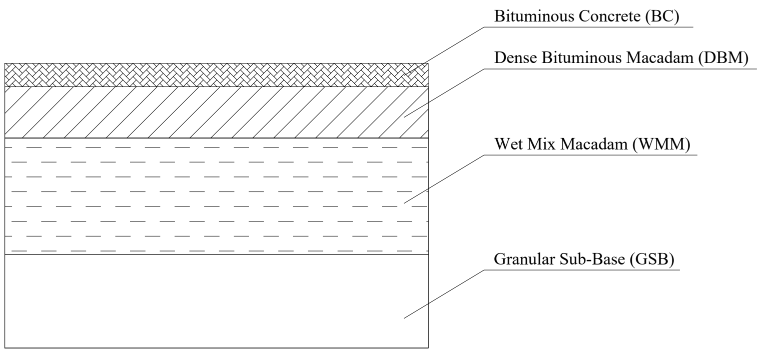
In the pavement design in the DPR, the opening of all sections in CPRR was assumed in 2016, and the design period is set to 20 years.

Design CBR

The DPR adopted the design CBR of 8% for pavements.

2) Pavement Layer Structure of DPR

The flexible pavement layer structure in the DPR is referred to IRC:37-2012, and consists of four types of layers, i.e., bituminous surfaces of Bituminous Concrete (BC) and Dense Bituminous Macadam (DBM), Wet Mix Macadam (WMM) base, and Granular Subbase (GSB) course of finite thickness.

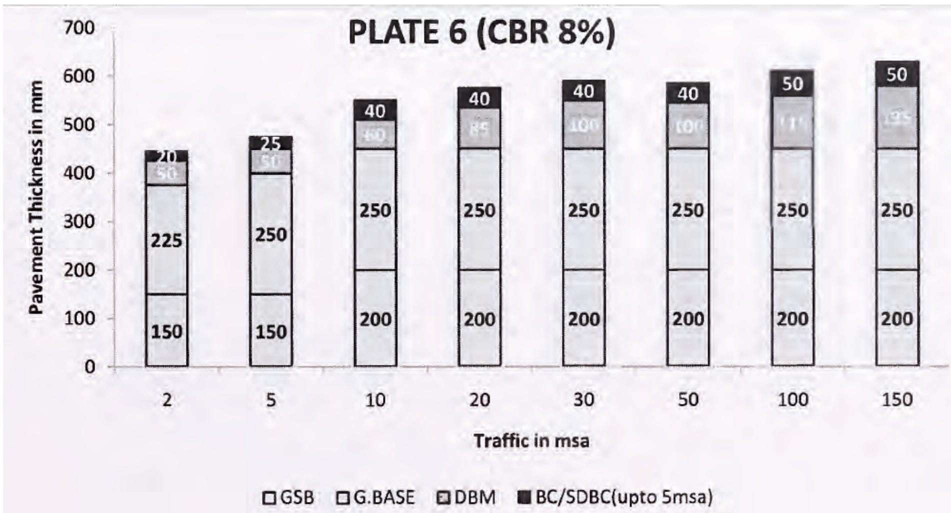


Source: JICA Study Team based on DPR Design Report (Highway)

Figure 6.2.15 Pavement Layer Structure of DPR

3) Methodology of the Pavement Design in the DPR

The DPR adopted IRC:37-2012 for pavement design. IRC:37-2012 prepared design catalogues in order to make pavement design easy and efficient. Figure 6.2.16 below shows an example of the design catalogue of IRC:37-2017. A plate can be determined based on pavement components (type of each layer). After determining the traffic load in MSA and the design CBR, the pavement thickness of each layer can be decided.



Source: IRC:37-2012

Figure 6.2.16 Example of the Design Catalogue Shown in the Adopted IRC

4) Thickness of Pavement Crust of DPR

The DPR calculated each pavement layer thickness with the abovementioned parameters in accordance with the related IRC. However, because of the possibility of delay in the start of the implementation of the project, the calculated thickness of pavement layers was slightly increased. The proposed pavement composition for each section in the DPR is shown in Table 6.2.14 below. After the review of the pavement design in the DPR, the JICA Study Team understood that the pavement design procedure is consistent with IRC:37-2012 and is reasonable.

Table 6.2.13 Proposed Pavement Thickness of Main Carriageway on DPR

Unit: mm

Description	Section 1	Section 2	Section 3	Section 4	Section 5
Loading for granular layer, MSA	90	90	100	200	80
Bituminous Concrete (BC)	50	50	50	50	50
Dense Bituminous Macadam (DBM)	115	110	115	135	110
Wet Mix Macadam (WMM)	250	250	250	250	250
Granular Sub-Base (GSB)	200	200	200	200	200
Total	615	615	615	635	610

Source: DPR Volume II, Design Report-Highways

5) Pavement Design Check

The DPR carried out pavement design check using the stress analysis software IITPAVE for the computation of stresses and strains in flexible pavements. The tensile strain at the bottom of the bituminous layers and the vertical compressive strain on the top of the sub-grade are conventionally considered as critical parameters for pavement design to limit cracking and rutting in the bituminous layers for prevention of fatigue phenomenon in accordance with IRC:37-2012.

After checking, the expected strain of each pavement layer is under the allowable strain. The DPR shows that pavement structure has enough durability during the design period.

6) Service Road Pavement of DPR

Service roads were proposed on both sides of the project road in all the sections in the DPR. The design of pavement for service road has been carried out in accordance with IRC:37-2012. The adopted design parameter was decided as follows:

・Design Traffic Loading : 30 MSA
・Subgrade CBR : 8%

The proposed pavement compositions for the service roads are given in Table 6.2.15 below.

Table 6.2.14 Proposed Pavement Thickness of Service Road in the DPR

Unit: mm

	BC	DBM	WMM	GSB	Total
Service Road	40	100	250	200	590

Source: DPR Volume II, Design Report-Highways

7) Overlay Thickness Design for the Existing Road of the DPR

Rebound deflection survey with Benkelman beam has been carried out in the DPR in order to assess the residual strength of the existing pavement and also to design the overlay thickness of pavement layers to be provided to withstand the future projected traffic loading as per IRC 81:1997.

The survey data obtained were analyzed as per IRC: 81:1997, including calculated mean deflection, standard deviation, and characteristic deflection against chainage. Based on these, cumulative differential variables were analyzed, and estimation of overlay pavement was determined as indicated below.

BC : 40 mm
DBM : 50 mm

(4) Pavement Design with Traffic Demand Forecast Made by the JICA Study Team

1) General

In order to review the validity of the pavement design in the DPR, the JICA Study Team carried out the pavement design in accordance with IRC: 37-2012 with the traffic survey result made by the JICA Study Team in 2017. In addition, the JICA Study Team also carried it out based on AASHTO and Japanese standard (TA method) and compared the result with the IRC:37-2017 to assess the validity of the pavement design in the DPR. Adopted standards are shown below.

IRC : IRC:37-2012, Tentative Guidelines for the Design of Flexible Pavements

AASHTO : AASHTO Guide for Design of Pavement Structures issued in 1993

Japanese standard: Design Guide for Pavement Design issued by Japan Road Association in 2006

2) Design Traffic Volume

The JICA Study Team carried out the traffic demand forecast in Chapter 3.3 (Traffic Demand Forecast), and traffic demand forecasts for six scenarios were carried out as shown in Figure 3.3.13 (Traffic Assignment Result) in the same chapter. For pavement design, the JICA Study Team prepared two scenarios of design traffic volume as described below. Forecasted traffic volumes in each section for pavement design are shown in Appendix-4. The conditions of traffic demand forecast (i.e., growth rate, modal share of future traffic demand, traffic handled at the port, etc.) made by the JICA Study Team are shown in Chapter 3.3 in this report. As shown in Chapter 3.3, traffic demand forecasts were carried out for 2021, 2024, and 2036.

<u>Case 1: Most Likely</u> Section 4 will be opened in 2021, Section 1 will be opened in 2024, and the remaining three sections (Sections 2, 3, and 5) will be opened in 2030.

<u>Case 2: Worst Case</u> Section 4 will be opened in 2021, and the remaining sections (Sections 1, 2, 3, and 5) will be opened in 2024.

Table 6.2.15 Preparation of Scenarios of Design Traffic Volume of the JICA Study Team

		Section 1	Section 2	Section 3	Section 4	Section 5
Case 1	2021	—	—	—	○	—
Most Likely	2024	○	—	—	○	—
	2030	○	○	○	○	○
Case 2	2021	—	—	—	○	—
Worst Case	2024	○	○	○	○	○
	2030	○	○	○	○	○

○: Opened, —: not yet opened

Note: Opening years were assumed as 2021, 2024, and 2030. On the other hand, target years of traffic demand forecasts are 2021, 2026, and 2036.

Source: JICA Study Team

3) Design Method and Adopted Parameters

The JICA Study Team carried out pavement design in the CPRR in accordance with IRC, AASHTO, and Japanese standards. In this section, the design methods are mentioned briefly, and the adopted parameters are explained.

<u>General</u>

The following parameters adopted the same values in the DPR for the JICA Study Team's pavement design:

- Design Life: 20 years for subbase.
- Lane Distribution Factor (LD): 0.225 (Section 1, 2, 3), 0.300 (Section 4), 0.375 (Section5)
- Vehicle Damage Factor (VDF): Same VDFs are adopted for pavement design.
- Design CBR: 8.0%
- Target Vehicle Type: 5 types of vehicles are adopted (LCV, 2-axle, 3-axle, Multi-axle, Bus)

<u>IRC:37-2012</u>

The design method as shown in IRC:37-2012 is adopted.

<u>AASHTO</u>

AASHTO Guide for Design of Pavement Structures issued in 1993 is adopted by the JICA Study Team for pavement design. Same as in IRC:37-2012, 8.16-ton (18 kips) equivalent standard axle is adopted for calculation of the traffic axle load for pavement design.

Equivalent Vehicle Number (EVN) per day is calculated as the VDF in the DPR multiplied by the AADT which was calculated by the JICA Study Team.

In addition, VDFs in the DPR are separated for five target vehicles. However, the traffic study result of the JICA Study Team involves four types only (LCV, truck, multi-axle, and bus). Thus, the number of trucks was separated for two-axle and three-axle using the respective ratios in the DPR.

The AASHTO formula to obtain the Structural Number (SN) is as follows:

$$\text{Log}_{10}(W_{18}) = Z_R * S_0 + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10}(M_R) - 8.07$$

Where

W18	:	18 kips converted number in design period
Zr	:	standard deviation (1.282 in case of reliability of 90%)
S0	:	standard deviation on forecasting traffic volume, 0.4
Δ PSI	:	difference of performance index, 2.5
Mr	:	resilient factor of subgrade, 12,000

The adopted layer coefficients for pavement design based on the AASHTO Guideline are shown in Table 6.2.17 below.

Table 6.2.16 Adopted Parameters of Pavement Design Based on AASHTO

Pavement Layer Coefficients		Source
BC	0.42	2.3.5 Layer Coefficients on AASHTO Guide Figure 2.5 Assuming elastic modulus of 400,000 psi
DBM	0.42	
WMM	0.14	2.3.5 Layer Coefficients on AASHTO Guide Figure 2.8 Assuming Unconfined Compressive Strength of 300 psi
GSB	0.11	2.3.5 Layer Coefficients on AASHTO Guide Figure 2.7 Assuming elastic modulus of 15,000 psi

Source: JICA Study Team based on AASHTO Guide

Japanese Standard

The Design Guide for Pavement Design issued by the Japan Road Association in 2006 was adopted for the pavement design of the JICA Study Team. Standard axle load based on Japanese standard is 10 tons; therefore, the total passing axle numbers are different from IRC and AASHTO. The Japanese pavement calculation formula (TA method) is shown below:

$$\text{Japanese Ta} = 3.84 * N^{0.16} / CBR^{0.3}$$

Where

N	:	Cumulative axle load in the design period

The adopted parameters for pavement design based on the Japanese standards are shown in Table 6.2.18 below.

Table 6.2.17 Adopted Parameters of Pavement Design Based on Japanese Standard

Reliability	90%		
Design CBR	8%		
Pavement Layer Coefficient		Source	
BC	1.00	Table- 5.2.11 on Design Guide for Pavement Design issued by the Japan Road Association in 2006	Bituminous
DBM	0.80		Bituminous mixing: Stability, over 3.43 kN
WMM	0.55		Cemented: 1 axle strength 7 days, over 2.9 MPa
GSB	0.25		Granular, sand, etc.: modified CBR, over 30

Source: JICA Study Team based on AASHTO Guide

4) Thickness of Pavement Crust

The results of the pavement design made by the JICA Study Team in accordance with IRC, AASHTO, and Japanese standards are shown in the table and figures below.

Section 1

In case of the result based on IRC, the pavement design made by the JICA Study Team in both Case 1 and Case 2 have the same pavement thickness as the proposed thickness in the DPR. On the other hand, in case of the result based on AASHTO and TA methods, the pavement thickness is a bit larger than the result from IRC. In addition, the pavement thickness of Case 2 is larger than Case 1. However, the maximum difference in accordance with IRC is only 5% (Case 2, TA method). Therefore, the difference can be understood as limited.

Section 2

Because of the difference regarding traffic demand forecast, the pavement thickness made by the JICA Study Team is 4% smaller than the proposed thickness in the DPR in both Case 1 and Case 2. Pavement thickness in accordance with AASHTO and TA method is 1% larger than that in accordance with IRC. However, the difference among them can be considered limited.

Section 3

In case of the result in accordance with IRC, the pavement design made by the JICA Study Team in both Case 1 and Case 2 are the same pavement thickness as that in the DPR. On the other hand, in case of the result in accordance with AASHTO and TA method, pavement thickness is quite larger than the result based on IRC. However, the maximum difference with the result in accordance with IRC is only 4% (case 1, TA method). Therefore, the difference can be considered as limited.

Section 4

Because of the difference regarding traffic demand forecast, pavement thickness made by the JICA Study Team is 7% smaller than the proposed thickness in the DPR, and pavement thicknesses in accordance with AASHTO and TA method are 2% smaller than that in accordance with IRC. In addition, pavement thickness of case 2 is larger than the result of case 1. However, the differences among them are small and can be considered limited.

Section 5

In case of the result in accordance with IRC, the pavement design made by the JICA Study Team in both Case 1 and Case 2 are 3% smaller than the pavement thickness as the proposed thickness in the DPR. Although pavement thickness in accordance with AASHTO is the same as the result based on the IRC, results with the TA method in both Case 1 and Case 2 are smaller. However, the differences among them are small, and can be considered limited.

Table 6.2.18 Result of Pavement Design Made by the JICA Study Team

Unit: mm

	Section 1							
	DPR		Case 1			Case 2		
	Original	Proposal	IRC	AASHTO	TA method	IRC	AASHTO	TA method
MSA	90		109	109	48	112	112.1	49.7
SN (AASHTO) / TA (TA method)				5	35		5.2	35.1
Bituminous Concrete (BC)	40	50	50	50	50	50	50	50
Dense Bituminous Macadam (DBM)	110	115	115	130	140	115	135	145
Wet Mix Macadam (WMM)	250	250	250	250	250	250	250	250
Granular Sub-base (GSB)	200	200	200	200	200	200	200	200
Total Thichness	600	615	615	630	640	615	635	645
Different with DPR proposal (mm)		0	0	15	25	0	20	30
Different with DPR proposal (%)		0%	0%	2%	4%	0%	3%	5%

	Section 2							
	DPR		Case 1			Case 2		
	Original	Proposal	IRC	AASHTO	TA method	IRC	AASHTO	TA method
MSA	90		78	78	34	76	76.2	33.8
SN (AASHTO) / TA (TA method)				5	33		5.0	33.0
Bituminous Concrete (BC)	40	50	40	40	40	40	40	40
Dense Bituminous Macadam (DBM)	110	115	100	130	130	100	130	130
Wet Mix Macadam (WMM)	250	250	250	250	250	250	250	250
Granular Sub-base (GSB)	200	200	200	200	200	200	200	200
Total Thichness	600	615	590	620	620	590	620	620
Different with DPR proposal (mm)		0	-25	5	5	-25	5	5
Different with DPR proposal (%)		0%	-4%	1%	1%	-4%	1%	1%

	Section 3							
	DPR		Case 1			Case 2		
	Original	Proposal	IRC	AASHTO	TA method	IRC	AASHTO	TA method
MSA	100		102	102	45	101	100.9	44.7
SN (AASHTO) / TA (TA method)				5	35		5.2	34.5
Bituminous Concrete (BC)	40	50	50	50	50	50	50	50
Dense Bituminous Macadam (DBM)	110	115	115	130	140	115	130	135
Wet Mix Macadam (WMM)	250	250	250	250	250	250	250	250
Granular Sub-base (GSB)	200	200	200	200	200	200	200	200
Total Thichness	600	615	615	630	640	615	630	635
Different with DPR proposal (mm)		0	0	15	25	0	15	20
Different with DPR proposal (%)		0%	0%	2%	4%	0%	2%	3%

	Section 4							
	DPR		Case 1			Case 2		
	Original	Proposal	IRC	AASHTO	TA method	IRC	AASHTO	TA method
MSA	200		87	87	39	97	97.1	43.0
SN (AASHTO) / TA (TA method)				5	34		5.1	34.3
Bituminous Concrete (BC)	50	50	40	50	50	50	50	50
Dense Bituminous Macadam (DBM)	135	135	100	125	125	115	125	135
Wet Mix Macadam (WMM)	250	250	250	250	250	250	250	250
Granular Sub-base (GSB)	200	200	200	200	200	200	200	200
Total Thichness	635	635	590	625	625	615	625	635
Different with DPR proposal (mm)		0	-45	-10	-10	-20	-10	0
Different with DPR proposal (%)		0%	-7%	-2%	-2%	-3%	-2%	0%

	Section 5							
	DPR		Case 1			Case 2		
	Original	Proposal	IRC	AASHTO	TA method	IRC	AASHTO	TA method
MSA	80		36	36	16	38	37.6	16.7
SN (AASHTO) / TA (TA method)				5	29		4.5	29.4
Bituminous Concrete (BC)	40	50	40	40	40	40	50	50
Dense Bituminous Macadam (DBM)	100	110	100	100	85	100	90	75
Wet Mix Macadam (WMM)	250	250	250	250	250	250	250	250
Granular Sub-base (GSB)	200	200	200	200	200	200	200	200
Total Thichness	590	610	590	590	575	590	590	575
Different with DPR proposal (mm)		0	-20	-20	-35	-20	-20	-35
Different with DPR proposal (%)		0%	-3%	-3%	-6%	-3%	-3%	-6%

Case 1	Section				
	1	2	3	4	5
2021	-	-	-	○	-
2024	○	-	-	○	-
2030	○	○	○	○	○

Case 2	Section				
	1	2	3	4	5
2021	-	-	-	○	-
2024	○	○	○	○	○
2030	○	○	○	○	○

- Closed (not open yet) ○ Openned

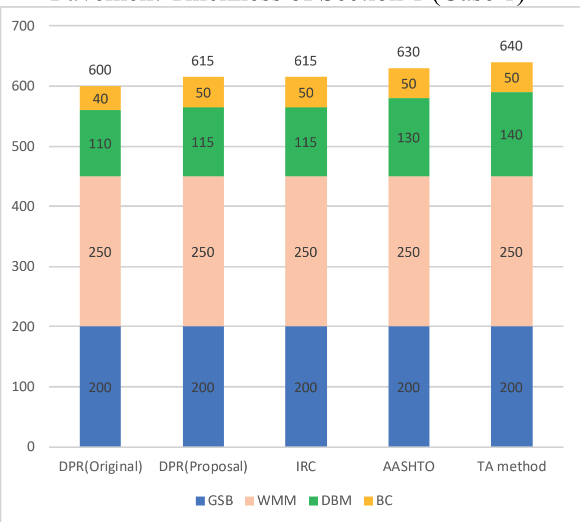
Note: Targer years of traffic demand forecast are 2021, 2026, and 2036

Source: JICA Study Team

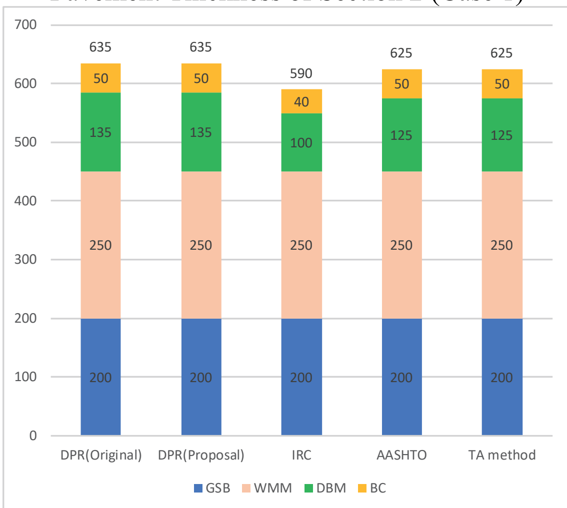
Unit: mm

Pavement Thickness of Section 1 (Case 1)

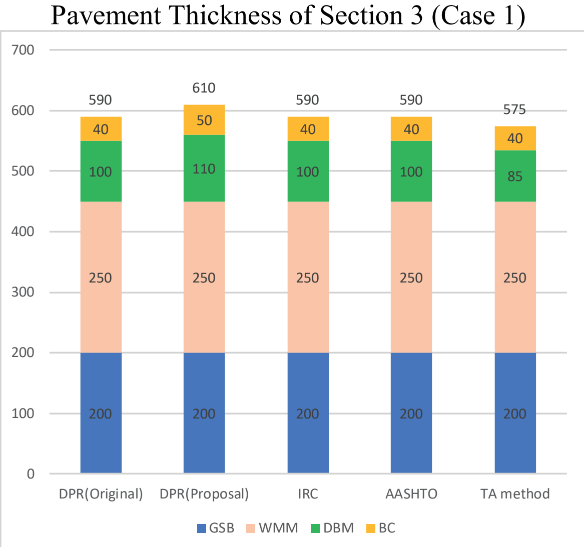
Pavement Thickness of Section 2 (Case 1)



Pavement Thickness of Section 3 (Case 1)



Pavement Thickness of Section 4 (Case 1)

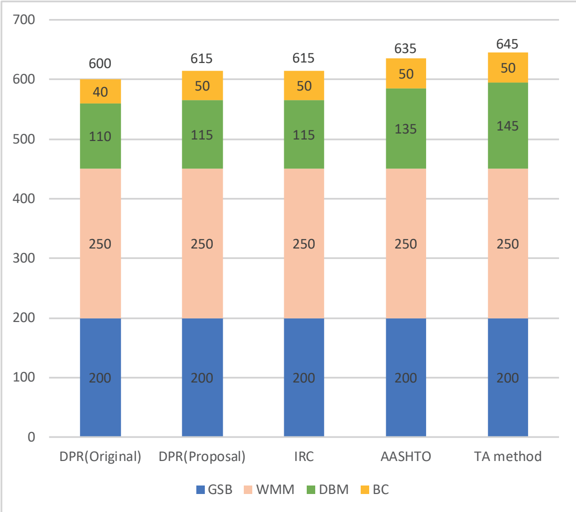


Pavement Thickness of Section 5 (Case 1)

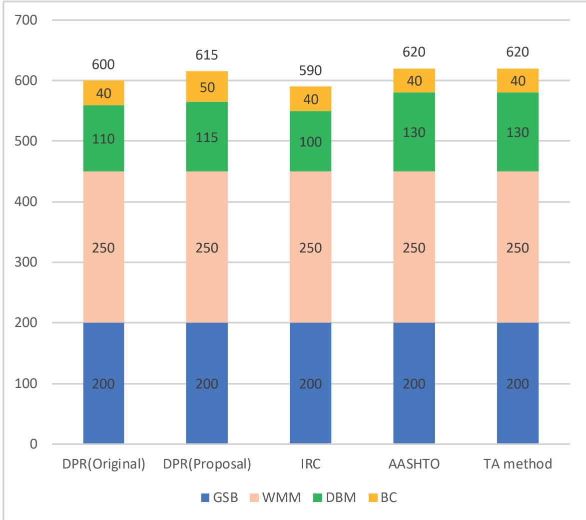
Source: JICA Study Team

Figure 6.2.17 Result of Pavement Design Made by the JICA Study Team (Case 1)

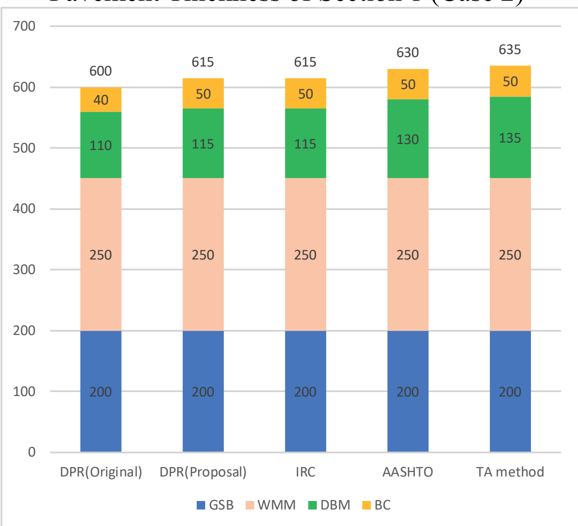
Unit: mm



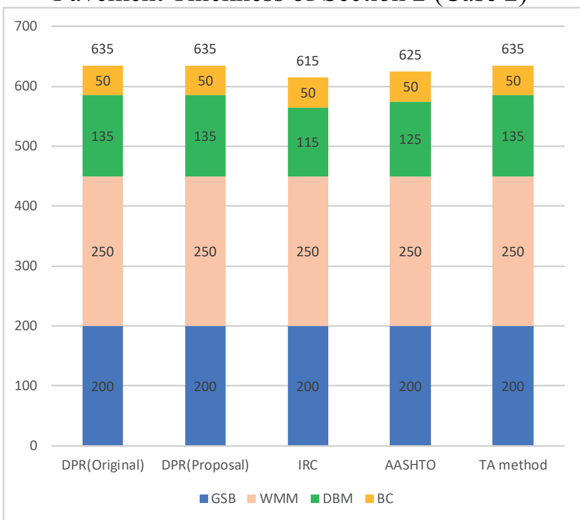
Pavement Thickness of Section 1 (Case 2)



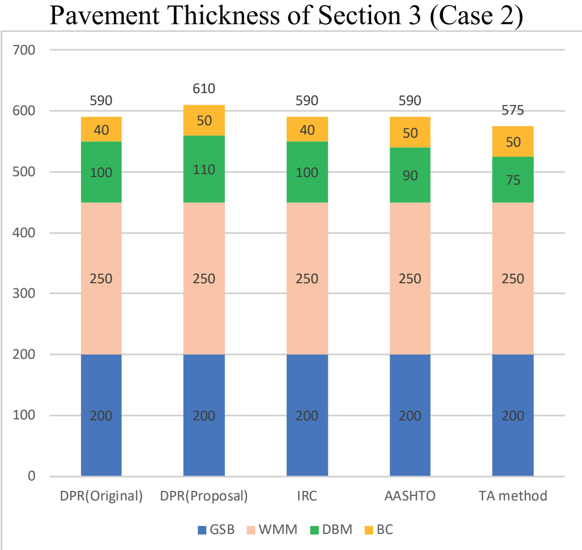
Pavement Thickness of Section 2 (Case 2)



Pavement Thickness of Section 3 (Case 2)



Pavement Thickness of Section 4 (Case 2)



Pavement Thickness of Section 5 (Case 2)

Source: JICA Study Team

Figure 6.2.18 Result of Pavement Design Made by the JICA Study Team (Case 2)

(5) Conclusion

Pavement design in the DPR is almost the same as the pavement design of the JICA Study Team, and the former has thicker pavement than the latter in Sections 2, 4, and 5. From the above, the pavement design in the DPR seems to be reasonable and more on the safe side.

6.2.5 Drainage

(1) Adopted Standards of DPR

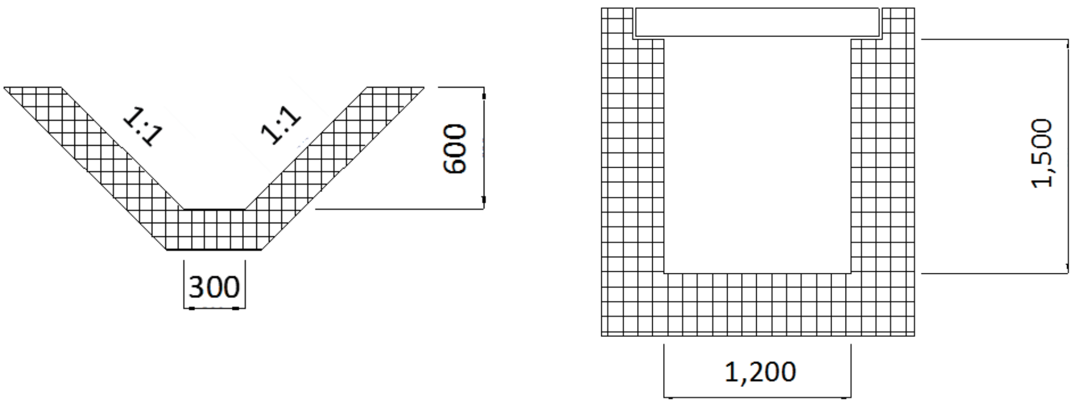
IRC: SP:42-2014, Guidelines of Road Drainage was adopted for drainage design as the design standard in the DPR. This standard is a general standard for drainage design of highway, and application of the standard for the design in the CPRR is reasonable.

(2) Drainage System of DPR

1) Longitudinal Drain

In the DPR, three types of drainages were proposed as longitudinal drainage as follows:

- Brick lined trapezoidal open drain : between main carriage and service road in Section 1
- RCC rectangular covered drain : under the footpath in the remaining sections
- Open trapezoidal drain : between start and end of transition curves



(a) Brick lined trapezoidal open drain (b) RCC rectangular covered drain

Source: DPR Design Report (Highway)

Figure 6.2.19 Proposed Longitudinal Drain in the DPR

2) Cross Drainage

The GAD shows that box culverts and pipe culverts are installed as cross drainages of CPRR as shown in Table 6.2.20 below. However, DPR did not show any description of the drainage design of box culverts and pipe culvert (including hydrologic discharge calculation and hydraulic design calculation).

Table 6.2.19 Number of Box Culverts and Pipe Culverts in General Arrangement Drawings of CPRR

	Section 1		Section 2	Section 3	Section 4	Section 5
	CPRR	TPP Link	CPRR	CPRR	CPRR	CPRR
Box Culvert	47	6	13	20	0	27
Pipe Culvert	11	2	84	61	0	58
Total	58	8	97	81	0	85

Source: JICA Study Team based on DPR Volume II, Design Report-Highways

(3) Design Target of Drainage Design of DPR

DPR shows that drainage designs of CPRR, including hydrologic discharge calculation and hydraulic design calculation were carried out for brick lined trapezoidal open drain and RCC rectangular covered drain only. Other drainage designs were not carried out in the DPR.

(4) Design Methodology in the DPR

1) Peak Runoff

Design capacity of the drains in the DPR is identified based on hydrologic analysis, and Rational Method is adopted in estimating the runoff. Peak runoff was calculated in the DPR as follows:

$$\text{Peak Runoff in cum/sec } (Q) = 0.028 \times P \times F \times A \times Ic$$

Where

P	:	Coefficient of runoff for the catchment characteristics
A	:	Area of catchment in hectares
Ic	:	Critical intensity of rainfall in cm/hr for the selected frequency and for the duration equal to the time of concentration
F	:	Spread factor for converting point rainfall into areal mean rainfall

2) Drain Capacity Requirement

Hydraulic design of the drain structure is carried out to fix the drain capacity. The drain capacity is finalized using Manning's formula for open channels:

$$\text{Discharge of the drain in cum/sec } (Q) = 1/n \times A \times R^{2/3} \times S^{1/2}$$

Where

n	:	Manning's roughness coefficient
A	:	Area of flow cross section in sqm
R	:	Hydraulic mean radius in m which is area of flow cross section divided by wetted perimeter
S	:	Energy slope of the channel, which is roughly taken as the slope of the drain bed

3) Storm Duration

Rainfall intensity in the DPR is referred to the Flood Estimation Report for Coast Region of Central Water Commission, and the 24 hour rainfall for 25 years for the project area is identified from the report. The intensity of rainfall for a particular duration of storm is estimated using the conversion factors and the following equation given in IRC: SP:42-2014:

$$Ic = F/T \times (T+1)/(t+1)$$

Where,

Ic	:	Intensity of rainfall within a shorter period of T hours within a storm
F	:	Total rainfall in a storm in cm falling within the duration of storm of T hours
t	:	Smaller time interval of t hours during a storm of T hours
T	:	Duration of total rainfall (F) in hours

4) Design Planning

The DPR explained the drainage design planning as discussed below.

Section 1: rain water is collected by longitudinal kerb channel which is located at 15 m intervals alongside the earthen shoulder and will be let down through precast chutes. Also, energy dissipation basins are used at the end of chutes.

Other sections: the lined drain is proposed under the footpath on the edge of the roadway, so there is no need for kerb drains in high embankments. Stone pitching with chutes is proposed on the side slopes above the retaining wall wherever the height of retaining wall is more than 3 m.

(5) Drainage Design for Longitudinal Drain of DPR

1) Brick-lined Trapezoidal Open Drain

The summary of drainage calculation of the brick lined trapezoidal open drain in the DPR is shown in Table 6.2.21 below. After the review of the JICA Study Team, the cross section of the proposed brick lined trapezoidal open drain seems to have sufficient drainage capacity.

Table 6.2.20 Summary of Drainage Calculation of Brick Lined Trapezoidal Open Drain in the DPR

Parameter		Value	Formula
Hydrologic Discharge Calculation			
Length of drain (L)		500m	Assuming
Longitudinal slope		1.0 %	
Manning roughness coefficient (n)		0.014	
Determination of Runoff Coefficient (P)		0.594	$P = \frac{W_1P_1+W_2P_2+W_3P_3+W_4P_4+W_5P_5+W_6P_6+W_7P_7}{W_1+W_2+W_3+W_4+W_5+W_6+W_7}$ W_1: Width of the Central Median in m W_2: Width of the Carriageway with Paved Shoulder in m W_3: Width of the Unpaved shoulder in m W_4: Space between the Shoulder edge and the Service Road in m W_5: Width of Unpaved shoulder in Service Road in m W_6: Width of Service Road in m W_7: Width of Footpath in m P_1: Runoff Coefficient for Central Median P_2: Runoff Coefficient for Carriageway and Paved shoulder P_3: Runoff coefficient for Unpaved shoulder P_4: Runoff coefficient of Space between the Shoulder edge and Service Road P_5: Runoff coefficient for Unpaved shoulder in Service Road P_6: Runoff coefficient for Service Road P_7: Runoff coefficient for Footpath W_1=2.0m, W_2=9.0m, W_3=2.0m, W_4=15.75m, W_5=1.0m, W_6=7.25m, W_7=2m, P_1=0.4, W_2=0.9m, W_3=0.4m, W_4=0.3m, W_5=0.4m, W_6=0.9m, W_7=0.9m
Determination of Time of Concentration (tc)		30.93 min	$tc = \left[\frac{W_1}{V_1}+\frac{W_2}{V_2}+\frac{W_3}{V_3}+\frac{0.5W_4}{V_4}+\frac{W_5}{V_5}\right]\times\frac{1}{60}$ Assume, V_1 = 0.06m/s, V_2 = 0.45m/s, V_3 = 0.45m/s, V_4 = 0.06m/s, V_5 = 0.3m/s
Determination of Catchment Area (A)		195,000 m^2	$A = W \times L$ $W = W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7$
Determination of Rainfall Intensity (Ic)	Option 1	20.87 cm/hour	25 years 24 hours rainfall = 320 mm (as per Flood Estimation Report 25 & 50 years) Conversion factor for 24 hours to 1 hour rainfall = 39% 1 hour rainfall of 25 years return period = 39% x 320 = 124.8 mm = 12.5 cm/hour Ratio for 60min rainfall to 30.93 minutes rainfall = 1.67 Design rainfall intensity (Ic) = 12.5 x 1.67 = 20.87 cm/hour
	Option 2	16.49 cm/hour	$Ic = \frac{F}{T}\times\left[\frac{T+1}{tc+1}\right] = \frac{12.5}{1}\times\left[\frac{1+1}{\frac{30.93}{60}+1}\right]$ = 16.49 cm/hour
Design Discharge		0.68 m^3/s	$Q = 0.028 \times P \times Ic \times A$
Hydraulic Design Calculation			
Bottom width		0.3 m	
Depth		0.5 m	Consideration that water level is under 0.1 m of top of drain
Free Board		0.1 m	
Side slope		1:1	
Top Width		1.3 m	
Cross section area (A)		0.4 m^2	
Wetted perimeter (P)		1.714	
Hydraulic Mean Depth (R)		0.233 m	A/P
Discharge capacity (Q)		1.08 m^3/s	Manning Formula, $\frac{1}{n}\times A\times R^{2/3}\times I^{1/2}$

Parameter	Value	Formula
Judgement		
Discharge capacity (1.08 m^3/s) of proposed drain in the DPR is greater than the design storm discharge (0.68 m^3/s). Cross section of proposed brick lined trapezoidal open drain seems to have sufficient drainage capacity.		

Source: JICA Study Team based on DPR Design Report (Highway)

2) RCC Rectangular Covered Drain

The summary of drainage calculation of RCC rectangular covered drain in the DPR is shown in Table 6.2.22 below. Discharge capacity of the proposed drain in the DPR is greater than the design storm discharge. Cross section of proposed RCC rectangular covered drain seems to have sufficient drainage capacity.

Table 6.2.21 Summary of Drainage Calculation of RCC Rectangular Covered Drain in the DPR

Parameter	Value	Formula
Hydrologic Discharge Calculation		
Length of drain (L)	500m	Assuming
Longitudinal slope	0.3 %	
Manning roughness coefficient (n)	0.014	
Determination of Runoff Coefficient (P)	0.411	$P = \frac{W_1P_1+W_2P_2+W_3P_3+W_4P_4+W_5P_5+W_6P_6+W_7P_7}{W_1+W_2+W_3+W_4+W_5+W_6+W_7}$ W_1: Width of the Central Median in m W_2: Width of the Carriageway with Paved Shoulder in m W_3: Width of the Divider in m W_4: Width of Service road in m W_5: Width of Footpath in m W_6: Space between the Footpath edge and the RoW in m W_7: Width of Abutting land in m P_1: Runoff Coefficient for Central Median P_2: Runoff Coefficient for Carriageway and Paved shoulder P_3: Runoff coefficient for Divider P_4: Runoff coefficient for Service road P_5: Runoff coefficient for Footpath P_6: Runoff coefficient of Space between the Footpath edge and the ROW P_7: Runoff coefficient of Abutting land W_1=2.0m, W_2=12.5m, W_3=2.0m, W_4=7.5m, W_5=3.0m, W_6=3.0m, W_7=100m, P_1=0.4, W_2=0.9m, W_3=0.4m, W_4=0.9m, W_5=0.9m, W_6=0.4m, W_7 = 0.3m
Determination of Time of Concentration (tc)	6.93 min	$tc = \left[\frac{W_1}{V_1}+\frac{W_2}{V_2}+\frac{W_3}{V_3}+\frac{0.5W_4}{V_4}+\frac{W_5}{V_5}\right]\times\frac{1}{60}$ Assume, V_1 = 0.06m/s, V_2 = 0.45m/s, V_3 = 0.45m/s, V_4 = 0.45m/s, V_5 = 1.5m/s
Determination of Catchment Area (A)	65,000 m^2	A = W × L W= $W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7$
Determination of Rainfall Intensity (Ic) — Option 1	39.88 cm/hour	25 years 24 hours rainfall = 320 mm (as per Flood Estimation Report 25 & 50 years) Conversion factor for 24 hours to 1 hour rainfall = 39% 1 hour rainfall of 25 years return period = 39% x 320 = 124.8 mm = 12.5 cm/hour Ratio for 60min rainfall to 6.93 minutes rainfall = 3.19 Design rainfall intensity (Ic) = 12.5 x 3.19 = 39.88 cm/hour
Option 2	21.52 cm/hour	$Ic = \frac{F}{T}\times\left[\frac{T+1}{tc+1}\right] = \frac{12.5}{1}\times\left[\frac{1+1}{\frac{9.7}{60}+1}\right]$ = 21.52 cm/hour
Design Discharge	2.99 m^3/s	Q = 0.028×P×Ic×A
Hydraulic Design Calculation		
Bottom width	1.2 m	
Depth	1.2 m	Consideration that water level is under 0.3 m of top of drain
Free Board	0.3 m	
Cross section area (A)	1.44 m^2	
Wetted perimeter (P)	3.60 m	

Parameter	Value	Formula
Hydraulic Mean Depth (R)	0.40 m	A/P
Discharge capacity (Q)	3.06 m^3/s	Manning Formula, $\frac{1}{n} \times A \times R^{2/3} \times I^{1/2}$
Judgement		
Discharge capacity (3.06 m^3/s) of proposed drain in the DPR is greater than the design storm discharge (2.99 m^3/s). Cross section of proposed RCC rectangular covered drain seems to have sufficient drainage capacity.		

Source: JICA Study Team based on DPR Design Report (Highway)

(6) Drainage Design for Cross Drain of DPR

In the GAD, box culvers and pipe culverts are located for cross drain in the CPRR. They are located at topographically lower places. Distances between box culverts and pipe culverts are about 150~200 m.

However, the drainage design of cross drain (hydrological calculation and hydraulic design) has not been carried out in the DPR.

(7) Conclusion

Drainage design in the DPR was carried out in accordance with IRC: SP:42-2014 for longitudinal drains such as brick lined trapezoidal open drain and RCC rectangular covered drain. After review by the JICA Study Team, the calculation and judgement results seem to be reasonable.

However, drainage design for box and pipe culvert was not carried out in the DPR but shown in the GAD. Therefore, cross drainage design should be carried out in the next project stage.

6.3 Interchange Design (All Sections)

6.3.1 Obtained Documents and Drawings

The documents and drawings concerning the interchange which are within the obtained DPR are as follows:

+ Design Reports:

    Volume-I. MAIN REPORT Chapter-7 7.9 Interchanges

    Volume-IIA. DESIGN REPORT (Highways) Chapter-6 Design of Interchanges

+ Design Drawings:

    Volume-III-A. DRAWINGS (Highways)

    Volume-III-E. DRAWINGS (Structures)-Interchanges

Review of the interchange design was conducted using the above reports and drawings.

It is noted that the Design Report (Structure) from Volume II-B to Volume II-H has not been provided at the time of review. Therefore, the contents are outside the review target although it was finally provided in February and March 2018.

6.3.2 Location and Type of Interchange

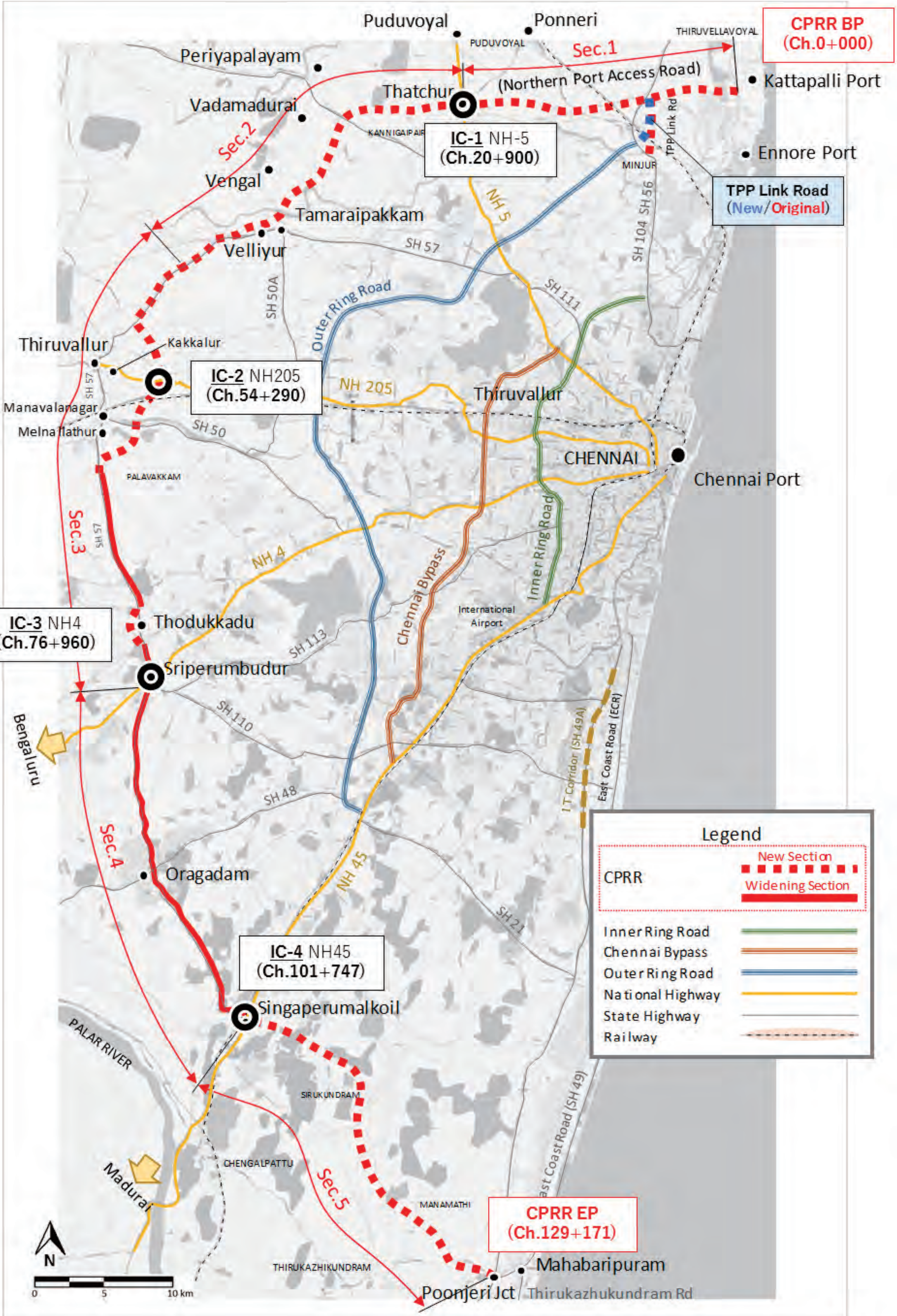
Interchanges are planned at every crossing point of the project road and of national roads. Location, type, and connecting road of each interchange are shown in Table 6.3.1. The locations of interchanges are also shown in Figure 6.3.1.

In the abovementioned DESIGN REPORT (Highway) Chapter-6, it is described that these interchange types have been approved by the Steering Committee of this project.

Table 6.3.1 Location and Type of Interchange

Interchange Name	Connecting National Highway (BP/EP)	Location Station No./ Section No.	Interval of Interchange	Type of Interchange (Number of Legs)
IC-1	NH-5 (Kolkata-Chennai)	Station 20+900/ Section-2		Cloverleaf (4 legs)
IC-2	NH-205 (Chennai-Anaatapur)	Station 54+290/ Section-3	L=33.390 km	Cloverleaf (4 legs)
IC-3	NH4 (Mumbai-Chennai)	Station 76+960/ Section-3	L=22.670 km	Cloverleaf (4 legs)
IC-4	NH-45 (Chennai-Dindigul)	Station 101+747/ Section-5	L=24.787 km	Elevated Roundabout (6 legs)

Source: JICA Study Team
*The interchange location (station of main road) is based on the drawings, but if the location is not indicated in the drawings, the JICA Study Team decided it.



Source: JICA Study Team

Figure 6.3.1 Location of Interchange

6.3.3 Geometric Design Standard of Interchange

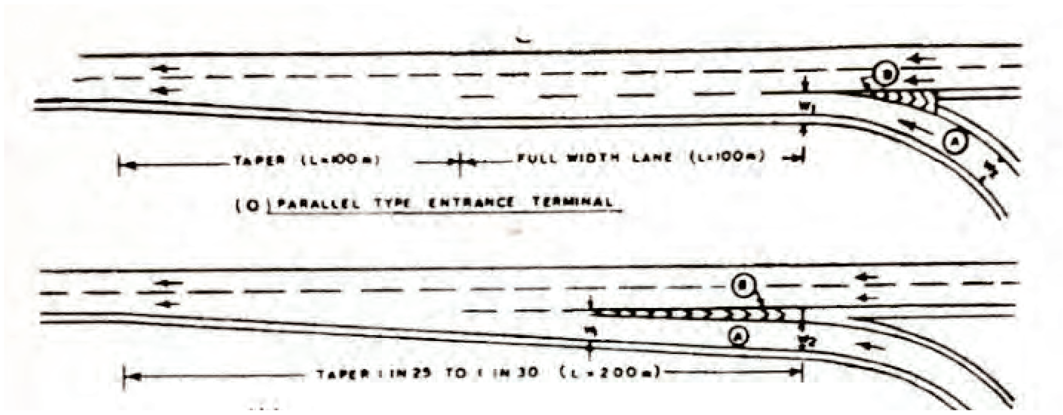
IRC:92-1985: Guidelines for the Design of Interchanges in Urban Areas was applied to the geometric design of interchange. IRC:92-1985: Manual for Grade Separators and Elevated Structures was applied to the explanation of the technique of the interchange design. The main geometric design standards of rampways provided in IRC:92-1985 are shown in Table 6.3.2. The design standard for loop rampways was provided without depending on the design speed of the main road.

Table 6.3.2 Geometric Design Standard of Rampway of Interchange

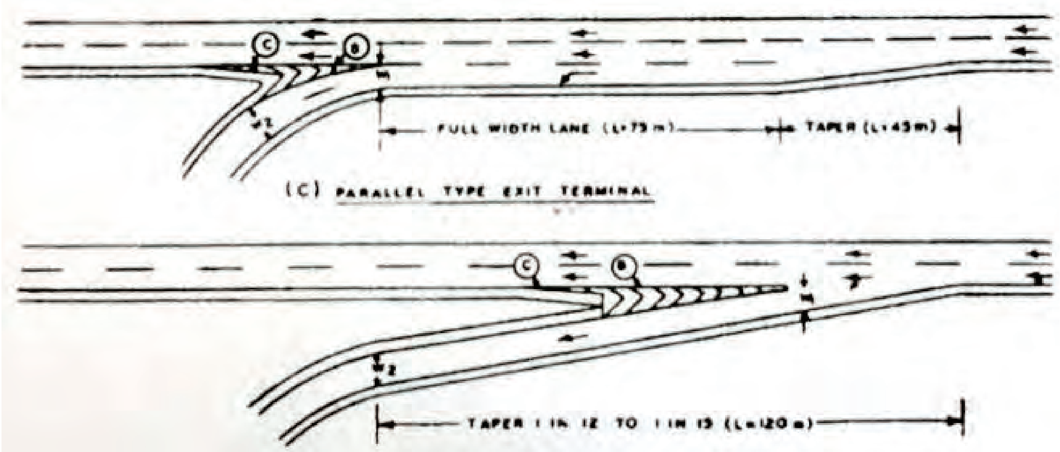
Design Speed of Main Road (Loop Ramp)	80 km/h				100 km/h				Loop Ramp			
	Minimum		Desirable		Minimum		Desirable		Minimum		Desirable	
Rampway												
Design Speed	40 km/h		50 km/h		50 km/h		65 km/h		30 km/h		40 km/h	
Minimum Curve Radius	60 m		90 m		90 m		155 m		30 m		60 m	
Maximum Superelevation	7%											
Stopping Sight Distance	45 m		60 m		60 m		90 m		25 m		45 m	
Maximum Gradient	4%											
Vertical Curve Length	Crest	Sag	Crest	Sag	Crest	Sag	Crest	Sag	Crest	Sag	Crest	Sag
Absolute Minimum	4.6A	6.6A	8.2A	10A	8.2A	10A	18.4A	17.4A	2.0A	3.5A	4.6A	6.6A
*A is the algebraic difference in grade(%)	20 m	20 m	30 m	30 m	30 m	30 m	40 m	40 m	15 m	15 m	20 m	20 m
Clearances												
Lateral	Roadway Width											
Vertical	5.5 m (in Urban Area)											
Ramp Terminal	Minimum						Desirable					
Acceleration	180 m						250 m					
Deceleration	90 m						120 m					

Source: IRC:92-1985

The shapes of acceleration and deceleration in the ramp terminal are shown below.



Acceleration Lane (parallel type, direct taper type)



Deceleration Lane (parallel type, direct taper type)

Source: IRC:92-1985

Figure 6.3.2 Shape of Acceleration and Deceleration Lanes in the Ramp Terminal

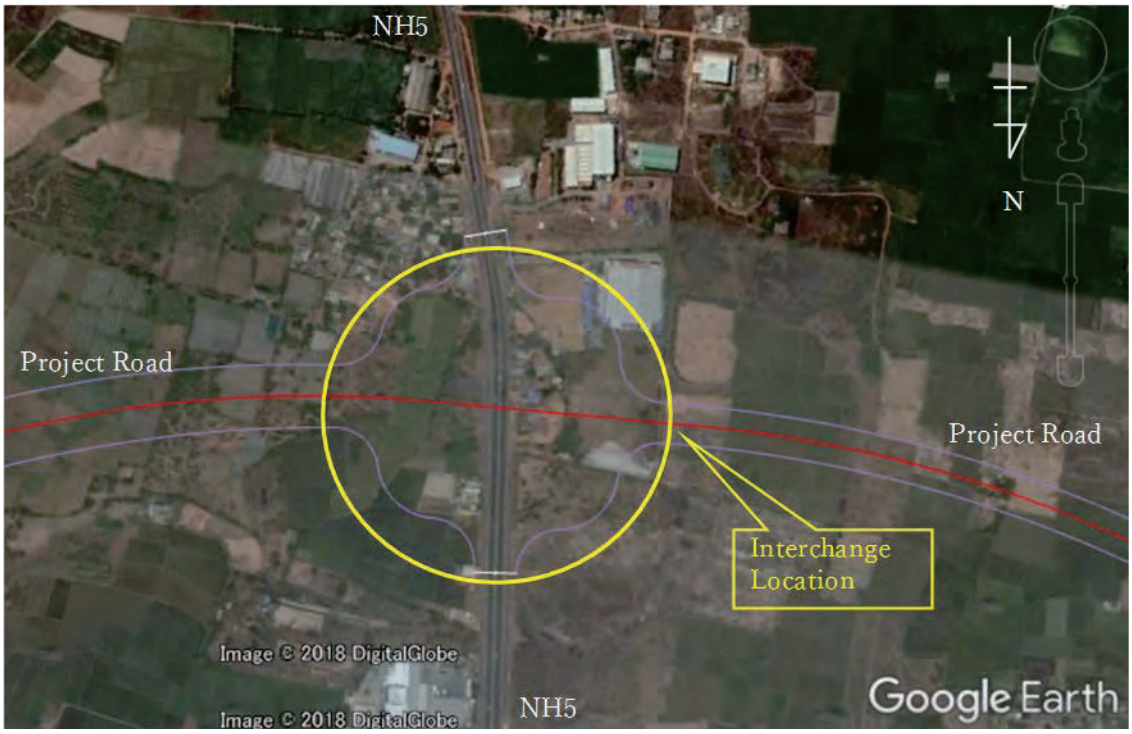
6.3.4 Outline of Interchange Design and Recommendation of Improvement

The design of the interchange was reviewed based on the obtained design reports, drawings, and the result of the site investigation at the location of interchange. As a result, the outlines of design of interchange are shown in Table 6.3.3. Moreover, the problem and the improvement countermeasure resulting from the review are described below according to the interchange.

(1) IC-1

1) Present Condition of Planned Location

IC-1 is the interchange connected with NH5 (29 km point) and planned at few inhabited areas in Thatchur of Thiruvallur District of the suburbs north of Chennai City. The present condition of IC-1 is shown in Figure 6.3.3.



Source: Edited by the JICA Study Team on Google Earth

Figure 6.3.3 Present Condition of IC-1

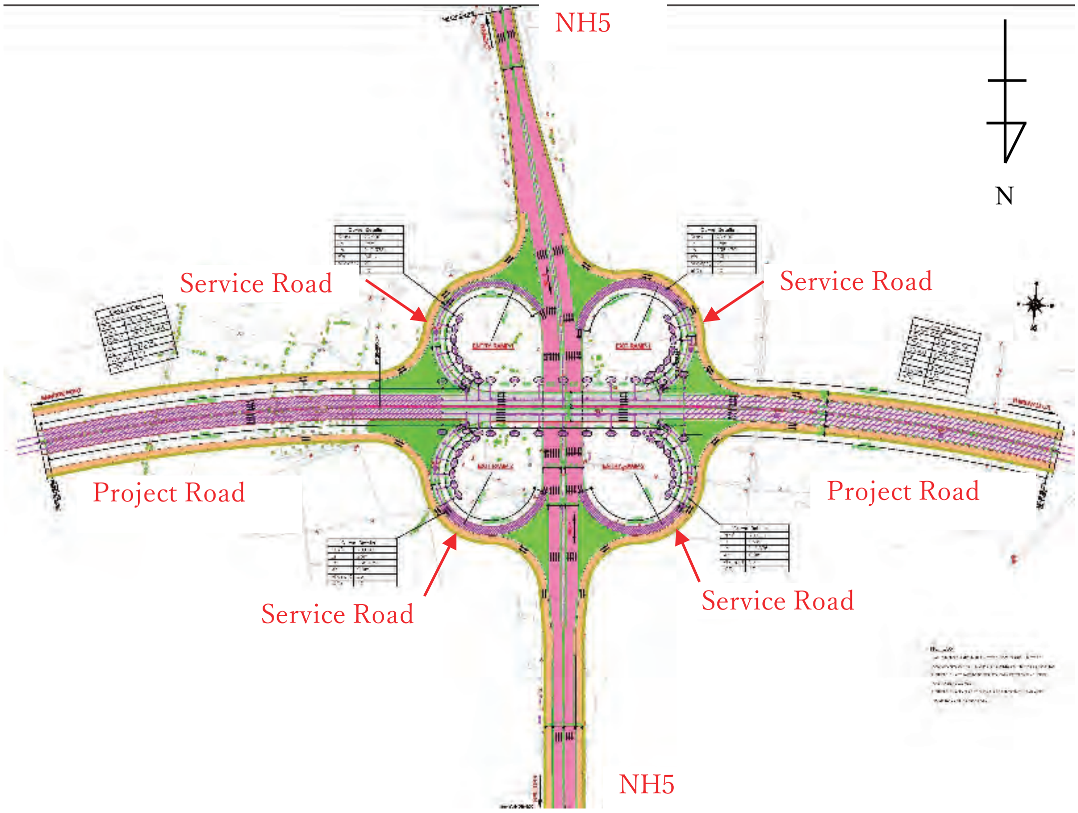
2) Outline of Design

The outline of the design of IC-1 is shown in Table 6.3.3, and the plan of IC-1 is shown in Figure 6.3.4.

Table 6.3.3 Outline of Design of IC-1

Section: 1	Location: Thatchur in Thiruvallur District	Station: 20+900 (Main Road)
Connecting Road: NH5 KP29km		
Type of Interchange: Cloverleaf		
Designed Value	Main road (Interchange section)	Design speed: 100 km/h
		Number of lane: 6 lanes (3 lanes for each direction)
		Horizontal alignment: R=2,000 m (e=2.5%)～R=∞ (e=2.5%)～R=2,000 m(e=2.5%)
		Vertical alignment: Gradient:2.5%～0%～-2.5% VCR Crest: 8,200 m, 8,200 m VCR Sag: NA
	Service road	Design speed: 40 km/h
		Number of lane: 2 lanes
		Horizontal alignment: Parallel to main road center line
		Vertical Alignment: Parallel to main road center line
	NH-5 (interchange section)	Design speed: 80 km/h
		Number of lane: 4 lanes (2 lanes for each direction)
		Horizontal alignment: R=∞
		Vertical alignment: gradient: almost level
	Rampway	Design speed: 40 km/h
		Number of lane: 2 lanes
		Cross section: 8.6 m (0.8+3.5+3.5+0.8)
		Horizontal alignment: R=70 m (loop ramp, e=4%) : Without transition curve
		Vertical alignment: max. gradient: 3.33% VCR Crest: 600 m (L=20 m) VCR Sag: 600 m (L=20 m)
		Vertical clearance: 5.5m

Source: DPRR



Source: JICA Study Team added to DPRR

Figure 6.3.4 Plan of IC-1

3) Problem and Measure

Problem 1

Left-turning traffic on the project road exits to the service road before the interchange. Traffic enters to the project road from the service road. Therefore, it takes a longer time and causes congestion on the service road.

Measure

Additional direct ramps for left-turning traffic and for service roads located outside these ramps are proposed. The service road connects to the south side of NH5 after the connection to the rampway because the service road is not installed for NH5.

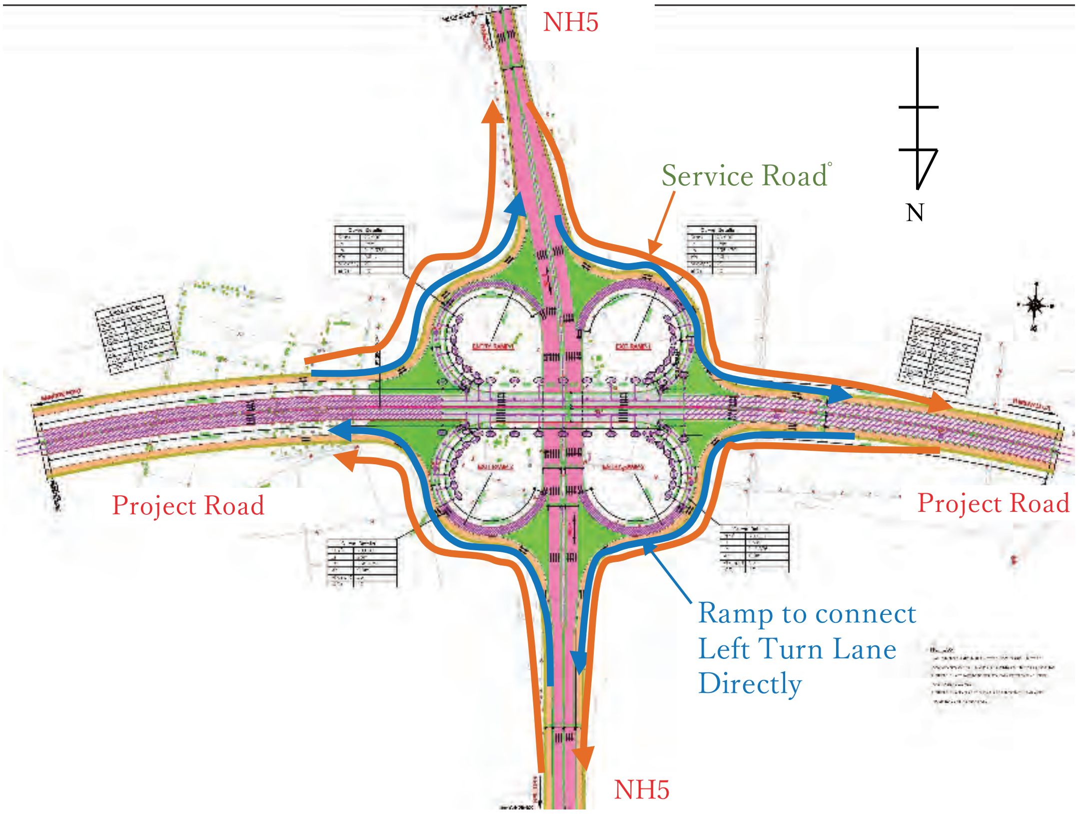
Problem 2

The curve radius of the loop rampway is 70 m. However, the transition curve is not inserted between the straight line and curve. Therefore, the horizontal alignment and transition of super-elevation are not smooth, which is not good for driving and safety.

Measure

It is desirable to insert the transition curve between the straight line and curve (R=70 m, e=5%).

The abovementioned improvement proposal is shown in Figure 6.3.5.



Source: JICA Study Team added to DPRR

Figure 6.3.5 Recommended Plan for IC-1

Problem 3

Weaving occurs between the merging point and diverging point at the connected section of the main road and the rampway. There are four lanes in this section (W=16 m), including a rampway (1 lane). The distance between the merging point and the diverging point is 240 m. It is expected that congestion will be caused by the decrease of running speed, considering the future traffic volume (weaving traffic and non-weaving traffic).

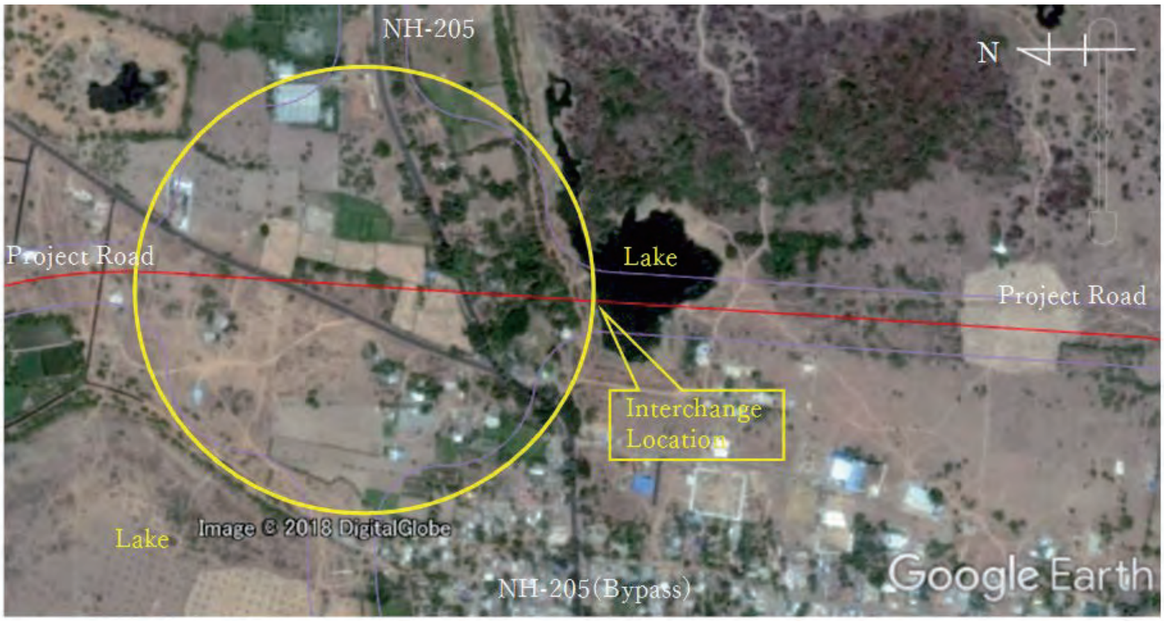
Measure

It is recommended to increase the rampway width (1 lane more) outside of the main road. The total width becomes 19.5 m (5 lanes).

(2) IC-2

1) Present Condition of Planned Location

IC-2 is the interchange connected with NH205 (51.65 km point) and planned in Kakkalur of Truvallur District of the suburbs in the west of Chennai City. It is located at an area between two lakes. The present condition of IC-2 is shown in Figure 6.3.6.



Source: Edited by the JICA Study Team on Google Earth

Figure 6.3.6 Present Condition of IC-2

2) Outline of Design

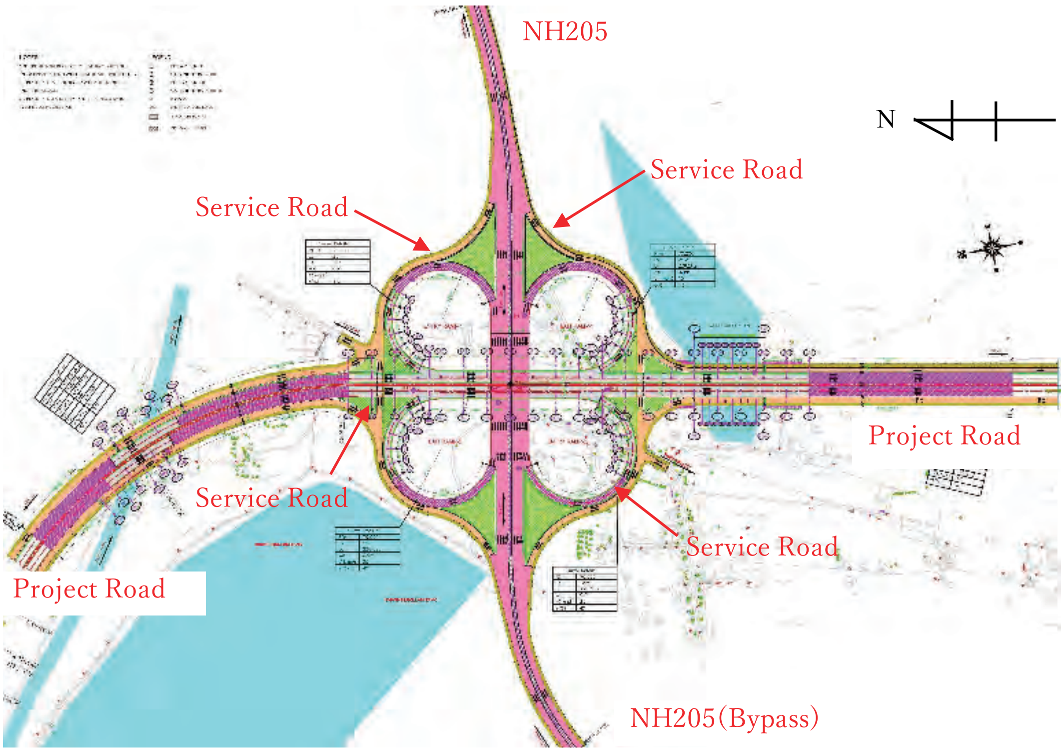
The outline of the design of IC-2 is shown in Table 6.3.4 and the plan of IC-2 is shown in Figure 6.3.7.

Table 6.3.4 Outline of IC-2

Section:3	Location: Kakkalur in Thiruvallur District	Station:54+290(Main Road)
Connecting Road: NH-205 KP51.65km		
Type of Interchange: Cloverleaf		
Designed Value	Main road (Interchange section)	Design speed: 80～100 km/h
		Number of lane: 6 lanes (3 lanes for each direction)
		Horizontal alignment: R=525 m(e=5%)～R=∞ (e=2.5%)～A=162 m～R=∞(e=2.5%)
		Vertical alignment: Gradient:2.5%～0%～2.5% VCR Crest: 10,000 m, 10,000 m VCR Sag: NA
	Service road	Design speed: 40 km/h
		Number of lane: 2 lanes
		Horizontal alignment: Parallel to main road center line
		Vertical Alignment: Parallel to main road elevation
	NH-205 (Interchange Section)	Design speed: 80 km/h?
		Number of lane: 2 lanes (1 lanes for each direction)
		Horizontal alignment: R=around 100 m
		Vertical alignment: gradient: almost level
		Design speed: 40 km/h
		Number of lane: 2 lanes

Section:3	Location: Kakkalur in Thiruvallur District	Station:54+290(Main Road)
	Rampway	Cross section: 8.6 m (0.8+3.5+3.5+0.8)
		Horizontal alignment: R=70 m (loop ramp, e=4%) : Without transition curve
		Vertical alignment: max. gradient: 2.5% VCR Crest: 600 m (L=20m) VCR Sag: 600 m (L=20m)
		Vertical clearance: 5.5 m

Source: DPRR



Source: JICA Study Team added to DPRR

Figure 6.3.7 Plan of IC-2

3) Problem and Measure

Problem 1

Left-turning traffic on the project road exits to the service road before the interchange. Then, it enters to the project road from the service road. Therefore, it takes a longer time and causes congestion on the service road.

Measure

Additional direct ramps for left-turn traffic and for service roads located outside these ramps are proposed. The service road connects to NH205 after the connection to the rampway because the service road is not installed for NH205.

Problem 2

The curve radius of loop rampway is 70 m. However, the transition curve is not inserted between the straight line and the curve. Therefore, the horizontal alignment and the transition of super-elevation are not smooth, which is not good for driving and safety.

Measure

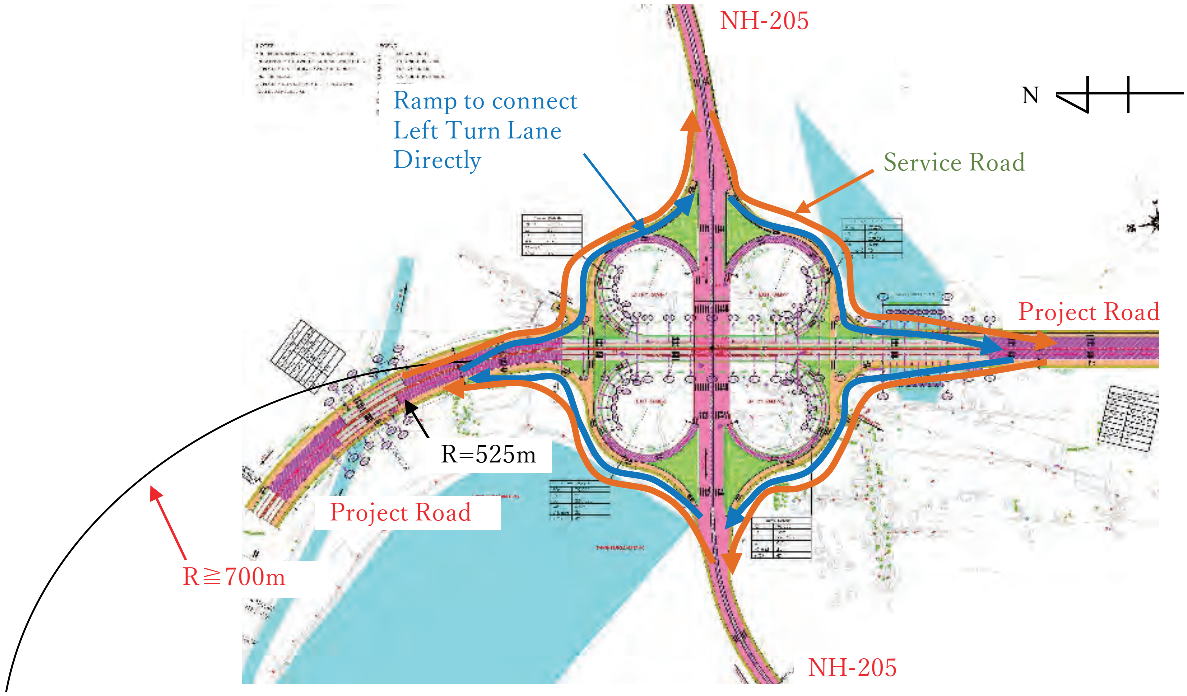
It is desirable to insert the transition curve between the straight line and the curve (R=70 m, e=5%).

Problem 3

The curve radius of the ramp terminal in the beginning side of the project road is 525 m. It is small and has a steep super-elevation (5%). It is dangerous for the car passing with high speed, even with the installation of the speed limitation sign (80 km/h). It is caused by large curve radius (1200 m) before this radius (525 m). In addition, it is dangerous because of the lower visibility of the diverging nose position.

Measure

To improve safety, it is recommended to apply a radius bigger than 700 m, which is prescribed in the standards of the Road Structure Ordinance of Japan for curve radius of ramp terminal of main road with design speed of 80 km/h.



Source: JICA Study Team added to DPRR

Figure 6.3.8 Proposal of the Abovementioned Improvement

Problem 4

Weaving occurs between the merging point and the diverging point at the connected section of the main road and the rampway. There are four lanes in this section (W=16 m), including a rampway (1 lane). The distance between the merging point and the diverging point is 240 m. It is expected that congestion will be caused by the decrease of running speed considering the future traffic volume (weaving traffic and non-weaving traffic).

Measure

It is recommended to increase the rampway width (1 lane more) outside of the main road. The total width becomes 19.5 m (5 lanes).

(3) IC-3

1) Present Condition of Planned Location

IC-3 is the interchange connected with NH4 (42.1 km point) and planned in Sriperumbudur of Tiruvallur District of the suburbs in the west of Chennai City. It is planned at the vicinity of the intersection connecting with NH4, SH57, and SH110. The present condition of IC-3 is shown in Figure 6.3.9.

Source: Edited by the JICA Study Team on Google Earth

Figure 6.3.9 Present Condition of IC-3

2) Outline of Design

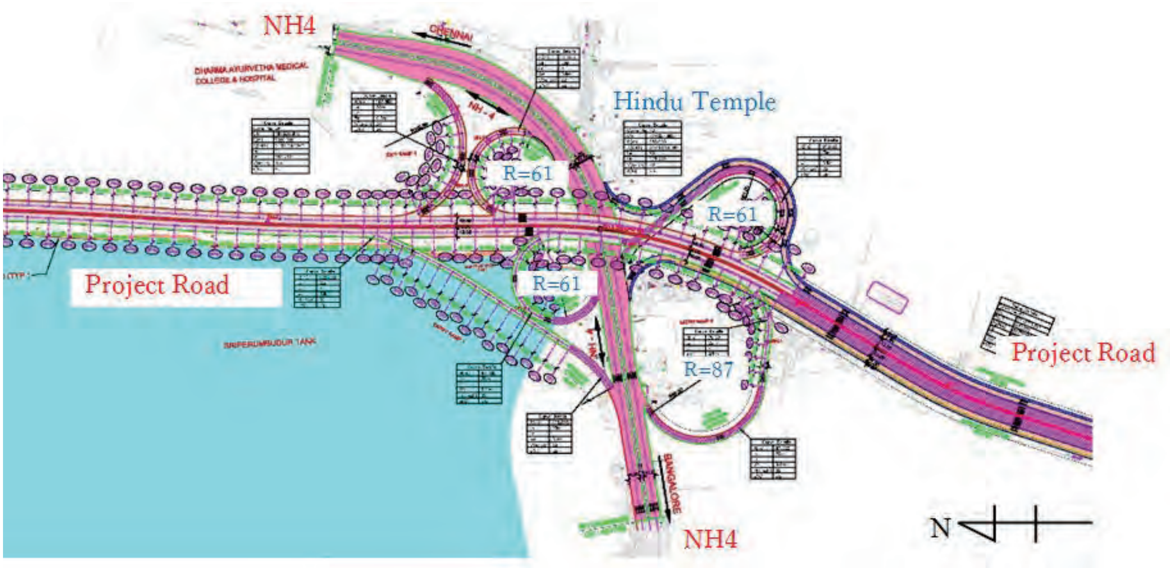
The outline of the design of IC-3 is shown in Table 6.3.5, and the plan of IC-3 is shown in Figure 6.3.10.

Table 6.3.5 Outline of IC-3

Section:3	Location: Kakkalur in Thiruvallur District	Station:76+960 (Main Road)
Connecting Road: NH-4 KP42.1km		
Interchange Type: Modified Cloverleaf		
Designed Value	Main road (Interchange section)	Design speed: 80 km/h
		Number of lane: 6 lanes (3 lanes for each direction)
		Horizontal alignment: R=5000 m(e=2.5%)～R=∞ (e=2.5%)～A=228 m～R=650 m(e=4.4%)～ A=228～R=∞(E=2.5%)～A=219～ R=600(e=4.7%)
		Vertical alignment: Gradient:0.55%～0%～-2.5% VCR Crest: 35,000 m, 7,500 m VCR Sag: NA
	Service road	Design speed: 40 km/h
		Number of lane: 2 lanes
		Horizontal alignment: Parallel to main road center line (before and after IC)
		Vertical Alignment: Parallel to main road elevation
		Design speed: 80 km/h

Section:3	Location: Kakkalur in Thiruvallur District	Station:76+960 (Main Road)
	NH-4 (Interchange Section)	Number of lane: 6 lanes (3 lanes for each direction)
		Horizontal alignment: R=300 m
		Vertical alignment: gradient: almost level
	Rampway	Design speed: 40 km/h
		Number of lane: 2 lanes
		Cross section: 8.6 m (0.8+3.5+3.5+0.8)
		Horizontal alignment: R=61 m, 81 m (loop ramp, e=4%), R=87 m (loop ramp) * Without transition curve
		Vertical alignment: max. gradient: 3.3% VCR Crest: 600 m (L=20 m) VCR Sag: 600 m (L=20 m)
		Vertical clearance: 5.5 m

Source: DPRR



Source: JICA Study Team added to DPRR

Figure 6.3.10 Plan of IC-3

3) Problems and Measure

Problem 1

This interchange is located near the existing intersection connecting with NH4, SH57, and SH110, and the interchange type is a cloverleaf. But the shape of the interchange is not symmetrical, avoiding the Hinduism Temple. Therefore, the distance between the merging nose and the diverging nose is short, and weaving becomes difficult. Also, it is difficult to guide the destination and safety is low.

Measure

It is recommended to provide the distributing lane (design speed 40 km/h) which is parallel to NH5 at the end point side and to connect the distributing lane and rampway. Moreover, the weaving distance becomes longer because the rampway alignment is changed.

Problem 2

The curve radius rampway (including loop rampway) is 61 m (minimum). However, the transition curve is not inserted between the straight line and the curve. Therefore, the horizontal alignment and transition of super-elevation are not smooth. Also, there is no cursoriality and safety.

Measure

It is desirable to insert the transition curve between the straight line and the curve.

Problem 3

Weaving occurs between the merging point and the diverging point at the connected section of the main road and the rampway. There are four lanes in this section (W=16 m), including a rampway (1 lane). The distance between the merging point and the diverging point is 260 m. It is expected that congestion will be caused by the decrease of running speed considering the future traffic volume (weaving traffic and non-weaving traffic).

Measure

It is recommended to increase the rampway width (1 lane more) outside the main road. The total width becomes 19.5 m (5 lanes).

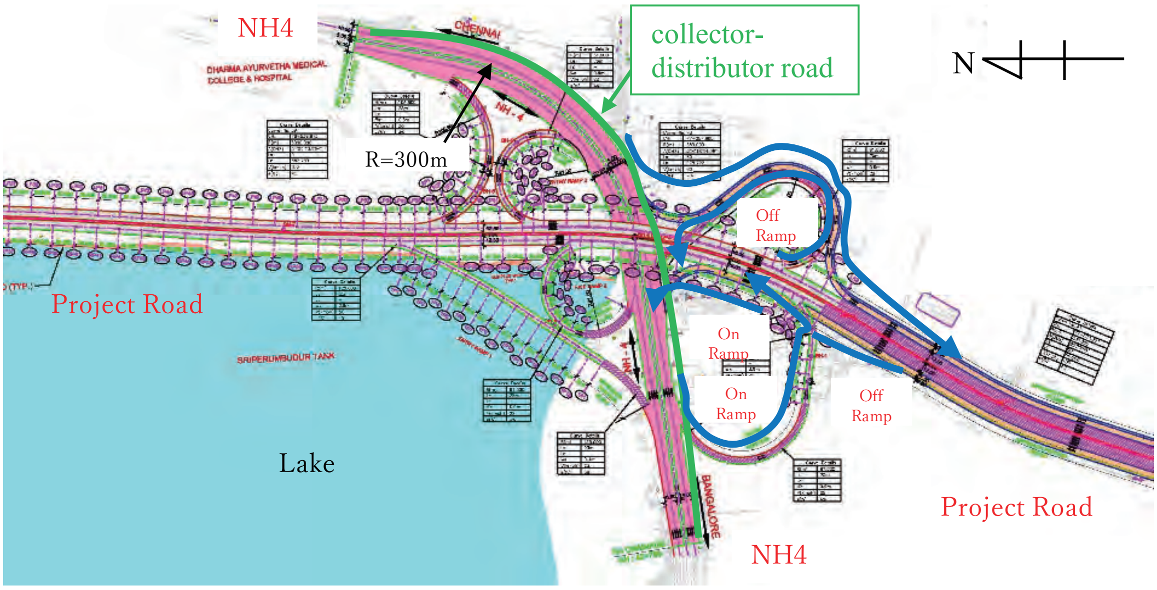
Problem 4

The acceleration lane and the deceleration lane are not installed at the ramp terminal connecting to the project road and rampway. Therefore, it is dangerous because of the big difference in running speed.

Measure

It is recommended to install the acceleration lane (parallel type) and deceleration lane (direct taper type) according to the standard of ramp terminal (IRC: 92-1985).

Figure 6.3.11 shows the proposal of the abovementioned improvement.



Source: JICA Study Team added to DPRR

Figure 6.3.11 Recommended Plan for IC-3

(4) IC-4

1) Present Condition of Planned Location

IC-4 is the interchange connected with NH45 (47.4 km point) and planned in Sigaoerumal Koil of Kancheepuram District of the suburbs in the south of Chennai City. The approach of interchange including viaduct crossing over the railway and retaining wall is constructed already. The present condition of IC-4 is shown in Figure 6.3.12.

Source: Edited by the JICA Study Team on Google Earth

Figure 6.3.12 Present Condition of IC-4

2) Outline of Interchange

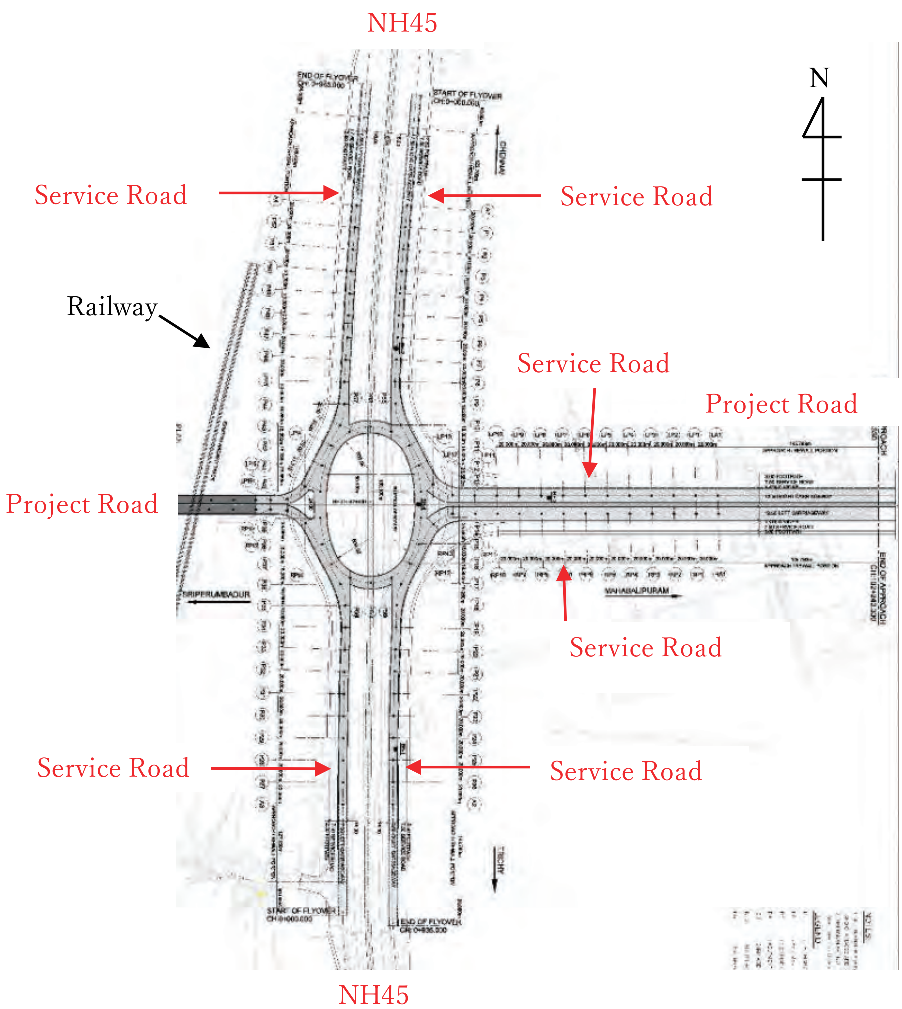
The outline of the design of IC-4 is shown in Table 6.3.6 and the plan of IC-4 is shown in Figure 6.3.13.

Table 6.3.6 Outline of IC-4

<table>
<tr><td colspan="2">Section: 5</td><td>Location: Sigaperumal Koil in Thiruvallur District</td><td>Station:101+747 (Main Road)</td></tr>
<tr><td colspan="4">Connecting Road: NH-45 KP47.4km</td></tr>
<tr><td colspan="4">Type of Interchange: Elevated roundabout (Rotary)</td></tr>
<tr><td rowspan="6">Designed Value</td><td rowspan="4">Main Road (interchange section)</td><td colspan="2">Design speed: 40 km/h (Section-4side)
100 km/h (Section-5 side)</td></tr>
<tr><td colspan="2">Number of lane:
4 lanes (2 lanes for each direction), Section-4 side
6 lanes (3 lanes for each direction), Section-5 side</td></tr>
<tr><td colspan="2">Horizontal alignment:
A=110 m～R=200(e=5%)～A=110 m ～R=∞ (e=2.5%): Section-4 side
R=∞: Section-5 side</td></tr>
<tr><td colspan="2">Vertical alignment:
Gradient: 3.33%～0%: Section-4 side
Gradient: 0%～-2.5%: Section-5 side
VCR Crest: 3,000 m: Section-4 side
VCR Sag: 4,000 m: Section-5 side</td></tr>
<tr><td rowspan="2">Service Road</td><td colspan="2">Design speed: 40 km/h</td></tr>
<tr><td colspan="2">Number of lane: 2 lanes</td></tr>
</table>

Section: 5	Location: Sigaperumal Koil in Thiruvallur District	Station:101+747 (Main Road)
	(Along Main Road	Horizontal alignment: Parallel to main road center line
		Vertical Alignment: Parallel to main road elevation
	NH-45 (Interchange section)	Design speed: 80 km/h
		Number of lane: 4 lanes (2 lanes for each direction) lanes for each direction)
		Horizontal alignment: R=577 m～R=∞
		Vertical alignment:
	Service Road (Along NH-45)	Design speed: 40 km/h
		Number of lane: 2 lanes
		Horizontal alignment: Parallel to main road center line
		Vertical Alignment: Parallel to main road elevation
	Rampway (Along NH-45)	Design speed: 40 km/h
		Number of lane: 2 lanes
		Cross section: 7.5 m (0.25+3.5+3.5+0.25)
		Horizontal alignment: R=35.05 m (Roundabout) : Without transition curve
		Vertical alignment: max. gradient: 2.5% VCR Crest: 600 m (L=20 m) VCR Sag: 600 m (L=20 m)
		Vertical clearance: 5.5 m

Source: DPRR



Source: JICA Study Team added to DPRR

Figure 6.3.13 Plan of IC-2

3) Problems and Measure

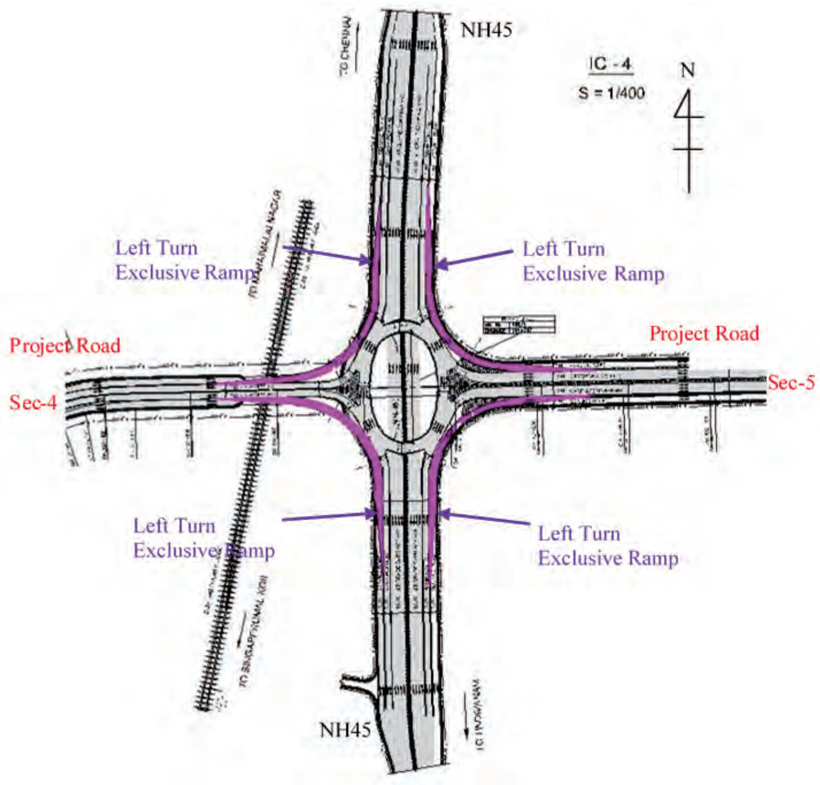
Problem 1

This interchange is planned at the area where NH45 and railway are near. Therefore, the elevated roundabout type is adopted as the interchange. The shape of the roundabout is elliptical, having a small radius of 35 m and a big radius of 100 m. The distance between the merging nose and the diverging nose is longer and the on-ramp and the off-ramp are separated in order to decrease the influence of weaving. However, it is expected that congestion will be caused by weaving, considering the future traffic volume.

Measure

It is recommended to add a separate left-turn rampway outside the roundabout in order to increase the capacity of the roundabout.

Figure 6.3.14 shows the recommended plan for IC-4.



Source: JICA Study Team added to DPRR

Figure 6.3.14 Recommended plan for IC-4

<u>Problem 2</u>

The approach section from SH57 to IC-4 including viaduct crossing over the railway is constructed already. However, the roundabout is not constructed yet. Therefore, the existing road is congested at the railway crossing and at the intersection with NH45 due to the uncompleted interchange.

<u>Measure</u>

It is recommended that the interchange should be constructed as soon as possible even if this interchange is not included in Section 4 (it is included in Section 5).

<u>Problem 3</u>

The straight advancing traffic (west side⇔east side) of the project road passes the roundabout. A temporary stop is required at the crossing point due to weaving when the number of straight advancing traffic increases in the future. It will become the cause of traffic congestion.

<u>Measure</u>

It is recommended to construct a new road which connects both sides of the project road (west and east) in order to avoid IC-4. Consequently, the straight advancing traffic will use this new road. As a result, the congestion of the roundabout will decrease.

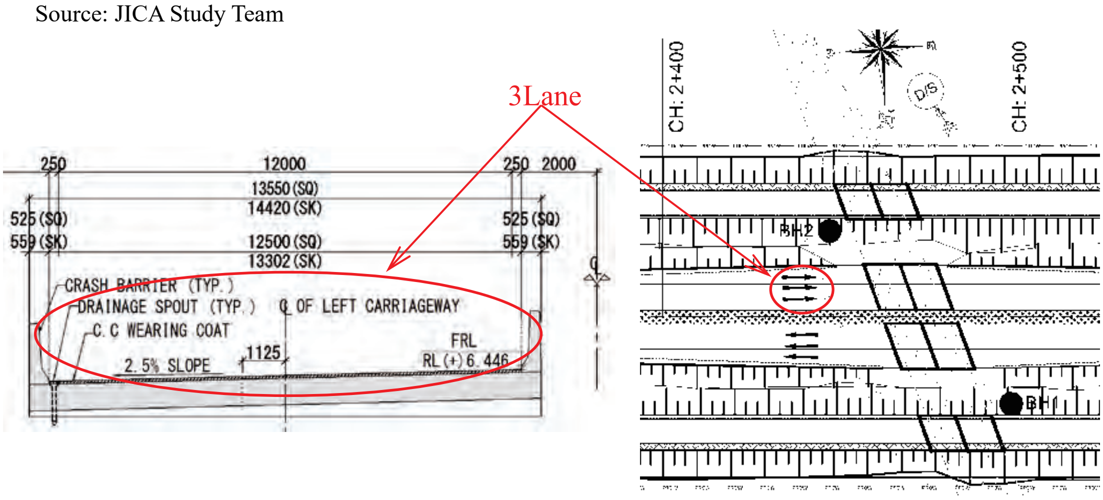
6.4 Structural Design (All Sections)

The bridge structures are planned to be a six-lane bridge, common for all sections. The plan takes into consideration the economy, constructability, and structural issues including the effect on traffic and the difficulty of widening construction relative to the existing structures of the future bridge widening works.

Table 6.4.1 Planned Number of Lanes

Project Summary		Sec.1		Sec.2	Sec.3	Sec.4	Sec.5
		CPRR	**TPP Link**	**CPRR**	**CPRR**	**CPRR**	**CPRR**
Number of Lane	Main Line	2x2Lane	2x2Lane	2x3Lane	2x3Lane	2x3Lane	2x2Lane
	Service Road	2x2Lane	2x2Lane	2x2Lane	2x2Lane	2x2Lane	2x2Lane
Bridge (Main Line)		2x3Lane					

Source: JICA Study Team



Source: JICA Study Team based on DPR Drawing (MNB101)

Figure 6.4.1 Planned Number of Lanes of the Bridge（Completed Structure for All Sections）

In this section, the result of the design review of the road structure planned in the DPR is described.

6.4.1 Types of Structures

The types of road structures according to DPR are classified as follows:

(1) Major Bridge (MJB)

・Bridges crossing relatively large rivers, canals, ponds, state roads, and the like are classified as major bridges in the DPR. There are more than six spans, resulting to a multi-span structure as compared to the minor bridge.

(2) Minor Bridge (MNB)

・Bridges crossing river or canal. In the DPR, bridges having 2~5 spans are classified as MNBs. A three-span continuous box culvert crossing a small canal is also classified as an MNB.

(3) Railway Over Bridge (ROB)

・Bridges over rail crossings.

・The abutments of the bridge are located outside the area of the railway, and within the railway area are the piers located outside the railway track and the quantity minimized.

(4) Underpasses (VUP and LVUP)

・Bridges at the intersection of service roads and existing roads.

・Bridges with fixed width and short spans, within crossroads with construction limits and both ends of the bridge are composed of reinforced earth walls.

(5) Box Culvert (BC)

- A concrete structure serving as a channel.
- Culverts are classified into two types: box culvert and pipe culvert.

(6) Interchange (IC)

- Interchanges intersecting four national highways and the project road are clover leaf structures and elevated roundabout structures; the elevated portions are bridge structures.
- The bridge is composed of a main line and ramps (entry/exit).

6.4.2 Obtained Documents and Drawings

As described in the earlier section in this report, the design report for structure works (bridge, underpass, interchange, etc.) has not been provided before the time of the review, except for a part of highway works. Because of these factors, the JICA Study Team requested HMPD to provide a part of the data shown in Table 6.1.1, but no material was provided during the review period.

The JICA Study Team conducted the review of the DPR with reference only to the Main Report and Drawings; however, details of design conditions and structure plan were not shown clearly. After completion of the review, missing documents were finally provided one after another from February 2018.

The following are the requested materials for the review:

(1) Cross Structure List

There was no information on the topography/geological condition or basic form in the DPR data. Moreover, there are missing information such as N-value, pile length, soil condition, and some foundation information which are difficult to verify. Thus, in this survey, the review of soil and foundation was not conducted, and the pile length of the foundation was assumed to be equal to the boring log (boring depth) in the drawing.

The numbers of structures from the DPR (Main Report) and from the documents on hand are listed in Appendix-7 of this report. Differences such as relocation of sections, MJB extension, BOX reduction, and others are reflected in this table.

(2) Report of Geological Survey

There is no information on the topography/geological condition or basic form in the DPR data. Moreover, there are missing information such as N-value, pile length, soil condition, and some foundation information which are difficult to verify. Thus, in this survey, the review of soil and foundation was not conducted, and the pile length of the foundation was assumed to be equal to the boring log (boring depth) in the drawing.

It is noted that foundation dimensions, boring log, N-value, and other details were reflected in the DPR upon receipt of the Design Report. Therefore, detailed review is strongly recommended at the detailed design stage.

(3) Required Clearance of Rivers

In order to confirm the validity, the JICA Study Team requested to provide information about clearance of girders over rivers. However, HMPD stated that there is no particular clearance required for bridges on rivers; hence, it will not be particularly considered.

Since the river cross section, water current, water level, and other river details are unclear, it is suggested to carry out investigations during the detailed design.

Table 6.4.2 Partially Requested Materials and Availability

No.	Requested Document	Purpose	Request Date	Status	Effect of Lack of Document	Countermeasure
1	Cross Structure List	To confirm the type and number of structures to be designed for all sections.	26 Oct. 2017	・Received: Culvert ・Not received: Other structures	The number and type of all planned structures are unknown. It is difficult to grasp/confirm the details of the structure that is recorded in the quantity.	The survey team listed the structure details (type, quantity, etc.) according to the DPR main report and drawing.
2	Geological Survey Report	To understand the geological conditions and to know the length of piles.	26 Oct. 2017	Not received	The ground details (N value, bearing layer and other properties) are unknown. Moreover, it is difficult to validate the unknown foundation type and pile length.	The pile diameter is based on the formula described in the DPR main report and drawing. The pile length is determined from the boring log (up to the bearing layer only).
3	Required Clearance of MJBs and MNBs on Rivers	To confirm the navigation clearance of bridges on river (necessary for the limit of ship height).	26 Oct. 2017	Not received	Required girder clearances for bridges on river is unknown. Clearances other than the route height are unknown.	Secure height clearance below the girder during high water level (construction height limit in case of bridges over roads) as indicated in the DPR main report and drawing. The navigation height clearance can be neglected as per HMPD.

Source: JICA Study Team

Table 6.4.3 Comparison of the Number of Planned Structures

Project Summary		**Sec.1**					**Sec.2**		**Sec.3**		**Sec.4**		**Sec.5**		**TOTAL TPP Link: Original**	
		CPRR		**TPP Link**			**CPRR**		**CPRR**		**CPRR**		**CPRR**			
				Original		**Realignment**										
Number of Lane	Main Line	2x2Lane		2x2Lane			2x3Lane		2x3Lane		2x3Lane		2x2Lane		-	
	Service Road	2x2Lane		2x2Lane			2x2Lane		2x2Lane		2x2Lane		2x2Lane		-	
Project		DPR Vol. I	Jica Study Team	DPR Vol. I	Jica Study Team	TNRDC/ Jica Study Team	DPR Vol. I	Jica Study Team	DPR Vol. I	Jica Study Team	DPR Vol. I	Jica Study Team	DPR Vol. I	Jica Study Team	**DPR Vol. I**	**Jica Study Team**
BP		Ch.0 +000	Ch.0 +000	Ch.0 +000	Ch.0 +351	Ch.0 +351	Ch.20 +870	Ch21 +506	Ch.47 +120	Ch.47 +561	Ch.76 +670	Ch.77 +900	Ch.101 +520	Ch.101 +672	-	-
EP		Ch.20 +870	Ch21 +506	Ch.4 +350	Ch.4 +560	Ch.3 +950	Ch.47 +120	Ch.47 +561	Ch.76 +670	Ch.77 +900	Ch.101 +520	Ch.101 +672	Ch.129 +020	Ch.129 +171	-	-
Structures	IC	0	1	0	0	0	1	0	2	2	0	0	1	1	**4**	**4**
	ROB	1	1	1	1	0	0	0	1	1	0	0	1	0	**4**	**3**
	MJB	1	1	0	0	1	2	2	1	1	0	0	1	1	**5**	**5**
	MNB	1	2	0	1	1	6	5	8	1	0	0	11	11	**26**	**20**
	VUP	6	5	0	0	0	5	5	6	7	9	9	6	6	**32**	**32**
	LVUP	6	1	0	2	0	4	3	2	1	4	3	7	7	**23**	**17**
	BC	39	46	0	7	Unclear	0	13	1	20	0	0	7	29	**47**	**115**
	PC	8	11	0	2	Unclear	204	84	107	61	0	0	132	57	**451**	**215**
	Entry/ Exit Ramps	0	1	0	0	1	2	0	2	1	0	0	2	1	**6**	**3**
	TOTAL	**62**	**69**	**1**	**13**	**Unclear**	**224**	**112**	**130**	**95**	**13**	**12**	**168**	**113**	**598**	**414**

Note: 1) CPRR: Chennai Peripheral Ring Road, IC: Interchange, ROB: Railway Over Bridge, MJB: Major Bridge, MNB: Minor Bridge, VUP: Vehicular Underpass, LVUP: Light Vehicular Underpass, BC: Box Culvert, PC: Pipe Culvert

2) BC and PC are planned for irrigation and utility crossings.

3) MJB: Sec.1: Buckingham Canal, Sec.3: Kannigaipper Tank, Kosathalai River, Sec.4: Coovam River, Sec.5: Sengundram Tank

Source: JICA Study Team

6.4.3 Major Bridges (MJB)

(1) Summary

An MJB is planned at the places listed below.

The location of MJBs is shown in Figure 6.4.2, and the MJB specification table is shown in Table 6.4.4.

1) MJB101

Section 1 consists of an elevated bridge crossing Buckingham Canal and Korttalaiyar River from Ennore Port towards the west and another elevated bridge connecting towards Kattupalli. The bridge location is near Ch. 0+662, and the structure number is Str. No. 1/1.

2) MJB202

In Section 2, a viaduct passes over the provincial road (SH51) and the Kannigaipper Tank. The viaduct location is near Ch. 29+332, and the structure number is Str. No. 30/3.

3) MJB201

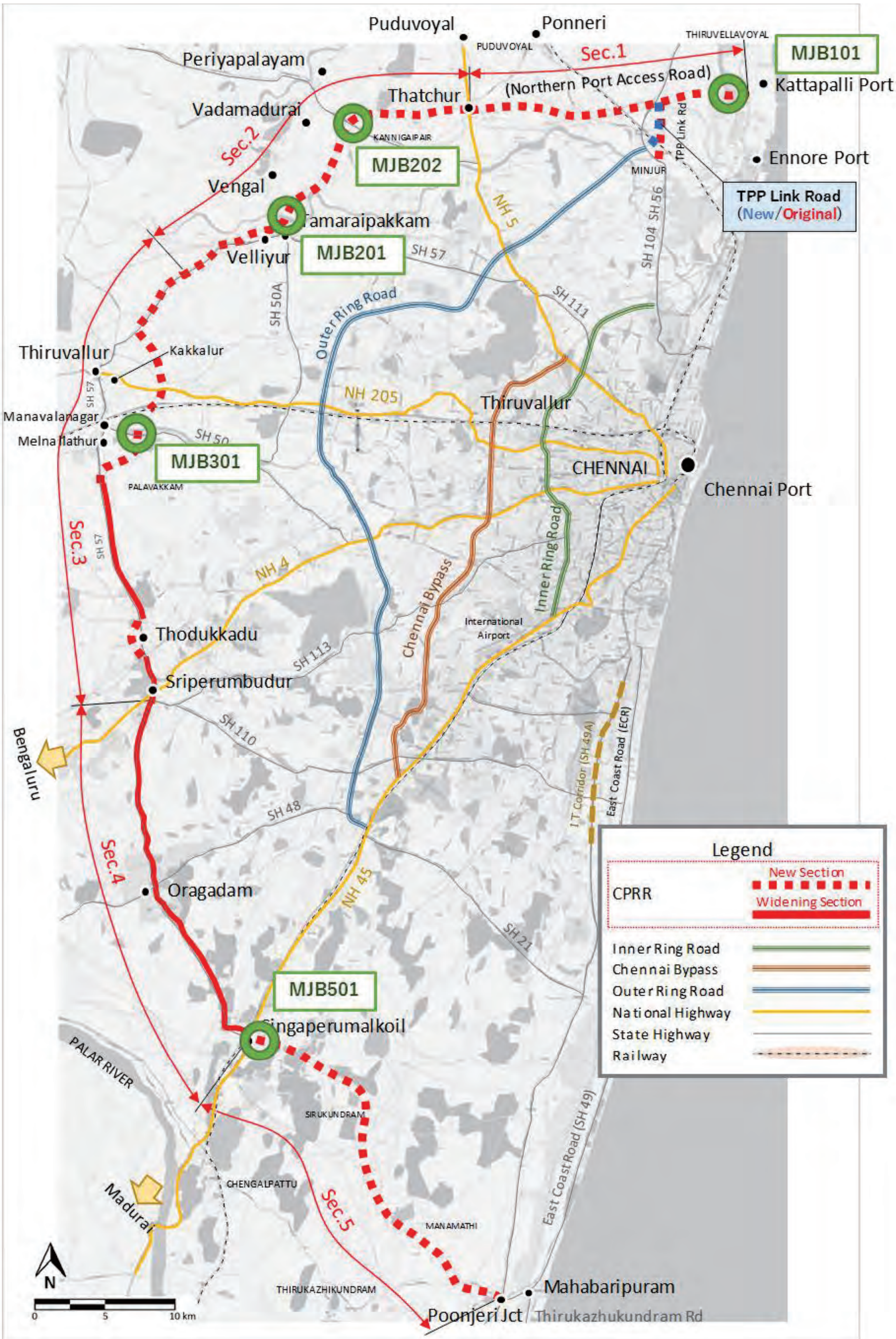
In Section 2, a viaduct crosses the Korattalaiyar River. The bridge location is near Ch. 36+886, and the structure number is Str. No. 37/4.

4) MJB301

In Section 3, a viaduct crosses Cooum River. The bridge location is near Ch. 57+532, and the structure number is Str. No. 58/3.

5) MJB501

In Section 5, a viaduct crosses over Sengunram Tank and pond. The bridge location is near Ch. 102+831, and the structure number is Str. No. 103/2.



Source: JICA Study Team based on OpenStreetMap

Figure 6.4.2 Location of Major Bridges

Table 6.4.4 MJB Specifications

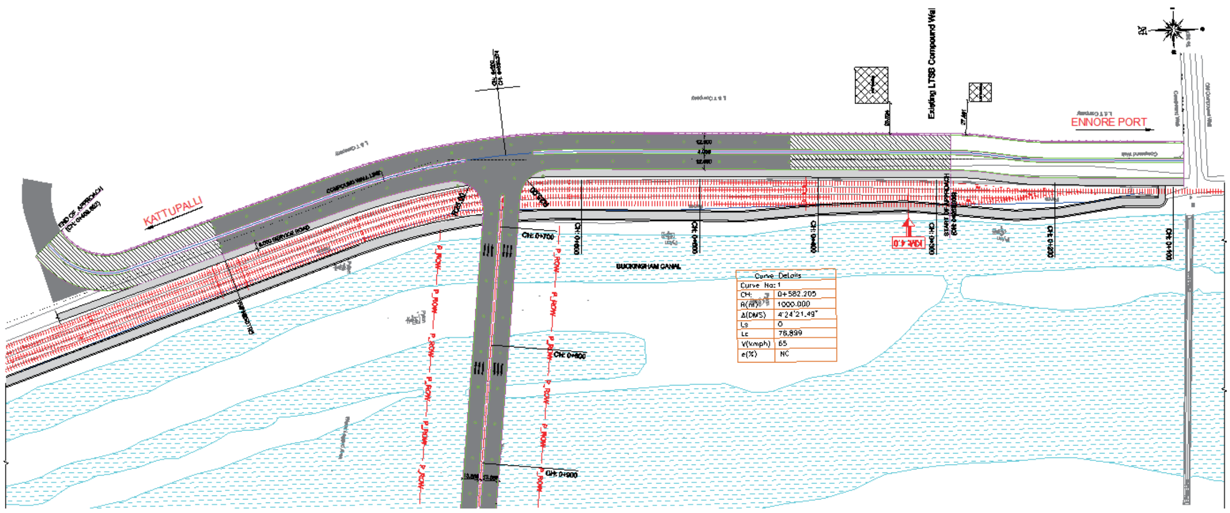
Sec.	No.	STRUCTURE CODE	CHAINAGE		STRUCTURE	INTERSECTIONS	TYPE OF STRUCTURE
			BP	EP			
Sec.1	1	MJB101-1 Str. No.1/1	0+425.450	1+046.166	MJB	Buckingham Canal, Korttalaiyar River, Kattupalli Road	2xPC BOX GIRDER L=620.716 m, 4span x 2 + 1span x 4 + 4span + 3span x 2
		MJB101-2 Str. No.1/1	0+224.543	0+660.450	MJB	-	2xPC BOX GIRDER L=230.00 m, 3span x 2 + 1span x 2
Sec.2	2	MJB202 Str. No.30/3	29+128	29+308	MJB	SH51, Kannigaipper Tank	2xPC BOX GIRDER L=180.00 m (2 x 3@30.00)
	3	MJB201 Str. No.37/4	36+781.103	36+991.103	MJB for main road	Korattalaiyar River	2xPC BOX GIRDER L=300.00 m(10@30.00)
		MJB201 Str. No.37/4	36+781.103	36+991.103	MJB for service road		2xPC BOX GIRDER L=210.00 m(7@30.00)
Sec.3	4	MJB301 Str. No.58/3-1	57+352	57+772	MJB for main road	Cooum River	2xBOX gIRDER L=420.00 m (14@30.00)
		MJB301 Str. No.58/3-2	57+352	57+652	MJB for service road		2xBOX GIRDER L=300.00 m (10@30.00) Both sides
Sec.4	-	-	-	-	-	-	-
Sec.5	5	MJB501 Str. No.103/2	102+670	103+150	MJB	Sengunram Tank, Pond	2xPC BOX GIRDER L=480.00m (4 x 4@30.00)

Source: JICA Study Team

It should be noted that the extension of the end chainage around IC-1 is not reflected in Table 6.4.4 since it is based on the DPR drawings.

HMPD states that MJB101 is planned to be connected by a railroad in the north and south, but it has no detailed plan as of now, and it is also not considered in the final DPR.

Details of the MJB101 railroad plan such as clearances, determination of bridge type based on construction limits, and span arrangement must be reflected in the detailed design. The railway company must be involved in the confirmation process as well.



Source: HMPD

Figure 6.4.3 Draft Railroad Plan at MJB101 Start Point

(2) Standard and Design Condition

In the DPR (Main Report: P7-1), it is stated that the planned structure conforms to the standards listed below. The design report has not been received, and the design conditions of each structure are unknown.

・Indian Roads Congress（IRC）
*IRC: 92-1985, IRC-18-2000, IRC: SP: 90-2012, IRC.gov.in.078.2014, etc.
・MoRTH

(3) Confirmation of Intersections

Structures and rivers intersecting MJBs are listed in Table 6.4.5. The following table shows the result of the confirmation whether the clearance below the girders can be ensured for the intersection. According to the results, the clearance under the girders can be ensured. Moreover, it is presumed that there will be no major problems because there is a fixed basis in the determination of the vertical alignment (profile).

Furthermore, the extension of MJB101 end point and the railroad plan must be considered in the detailed design.

Table 6.4.5 Confirmation of the Clearance Below Girders and the Vertical Alignment (MJB)

Sec.	No.	STRUCTURE CODE	INTERSECTIONS	CLEARANCE	Fixed Basis for Profile
Sec.1	1	MJB101（Str. No.1/1）	Buckingham Canal Korttalaiyar River	Sufficient clearance for HFL is ensured.	
			Kattupalli Road	Clearance limit of 5.5 m is ensured for road crossing.	✓
Sec.2	2	MJB202（Str. No.30/3）	SH51	Clearance limit of 5.5 m is ensured for SH51.	✓
			Kannigaipper Tank	Sufficient clearance for HFL is ensured. (*There is no description of HFL.)	
	3	MJB201（Str. No.37/4）	Korattalaiyar River	Sufficient clearance for HFL is ensured.	
			—	Clearance limit of VUP located on the end point side.	✓
Sec.3	4	MJB301（Str. No.58/3）	Cooum River	Sufficient clearance for HFL is ensured.	
			Service Road	Clearance limit of 5.5 m is ensured for road crossing.	✓
Sec.5	5	MJB501（Str. No.103/2）	Sengunram Tank Pond	Sufficient clearance for HFL is ensured. (*clearance is about 1 m：Read from drawing)	✓

Source: JICA Study Team

(4) Confirmation of Bridge Type and Structure

1) Bridge Length and Span Length

It is considered that the necessary bridge length is ensured for the intersections (rivers, canals, national highways, etc.). In addition, since the span length of the bridge is equal to the standard span length of concrete bridges that is constructible, i.e., from 30~40 m, it is presumed that there will be no major problem with the bridge plan (span and bridge lengths).

Since the transverse details of rivers, canals, ponds, and the like are not described in the report, it is presumed that the topography described in the drawing is correct.

2) Type of Superstructure

Bridge span length is set to be 30 m to 40 m to basically avoid interference with intersections. In addition, in the CPRR, the plan of superstructure is based on a concrete bridge which is more economical than a steel bridge and the span length is based on applicability to a concrete bridge. In addition, since several MJBs have planar curves, a PC box girder bridge is adopted as the substructure.

➢ The investigation team concluded that there is no particular problem with the adoption of a concrete bridge as the superstructure since no special bridge is being adopted.

Table 6.4.6 Confirmation of Span Length and Type of Superstructure of MJB

Type					Span (m) (10 / 20 / 30 / 40 / 50) — Span30m～40m	Adaptation to curve	Height of girder/span
PC	precast girder erection	Pre tension	simple	hollow slab	10–25	×	1/20～1/24
				Tgirder	15–25	×	1/13～1/17
			continuous	Tgirder	15–25	×	1/13～1/17
		post tension	simple	Tgirder	15–50	×	1/13～1/17
				composite I	20–40	×	1/12～1/16
			continuous	Tgirder	20–35	×	1/13～1/17
	support erection		simple	hollow slab	20–30	○	1/20～1/24
				Box	25–50	○	1/15～1/20
			continuous	Box	30–50	○	1/15～1/20
	PRC hollow slab				15–30	○	1/18～1/22
	PC compo				20–45	×	1/16～1/15
RC				hollow slab	10–15	○	1/15～1/18

Source: JICA Study Team

3) Type of Substructure

The substructure type is based on a single column pier. Since there is no special condition, single column pier, which is considered to be appropriate, is generally adopted.

Lots of hybrid structures (a combination of pier type and reinforced earth wall) are adopted as abutments for MJBs and other bridges in India. Since reinforced earth walls are set at both ends of the bridge, the adoption of this structure at the ground portion is considered to be effective in terms of concrete size and weight reduction as well as constructability. In a river bridge, it is preferable to adopt the abutment type in the end piers due to concerns of erosion from running water and water barrier of reinforced earth walls. The hydrological survey results should be considered in the detailed design. (Refer to (5) Advice and Suggestions for DPR.)

Source: JICA Study Team

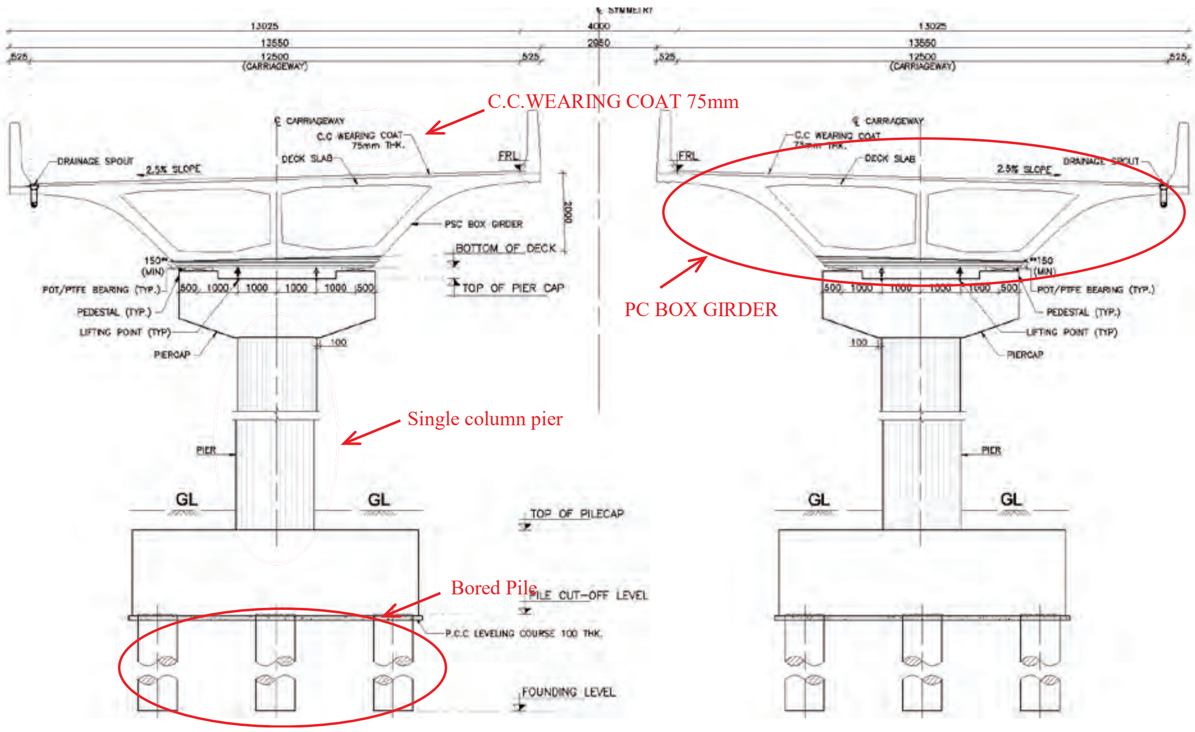
Figure 6.4.4 Sample of Adopted Hybrid Structures as Abutments in India

4) Type of Foundation

The plan for the pile foundation of MJB is a bored pile with φ 1000 mm. The design report received after the completion of the review specifies ground condition, type of pile foundation, extensions, and other design details.

5) Type of Pavement

In the final DPR, the planned bridge pavement material is concrete. However, asphalt pavement is used in the vicinity of the earthworks section as well as the ORR, while concrete asphalt is used in the already constructed bridge at the end of Section 4. Although material procurement could be the main consideration, other factors such as consistency must also be considered in the determination of pavement material during the detailed design.



Source: JICA Study Team based on DPR (Drawing)

Figure 6.4.5 Bridge Cross Section (MJB101)

Source: JICA Study Team

Figure 6.4.6 Ends of Bridge Constructed at Section 4 (Concrete Wearing Coat)

6) Reinforced Earth Wall

In CPRR, the height of the reinforced earth wall at both ends of the bridge tends to be larger than average. The objective is to shorten the bridge by increasing the height of the reinforced earth wall. In general, it is said that the actual height and the empirical standard height are about 12 m at maximum; thus, it was verified whether the reinforced soil wall height planned in the CPRR exceeds the said value or not.

- Since there is no reinforced earth wall exceeding the reference height (12 m), it was concluded that the setting of the reinforced earth wall section is acceptable.

Note: The extension of MJB101 end point is not considered here.

Table 6.4.7 Confirmation Result of Reinforced Earth Wall Height (MJB)

Sec.	Name of structure	Chainage		Maximum height of re-Wall (m)		
Sec.1	MJB101	0+313.450	0+425.450	5.60	<	12.00
		1+046.166	1+200	6.30	<	12.00
		0+399.19	0+224.534	7.00	<	12.00
Sec.2	MJB202	28+820	29+128	10.40	<	12.00
		29+308	29+468	5.50	<	12.00
	MJB201	36+640	36+781.103	2.50	<	12.00
		37+083.103	37+213.300	8.20	<	12.00
Sec.3	MJB301	57+292	57+352	4.30	<	12.00
		57+772	58+172	8.70	<	12.00
Sec.5	MJB101	-	-	10.00	<	12.00
		-	-	10.00	<	12.00

※For the height of the reinforced soil wall, PDR (Dwrawing) was referred to.For those without dimensions, we measured the drawing.
※As the reinforcing earth wall of Sec.5 has no stationary point of the starting point, the station is not stated in the above table.

Source: JICA Study Team

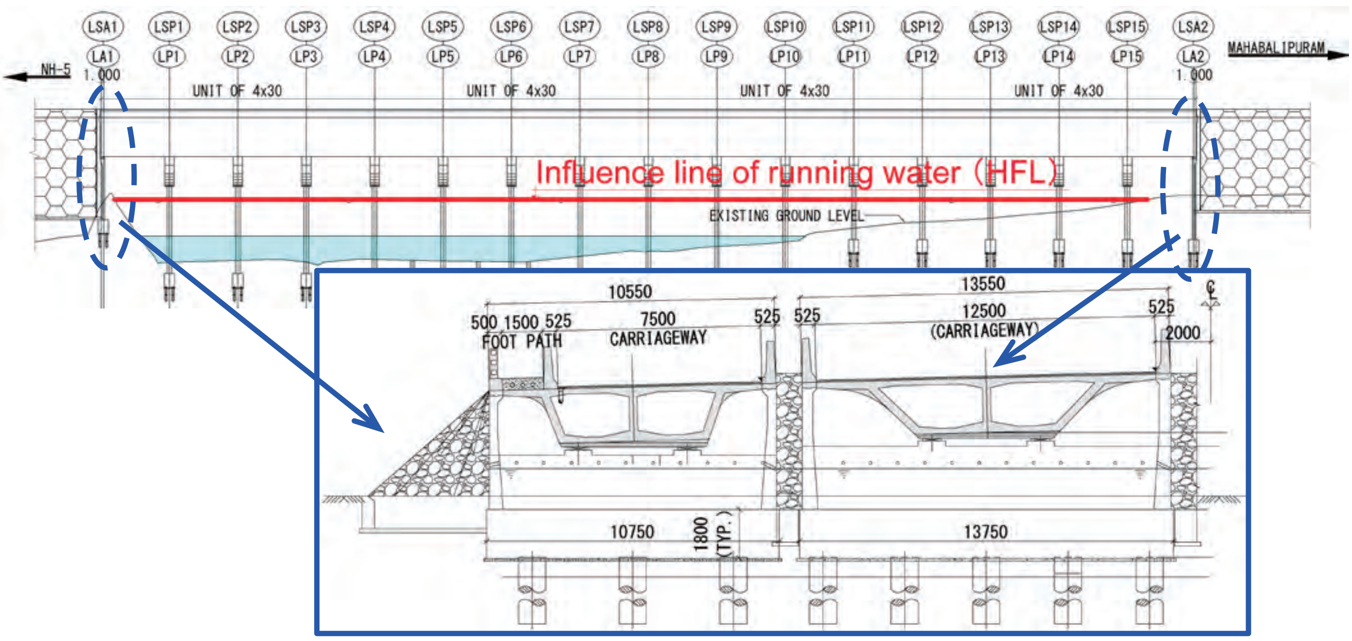
(5) Advice and Suggestions for DPR

1) Structure of River Bridge Abutment

The structure of the abutments affected by the river current is found to be a hybrid of a reinforced earth wall and a pier structure.

Although HMPD stated that the structures are not affected by water current, it can be concluded that it would be better to adopt the abutment structure and hydraulic force countermeasures because the common reinforced earth wall is weak against hydraulic force. In the detailed design, it is necessary to review and study the abutment structures upon conducting hydrologic surveys and upon checking the water level.

* MJB extension is not considered here; hence, it must be investigated during the detailed design.



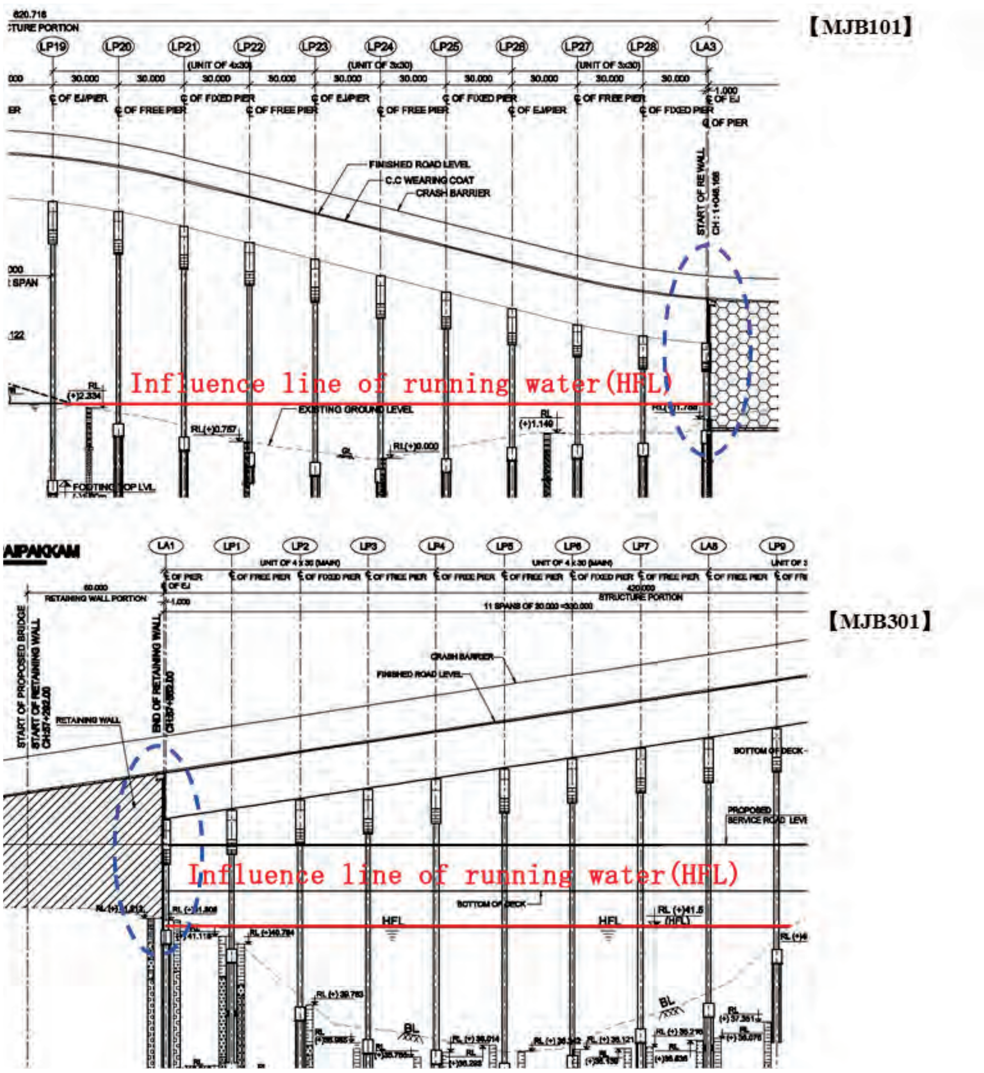
Source: JICA Study Team based on DPR (Drawing)

Figure 6.4.7 MJB501 : Type of Substructure Located at Bridge Ends (Abutment)

Table 6.4.8 Revision Suggestions on the Substructure Located at Bridge Ends (MJB)

Sec.	No.	STRUCTURE CODE	Location	Revision Suggestion			
				Plan of DPR	Affected by running water		Suggestion
Sec.1	1	MJB101-1 Str.No.1/1	A1(Start point)	Pier + RE Wall	No (land)	→	No change
			A3 End point	Pier + RE Wall	Yes	→	Change from pier to Abutment
		MJB101-2 Str.No.1/1	A2(End point)	Pier + RE Wall	No (land)	→	No change
Sec.2	2	MJB202 Str.No.30/3	A1(Start point)	Pier + RE Wall	No (land)	→	No change
			A2(End point)	Pier + RE Wall	Yes	→	Change from pier to Abutment
	3	MJB201 Str.No.37/4	A1(Start point)	Abutment	Yes	→	No change
			A2(End point)	Abutment	Yes	→	No change
Sec.3	4	MJB301 Str.No.58/3-1 (Main Road)	A1(Start point)	Pier + RE Wall	Yes	→	Change from pier to Abutment
			A2(End point)	Pier + RE Wall	No (land)	→	No change
		MJB301 Str.No.58/3-2 (Survice Road)	SA1(Start point)	Abutment	Yes	→	No change
			SA2(End point)	Abutment	Yes	→	No change
Sec.5	5	MJB501 Str.No.103/2	A1(Start point)	Abutment	Yes	→	No change
			A2(End point)	Abutment	Yes	→	No change

Source: JICA Study Team

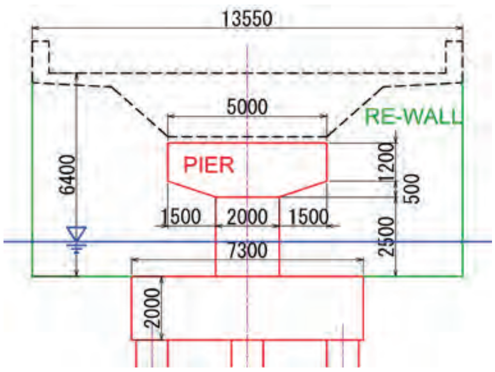
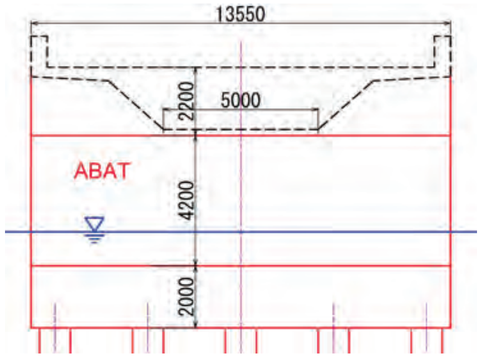


Source: JICA Study Team based on DPR (Drawing)

Figure 6.4.8 Revision of Bridge End Structure of MJB

The effect on the construction cost due to the revision from pier to abutment is as follows. By using the pier as a bridge, the reinforced earth wall surface at the back of the substructure becomes unnecessary, but the concrete volume of the substructure and the size of the foundation tend to increase. At the time of detailed design, the implementation of this plan/design is proposed.

Table 6.4.9 Estimation of Cost Fluctuation Due to Substructure Revision (MJB101-LA3)

MJB101(LA3)	DPR				Revision Suggestion			
Outline								
	Quantity	Unit (JPY)	Cost (JPY)	Total (JPY)	Quantity	Unit (JPY)	Cost (JPY)	Total (JPY)
Concrete	110 m3	27,000	2,970,000	51,170,000	240 m3	27,000	6,480,000	75,730,000
Steel	20 tf	175,000	3,500,000		30 tf	175,000	5,250,000	
Pile Foundation	240 m	160,000	38,400,000		400 m	160,000	64,000,000	
RE Wall	90 m2	70,000	6,300,000		0 m2	70,000	0	
Total	construction cost (Rs)			26,932,000 (1.00)	construction cost (Rs)			39,858,000 (1.48)

※For dimensions not stated in DPR(Drawing), dimensions are set by reading / estimation etc. from the drawing.
Source: JICA Study Team

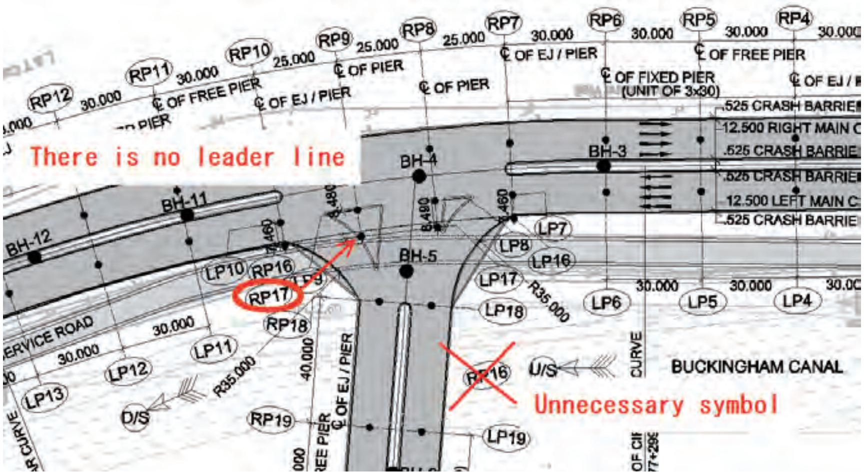
2) Inconsistencies to Correct in the DPR

Because there are inconsistencies to be corrected in the data of the DPR, the JICA Study Team organized and presented the items described in the structure list. The contents are described below. For other points to be noted, refer to the COMMENTS column in the table of Appendix-7 of this report.

【Section 1】

Drawing (14518/E/MJB101/DD001 (SH - 1 OF 3) has the following mistakes for correction:

- ➢ Duplication of RP 16, unnecessary description.
- ➢ The position of RP 17 is unknown (missing leader line).

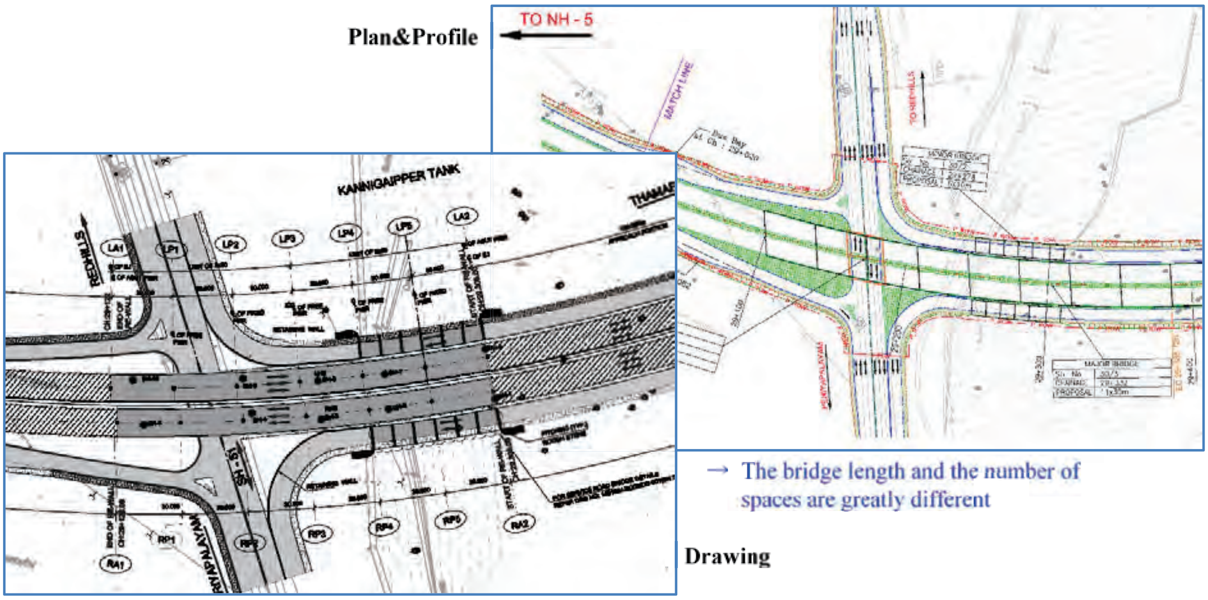


Source: DPR Drawing（14518/E/MJB101/DD001: SH-1 OF 3）

Figure 6.4.9 Typographical Error in Drawing

【Section 3】

There is a lot of difference in the Plan &Profile and the Drawing of the structure of MJB202 (Str. 30/3). Based on the topography, the content of the Drawing is correct. It is considered that there is a mistake in the updated Plan & Profile. Therefore, a correction is being suggested.



Source: DPR Plan&Profile(14518/E/PP/DD209), Drawing（14518/E/MJB202/DD001: SH-1 OF 3）

Figure 6.4.10　Mistake in Plan & Profile

3) Others

As shown in Figure 6.4.4, there is no width allowance for the superstructure's bearing in the substructure's coping. It is preferable to provide an allowance in case unexpected large forces, such as earthquakes, occur. The width of the substructure, bearing width allowance, and other details must be reconsidered in the detailed design.

6.4.4 Minor Bridges (MNBs)

(1) Summary

Bridges intersecting rivers are considered as MNBs. In the DPR, bridges having 2 to 5 spans are classified as MNBs. Three-span continuous box culverts crossing small canals are also classified as MNBs.

Table 6.4.10 MNB Specification

Sec.	No.	STRUCTURE CODE	CHAINAGE		STRUCTURE	INTERSECTIONS	TYPE OF STRUCTURE
			BP	EP			
Sec.1	1 ※	MNB101 Sta.No.3/2	2+465	2+485	MNB	Canal	RCC SOLID SLAB L=20.00m (2@10.00)
Sec.1	2	MNB103 Str.No.8/1	7+163	7+193	MNB	korttalaiyar River	RCC SOLID SLAB L=30.00m (3@10.00)
Sec.1 TPP Link	3	MNB102 Str.No.3/1	2+013	-	BOX CULVERT	-	3 @ 5.00 x 2.50m, L=47.22m
Sec.2	4	MNB201 Sta.No.27/3	26+522	-	BOX CULVERT	Canal	3@5.00x2.50m, L=54.00m
Sec.2	5	MNB Str.No.30/2 (Within MJB202)	29+248	29+308	MNB	Kannigaipper Tank	RCC SOLID SLAB L=60.00m (6@10.00)
Sec.2	6	MNB202 Str.31/4	30+735	30+765	MNB	River	RCC SOLID SLAB L=30.00m (3@10.00)
Sec.2	7	MNB Str.38/2 (Within MJB201)	37+345	37+435	MNB for main road	River	2xPC BOX GIRDER L=90.00m(3@30.00)
Sec.2	7	MNB-203 Str.38/2	37+375	37+405	MNB for service road	River	RCC SOLID SLAB L=30.00m (3@10.00)
Sec.2	8	MNB-204 Str.No.45/1	44+135	-	BOX CULVERT	River	3x5.00x2.50m, L=61.16m
Sec.3	9	MNB-301 Str.No.64/2	63+340	-	BOX CULVERT	POND	3x5.00x2.50m.L=59.60m
Sec.4	-	-	-	-	-	-	-
Sec.5	10	MNB501 Str.107/1	106+101	106+151	MNB	Pond	RCC SOLID SLAB L=50.00m (5@10.00)
Sec.5	11	MNB502 Str.111/1	110+261	110+311	MNB	Sirukundram Tank	RCC SOLID SLAB L=50.00m (5@10.00)
Sec.5	12	MNB503 Str.111/2	110+618	110+668	MNB	Sirukundram Tank	RCC SOLID SLAB L=50.00m (5@10.00)
Sec.5	13	MNB504 Str.116/2	115+266	115+296	MNB	Nalloh	RCC SOLID SLAB L=30.00m (3@10.00)
Sec.5	14	MNB505 Str.116/3	115+468	115+498	MNB	Nalloh	RCC SOLID SLAB L=30.00m (3@10.00)
Sec.5	15	MNB506 Str.119/1	118+028	118+058	MNB	Nalloh	RCC SOLID SLAB L=30.000m (3@10.00)
Sec.5	16	MNB507 Str.119/3	118+510	118+530	MNB	Nalloh	RCC SOLID SLAB L=20.000m (2@10.00)
Sec.5	17	MNB508 Str.120/5	119+931	119+981	MNB	Manamathi Tank	RCC SOLID SLAB L=50.00m (5@10.00)
Sec.5	18	MNB509 Str.122/2	121+403	121+423	MNB	Nalloh	RCC SOLID SLAB L=20.000m (2@10.00)
Sec.5	19	MNB510 Str.122/4	121+953	122+003	MNB	Nalloh	RCC SOLID SLAB L=50.00m (5@10.00)
Sec.5	20	MNB511 Str.124/3	123+523	123+543	MNB	Nalloh	RCC SOLID SLAB L=20.000m (2@10.00)

*MNB101 will be deleted due to the extension of MJB101. To be confirmed in the detailed design.
Source: JICA Study Team

(2) Standard and Design Condition

In the DPR Main Report: P7-1, it is stated that the planned structure conforms to the following standards:

・Indian Roads Congress (IRC)
*IRC: 92-1985, IRC-18-2000, IRC: SP: 90-2012, IRC.gov.in.078.2014, etc.
・MORTH

(3) Confirmation of Intersections

The intersections in MNBs are shown in Table 6.4.10 (MNB specifications table). The result of confirmation whether clearance below the girders can be ensured for the intersection is shown in Table 6.4.11. Based on the result, it is concluded that the clearance below the girders can be ensured; moreover, it is presumed that there will be no major problem because there is a fixed basis in the determination of the vertical alignment (profile).

Table 6.4.11 Confirmation of the Clearance Below Girders and Vertical Alignment (MNB)

<table>
<tr><th>Sec.</th><th>No.</th><th>STRUCTURE CODE</th><th>INTERSECTIONS</th><th>CLEARANCE</th><th>Fixed Basis for Profile</th></tr>
<tr><td rowspan="2">Sec.1</td><td>1*</td><td>MNB101 Sta.No.3/2</td><td>Canal</td><td>Sufficient clearance for HFL is ensured. (approx. 1.5 m)</td><td>✓</td></tr>
<tr><td>2</td><td>MNB103 Str. No.8/1</td><td>Korttalaiyar River</td><td>Sufficient clearance for HFL is ensured. (approx. 2.0 m)</td><td>✓</td></tr>
<tr><td rowspan="6">Sec.2</td><td rowspan="2">5</td><td rowspan="2">MNB Str. No.30/2 (Within MJB202)</td><td rowspan="2">Kannigaipper Tank</td><td>Sufficient clearance for HFL is ensured. (approx. 2.5 m)</td><td></td></tr>
<tr><td>Vertical alignment is determined by the topography before and after the bridge.</td><td>✓</td></tr>
<tr><td>6</td><td>MNB202 Str.31/4</td><td>River</td><td>Sufficient clearance for HFL is ensured. (approx. 1.0 m)</td><td>✓</td></tr>
<tr><td rowspan="3">7</td><td rowspan="2">MNB Str.38/2 (Within MJB201) Main Road</td><td rowspan="2">River</td><td>Sufficient clearance for HFL is ensured. (more than 3 m)</td><td></td></tr>
<tr><td>Vertical alignment is determined by MJB · VUP before and after.</td><td>✓</td></tr>
<tr><td>MNB-203 Str.38/2 Service Road</td><td>River</td><td>Sufficient clearance for HFL is ensured. (approx. 1.0 m)</td><td>✓</td></tr>
<tr><td rowspan="12">Sec.5</td><td rowspan="2">10</td><td rowspan="2">MNB501 Str.107/1</td><td rowspan="2">Pond</td><td>Sufficient clearance for HFL is ensured. (approx. 2.6 m)</td><td></td></tr>
<tr><td>Vertical alignment is determined by the topography before and after the bridge.</td><td>✓</td></tr>
<tr><td>11</td><td>MNB502 Str.111/1</td><td>Sirukundram Tank</td><td>Sufficient clearance for HFL is ensured. (approx. 1.2 m)</td><td>✓</td></tr>
<tr><td>12</td><td>MNB503 Str.111/2</td><td>Sirukundram Tank</td><td>Sufficient clearance for HFL is ensured. (approx. 1.5 m)</td><td>✓</td></tr>
<tr><td>13</td><td>MNB504 Str.116/2</td><td>Nalloh</td><td>Sufficient clearance for HFL is ensured. (approx. 1.0 m)</td><td>✓</td></tr>
<tr><td>14</td><td>MNB505 Str.116/3</td><td>Nalloh</td><td>Sufficient clearance for HFL is ensured. (approx. 1.2 m)</td><td>✓</td></tr>
<tr><td>15</td><td>MNB506 Str.119/1</td><td>Nalloh</td><td>Sufficient clearance for HFL is ensured. (approx. 1.4 m)</td><td>✓</td></tr>
<tr><td>16</td><td>MNB507 Str.119/3</td><td>Nalloh</td><td>Sufficient clearance for HFL is ensured. (approx. 1.0 m)</td><td>✓</td></tr>
<tr><td>17</td><td>MNB508 Str.120/5</td><td>Manamathi Tank</td><td>Sufficient clearance for HFL is ensured. (approx. 1.4 m)</td><td>✓</td></tr>
<tr><td>18</td><td>MNB509 Str.122/2</td><td>Nalloh</td><td>Sufficient clearance for HFL is ensured. (approx. 2.0 m)</td><td>✓</td></tr>
<tr><td>19</td><td>MNB510 Str.122/4</td><td>Nalloh</td><td>Sufficient clearance for HFL is ensured. (approx. 1.0 m)</td><td>✓</td></tr>
<tr><td>20</td><td>MNB511 Str.124/3</td><td>Nalloh</td><td>Sufficient clearance for HFL is ensured. (approx. 1.2 m)</td><td>✓</td></tr>
</table>

Source: JICA Study Team

(4) Confirmation of Bridge Type and Structure

1) Bridge Length and Span Length

For bridges on rivers, canals, etc., the necessary bridge length is considered to be ensured. In addition, the span of the bridge is to be set to a standard length applicable to concrete bridges which are 30 m due to constraints in intersecting rivers and 10 m in other locations.

- ➢ Details of the width of rivers, canals, ponds, etc. are not described in the report; hence, as long as the terrain in the drawing is correct, it can be assumed that there is no major problem in setting the bridge length. However, since the span was set to be very short, detailed study is required at the time of detailed design since there are several substructures in the river (described later).

2) Type of Superstructure

In order to prevent interference with the intersections, the span of the bridge is set to 30 m on intersections (rivers) and 10 m on other locations. The said lengths are standards for which concrete bridge construction is possible. The superstructure construction method in the CPRR is planned based on concrete bridges which are more economical than steel bridges, and the span length is based on small spans applicable to concrete bridges.

Bridges with a span of 30 m shall adopt PC box girder similar to MJBs. Other bridges that have a span of 10 m shall adopt the economical RC slab bridge.

The economical RC deck can be applied by shortening the span, but the number of bridges on the river increases and the following difficulties will occur:

- ➢ In pier construction, drilling in a river is more difficult than onshore.
- ➢ Concerning river management, it is advantageous to keep the number of bridges on the river as few as possible in order to ensure river flow.
- ➢ It is possible to lengthen the span by adopting RC hollow floor slabs and continuous girders. Even if the superstructure expenses rise, there are cases in which it can still be more economical by reducing the number of piers.

The DPR considers improving the accuracy of the bridge plan, including structural investigation at the time of detailed design, by setting the short span and economical RC slab bridge as standard. However, reducing the number of piers in rivers is important in river management, and it is considered to lead to the improvement of economic efficiency and construction feasibility. Therefore, planning of span proportion and span length should be considered in the future.

Table 6.4.12 Confirmation of Span Length and Type of Superstructure (MNB)

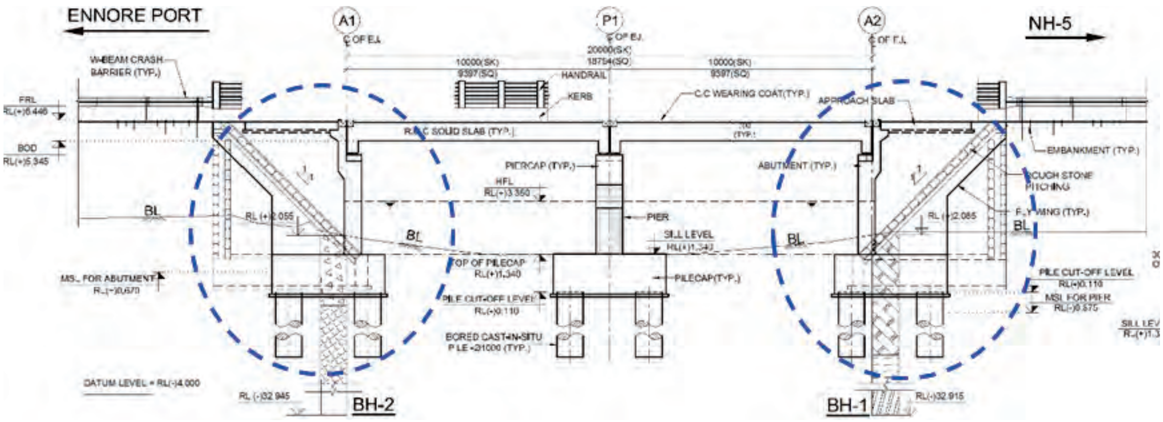
Type				Span (m)	Span10m	10		20		30		40		50	Adaptation to curve	Height of girder/span
PC	precast erection	Pre tension	simple	hollow slab		■	■	■							×	1/20～1/24
				Tgirder			■	■							×	1/13～1/17
			continuous	Tgirder			■	■							×	1/13～1/17
		post tension	simple	Tgirder			■	■	■	■	■	■	■		×	1/13～1/17
				composite I				■	■	■	■				×	1/12～1/16
			continuous	Tgirder				■	■	■					×	1/13～1/17
	support erection		simple	hollow slab				■	■						○	1/20～1/24
				Box					■	■	■	■	■		○	1/15～1/20
			continuous	Box						■	■	■	■		○	1/15～1/20
	PRC hollow slab						■	■	■						○	1/18～1/22
	PC compo							■	■	■	■	■			×	1/16～/15
RC			hollow slab		■	■									○	1/15～1/18

Source: JICA Study Team

3) Type of Substructure

Substructure type is based on single column pier. Since there is no special condition, single column pier, which is considered to be appropriate, is generally adopted.

Substructure at bridge ends is planned to be the abutment type. Since there is protection against running water, the JICA Study Team decided that the adoption of the abutment type (same with MJB) is effective for maintenance.



Source: JICA Study Team based on DPR（Drawing: MNB101）

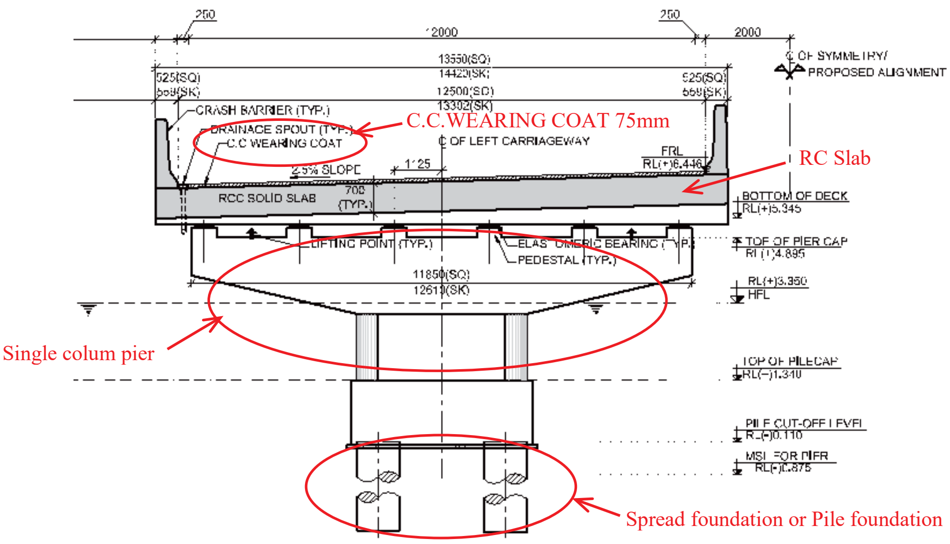
Figure 6.4.11 Substructure Located at Bridge Ends of MNB（Abutment Type）

4) Type of Foundation

The plan for the pile foundation of MNB is a bored pile with φ 1000 mm. The design report received after the completion of the review specifies ground condition, type of pile foundation, extensions, and other design details.

5) Type of Pavement

In the final DPR, the planned bridge pavement material is concrete. However, asphalt pavement is used in the vicinity of the earthworks section as well as ORR, while concrete asphalt is used in the already constructed bridge at the end of Section 4. Although material procurement could be the main consideration, other factors such as consistency must also be considered in the determination of pavement material during the detailed design.



Source: JICA Study Team based on DPR（Drawing: MNB101）

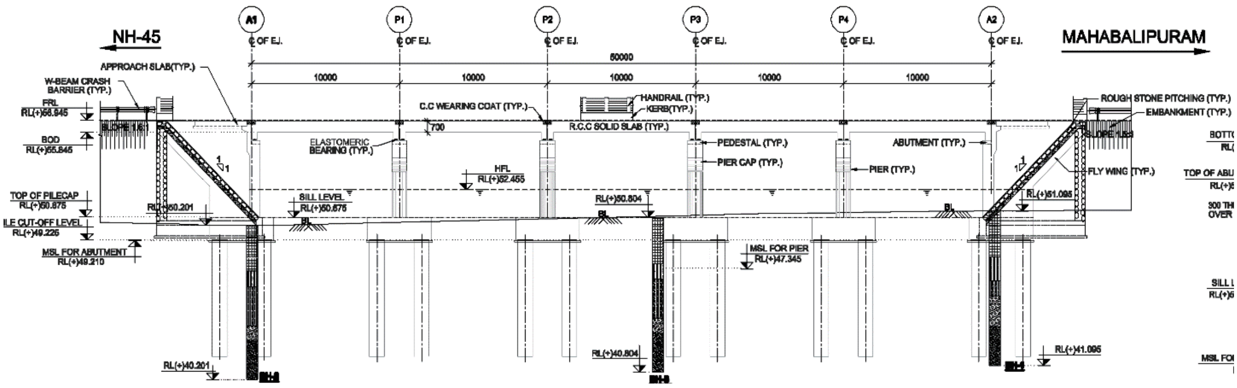
Figure 6.4.12 Bridge Cross Section（MNB101）

(5) Advice and Suggestions for DPR

1) Revision of Span Length of River Bridges

As mentioned above, the span of several MNBs is set at the minimum 10 m. The DPR considers improving the accuracy of the bridge plan including structural investigation at the time of detailed design by setting the short span and economical RC slab bridge as standard. The following should be examined and confirmed at the time of detailed design:

- Investigation to increase economic efficiency by increasing the span and reducing the number of piers.
- Study to improve the river flow and constructability by reducing pier on the river.
- Confirmation of bridge plan details through consultation with environmental authorities.



*Bridge length L=50 m, Span 5@10 m

Source: DPR（Drawing: MNB501）

Figure 6.4.13　Several Piers on the River（MNB501）

2) Inconsistencies to Correct in the DPR

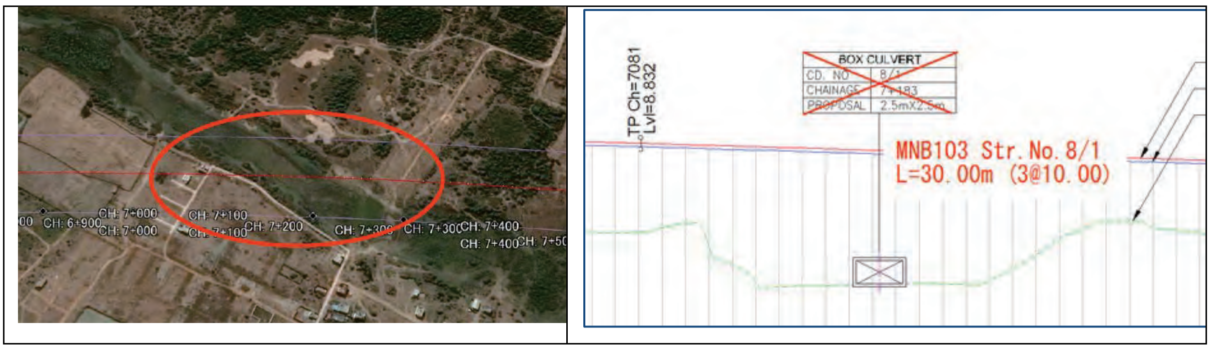
Because there are inconsistencies to be corrected in the data of the DPR, the JICA Study Team organized and presented the items described in the structure list. The contents are described below. For other points to be noted, refer to the COMMENTS column in the table of Appendix-7 of this report.

【Section 1】

There is a difference between the Plan & Profile and the Drawing (14518/E/MNB103/DD001) in the structure of Str. No. 8/1.

・Plan & Profile: Box Culvert
・Drawing (14518/E/MNB103/DD001: Minor Bridge)

- For MJB103 crossing the Korttalaiyar River, a bridge structure is required. Therefore, it is concluded that Plan & Profile is wrong, and MNB is correct and a correction is proposed.



Source: Google Earth　　Source: JICA Study Team based on Plan&Profile(14518/E/PP/DD-102)

Figure 6.4.14　Bridge Location（MNB103）

As shown in Figure 6.4.4, there is no width allowance for the superstructure's bearing in the substructure's coping. It is preferable to provide an allowance in case unexpected large forces, such as earthquakes, occur. The width of the substructure, bearing width allowance, and other details must be reconsidered in the detailed design.

6.4.5 Railway Over Bridge (ROB)

(1) Summary

ROB is a bridge at the intersection of a rail and road. The abutments of the bridge are located outside the area of the railway, and the piers with minimum quantity are located outside the railway track within the railway area.

ROBs are located in the areas listed below.
The location map is shown in Figure 6.4.15, and the ROB specification table is shown in Table 6.4.13.

1) ROB101

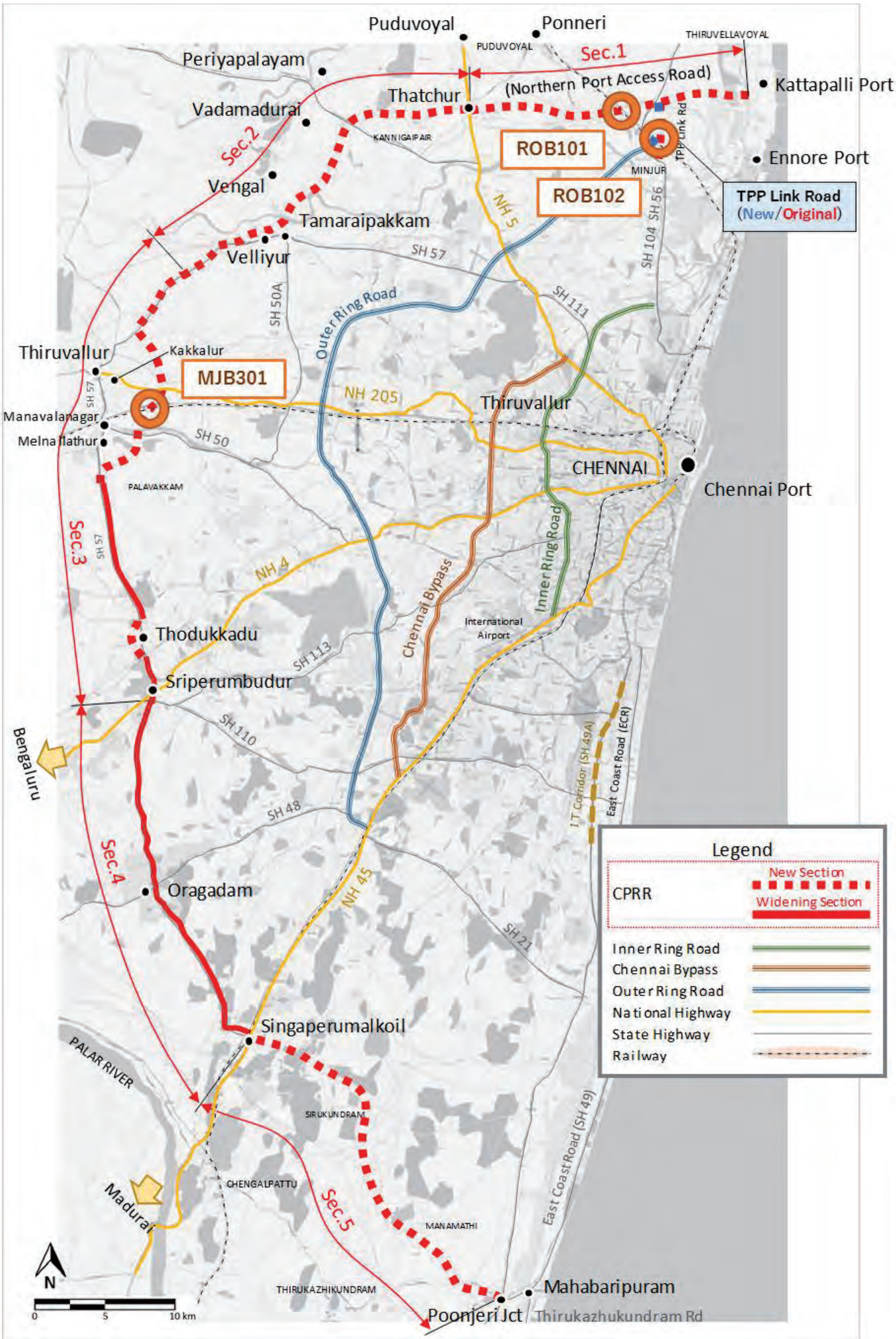
In Section 1 (CPRR), there is an overpass bridge crossing the railroad near Ch. 9+750. The structure number is Str. No. 10/3.

2) ROB102

In Section 1 (TPP Link Road), there is an overpass bridge crossing the railroad near Ch. 3+378. The structure number is Str. No.4/2.

3) ROB301

In Section 3 (CPRR), there is an overpass bridge crossing the railroad near Ch. 55+438. The structure number is Str. No.56/3.



Source: JICA Study Team based on Open Street Map

Figure 6.4.15 Location of Railway Over Bridges

Table 6.4.13 ROB Specifications

Sec.	No.	STRUCTURE CODE	CHAINAGE		STRUCTURE	INTERSECTIONS	TYPE OF STRUCTURE
			BP	EP			
Sec.1	1	ROB101 Str.No.10/3	9+681	9+819	ROB	Railway Track	PC I-GIRDER+CONPOSIT STEEL GIRDER L=138.00m 21.0+2@48.0+21.0)
Sec.1 TPP Link	2	ROB102 Str.No.4/2	3+307	3+449	ROB	Railway Track	PC I-GIRDER+CONPOSIT STEEL GIRDER L=142.00m (21.0+30.0+40.0+30.0+21.0)
Sec.2	-	-	-	-	-	-	-
Sec.3	3	ROB301 Str.No.56/3	55+142.835	55+509.085	ROB	Railway Track	COMPOSITE STEEL GIRDER L=366.50m(8@30.00+22.00+52.50+22.00+30.00)
Sec.4	-	-	-	-	-	-	-
Sec.5	-	-	-	-	-	-	-

Source: JICA Study Team

(2) Standard and Design Condition

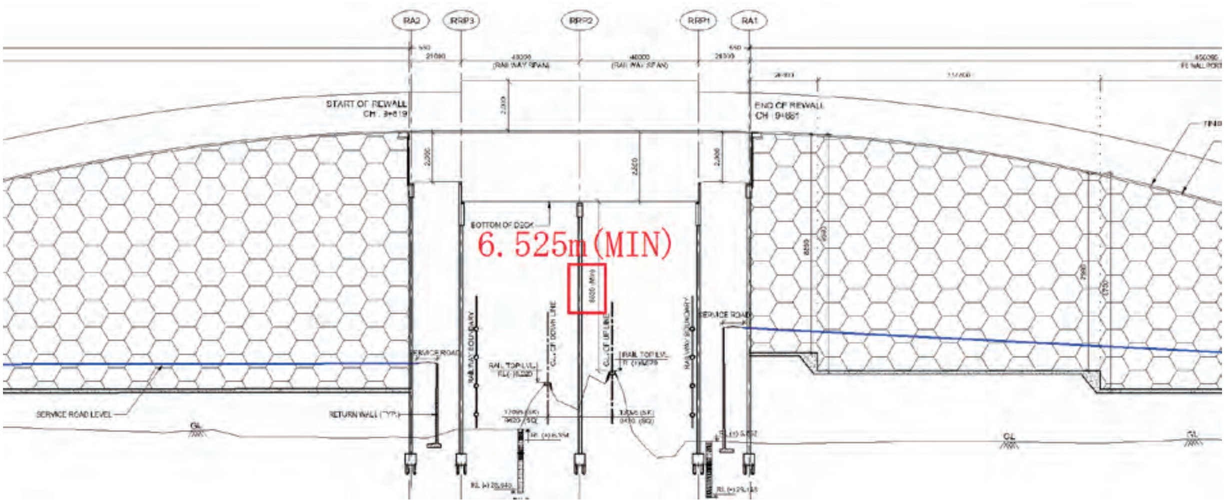
From the DPR Main Report: P7-1, it is stated that the planned structure conforms to the following standards:

・Indian Roads Congress (IRC)
*IRC: 92-1985, IRC-18-2000, IRC: SP: 90-2012, IRC.gov.in.078.2014, etc.
・MoRTH

(3) Confirmation of Intersections

The intersections of ROBs are as shown in Table 6.4.13. Based on the result of confirmation, it is concluded that the clearance below the girders can be ensured for the intersection; moreover, it is presumed that there will be no major problems because there is a fixed basis in the determination of the vertical alignment (profile).

In ROB, a clearance is set to ensure the building limit of H=6.525 m from the railway orbit (three common bridges). The construction limit is to be decided through consultation with the railroad company, but the history of consultation and determination of construction limit was not described in the DPR. Therefore, the investigation team proposes to consult with the railway company.



Source: JICA Study Team based on OpenStreetMap

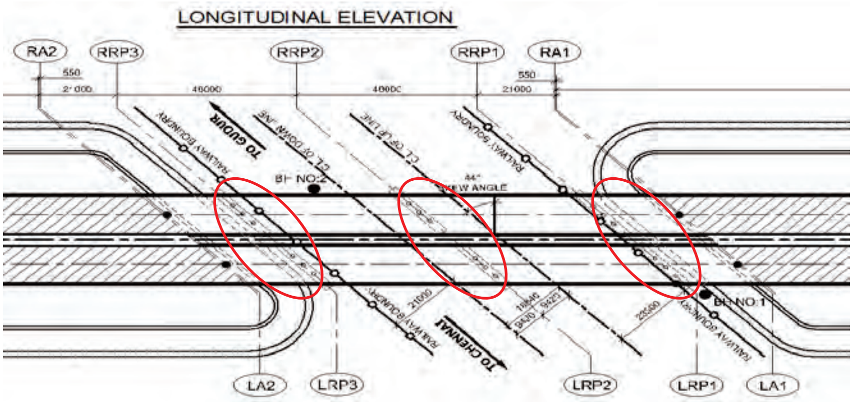
Figure 6.4.16 Clearance Below the Girder

(4) Confirmation of Bridge Type and Structure

1) Bridge Length and Span Length

With the planned bridge length, the abutment locations are outside the boundary of the railroad crossing. Also, the piers within the boundary of the railway are minimized and are positioned to avoid the tracks. As a result, the length of the overpass bridge became 40 m to 50 m.

- Outside the railway area, the investigation team has no major problem with the bridge plan (bridge and span length) since the span is set to the minimum for concrete bridges.
- As for the bridge plan, it will be described again as an item to be decided upon consultation with the railroad company, which is an intersection property manager.
- Considerable consideration is required for the design of steel bridge with small bevel angle (ROB: 46° ～56°). Grasp the stress distribution at the corner of the deck slab, perform lattice calculation taking into consideration the stress state of each girder, consider the structure of accessories such as joint, etc.) Also, it should be comfirmed at the time of detailed design, including alignment adjustment that the bevel angle (ideally 60° ～90°).



Source: JICA Study Team based on DPR（Drawing: ROB101）

Figure 6.4.17 Pier Arrangement（ROB101）

2) Type of Superstructure

The planned span length of the bridge at the railway area is 40 m to 50 m for the purpose of minimizing the quantity of substructure within the railway and avoiding the rail track. Steel bridge is adopted for this section due to its long span and faster construction on the railway area. The steel bridge is adopted by CPRR for three ROBs in the railway area. Other types of superstructure are planned as concrete bridges which are more economical than steel bridges, and the spans are short which are appropriate for concrete bridges.

- Regarding the adopted steel bridge, the JICA Study Team concluded that there is no particular problem since the general steel plate girder structure is adopted. (Reinvestigation is required in case there are requests such as shortening of girder height during the railway consultation.)

Table 6.4.14 Confirmation of Span Length and Type of Superstructure (ROB)

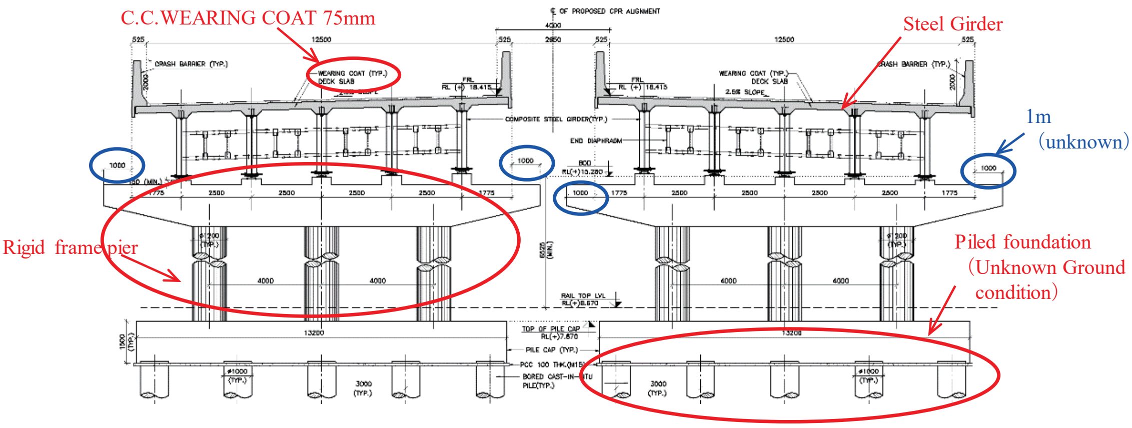
Type / Span(m)			Span:30～50m										Adaptation to curve	Height of girder/span
				10		20		30		40		50		
Plate girder	simple	H-section	■	■	■								×	1/14～1/27
		I girder				■	■	■	■	■	■		○	1/15～1/20
		Box girder					■	■	■	■	■	■	○	1/18～1/25
		I girder (few)				■	■	■	■	■			○	1 / 18
		Box(open cross section)									■	■	○	1/20～1/30
	continuous	I girder					■	■	■	■	■	■	○	1/16～1/22
		Box girder							■	■	■	■	○	1/20～1/30
		I girder (few)					■	■	■	■	■	■	○	1/15～1/20
	steel deck						■	■	■	■	■	■	○	1/22.5

Source: JICA Study Team

3) Type of Substructure

Three column-type rahmen bridge piers are adopted as the substructure. It is considered to have no major problem in terms of ensuring the passage of train and the like due to the wide space between the I-girders.

The plan of 1.0-m lengthening of the substructure girder is not described in the DPR and the setting conditions are unknown.



Source: JICA Study Team based on DPR (Drawing: ROB101)

Figure 6.4.18 Bridge Cross Section (ROB)

4) Type of Foundation

The plan for the pile foundation of ROB is a bored pile with φ 1000 mm. The design report received after the completion of the review specifies ground condition, type of pile foundation, extensions, and other design details.

5) Type of Pavement

In the final DPR, the planned bridge pavement material is concrete. However, asphalt pavement is used in the vicinity of earthworks section as well as ORR, while concrete asphalt is used in the already constructed bridge at the end of Section 4. Although material procurement could be the main consideration, others such as consistency must also be considered in the determination of pavement material during the detailed design.

6) Reinforced Earth Wall

In CPRR, the height of the reinforced earth wall at both ends of the bridge tends to be larger than the average. The objective is to shorten the bridge by increasing the height of the reinforced earth wall. In general, it is said that the actual height and the empirical standard height are about 12 m at maximum; thus, it was verified whether the reinforced soil wall height planned in the CPRR exceeds the said value or not.

- Since there is no reinforced earth wall exceeding the reference height (12 m), it was concluded that the setting of the reinforced earth wall section is acceptable.

Table 6.4.15 Confirmation Result of Reinforced Earth Wall Height (ROB)

Sec.	Name of structure	Chainage		Maximum height of re-Wall (m)		
Sec.1	ROB101	9+230	9+681	10.50	<	12.00
		9+819	10+292	8.90	<	12.00
Sec.1 TPP Link	ROB102	3+040.3	3+307	10.60	<	12.00
		3+449	3+864.8	10.70	<	12.00
Sec.3	ROB301	54+781.505	55+142.835	9.30	<	12.00
		55+509.085	55+869.370	8.90	<	12.00

※For the height of the reinforced soil wall, PDR (Dwrawing) was referred to.For those without dimensions, we measured the drawing.

Source: JICA Study Team

(5) Advice and Suggestions for the DPR

Because there are inconsistencies to be corrected in the data of the DPR, the JICA Study Team organized and presented the items described in the structure list. The contents are described below. For other points to be noted, refer to the COMMENTS column in the table of Appendix-7 of this report.

6.4.6 Underpasses

(1) Summary

An underpass is located in important intersections along the project road and built-up sections. Vehicle Under Pass (VUP) and Light Vehicle Under Pass (LVUP) that have different construction limits are planned based on the classification of their intersecting roads (general vehicles or light vehicles). The location and type of underpass are being approved by the Working Committee (* DPR Main Report, P7-15).

Table 6.4.16 VUP and LVUP Specification

Sec.	No.		STRUCTURE CODE	CHAINAGE		STRUCTURE	INTER-SECTIONS	TYPE OF STRUCTURE
	VUP	LVUP		BP	EP			
Sec.1	1		VUP101 Str. No.8/3	7+836.6	7+849.4	VUP	Route 104	1xRCC Solid Slab L=12.80 m
	2		VUP102 Str. No.12/1	11+265.6	11+278.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	3		VUP103 Str. No.13/1	12+303.6	12+316.4	VUP	Route 56	1xRCC Solid Slab L=12.80 m
	4		VUP104 Str. No.15/1	14+147.6	14+160.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	-	1	LVUP101 Str. No.18/1	17+080.6	17+093.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	5		VUP105 Str. No.19/4	18+961.6	18+974.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
Sec.1 TPP Link	-	2	LVUP101 Str. No. 3/2	2+295.6	2+308.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	-	3	LVUP (within ROB102) Str. No. 4/1	3+025.6	3+038.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
Sec.2	-	4	LVUP Str. No.24/1	23+307.6	23+320.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	-	5	LVUP Str. No.25/2	24+484.6	24+495.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	6	-	VUP201 Str. No.28/3	27+685.6	27+698.4	VUP	Existing Road	1xRCC Solid Slab L=12.80m
	7	-	VUP202 Str. No.33/4	32+855.6	32+868.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	-	6	LVUP203 Str. No.36/3	35+475.6	35+488.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	8	-	VUP Str. No.38/1 (Within MJB201)	37+215.200	37+240.800	VUP	Existing Road	1xRCC Solid Slab L=25.6 m(2@12.80)
	9	-	VUP203 Str. No.43/2	42+235.2	42+260.8	VUP	Existing Road	1xRCC Solid Slab L=25.60 m(2@12.80 m)
	10	-	VUP204 Str. No.48/2	47+259.2	47+284.8	VUP	Route 114	1xRCC Solid Slab L=25.60 m(2@12.80 m)
Sec.3	11	-	VUP-301 Str. No.51/5	50+901.6	50+914.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	12	-	VUP-302 Str. No.57/3	56+746.4	56+759.2	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	13	-	VUP-303 Str. No.60/2	59+443.6	59+456.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	14	-	VUP-304 Str. No.63/4	62+781.2	62+806.8	VUP	Existing Road	1xRCC Solid Slab L=25.60 m (2@12.80 m)
	-	7	LVUP-301 Str. No.65/1	64+956.6	64+969.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	15	-	VUP-305 Str. No.70/2	69+762.2	69+787.8	VUP	Existing Road	1xRCC Solid Slab L=25.6 m(2@12.80)
	16	-	VUP-306 Str. No.72/3	71+569.6	71+582.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	17	-	VUP	around 75+020		VUP	Existing Road	1xRCC Solid Slab L=12.80 m

Sec.	No.		STRUCTURE CODE	CHAINAGE		STRUCTURE	INTER-SECTIONS	TYPE OF STRUCTURE
	VUP	LVUP		BP	EP			
Sec.4	18	-	VUP401 Str. No.79/1	78+187.2	78+212.8	VUP	Existing Road	1xRCC Solid Slab L=25.60 m (2@12.80 m)
	19	-	VUP402 Str. No.82/1	80+987.2	81+012.8	VUP	Existing Road	1xRCC Solid Slab L=25.60 m (2@12.80 m)
	-	8	LVUP402 Str. No.83/1	82+748.6	82+761.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	20	-	VUP403 Str. No.86/1	85+322.6	85+335.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	-	9	LVUP402 Str. No.87/1	86+651.6	86+664.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	21	-	VUP404 Str. No.89/1	88+247.2	88+272.8	VUP	Existing Road	1xRCC Solid Slab L=25.60 m (2@12.80 m)
	22	-	VUP405 Str. No.90/1	89+586.2	89+611.8	VUP	Existing Road	1xRCC Solid Slab L=25.60 m (2@12.80 m)
	23	-	VUP406 Str. No.91/1	90+935.2	90+960.8	VUP	Existing Road	1xRCC Solid Slab L=25.60 m(2@12.80 m)
	24	-	VUP407 Str. No.93/1	92+646.2	92+671.8	VUP	Existing Road	1xRCC Solid Slab L=25.60 m (2@12.80 m)
	-	10	LVUP403 Str. No.94/1	93+612.6	93+625.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	25	-	VUP408 Str. No.96/1	95+431.6	95+444.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	26	-	VUP409 Str. No.100/1	99+831.6	99+844.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
Sec.5	-	11	LVUP501 Str.104/3	103+577.6	103+589.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	-	12	LVUP502 Str.107/2	106+771.6	106+784.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	27	-	VUP501 Str.109/4	108+920.6	108+933.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	-	13	LVUP503 Str.112/3	111+494.6	111+507.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	28	-	VUP502 Str.115/1	114+010.8	114+037.2	VUP	Existing Road	1xRCC Solid Slab L=25.6 m(2@12.80)
	-	14	LVUP504 Str.118/5	117+789.6	117+802.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	29	-	VUP503 Str.120/1	119+256.6	119+269.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	-	15	LVUP505 Str.121/4	120+767.6	120+780.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	30	-	VUP504 Str.123/2	122+355.8	122+382.2	VUP	Existing Road	1xRCC Solid Slab L=25.6 m (2@12.80)
	-	16	LVUP506 Str.125/1	124+041.6	124+054.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m
	31	-	VUP505 Str.126/2	125+475.6	125+488.4	VUP	Existing Road	1xRCC Solid Slab L=12.80 m
	32	-	VUP506 Str.128/1	127+064.2	127+089.7	VUP	Existing Road	1xRCC Solid Slab L=25.6 m (2@12.80)
	-	17	LVUP507 Str.128/4	127+864.6	127+877.4	LVUP	Existing Road	1xRCC Solid Slab L=12.80 m

Source: JICA Study Team

(2) Standard and Design Condition

In the DPR Main Report: P7-1, it is stated that the planned structure conforms to the following standards:

・Indian Roads Congress（IRC）
*IRC: 92-1985, IRC-18-2000, IRC: SP: 90-2012, IRC-87:2013, IRC.gov.in.078.2014, etc.
・MORTH

(3) Confirmation of Crossing Condition

The DPR plans to secure the following construction limits for roads crossing VUP and LVUP:

- VUP: vertical clearance 5.5 m
- LVUP: vertical clearance 4.0 m

Table 6.4.17 Vertical Clearance

7.10 Underpasses

Underpasses are proposed at important junctions and built-up sections along the project road. Two types of underpasses are proposed as per IRC-87:2013.

1. Vehicular Underpass (Vertical Clearance - 5.5m)
   - 2 vents X 12 m for SH & MDR and
   - 1 vent X 12 m for ODR & Panchayat roads
2. Light Vehicular Underpass (Vertical Clearance - 4m)
   - 1 vent X 12 m for ODR & Panchayat roads

Source: JICA Study Team based on DPR Main Report P7-15

The vertical clearance of LVUP is set with a margin with respect to the height of 3.5 m at IRC-87: 2013. (Set value: 4.5 m)

Table 6.4.18 Vertical Clearance（IRC-87:2013 Page15）

2.10.2 *Vertical clearance*

Vertical clearance at Underpasses shall not be less than the values given below:

i)	Vehicular Underpass	5.5 m
ii)	Light Vehicular Underpass	3.5 m →4.0m
iii)	Pedestrian and Cattle Underpass	3.0 m (to be increased to 4.5 m, in case certain categories of animals such as elephant/camel are expected to cross the Project Highway frequently. This will be as specified in Schedule 'B')

Source: JICA Study Team based on IRC-87:2013 Page15

The investigation team verified whether VUP and LVUP are satisfied with respect to the vertical clearance.

➢ Result: VUP and LVUP satisfy the vertical clearance.

Table 6.4.19 Result of Vertical Clearance Verification (VUP, LVUP)

Sec.		STRUCTURE CODE	CHAINAGE		TYPE	VERTICAL CLEARRANCEI(m)			
Sec.1	CPRR	VUP101 Str.No.8/3	7+836.6	7+849.4	VUP	5.85	>	5.50	OK
		VUP102 Str.No.12/1	11+265.6	11+278.4	VUP	5.85	>	5.50	OK
		VUP103 Str.No.13/1	12+303.6	12+316.4	VUP	5.85	>	5.50	OK
		VUP104 Str.No.15/1	14+147.6	14+160.4	VUP	5.85	>	5.50	OK
		LVUP101 Str.No.18/1	17+080.6	17+093.4	LVUP	5.12	>	4.00	OK
		VUP105 Str.No.19/4	18+961.6	18+974.4	VUP	5.85	>	5.50	OK
	TPP-LINK	LVUP101 Str.No. 3/2	2+295.6	2+308.4	LVUP	4.85	>	4.00	OK
		LVUP (within ROB102)Str.No. 4/1	3+025.6	3+038.4	LVUP	5.15	>	4.00	OK
Sec.2		LVUP Str.No.24/1	23+307.6	23+320.4	LVUP	4.85	>	4.00	OK
		LVUP Str.No.25/2	24+484.6	24+495.4	LVUP	4.85	>	4.00	OK
		VUP201 Str.No.28/3	27+685.6	27+698.4	VUP	5.85	>	5.50	OK
		VUP202 Str.No.33/4	32+855.6	32+868.4	VUP	5.85	>	5.50	OK
		LVUP203 Str.No.36/3	35+475.6	35+488.4	LVUP	4.84	>	4.00	OK
		VUP Str.No.38/1 (Within MJB201)	37+215.200	37+240.800	VUP	6.15	>	5.50	OK
		VUP203 Str.No.43/2	42+235.2	42+260.8	VUP	5.83	>	5.50	OK
		VUP204 Str.No.48/2	47+259.2	47+28 4 .8	VUP	6.03	>	5.50	OK
Sec.3		VUP-301 Str.No.51/5	50+901.6	50+914.4	VUP	5.85	>	5.50	OK
		VUP-302 Str.No.57/3	56+746.4	56+759.2	VUP	5.89	>	5.50	OK
		VUP-303 Str.No.60/2	59+443.6	59+456.4	VUP	5.85	>	5.50	OK
		VUP-304 Str.No.63/4	62+781.2	62+806.8	VUP	5.83	>	5.50	OK
		VUP-305 Str.No.70/2	69+762.2	69+787.8	VUP	5.84	>	5.50	OK
		VUP-306 Str.No.72/3	71+569.6	71+582.4	VUP	5.85	>	5.50	OK
Sec.4		VUP401 Str.No.79/1	78+187.2	78+212.8	VUP	6.29	>	5.50	OK
		VUP402 Str.No.82/1	80+987.2	81+012.8	VUP	6.65	>	5.50	OK
		LVUP402 Str.No.83/1	82+748.6	82+761.4	LVUP	5.21	>	4.00	OK
		VUP403 Str.No.86/1	85+322.6	85+335.4	VUP	6.61	>	5.50	OK
		LVUP402 Str.No.87/1	86+651.6	86+664.4	LVUP	5.64	>	4.00	OK
		VUP404 Str.No.89/1	88+247.2	88+272.8	VUP	6.23	>	5.50	OK
		VUP405 Str.No.90/1	89+586.2	89+611.8	VUP	6.25	>	5.50	OK
		VUP406 Str.No.91/1	90+935.2	90+960.8	VUP	5.97	>	5.50	OK
		VUP407 Str.No.93/1	92+646.2	92+671.8	VUP	6.07	>	5.50	OK
		LVUP403 Str.No.94/1	93+612.6	93+625.4	LVUP	5.46	>	4.00	OK
		VUP408 Str.No.96/1	95+431.6	95+444.4	VUP	6.66	>	5.50	OK
		VUP409 Str.No.100/1	99+831.6	99+844.4	VUP	6.70	>	5.50	OK
Sec.5		LVUP501 Str.104/3	103+577.6	103+589.4	LVUP	4.83	>	4.00	OK
		LVUP502 Str.107/2	106+771.6	106+784.4	LVUP	6.33	>	4.00	OK
		VUP50 1 Str.109/4	108+920.6	108+933.4	VUP	7.42	>	5.50	OK
		LVUP503 Str.112/3	111+494.6	111+507.4	LVUP	4.87	>	4.00	OK
		VUP502 Str.115/1	114+010.8	114+037.2	VUP	5.86	>	5.50	OK
		LVUP504 Str.118/5	117+789.6	117+802.4	LVUP	4.85	>	4.00	OK
		VUP503 Str.120/1	119+256.6	119+269.4	VUP	5.85	>	5.50	OK
		LVUP505 Str.121/4	120+767.6	120+780.4	LVUP	4.85	>	4.00	OK
		VUP504 Str.123/2	122+355.8	122+382.2	VUP	5.85	>	5.50	OK
		LVUP506 Str.125/1	124+041.6	124+054.4	LVUP	4.85	>	4.00	OK
		VUP505 Str.126/2	125+475.6	125+488.4	VUP	5.85	>	5.50	OK
		VUP506 Str.128/1	127+064.2	127+089.7	VUP	5.84	>	5.50	OK
		LVUP507 Str.128/4	127+864.6	127+877.4	LVUP	4.86	>	4.00	OK

※Comparison of the transverse slope of the bridge (2.5%) and the estimated girder height (1.28m) with the difference between the road surface elevation and the intersecting road height in the drawing.

Source: JICA Study Team

(4) Confirmation of Bridge Type and Structure

1) Bridge Length and Span Length

It is considered that the necessary bridge length is ensured for the intersections (rivers, canals, national highways, etc.). In addition, the span length of the bridge is set to the standard 12.8 m (configuration possible) for concrete bridges.

- ➢ The JICA Study Team concluded that there is no major problem with the bridge plan (bridge and span length).

2) Type of Superstructure

The number of span is planned to be 1 or 2 spans based on the 12.8 m length on the premise of avoiding interference with the intersections. The superstructure construction type in CPRR is based on concrete bridges which are more economical than steel bridges, and the span length is set as short span which is appropriate for concrete bridges.

- ➢ The investigation team concluded that there is no particular problem with the adoption of concrete bridge as the superstructure since no special bridge is being adopted.

Table 6.4.20 Confirmation of Span Length and Type of Superstructure (VUP･LVUP)

Type				Span(m)	Span10m		10		20		30		40		50	Adaptation to curve	Height of girder/span
PC	precast erection	Pretension	simple	hollow slab		■	■	■								×	1/20～1/24
				Tgirder			■	■								×	1/13～1/17
			continuous	Tgirder			■	■								×	1/13～1/17
		post tension	simple	Tgirder			■	■	■	■	■	■				×	1/13～1/17
				composite I				■	■	■	■					×	1/12～1/16
			continuous	Tgirder				■	■	■						×	1/13～1/17
	support erection		simple	hollow slab				■	■							○	1/20～1/24
				Box					■	■	■	■	■			○	1/15～1/20
			continuous	Box						■	■	■	■			○	1/15～1/20
	PRC hollow slab						■	■	■							○	1/18～1/22
	PC compo							■	■	■	■	■				×	1/16～/15
RC				hollow slab	■	■										○	1/15～1/18

Source: JICA Study Team

3) Type of Substructure

The cross section of the main bridge is not described in the DPR. However, since both ends of the bridge are made up of reinforced earth walls, and because they are located on land, the substructure is considered to be a combination of a pier type and a reinforced earth wall which has already been adopted in India.

- ➢ It is concluded that there is no particular problem with the adoption of this structure.

4) Type of Foundation

Spread foundation and pile foundation (bored pile φ 1000) are planned for VUP and LVUP. The design report received after the completion of the review specifies ground condition, type of pile foundation, extensions, and other design details.

5) Type of Pavement

In the final DPR, the planned bridge pavement material is concrete. However, asphalt pavement is used in the vicinity of earthworks section as well as ORR, while concrete asphalt is used in the already constructed bridge at the end of Section 4. Although material procurement could be the main consideration, others such as consistency must also be considered in the determination of pavement material during the detailed design.

6) Reinforced Earth Wall

In CPRR, the height of the reinforced earth wall at both ends of the bridge tends to be larger than average. The objective is to shorten the bridge by increasing the height of the reinforced earth wall. In general, it is said that the actual height and the empirical standard height are about 12 m at maximum. Thus, it was verified whether the reinforced soil wall height planned in the CPRR exceeds the said value or not.

- Since there is no reinforced earth wall exceeding the reference height (12 m), it was concluded that the setting of the reinforced earth wall section is acceptable.

Table 6.4.21 Confirmation Result of Reinforced Earth Wall Height (VUP・LVUP) (1/2)

Sec.	Name of structure	Chainage		Maximum height of re-Wall（m）		
Sec.1	VUP101 Str.No.8/3	7+528	7+834.7	8.10	＜	12.00
		7+851.3	8+161	8.10	＜	12.00
	VUP102 Str.No.12/1	10+960	11+263.7	8.10	＜	12.00
		11+280.3	11+595	8.10	＜	12.00
	VUP103 Str.No.13/1	11+978	12+301.7	7.90	＜	12.00
		12+318.3	12+635	7.90	＜	12.00
	VUP104 Str.No.15/1	13+778	14+145.7	8.10	＜	12.00
		14+162.3	14+501	8.10	＜	12.00
	LVUP101 Str.No.18/1	16+797	17+078.7	7.40	＜	12.00
		17+095.3	17+379	7.40	＜	12.00
	VUP105 Str.No.19/4	18+618	18+959.7	8.10	＜	12.00
		18+976.3	19+256	8.10	＜	12.00
Sec.1 TPP Link	LVUP101 Str.No. 3/2	2+070	2+293.7	7.30	＜	12.00
		2+310.3	2+590	7.30	＜	12.00
	LVUP (within ROB102)	2+834.5	3+023.7	7.40	＜	12.00
Sec.2	LVUP Str.No.24/1	23+097	23+306	7.10	＜	12.00
		23+322.3	23+566	7.10	＜	12.00
	LVUP Str.No.25/2	24+207	24+482.7	7.10	＜	12.00
		24+499.3	24+816	7.10	＜	12.00
	VUP201 Str.No.28/3	27+376	27+683.7	8.10	＜	12.00
		27+700.3	28+008	8.10	＜	12.00
	VUP202 Str.No.33/4	32+480	32+853.7	8.10	＜	12.00
		32+870	33+147	8.10	＜	12.00
	LVUP203 Str.No.36/3	35+264	35+473.4	7.10	＜	12.00
		35+490.3	35+716	7.10	＜	12.00
	VUP203 Str.No.43/2	41+960	42+233.3	8.10	＜	12.00
		42+262.7	42+535.0	8.10	＜	12.00
	VUP204 Str.No.48/2	46+951	47+257.3	8.50	＜	12.00
		47+286.7	47+557	8.30	＜	12.00
Sec.3	VUP-301 Str.No.51/5	50+574	50+899.7	9.70	＜	12.00
		50+916.3	51+218	9.40	＜	12.00
	VUP-302 Str.No.57/3	56+423	56+744.5	8.10	＜	12.00
		56+761.1	57+126	8.10	＜	12.00
	VUP-303 Str.No.60/2	59+072	59+441.7	8.10	＜	12.00
		59+458.3	59+711	8.10	＜	12.00
	VUP-304 Str.No.63/4	62+525	62+779.8	8.10	＜	12.00
		62+809.9	63+091	8.10	＜	12.00
	LVUP-301 Str.No.65/1	64+684	64+954.7	7.00	＜	12.00
		64+971.3	65+316	7.00	＜	12.00
	VUP-305 Str.No.70/2	69+300	69+760.3	8.10	＜	12.00
		69+789.7	70+133	8.10	＜	12.00
	VUP-306 Str.No.72/3	71+235	71+567.7	8.10	＜	12.00
		71+584.3	71+875	8.10	＜	12.00

※For the height of the reinforced soil wall, PDR (Dwrawing) was referred to.For those without dimensions, we measured the drawing.

Source: JICA Study Team

Table 6.4.22 Confirmation Result of Reinforced Earth Wall Height (VUP・LVUP) (2/2)

Sec.	Name of structure	Chainage		Maximum height of re-Wall（m)		
Sec.4	VUP401 Str.No.79/1	77+916	78+185.3	8.50	＜	12.00
		78+214.7	78+600	8.90	＜	12.00
	VUP402 Str.No.82/1	80+505	80+985.3	8.40	＜	12.00
		81+014.7	81+286	8.70	＜	12.00
	LVUP402 Str.No.83/1	82+359	82+746.7	7.80	＜	12.00
		82+763.3	83+175	8.10	＜	12.00
	VUP403 Str.No.86/1	84+953	85+320.7	9.00	＜	12.00
		85+337.3	85+643	8.90	＜	12.00
	LVUP402 Str.No.87/1	86+144	86+649.7	8.70	＜	12.00
		86+666.3	86+910	7.70	＜	12.00
	VUP404 Str.No.89/1	87+800	88+245.3	8.50	＜	12.00
		88+274.7	88+557	9.10	＜	12.00
	VUP405 Str.No.90/1	89+273	89+584.3	8.70	＜	12.00
		89+613.7	89+909	8.40	＜	12.00
	VUP406 Str.No.91/1	90+684	90+933.3	8.20	＜	12.00
		90+962.7	91+381	8.90	＜	12.00
	VUP407 Str.No.93/1	92+314	92+644.3	8.50	＜	12.00
		92+673.7	93+074	8.90	＜	12.00
	LVUP403 Str.No.94/1	93+336	93+610.7	8.00	＜	12.00
		93+627.3	93+882	7.50	＜	12.00
	VUP408 Str.No.96/1	94+992	95+429.7	9.60	＜	12.00
		95+446.3	95+864	8.80	＜	12.00
	VUP409 Str.No.100/1	99+495	99+829.7	8.60	＜	12.00
		99+846.3	100+176	8.70	＜	12.00
Sec.5	LVUP501 Str.104/3	103+330	103+574.7	7.10	＜	12.00
		103+591.3	103+854	7.10	＜	12.00
	LVUP502 Str.107/2	106+362	106+769.7	8.30	＜	12.00
		106+786.3	107+091	8.60	＜	12.00
	VUP501 Str.109/4	108+608	108+908.7	8.10	＜	12.00
		108+935.3	109+265	8.10	＜	12.00
	LVUP503 Str.112/3	111+182	111+492.7	6.70	＜	12.00
		111+509.3	111+870	7.10	＜	12.00
	VUP502 Str.115/1	113+815	114+008.9	7.30	＜	12.00
		114+039.1	114+356	8.10	＜	12.00
	LVUP504 Str.118/5	117+510	117+787.7	7.10	＜	12.00
		117+804.3	118+018	7.10	＜	12.00
	VUP503 Str.120/1	118+929	119+254.7	8.10	＜	12.00
		119+271.3	119+550	8.10	＜	12.00
	LVUP505 Str.121/4	120+528	120+755.7	7.10	＜	12.00
		120+782.3	121+141	8.10	＜	12.00
	VUP504 Str.123/2	122+083	122+353.9	8.10	＜	12.00
		122+384.1	122+698	8.10	＜	12.00
	LVUP506 Str.125/1	123+820	124+039.7	7.10	＜	12.00
		124+056.3	124+296	7.10	＜	12.00
	VUP505 Str.126/2	125+183	125+473.7	8.10	＜	12.00
		125+490.3	125+754	8.10	＜	12.00
	VUP506 Str.128/1	126+770	127+062.3	8.10	＜	12.00
		127+091.7	127+345	8.10	＜	12.00
	LVUP507 Str.128/4	127+658	127+862.7	7.10	＜	12.00
		127+879.3	128+112	7.10	＜	12.00

※For the height of the reinforced soil wall, PDR (Dwrawing) was referred to.For those without dimensions, we measured the drawing.

Source: JICA Study Team

(5) Advice and Suggestions for the DPR

1) Structure of VUP in the Outer Ring Road (ORR)

The DPR Drawing does not describe the details of the reinforced earth wall structure at the ends of VUP; however, the same "Terre Armee" structure used in other bridges (MNB · ROB · Interchange, etc.) is drawn. Although the height of the reinforced earth wall is relatively large, it is considered that the application of this structure is not a problem. However, the ORR that has been constructed and is under construction uses a simple block wall (masonry structure), and there are many structures that use such. It is assumed that there will be requirements such as the shortening of height in some portions (there is no effect of soil pressure or earthquake). Hence, the fact that such a simple wall structure is adopted in India is described here.

In addition, VUP will be constructed in the ORR as a box culvert rather than a bridge structure. If the bridge is small, a box culvert can be adopted while the bearing and expansion joints can be omitted and in doing so, the maintenance will be eased.

At this stage, it is concluded that adopting the bridge type and the "Terre Armee" structure as in the DPR plan is possible. However, during the detailed design, it is better to consider other conditions such as the terrain for the structure.

Source: JICA Study Team

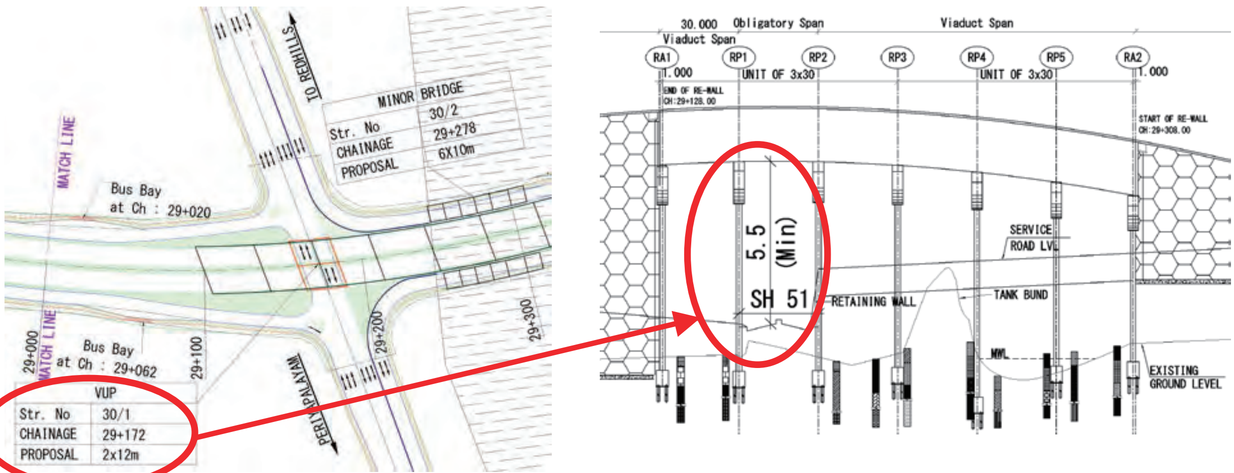
Figure 6.4.19 VUP in the ORR（Box, Block Wall）

2) Inconsistencies to Correct in the DPR

Because there are inconsistencies to be corrected in the data of the DPR, the JICA Study Team organized and presented the items described in the structure list. The contents are described below. For other points to be noted, refer to the COMMENTS column in the table of Appendix-7 of this report.

【Section 2】

Since MJB is located at the same location as VUP (Str. 30/1) as described in Plan & Profile, the VUP is considered unnecessary. It is proposed to revise the plan upon confirmation.

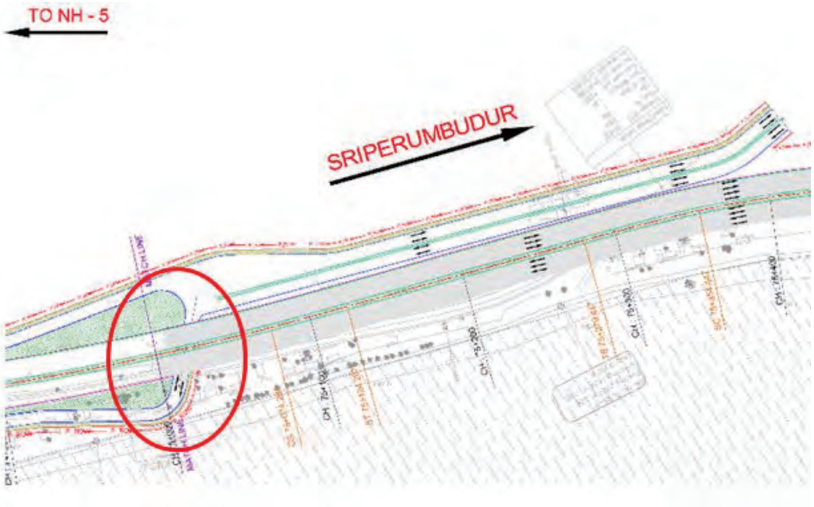


Source: DPR Plan&Profile(14518/E/PP/DD209), Drawing（14518/E/MJB202/DD001: SH-1 OF 3）Added by the JICA Study Team

Figure 6.4.20 VUP Shown in the Plan&Profile

【Section 3】

For the road crossing, there is no VUP around Ch. 75+020. Since VUP is considered to be necessary in the said location, it is proposed to add a VUP upon confirmation.



Source: JICA Study Team based on DPR Plan&Profile(14518/E/PP/DD329)

Figure 6.4.21 Location of Road Crossing（Near Section 3 Ch. 70+020）

6.4.7 Box Culverts (BC)

(1) Summary

A culvert is planned as a concrete structure that functions as a waterway. Culverts are classified into two types, namely box culvert and pipe culvert.

Since the design report has not been received during the survey, the verification of water flow section and water level as described in the drawing is not carried out.

Source: JICA Study Team

Figure 6.4.22 Box Culvert (ORR)

Table 6.4.23　　Box Culvert Specification（1/6）

Sec.	No.		STRUCTURE CODE	CHAINAGE	STRUCTURE	TYPE OF STRUCTURE
	BOX	PIPE				
Sec.1	1※	-	BC-Str.No.2/1	1+400	BOX CULVERT	1 x 2.0 × 2.0 m, L=40.50m
	2	-	BC-Str.No.2/2	1+650	BOX CULVERT	1 x 2.5 × 2.5 m, L=40.50m
	3	-	BC-Str.No.2/3	1+820	BOX CULVERT	1 x 2.5 × 2.5 m, L=40.50m
	4	-	BC-Str.No.3/1	2+080	BOX CULVERT	1 x 2.5 × 2.5 m, L=40.50m
	5	-	BC-Str.No.3/3	2+750	BOX CULVERT	1 x 2.5 × 2.5 m, L=40.50m
	6	-	BC-Str.No.4/1	3+020	BOX CULVERT	1 x 2.5 × 2.5 m, L=40.50m
	7	-	BC-Str.No.4/2	3+280	BOX CULVERT	1 x 2.0 × 2.0 m, L=40.50m
	8	-	BC-Str.No.4/3	3+540	BOX CULVERT	1 x 2.0 × 2.0 m, L=40.50m
	9	-	BC-Str.No.4/4	3+780	BOX CULVERT	1 x 2.5 × 2.5 m, L=40.50m
	10	-	BC-Str.No.5/1	4+010	BOX CULVERT	1 x 2 × 2 m, L=40.50m
	11	-	BC-Str.No.5/2	4+240	BOX CULVERT	1 x 2 × 2 m, L=40.50m
	12	-	BC-Str.No.5/3	4+490	BOX CULVERT	1 x 2 × 2 m, L=40.50m
	13	-	BC-Str.No.5/4	4+710	BOX CULVERT	1 x 2 × 2 m, L=40.50m
	14	-	BC-Str.No.5/5	4+950	BOX CULVERT	1 x 2 × 2 m, L=40.50m
	15	-	BC-Str.No.6/1	5+230	BOX CULVERT	1 x 2 × 2 m, L=40.50m
	16	-	BC-Str.No.6/2	5+542	BOX CULVERT	1 x 1.5 × 1.5 m, L=40.50m
	17	-	BC-Str.No.6/3	5+788	BOX CULVERT	1 x 1.5 × 1.5 m, L=40.50m
	18	-	BC-Str.No.7/1	6+048	BOX CULVERT	1 x 1.5 × 1.5 m, L=40.50m
	19	-	BC-Str.No.7/1	6+500	BOX CULVERT	1 x 1.5 × 1.5 m, L=40.50m
	20	-	BC-Str.No.7/1	6+800	BOX CULVERT	1 x 1.5 × 1.5 m, L=40.50m
	21	-	BC-Str.No.8/2	7+578	BOX CULVERT	1 x 2.5 × 2.5 m, L=59.04m
	22	-	BC-Str.No.9/1	8+250	BOX CULVERT	2 @ 3 × 2 m, L=46.50m
	23	-	BC-Str.No.9/2	8+550	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	24	-	BC-Str.No.9/3	8+758	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	25	-	BC-Str.No.10/1	9+038	BOX CULVERT	2 × 2 m, L=46.50m
	26	-	BC-Str.No.10/2	9+318	BOX CULVERT	2 × 2 m, L=50.55m
	27	-	BC-Str.No.11/1	10+310	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	28	-	BC-Str.No.11/2	10+588	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	29	-	BC-Str.No.11/3	10+888	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	30	-	BC-Str.No.12/2	11+350	BOX CULVERT	1 x 3 × 1.5 m, L=71.49m
	31	-	BC-Str.No.12/3	11+698	BOX CULVERT	1 x 1.5 × 1.5 m, L=46.50m
	32	-	BC-Str.No.12/4	11+968	BOX CULVERT	1 x 1.5 × 1.5 m, L=50.55m
	33	-	BC-Str.No.13/2	12+700	BOX CULVERT	1 x 1.5 × 1.5 m, L=46.50m
	34	-	BC-Str.No.13/3	12+900	BOX CULVERT	1 x 1.5 × 1.5 m, L=46.50m
	35	-	BC-Str.No.14/1	13+315	BOX CULVERT	1 x 2.5 × 2.5 m, L=49.49m
	36	-	BC-Str.No.14/2	13+638	BOX CULVERT	1 x 1.5 × 1.5 m, L=46.50m
	37	-	BC-Str.No.15/2	14+510	BOX CULVERT	1 x 2 × 2 m, L=50.55m
	38	-	BC-Str.No.15/3	14+778	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	39	-	BC-Str.No.15/4	14+928	BOX CULVERT	1 x 1.5 × 1.5 m, L=46.50m
	40	-	BC-Str.No.16/1	15+158	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	41	-	BC-Str.No.16/2	15+418	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	42	-	BC-Str.No.16/3	15+778	BOX CULVERT	1 x 2 × 2 m, L=46.50m
	43	-	BC-Str.No.17/1	16+288	BOX CULVERT	1 x 1.5 × 1.5 m, L=46.50m
	44	-	BC-Str.No.17/2	16+508	BOX CULVERT	1 x 1.5 × 1.5 m, L=46.50m
	45	-	BC-Str.No.17/3	16+778	BOX CULVERT	1 x 1.5 × 1.5 m, L=46.50m
	46	-	BC-Str.No.18/2	17+200	BOX CULVERT	1 x 1.5 × 1.5 m, L=71.49m
	-	1	PC-Str.18/3	17+440	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	2	PC-Str.18/4	17+670	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	3	PC-Str.18/5	17+900	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	4	PC-Str.19/1	18+130	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	5	PC-Str.19/2	18+360	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	6	PC-Str.19/3	18+590	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	7	PC-Str.20/1	19+360	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	8	PC-Str.20/2	19+560	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	9	PC-Str.20/3	19+810	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	10	PC-Str.20/4	19+960	PIPE CULVERT	1 x 1.2 m φ, L＝46.50m
	-	11	PC Str.21/1	20+160	PIPE CULVRET	1 x 1.2 m φ L=46.50m
	-	12	PC Str.22/1	21+451	PIPE CULVERT	1 x 1.5 m φ L=54.00m

*BC-Str. No.2/1 will be removed due to the planned extension of MJB101. This shall be confirmed in the detailed design.
Source: JICA Study Team

Table 6.4.24 Box Culvert Specification（2/6）

Sec.	No.		STRUCTURE CODE	CHAINAGE	STRUCTURE	TYPE OF STRUCTURE
	BOX	PIPE				
Sec.1 TPP Link	47	-	BC-Str.No.1/1	0+625	BOX CULVERT	1 x 2.50 x 2.50m, L=46.50m
	48	-	BC-Str.No.1/2	0+752	BOX CULVERT	1 x 2.50 x 2.50m, L=46.50m
	49	-	BC-Str.No.2/1	1+070	BOX CULVERT	1 x 2.50 x 2.50m, L=46.50m
	50	-	BC-Str.No.2/2	1+260	BOX CULVERT	1 x 1.50 x 1.50m, L=46.50m
	-	12	PC-Str.No.2/3	1+445	PIPE CULVERT	1.20m ϕ ,L=46.50m
	-	13	PC-Str.No.2/4	1+685	PIPE CULVERT	1.20m ϕ ,L=46.50m
	51	-	BC-Str.No.3/3	2+775	BOX CULVERT	1 x 2.00 x 2.00m, L=46.50m
	52	-	BC-Str.No.3/4	2+925	BOX CULVERT	1 x 2.50 x 2.50m, L=46.50m
	53	-	BC-Str.No.1/5	4+100	BOX CULVERT	1 x 1.50 x 1.50m, L=46.50m
Sec.2 (2/1)	-	14	PC Str.22/1	21+451	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	15	PC Str.22/2	21+652	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	16	PC Str.23/1	22+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	17	PC Str.23/2	22+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	18	PC Str.23/3	22+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	19	PC Str.23/4	22+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	20	PC Str.23/5	22+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	54	-	BC-Str.No.24/2	23+623	BOX CULVERT	2@3.00x2.00m, L=54.00m
	-	21	PC-Str.No.24/3	23+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	22	PC-Str.No.25/1	24+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	23	PC-Str.No.25/3	24+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	24	PC-Str.No.26/1	25+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	25	PC-Str.No.26/2	25+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	26	PC-Str.No.26/3	25+520	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	27	PC-Str.No.26/4	25+780	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	28	PC-Str.No.26/5	25+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	29	PC-Str.No.27/1	26+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	30	PC-Str.No.27/2	26+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	31	PC-Str.No.27/4	26+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	32	PC-Str.No.27/5	26+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	33	PC-Str.No.28/1	27+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	34	PC-Str.No.28/2	27+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	35	PC-Str.No.29/1	28+040	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	36	PC-Str.No.29/2	28+290	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	37	PC-Str.No.29/3	28+453	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	38	PC-Str.No.29/4	28+653	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	39	PC-Str.No.30/4	29+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	40	PC-Str.No.30/5	29+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	41	PC-Str.No.30/6	29+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	42	PC-Str.No.31/1	30+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	55	-	BC-Str.No.31/2	30+398	BOX CULVERT	1.5x1.5m, L=63.00m
	56	-	BC-Str.No.31/3	30+483	BOX CULVERT	1.5x1.5m, L=63.00m
	-	43	PC-Str.No.32/1	31+270	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	44	PC-Str.No.32/2	31+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	45	PC-Str.No.32/3	31+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	46	PC-Str.No.32/4	31+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	47	PC-Str.No.33/1	32+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	48	PC-Str.No.33/2	32+403	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	57	-	BC-Str.No.33/3	32+648	BOX CULVERT	1.5x1.5m, L=63.00m
	-	49	PC-Str.No.34/1	33+303	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	50	PC-Str.No.34/2	33+503	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	51	PC-Str.No.34/3	33+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	52	PC-Str.No.34/4	33+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	58	-	BC-Str.No.35/1	34+133	BOX CULVERT	1.5x1.5m, L=54.00m
	59	-	BC-Str.No.35/2	34+393	BOX CULVERT	2@3.0x2.0m, L=63.00m
	-	53	PC-Str.No.35/3	34+653	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	54	PC-Str.No.35/4	34+770	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	55	PC-Str.No.36/1	35+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	56	PC-Str.No.36/2	35+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	57	PC-Str.No.36/4	35+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m

Source: JICA Study Team

Table 6.4.25 Box Culvert Specification（3/6）

Sec.	No.		STRUCTURE CODE	CHAINAGE	STRUCTURE	TYPE OF STRUCTURE
	BOX	PIPE				
Sec.2 (2/2)	-	58	PC-Str.No.36/5	35+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	60	-	BC-Str.No.37/1	36+153	BOX CULVERT	2@3.0x2.0m, L=63.00m
	-	59	PC-Str.No.37/2	36+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	60	PC-Str.No.37/3	36+653	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	61	PC-Str.No.38/3	37+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	62	PC-Str.No.39/1	38+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	63	PC-Str.No.39/2	38+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	64	PC-Str.No.39/3	38+453	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	65	PC-Str.No.39/4	38+653	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	66	PC-Str.No.39/5	38+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	67	PC-Str.No.40/1	39+003	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	61	-	BC-Str.No.40/2	39+219	BOX CULVERT	1 x 1.50x1.50m, L=57.45m
	62	-	BC-Str.No.40/3	39+486	BOX CULVERT	1 x 1.50x1.50m, L=57.45m
	-	68	PC-Str.No.40/4	39+703	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	69	PC-Str.No.40/5	39+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	70	PC-Str.No.41/1	40+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	71	PC-Str.No.41/2	40+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	72	PC-Str.No.41/3	40+420	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	73	PC-Str.No.41/4	40+680	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	74	PC-Str.No.41/5	40+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	63	-	BC-Str.No.42/1	41+132	BOX CULVERT	1 x 2.0x2.0m, L=76.365m
	64	-	BC-Str.No.42/2	41+573	BOX CULVERT	2 x 3.00x2.00m, L=54.00m
	-	75	PC-Str.No.42/3	41+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	76	PC-Str.No.42/4	41+943	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	65	-	BC-Str.No.43/1	42+103	BOX CULVERT	1 x 1.50x1.50m, L=54.0m
	-	77	PC-Str.No.43/3	42+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	78	PC-Str.No.43/4	42+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	79	PC-Str.No.43/5	42+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	80	PC-Str.No.44/1	43+130	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	81	PC-Str.No.44/2	43+370	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	82	PC-Str.No.44/3	43+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	83	PC-Str.No.44/4	43+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	84	PC-Str.No.44/5	43+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	85	PC-Str.No.45/2	44+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	86	PC-Str.No.45/3	44+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	87	PC-Str.No.45/4	44+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	88	PC-Str.No.45/5	44+933	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	89	PC-Str.No.46/1	45+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	90	PC-Str.No.46/2	45+510	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	91	PC-Str.No.46/3	45+800	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	92	PC-Str.No.46/4	45+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	93	PC-Str.No.47/1	46+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	94	PC-Str.No.47/2	46+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	95	PC-Str.No.47/3	46+523	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	96	PC-Str.No.47/4	46+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	97	PC-Str.No.47/5	46+883	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	66	-	BC-Str.No.48/1	47+013	BOX CULVERT	1 x 2.00x2.00m, L=54.00m
Sec.3 (3/1)	67	-	BC-Str.No.48/3	47+593	BOX CULVERT	1x2.50x2.50m, L=54.00m
	68	-	BC-Str.No.48/4	47+803	BOX CULVERT	2x3.00x2.00m, L=54.00m
	-	98	PC-Str.No.49/1	48+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	99	PC-Str.No.49/2	48+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	100	PC-Str.No.49/3	48+470	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	101	PC-Str.No.49/4	48+653	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	102	PC-Str.No.49/5	48+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	103	PC-Str.No.50/1	49+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	104	PC-Str.No.50/2	49+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	105	PC-Str.No.50/3	49+420	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	106	PC-Str.No.50/4	49+680	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	107	PC-Str.No.50/5	49+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m

Source: JICA Study Team

Table 6.4.26 Box Culvert Specification（4/6）

Sec.	No. BOX	No. PIPE	STRUCTURE CODE	CHAINAGE	STRUCTURE	TYPE OF STRUCTURE
Sec.3 (3/2)	-	108	PC-Str.No.51/1	50+003	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	69	-	BC-Str.No.51/2	50+213	BOX CULVERT	1x2.50x2.50m, L=54.00m
	-	109	PC-Str.No.51/3	50+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	110	PC-Str.No.51/4	50+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	111	PC-Str.No.52/1	51+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	70	-	BC-Str.No.52/2	51+611	BOX CULVERT	2x3.00x2.00m, L=54.00m
	-	112	PC-Str.No.52/3	51+803	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	113	PC-Str.No.52/4	51+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	114	PC-Str.No.53/1	52+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	115	PC-Str.No.53/2	52+280	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	71	-	BC-Str.No.53/3	52+678	BOX CULVERT	1x2.50x2.50m, L=54.00m
	-	116	PC-Str.No.53/4	52+853	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	117	PC-Str.No.54/1	53+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	118	PC-Str.No.54/2	53+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	72	-	BC-Str.No.54/3	53+393	BOX CULVERT	1x2.50x2.50m, L=59.58m
	73	-	BC-Str.No.54/4	53+518	BOX CULVERT	1x2.50x2.50m, L=54.00m
	-	119	PC-Str.No.56/1	55+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	74	-	BC-Str.No.56/2	55+303	BOX CULVERT	1x3.00x1.50m, L=54.00m
	-	120	PC-Str.No.56/4	55+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	121	PC-Str.No.56/5	55+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	122	PC-Str.No.57/1	56+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	75	-	BC-Str.No.57/2	56+553	BOX CULVERT	1x2.00x2.00m, L=54.00m
	-	123	PC-Str.No.58/1	57+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	124	PC-Str.No.58/2	57+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	125	PC-Str.No.59/1	58+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	76	-	BC-Str.No.59/2	58+303	BOX CULVERT	2x3.00x2.00m, L=54.00m
	-	126	PC-Str.No.59/3	58+653	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	127	PC-Str.No.59/4	58+890	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	128	PC-Str.No.60/1	59+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	129	PC-Str.No.60/3	59+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	130	PC-Str.No.60/4	59+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	131	PC-Str.No.61/1	60+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	132	PC-Str.No.61/2	60+353	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	133	PC-Str.No.61/3	60+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	134	PC-Str.No.61/4	60+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	135	PC-Str.No.61/5	60+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	136	PC-Str.No.62/1	61+120	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	137	PC-Str.No.62/2	61+380	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	138	PC-Str.No.62/3	61+553	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	139	PC-Str.No.62/4	61+753	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	140	PC-Str.No.62/5	61+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	141	PC-Str.No.63/1	62+153	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	77	-	BC-Str.No.63/2	62+338	BOX CULVERT	1x2.50x2.50m, L=54.00m
	78	-	BC-Str.No.63/3	62+717	BOX CULVERT	1x1.50x1.50m, L=54.00m
	79	-	BC-Str.No.63/5	62+890	BOX CULVERT	1x3.00x2.00m, L=54.00m
	-	142	PC-Str.No.64/1	63+053	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	80	-	BC-Str.No.66/1	65+038	BOX CULVERT	1x2.00x2.00m, L=54.00m
	81	-	BC-Str.No.66/2	65+133	BOX CULVERT	2x3.00x2.00m, L=54.00m
	-	143	PC-Str.No.67/1	66+503	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	144	PC-Str.No.70/1	69+503	PIPE CULVERT	1 x 1.2 m φ L=54.00m
	-	145	PC-Str.No.71/1	70+143	PIPE CULVERT	1 x 1.2 m φ L=54.00m
	-	146	PC-Str.No.71/2	70+455	PIPE CULVERT	1 x 1.2 m φ L=54.00m
	-	147	PC-Str.No.72/1	71+053	PIPE CULVERT	1 x 1.2 m φ L=54.00m
	-	148	PC-Str.No.72/2	71+253	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	149	PC-Str.No.72/4	71+953	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	150	PC-Str.No.73/1	72+163	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	82	-	BC-Str.No.73/2	72+298	BOX CULVERT	1 x 3.00m x 1.50m
	-	151	PC-Str.No.73/3	72+503	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	83	-	BC-Str.No.73/4	72+718	BOX CULVERT	2 x 3.00m x 2.00m, L=54.00m

Source: JICA Study Team

Table 6.4.27 Box Culvert Specification（5/6）

Sec.	No. BOX	No. PIPE	STRUCTURE CODE	CHAINAGE	STRUCTURE	TYPE OF STRUCTURE
Sec.3 (3/3)	-	152	PC-Str.No.73/5	72+903	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	153	PC-Str.No.74/1	73+183	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	154	PC-Str.No.74/2	73+453	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	84	-	BC-Str.No.74/3	73+583	BOX CULVERT	2 x 2.00m x 2.00m, L=54.00m
	-	155	PC-Str.No.74/4	73+803	PIPE CULVERT	1 x 1.5 m φ L=76.36m
	-	156	PC-Str.No.75/1	74+003	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	85	-	BC-Str.No.75/2	74+190	BOX CULVERT	1 x 2.50m x 2.50m, L=54.00m
	-	157	PC-Str.No.75/3	74+403	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	158	PC-Str.No.75/4	74+653	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	86	-	BC-Str.No.75/5	74+843	BOX CULVERT	1 x 2.00m x 2.00m, L=54.00m
Sec.4	-	-	-	-	-	-
Sec.5 (2/1)	-	159	PC-Str.103/1	102+506	PIPE CULVERT	1 x 1.5 m φ L=54.00m
	-	160	PC-Str.104/1	103+156	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	87	-	PC-Str.104/2	103+356	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	-	161	PC-Str.104/4	103+956	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	88	-	BC-Str.No.105/1	104+336	BOX CULVERT	2.5 × 2.5 m, L=54.0m
	-	162	PC-Str.105/2	104+556	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	163	PC-Str.105/3	104+756	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	164	PC-Str.106/1	105+006	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	165	PC-Str.106/2	105+256	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	166	PC-Str.106/3	105+506	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	167	PC-Str.106/4	105+756	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	168	PC-Str.108/1	107+256	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	169	PC-Str.108/2	107+456	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	170	PC-Str.108/3	107+656	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	171	PC-Str.108/4	107+956	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	172	PC-Str.109/1	108+156	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	89	-	BC-Str.No.109/2	108+381	BOX CULVERT	2 @ 3 × 2 m, L=54.0m
	-	173	PC-Str.109/3	108+566	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	90	-	BC-Str.No.110/1	109+116	BOX CULVERT	3 × 1.5 m, L=54.0m
	91	-	PC-Str.110/2	109+306	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	-	174	PC-Str.110/3	109+506	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	92	-	BC-Str.No.110/4	109+706	BOX CULVERT	2 × 2 m, L=54.0m
	-	175	PC-Str.110/5	109+990	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	176	PC-Str.111/3	110+856	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	93	-	BC-Str.No.111/4	110+999	BOX CULVERT	2 × 2 m, L=54.0m
	94	-	BC-Str.No.112/1	111+206	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	95	-	BC-Str.No.112/2	111+406	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	96	-	BC-Str.No.112/4	111+700	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	97	-	BC-Str.No.112/5	111+856	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	-	177	PC-Str.113/1	112+056	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	178	PC-Str.113/2	112+256	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	179	PC-Str.113/3	112+456	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	180	PC-Str.113/4	112+656	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	181	PC-Str.113/5	112+856	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	182	PC-Str.114/1	113+020	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	183	PC-Str.114/2	113+280	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	184	PC-Str.114/3	113+706	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	98	-	BC-Str.No.114/4	113+932	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	99	-	BC-Str.No.115/2	114+250	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	100	-	BC-Str.No.115/3	114+382	BOX CULVERT	2 × 2 m, L=54.0m
	-	185	PC-Str.115/4	114+606	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	186	PC-Str.115/5	114+756	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	187	PC-Str.115/6	114+956	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	188	PC-Str.116/1	115+106	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	189	PC-Str.116/4	115+656	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	190	PC-Str.116/5	115+800	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	191	PC-Str.117/1	116+080	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	192	PC-Str.117/2	116+256	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m

Source: JICA Study Team

Table 6.4.28 Box Culvert Structure List（6/6）

Sec.	No.		STRUCTURE CODE	CHAINAGE	STRUCTURE	TYPE OF STRUCTURE
	BOX	PIPE				
Sec.5 (2/2)	-	193	PC-Str.117/3	116+456	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	194	PC-Str.117/4	116+610	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	195	PC-Str.118/1	117+056	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	196	PC-Str.118/2	117+256	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	197	PC-Str.118/3	117+456	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	101	-	-	117+600	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	-	198	PC-Str.119/2	118+256	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	199	PC-Str.119/4	118+756	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	102	-	BC-Str.No.119/5	118+956	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	103	-	BC-Str.No.120/2	119+356	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	104	-	BC-Str.No.120/3	119+556	BOX CULVERT	2 × 2 m, L=54.0m
	105	-	BC-Str.No.120/4	119+756	BOX CULVERT	2 × 2 m, L=54.0m
	-	200	PC-Str.121/1	120+166	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	106	-	BC-Str.No.121/2	120+376	BOX CULVERT	2 @ 3 × 2 m, L=54.0m
	107	-	BC-Str.No.121/3	120+656	BOX CULVERT	1.5 × 1.5 m, L=60.0m
	-	201	PC-Str.No.122/1	121+106	PIPE CULVERT	1 × 1.5 m, L=54.0m
	-	202	PC-Str.112/3	121+656	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	108	-	BC-Str.No.123/1	122+160	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	109	-	BC-Str.No.123/3	122+836	BOX CULVERT	2 × 2 m, L=54.0m
	-	203	PC-Str.124/1	123+116	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	204	PC-Str.124/2	123+406	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	205	PC-Str.124/4	123+696	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	110	-	BC-Str.No.124/5	123+920	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	-	206	PC-Str.125/2	124+306	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	207	PC-Str.125/3	124+446	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	111	-	BC-Str.No.125/4	124+620	BOX CULVERT	2 × 2 m, L=54.0m
	-	208	PC-Str.125/5	124+956	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	209	PC-Str.126/1	125+106	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	112	-	BC-Str.No.126/3	125+706	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	-	210	PC-Str.126/4	125+906	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	211	PC-Str.127/1	126+106	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	212	PC-Str.127/2	126+220	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	213	PC-Str.127/3	126+506	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	214	PC-Str.127/4	126+706	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	-	215	PC-Str.128/2	127+356	PIPE CULVERT	1 x 1.5 m φ, L＝54.0m
	113	-	BC-Str.No.128/3	127+536	BOX CULVERT	2 × 2 m, L=54.0m
	114	-	BC-Str.No.129/1	128+103	BOX CULVERT	1.5 × 1.5 m, L=54.0m
	115	-	BC-Str.No.130/1	129+006	BOX CULVERT	2 × 2 m, L=54.0m

Source: JICA Study Team

(2) Standard and Design Condition

In the DPR Main Report: P7-1, it is stated that the planned structure conforms to the following standards:

・Indian Roads Congress（IRC）

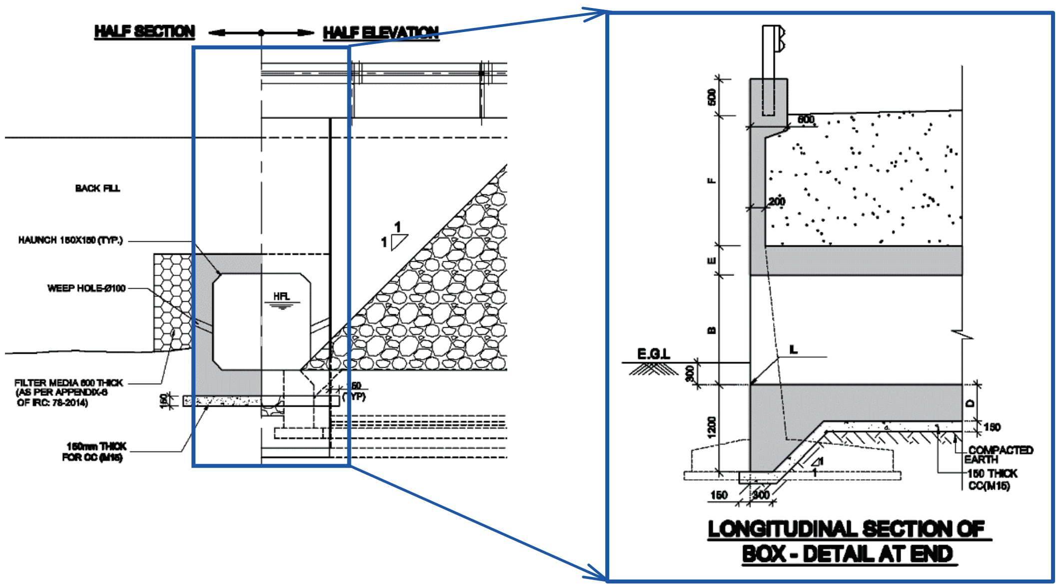
*IRC: 92-1985, IRC-18-2000, IRC: SP: 90-2012, IRC.gov.in.078.2014, etc.
・MoRTH

(3) Advice and Suggestions for the DPR

1) Joint Between Box Culvert and Retaining Wall Structure

In the DPR Drawing, there is a part where the connection between the box culvert and the retaining wall structure on the box is simplified and integrated. Since the collision load of the guardrail vehicle may act on the top of the retaining wall, it is necessary to pay attention to the following:

- In order to ensure the rigidity of the end of the retaining wall, it is preferable to separate the box and retaining wall at the ends as a foundation.
- The base of the retaining wall should be a spread foundation after carrying out the member calculation and stability calculation as a protective fence foundation.



Source: JICA Study Team based on DPR（Drawing: 14518/E/S5/PC/DD-001）

Figure 6.4.23 Proposed Correction of Retaining Wall Structure on Box

2) Inconsistencies to Correct in the DPR

Because there are inconsistencies to be corrected in the data of the DPR, the JICA Study Team organized and presented the items described in the structure list. The contents are described below. For other points to be noted, refer to the COMMENTS column in the table of Appendix-7 of this report.

6.4.8 Interchange (IC)

(1) Summary

The interchange (IC) is the structure that connects the four national highways (NHs) that intersect the project road. The outline of each IC is shown below:

1) Interchange at NH-5

For the IC that connects CPRR and NH5, the starting point is Kolkata and the end point is Chennai. This IC is a cloverleaf type.

2) Interchange at NH-205

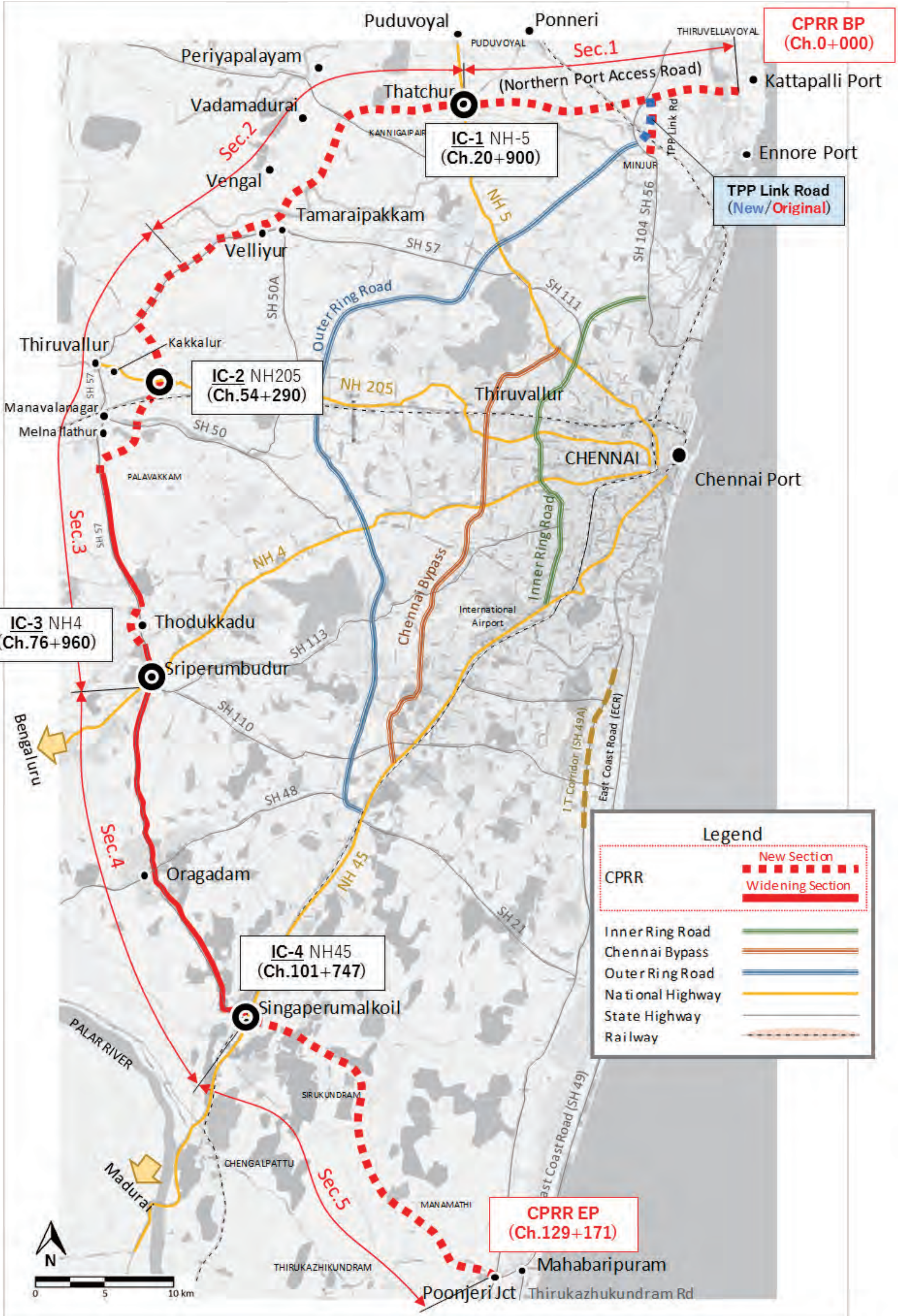
For the IC connecting CPRR and NH205, the starting point is Chennai and the end point is Anaatapur. This IC is a cloverleaf type.

3) Interchange at NH-4

For the IC connecting CPRR and NH4, the starting point is Mumbai and the end point is Chennai. This IC is a cloverleaf type.

4) Interchange at NH-45

For the IC connecting CPRR and NH45, the starting point is Chennai and the end point is Dindigul. This IC is an elevated roundabout type.



Source: JICA Study Team based on Open Street Map

Figure 6.4.24 Location of Interchanges

Table 6.4.29 Interchange Specification

Sec.	No.	STRUCTURE CODE	CHAINAGE		STRUCTURE	INTERSECTIONS	TYPE OF STRUCTURE
			BP	EP			
Sec.1	1	IC/NH5 Str.21/2	20+743	21+043	IC/NH5	NH5	2xPC BOX GIRDER L=300.00m (30.00+2@15.00+6@30.00+2@15.00+30.00)
		IC/NH5 Entry R01	20+803	0+120	IC/NH5 (Rampway)		1xRC BOX GIRDER L=120.00m (6@20.00)
		IC/NH5 Exit R02	0+120	0+000	IC/NH5 (Rampway)		1xRC BOX GIRDER L=120.00m (6@20.00)
		IC/NH5 Exit R01	0+120	0+000	IC/NH5 (Rampway)		1xRC BOX GIRDER L=120.00m (6@20.00)
		IC/NH5 Entry R04	0+120	0+000	IC/NH5 (Rampway)		1xRC BOX GIRDER L=120.00m (6@20.00)
Sec.1 TPP Link	-	-	-	-	-	-	-
Sec.2	-	-	-	-	-	-	-
Sec.3	2	IC/NH205 M01	53+740	53+840	IC/NH205(Main Road)	PWD CANAL	2xPC BOX GIRDER L=100.00m (30.00+40.00+30.00)
		IC/NH205 S01	53+740	53+840	IC/NH205 (Service Road)		2xPC BOX GIRDER L=100.00m (30.00+40.00+30.00) Both side
		IC/NH205 M02	54+090	54+840	IC/NH205 (Main Road)	NH205 & Thanneerkulam Tank	2xPC BOX GIRDER L=600.00m (3@30.00+2@15.00+6@30.00+2@15.00 +9@30.00)
		IC/NH205 S02	54+530	54+620	IC/NH205 (Service Road)		RCC SOLID SRAB L=90.00m(9@10.00)
	3	IC/NH4 M01	74+998	77+253	IC/NH4	NH4, Sriperumbudur Tank	2xPC BOX GIRDER L=2,254.77m (n @ 15.00 ~30.00m) 2 ways
		IC/NH4 R01	0+000	0+300	IC/NH4 (On Ramp)	Sriperumbdur Tank	1 x RC BOX GIERDER L=300.00m (15@20.00m)
		IC/NH4 R02	0+000	0+160	IC/NH4 (Off Ramp)	-	1 x RC BOX GIERDER L=160.00m (8@20.00m)
		IC/NH4 R03	0+000	0+180	IC/NH4 (On Ramp)	-	1 x RC BOX GIERDER L=180.00m (9@20.00m)
		IC/NH4 R04	0+000	0+160	IC/NH4 (Off Ramp)	Sriperumbdur Tank	1 x RC BOX GIERDER L=160.00m (8@20.00m)
		IC/NH4 R05	0+000	0+140	IC/NH4 (On Ramp)	-	1 x RC BOX GIERDER L=140.00m (7@20.00m)
		IC/NH4 R06	0+000	0+140	IC/NH4 (Off Ramp)	-	1 x RC BOX GIERDER L=140.00m (7@20.00m)
Sec.4	-	-	-	-	-	-	-
Sec.5	4	IC/NH45 R01	0+183.790	0+731.21	IC/NH45 (Ramp-1)	NH45	3xRCC T-GIRDER L=547.420m (10@20.0+2@20.0+21.71+24.0+21.
		IC/NH45 R02	0+734.57	0+187.15	IC/NH45 (Ramp-2)		3xRCC T-GIRDER L=547.420m (10@20.0+2@20.0+21.71+24.0+21.
		IC/NH45 Str.102/1	101+837.22	102+097.55	IC/NH45 (Main Roa		1xPC BOX GIRDER L=263.409m (20.00+20.33+11@20.00)

Source: JICA Study Team

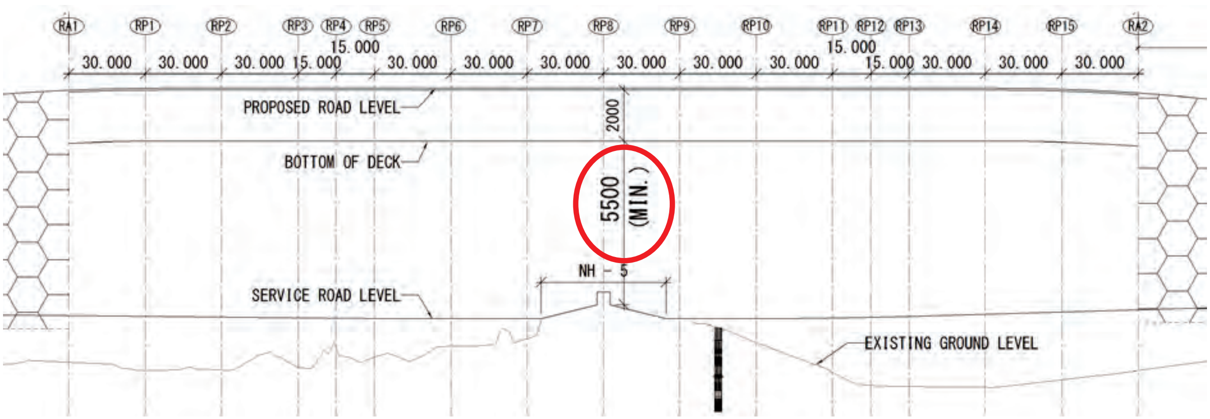
(2) Standard and Design Condition

In the DPR Main Report: P7-1, it is stated that the planned structure conforms to the following standards:

・Indian Roads Congress（IRC）・MORTH
・IRC: SP: 90-2012,: Manual for Grade Separators and Elevated Structures.
・IRC: 92-1985: Guidelines for the Design of Interchanges for the Urban Area.

(3) Confirmation of Intersections

For the IC, the longitudinal alignment has been determined so as to secure a building limit of 5.5 m from the intersecting NH, and it is concluded that there is no particular problem with regard to this plan.



Source: JICA Study Team based on DPR (Drawing: 14518/E/IC/NH5/DD-001, SHEET 2 OF 3)

Figure 6.4.25 Vertical Clearance (IC/NH5)

(4) Confirmation of Bridge Type and Structure

1) Bridge Length and Span length

It is considered that the necessary bridge length is ensured for the intersections (rivers, canals, national highways, etc.). In addition, since the span length of the bridge is equal to the standard span length of concrete bridges that is constructable, i.e., from 25~30 m, it is presumed that there will be no major problem with the bridge plan (span and bridge lengths).

2) Type of Superstructure

Bridge span length is set to be 20 to 30 m to basically avoid interference with intersections. In addition, in CPRR, the plan of superstructure is based on a concrete bridge which is more economical than a steel bridge, and the span length is based on the span applicable to a concrete bridge.

The IC is a curved bridge, and the superstructure (main line bridge: PC box girder) must be suitable for curves. In Sections 2 and 3, the ramp bridge is consolidated in the shape of a box girder with a small span, L = 20 m.

The investigation team concluded that there is no particular problem with the adoption of concrete bridge as the superstructure since no special bridge is being adopted. However, it is necessary to confirm whether there is no mistake in the following descriptions:

- ➢ The superstructure of the ramp bridge adopts box girder to match the structure of the main road bridge; it is an RC box girder due to its short span length (Sections 2 and 3).
- ➢ According to the drawing, the superstructure of the ramp bridge of Section 5 is an RC-T girder structure. To match the structures in CPRR, the possibility of changing to RC box structure during the detailed design is being considered.

Table 6.4.30 Confirmation of Span Length and Type of Superstructure (IC)

Type				Span (m)	Span20m～30m (10 / 20 / 30 / 40 / 50)	Adaptation to curve	Height of girder/span
P	precast girder erection	Pre tension	simple	hollow slab		×	1/20～1/24
				Tgirder		×	1/13～1/17
			continuous	Tgirder		×	1/13～1/17
		post tension	simple	Tgirder		×	1/13～1/17
				composite I		×	1/12～1/16
			continuous	Tgirder		×	1/13～1/17
C	support erection		simple	hollow slab		○	1/20～1/24
				Box		○	1/15～1/20
			continuous	Box		○	1/15～1/20
	PRC hollow slab					○	1/18～1/22
	PC compo					×	1/16～1/15
	RC		Box			○	1/10～1/15

Source: JICA Study Team

3) Type of Substructure

The cross section of the main bridge is not described in the DPR. However, since both ends of the bridge are made up of reinforced earth walls and because they are located on land, the substructure is considered to be a combination of a pier type and a reinforced earth wall which has already been adopted in India.

- The adoption of this structure is considered to have no problem.

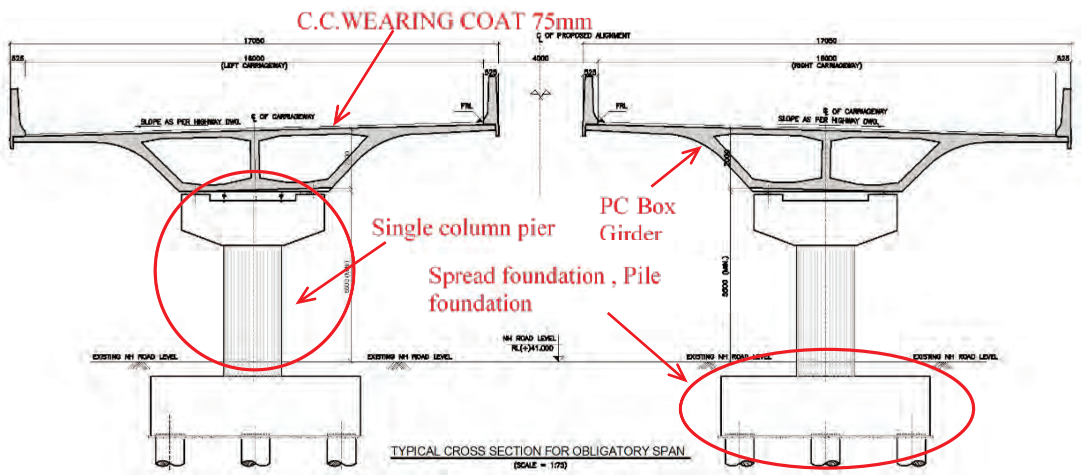
4) Type of Foundation

Spread foundation and pile foundation (bored pile φ 1000 mm) is planned for the IC.

The design report received after the completion of the review specifies ground condition, type of pile foundation, extensions, and other design details.

5) Type of Pavement

In the final DPR, the planned bridge pavement material is concrete. However, asphalt pavement is used in the vicinity of earthworks section as well as ORR while concrete asphalt is used in the already constructed bridge at the end of Section 4. Although material procurement could be the main consideration, other factors such as consistency must also be considered in the determination of pavement material during the detailed design.



Source: JICA Study Team based on DPR（Drawing: 14518/E/IC/NH5/DD-001, SHEET 2 OF 3）

Figure 6.4.26 Bridge Cross Section（IC/NH5）

6) Reinforced Earth Wall Protection

In CPRR, the height of the reinforced earth wall at both ends of the bridge tends to be larger than average. The objective is to shorten the bridge by increasing the height of the reinforced earth wall. In general, it is said that the actual height and the empirical standard height are about 12 m at maximum. Thus, it was verified whether the reinforced soil wall height planned in the CPRR exceeds the said value or not.

- Since there is no reinforced earth wall exceeding the reference height (12 m), it was concluded that the setting of the reinforced earth wall section is acceptable.

Table 6.4.31 Confirmation Result of Reinforced Earth Wall Height (IC)

Sec.	Name of structure	Chainage		Maximum height of re-Wall（m)		
Sec.2	IC/NH5	20+246	20+742	6.50	<	12.00
		21+043	21+506	6.80	<	12.00
		0+288.479	0+120	4.10	<	12.00
		0+288.479	0+120	4.50	<	12.00
		0+120	0+000	4.50	<	12.00
		0+262.375	0+120	4.10	<	12.00
Sec.3	IC/NH205	53+617	53+740	6.10	<	12.00
		54+090	54+840	10.30	<	12.00
		54+840	54+944	8.60	<	12.00
		0+120	0+273	6.30	<	12.00
		0+120	0+278.282	6.00	<	12.00
		0+120	0+278.626	6.30	<	12.00
		0+120	0+278.485	6.30	<	12.00
	IC/NH4	74+633	74+998	8.00	<	12.00
		77+253	77+865	7.80	<	12.00
		0+300	0+383	7.00	<	12.00
		0+160	0+270	7.00	<	12.00
		0+180	0+192	7.00	<	12.00
		0+160	0+233.3	7.00	<	12.00
		0+140	0+364	7.00	<	12.00
		0+140	0+412	7.00	<	12.00
Sec.5	IC/NH45	0+060	0+183.790	5.30	<	12.00
		0+731.21	0+875	5.70	<	12.00
		0+891	0+734.57	4.80	<	12.00
		0+187.15	0+060	4.30	<	12.00
		102+097.55	102+243.33	6.30	<	12.00

※For the height of the reinforced soil wall, PDR (Dwrawing) was referred to.For those without dimensions, we measured the drawing.

Source: JICA Study Team

(5) Advice and Suggestions for the DPR

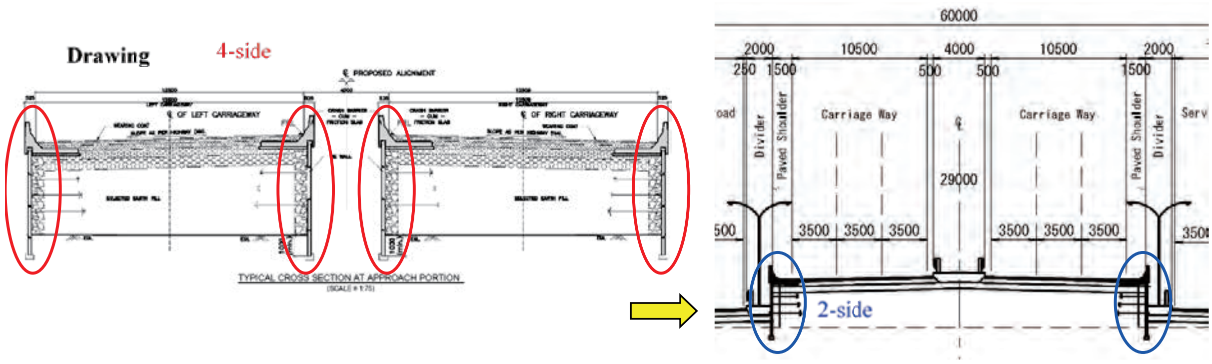
1) Inconsistencies to Correct in the DPR

Because there are inconsistencies to be corrected in the data of the DPR, the JICA Study Team organized and presented the items described in the structure list. The contents are described below. For other points to be noted, refer to the COMMENTS column in the table of Appendix-7 of this report.

【Common Subject Matter】

The sectional view of a reinforced earth wall is in the drawing, and "Terre Armee" is placed between the northbound and southbound lanes and the total count is four lanes. However, for bridges other than IC, there is no cross section drawing but the number is counted in two-surface construction where no reinforced earth wall is placed between the northbound and southbound lanes.

- The distance between the northbound and southbound lanes is about 4 m. If the reinforced earth wall is arranged on the back of the bridge end, two sides can be constructed, and the structure is economical. Therefore, a plan for reinforced earth wall of IC with two side construction is proposed.



Source: JICA Study Team based on DPR Drawing（14518/E/IC/NH5/DD001: SH-2 OF 3）

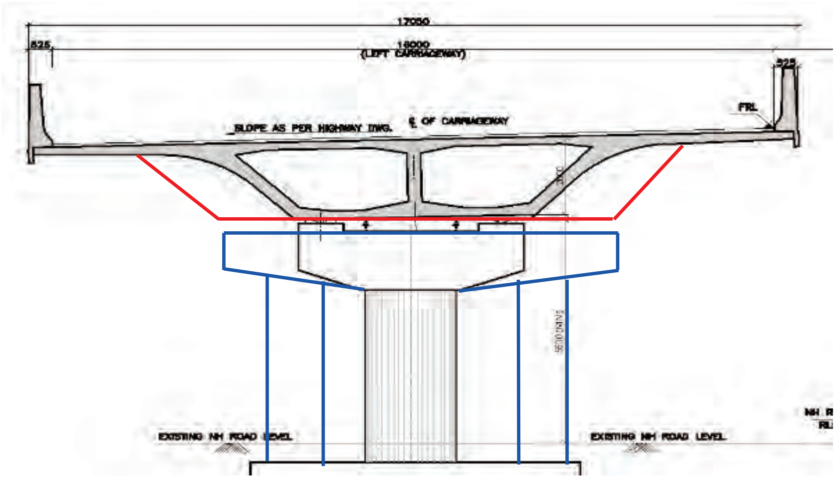
Figure 6.4.27　Cross Section of Reinforced Earth Wall (IC)

【Section 2】

The cantilever slab length is about 4.5 m as measured in the drawing. This length is extremely long and is considered to be a heavy structural burden with the assumed dead and live loads.

- It is generally preferable that the cantilever length of PC slab is within 3 m and a review of the structure of the PC box girder for the purpose of reducing the cantilever length is proposed.
- It is better to plan a three box girder because the space is wide. In addition, concerning the width of the beam of piers, it is necessary to revise the structure as well as review the box girder.
- The distance from the edge of the footing to the center of the pile should be at least the diameter of the pile.
- Also, confirm at the time of detailed design whether a punching shear strength is secured in the case of the horizontal force act from the pile to the footing.

Note: For example, changing the structure to Rahmen type piers, etc.



Source: JICA Study Team based on DPR Drawing（14518/E/IC/NH5/DD001: SH-2 OF 3）

Figure 6.4.28　Proposed Cantilever Length of Slab

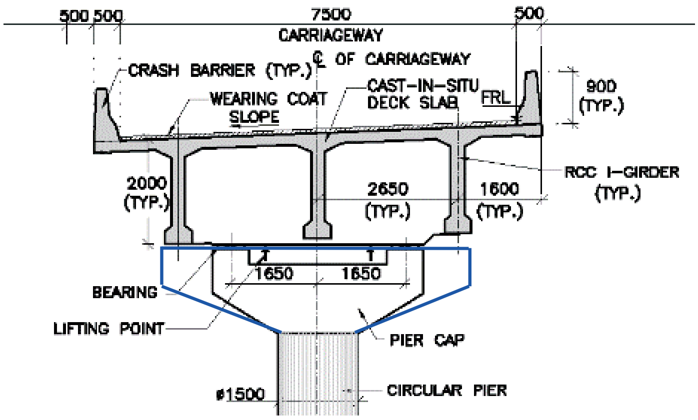
【Section 3】

The section along the shore of Sriperumbudur is the approach section to the interchange with National Highway No. 4 and consists of the retaining wall section and the bridge section. Since the route is located in the green area of the lake shore, it is proposed to consider the landscape at the detailed design stage such as greening the lower part of the girder bridge section considering the water scenery from the lake shore side.

【Section 5】

The position of the bearing that supports the superstructure is based on the cross beams and the spacing of the outer main girders is greater than the width of the beam of pier.

- To ensure that the vertical load is supported and to preserve the rigidity of the main girder, it is proposed that the beam width be larger than the outer main girder spacing and that the bearing be placed under the main girders.



Source: DPR Drawing (14518/E/IC/NH5/DD001: SH-2 OF 3) Added by JICA Study Team

Figure 6.4.29 Proposed Revision of Pier Support

6.4.9 Structure List and General Drawings

The Structure List prepared by the JICA Study Team is shown in Appendix-7 of this report. In addition, the bridge general drawings for MJB, MNB, ROB, VUP, VUP, BC/PC, and IC are shown in Appendix-8.

6.5 Design Update (Section 1)

As described earlier in this report, some missing parts of the DPR such as “Design Report (Structures)”, “Drawings”, and “Rate Analysis” were provided after the review period. Major changes in the newly provided materials are: design update by HMPD, modifications for the JICA Study Team comments at IT/R2, agreement issues in the JICA mission held in February and April 2018, and other updates. However, further modification and updating of the DPR are still ongoing by HMPD even at the time of the DFR, and this situation results in inconsistencies among the series of provided materials, such as report, drawing, and quantities.

In this section, the result of the review of the provided materials and suggestions to be considered in the further detailed design stage are described.

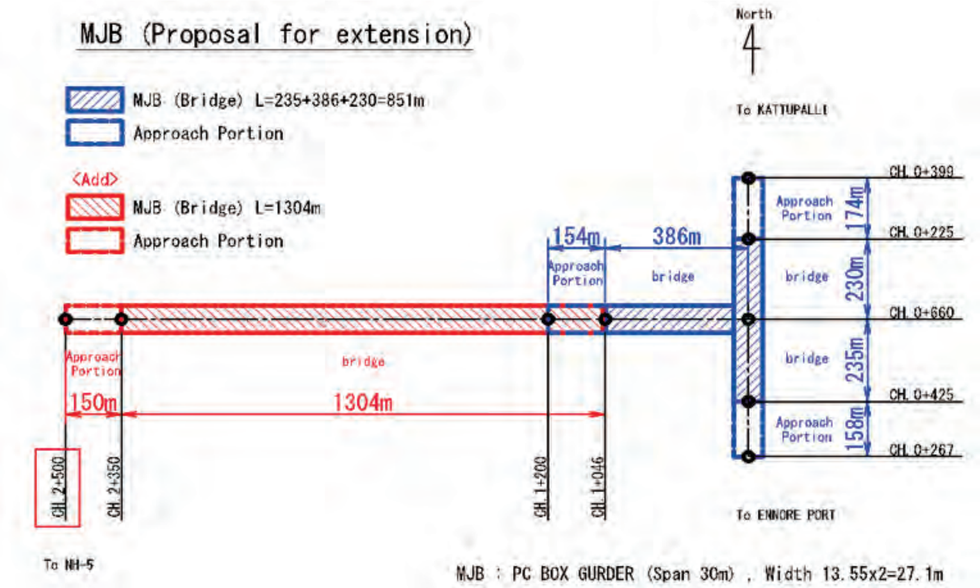
6.5.1 Main Renewed Points

(1) Bridge Extension Near the Beginning Point (MJB101)

The end chainage of MJB101 was originally Ch.1+200 but it will be revised to approx. Ch.2+500 as per TNRDC meeting held on April 24, 2018. The JICA Study Team considered the extension but could not be reviewed since there is no detailed plan yet. Therefore, a thorough design review of the extension must be carried out during the detailed design.

The following are considered in the cost estimate of the JICA Study Team:

- Extension of MJB end chainage to Ch. 2+500 from Ch. 1+200
- The bridge type is initially set as a 30 m span PC box girder according to the DPR
- One bridge and four box culverts are removed from this section: MNB101, BC2/1～BC2/3 and BC3/1



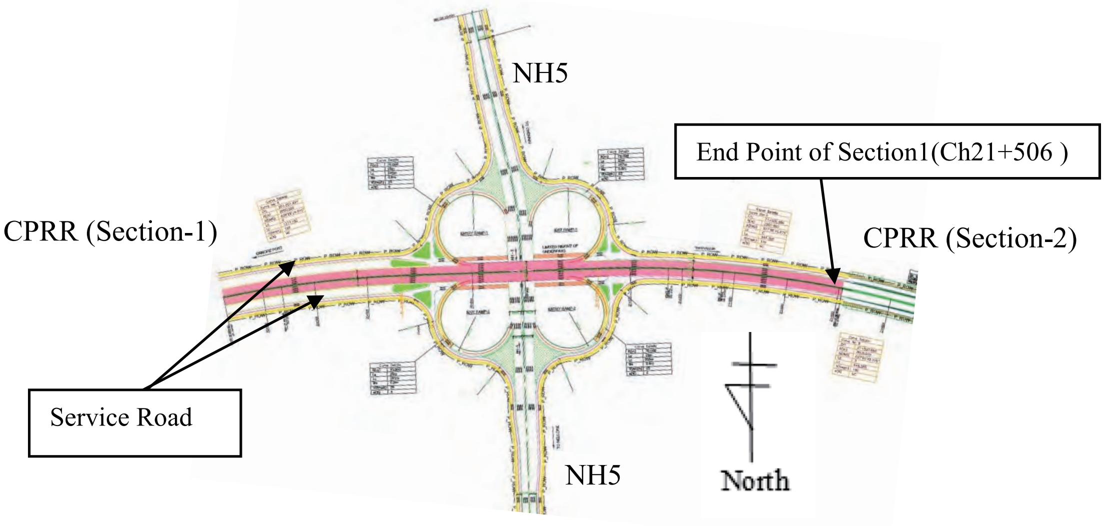
Source: JICA Study Team

Figure 6.5.1 MJB101 Extension Plan

(2) Changing of IC-1 (NH5) to Section 1

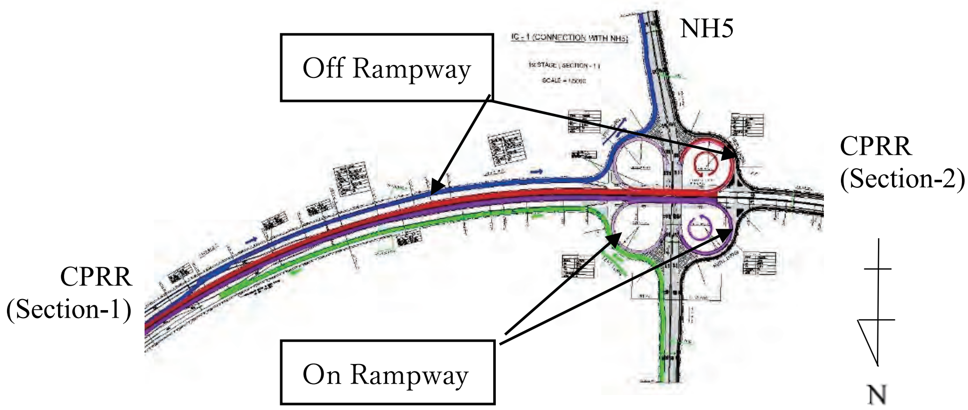
When the review of the DPR was executed for the whole section, IC-1 was included in Section 2. However, when the meeting with HMPD was held in February 2018, it was decided that IC-1 will be included in Section 1. Therefore, the end point of Section 1 became the edge of the retaining wall (Ch.21+506) which is connected to the interchange bridge (this position was confirmed at the TNRDC meeting on April 24, 2018). For this reason, the access to Section 2 becomes unnecessary. The study of traffic operation and the stage construction for connection with Section 1 and NH5 are required.

Plan of IC-1 is shown in Figure 6.5.2, and Traffic Operation Chart of IC-1 is shown in Figure 6.5.3.



Source: JICA Study Team

Figure 6.5.2 Plan of IC-1



Source: JICA Study Team

Figure 6.5.3 Traffic Operation Chart of IC-1

(3) Installation of Toll Barrier

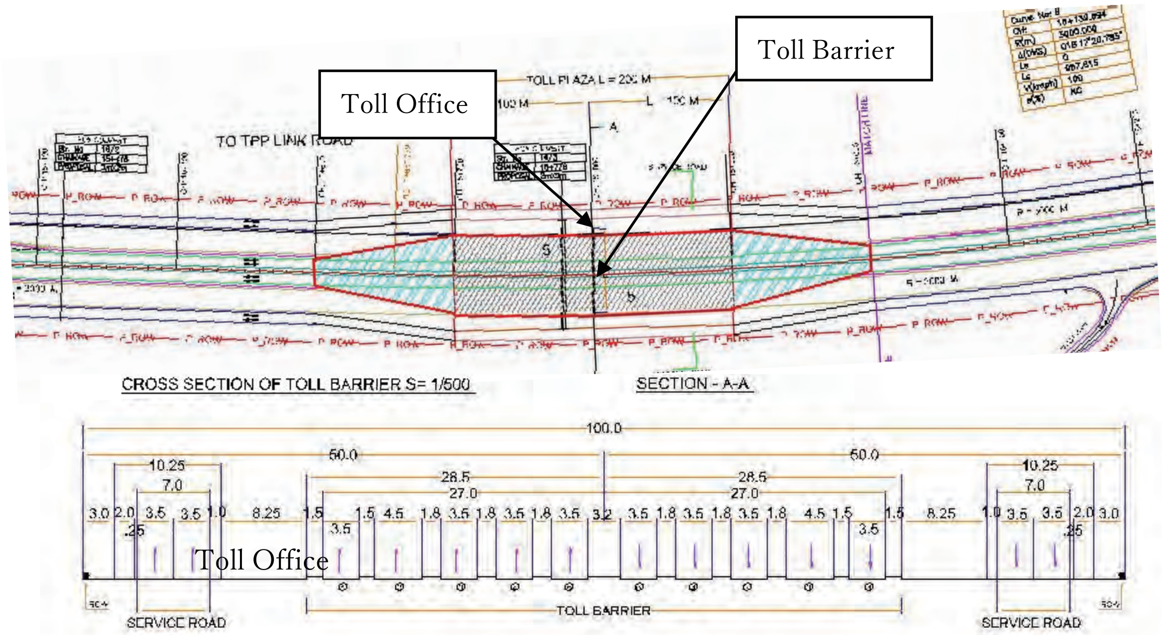
Partial access control of toll road was studied in which it is possible to access the service road from the entry and exit to the service road except in interchange considering the type of interchange (clover leaf is unfavorable to install toll gate) and the connection with the service road. Therefore, open system was adopted, and some toll barriers were planned in order to reduce the inequality of the toll rate.

Toll barrier was planned at the location with high visibility of the toll gate at the grand horizontal and vertical alignment, avoiding the structure section, and also away from at-grade intersection. Locations of toll barriers were at Ch.15+800 and Ch.2+200 on CPRR, and at Ch.1+200 on TPP Link Road.

Moreover, the toll booth and the toll office were planned within the right of way (ROW 100 m) in consideration of the installation of ETC lane and the width of the island. As a result, the service road was shifted outside at the toll barrier section.

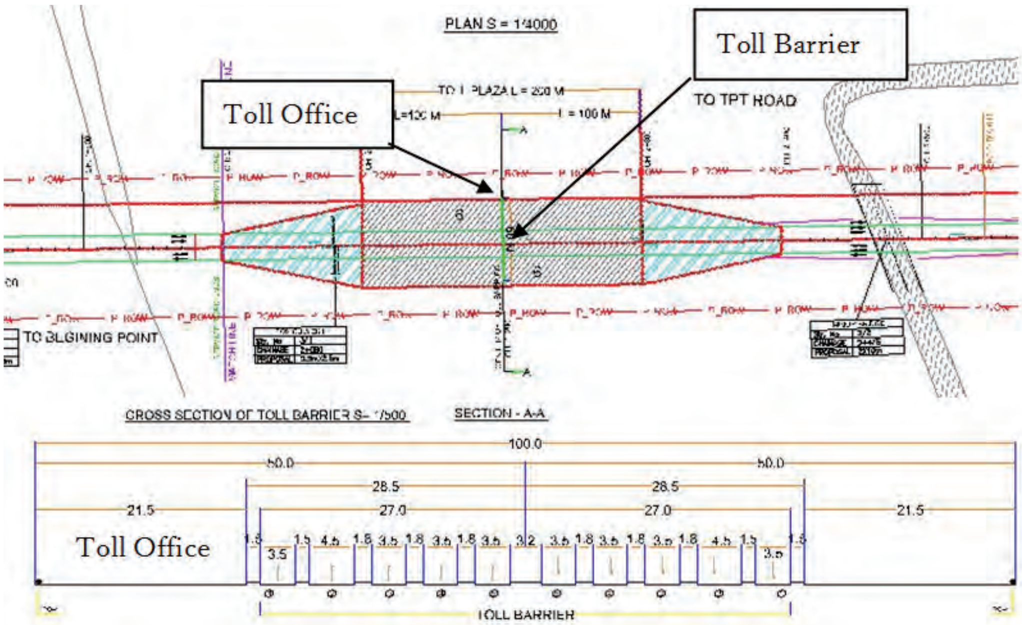
The width and the length of the island conformed to the Indian expressway design standard (IRC-SP99-2013).

Plan and cross section of toll barriers on CPRR are shown in Figure 6.5.4 and Figure 6.5.5, respectively, and that of TPP Link Road is shown in Figure 6.5.6.



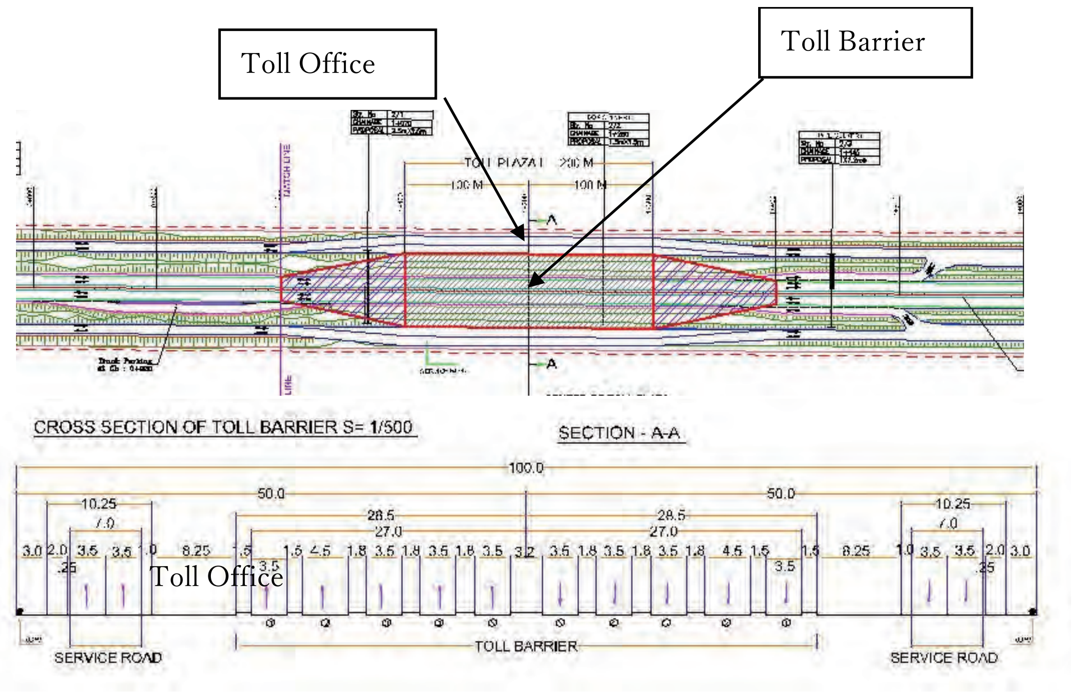
Source: JICA Study Team

Figure 6.5.4 Toll Barrier on CPRR Ch.15+800



Source: JICA Study Team

Figure 6.5.5 Toll Barrier on CPRR Ch.2+200



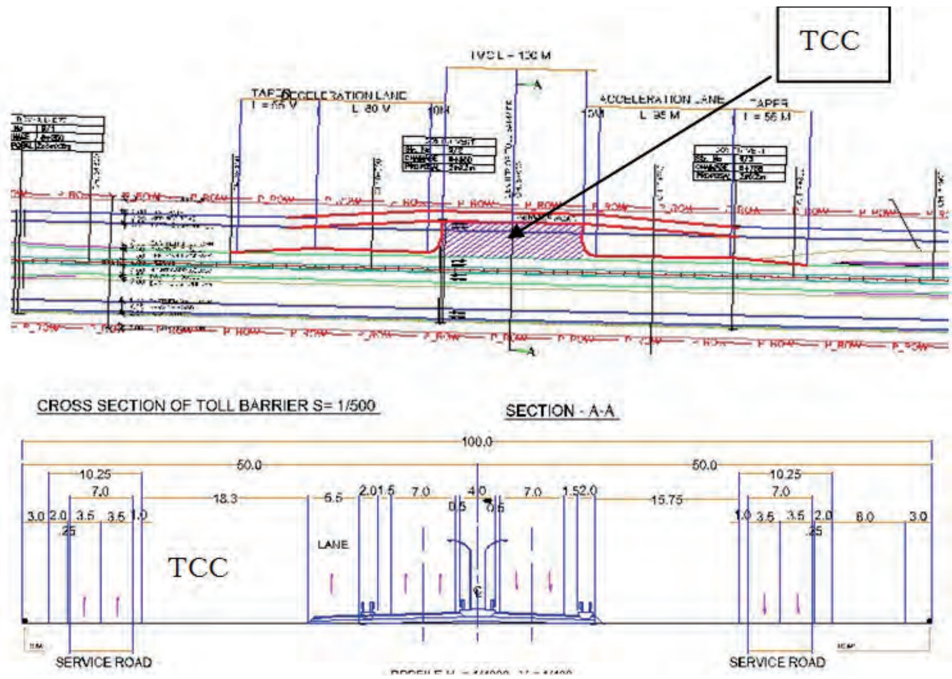
Source: JICA Study Team

Figure 6.5.6 Toll Barrier on TPP Link Road Ch.1+200

(4) Installation of Traffic Control Center

Traffic control center (TCC) was planned in the earthwork section within Section 1 in consideration of road alignment and land area which is for office building and parking area. The location of TCC was planned at Ch.8+600 on CPRR. Acceleration lane and deceleration lane were planned in consideration of traffic safety because there are exits and entrances at the connection between the main road and TCC.

Plan and cross section of TRC are shown in Figure 6.5.7.



Source: JICA Study Team

Figure 6.5.7 Traffic Control Center on CPRR Ch.8+600

(5) Alignment Change of TPP Link Road

The road stretch of Section 1 consists of Northern Port Access Road (NPAR) and TPP Link Road.

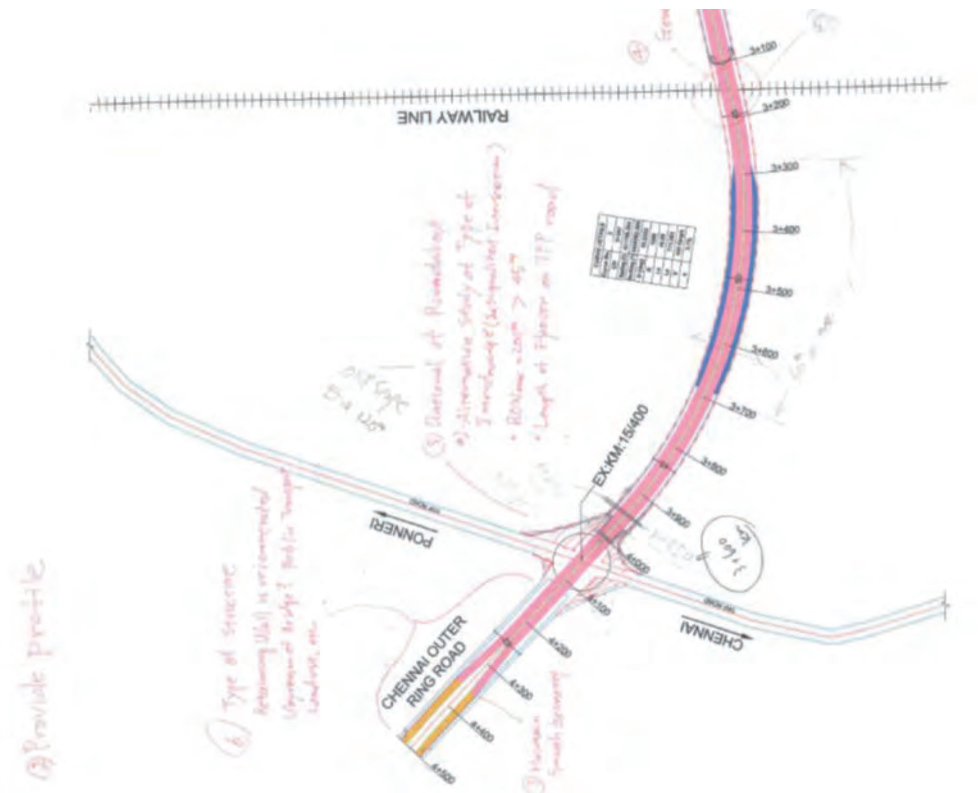
During consultation with inhabitants around the site of TPP Link Road (original alignment), it was found that it is important to obtain social consensus for the road construction. As an alternative solution to minimize the social impact, the south end of TPP Link Road is to be shifted approximately 1.5 km west from the original alignment. This new alternative alignment has a total length of 3.6 km from the connecting point with NPAR to the southern end. The length of 1.65 km in the northern part is the same as the original alignment, and the remaining 1.95 km in the southern part is different from the original alignment.

Through an additional survey at the alternate site, social consensus was confirmed for the new alignment. Therefore, it is expected that NPAR and TPP Link Road (new alignment) will become Section 1 of the Japanese ODA Loan Project.

At the southern end of TPP Link Road (new alignment), it is planned to cross overhead of the TPP Link Road near Minjur and connect directly to the ORR.

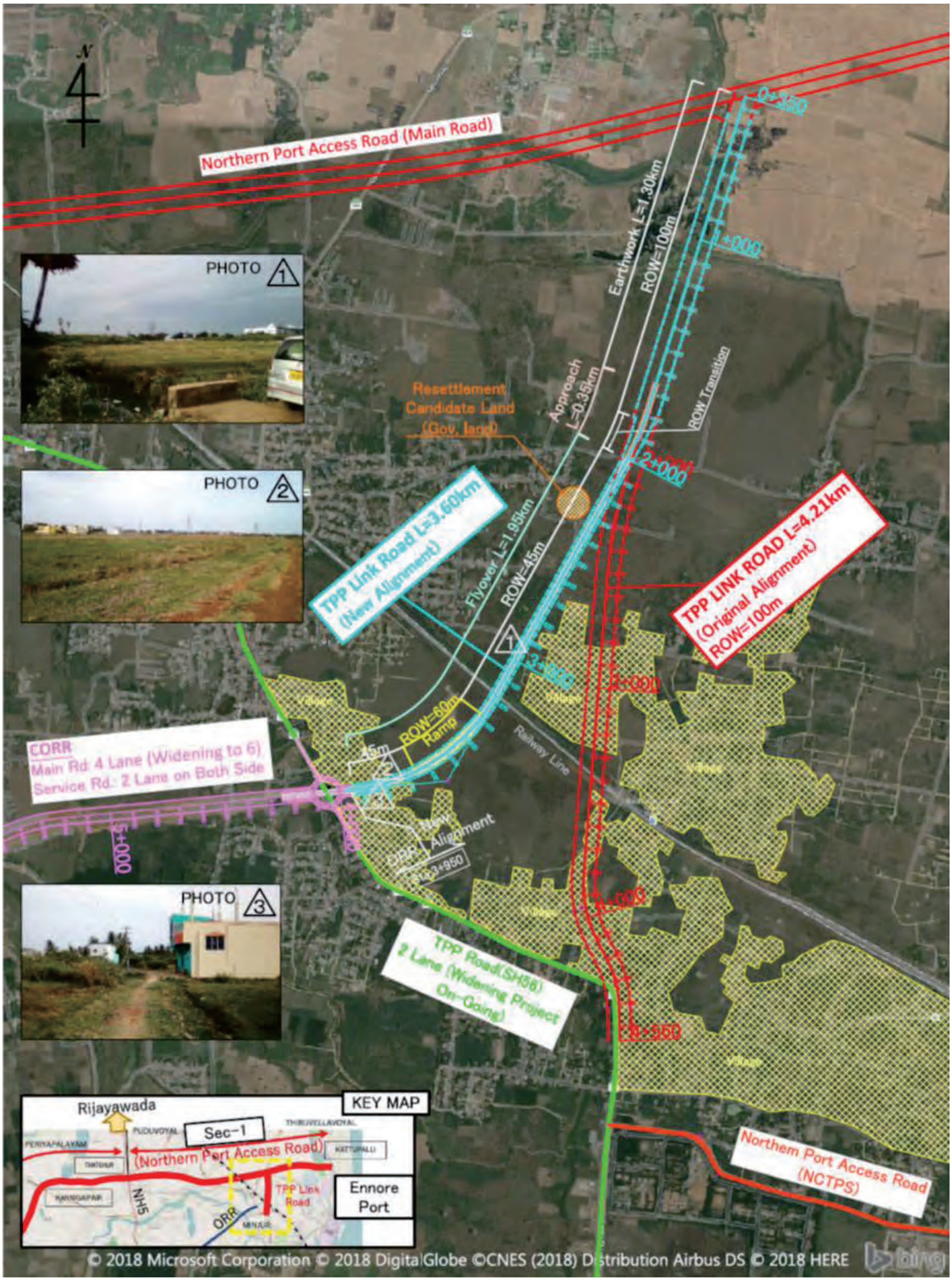
In the TPP Link Road (new alignment), the section subject to ODA loan will be a stretch from Ch.0+350 (the north end) up to Ch.3 + 950, and the south is to be constructed under the ORR development project.

A part of the design drawing obtained from the local consultant STUP is shown in Figure 6.5.4, and the overall view relating to the alignment change is shown in Figure 6.5.8.



Source: STUP

Figure 6.5.8 Connecting Point with ORR at the South End of TPP Link Road (New Alignment)



Source: JICA Study Team

Figure 6.5.9 Alignment Change Plan of TPP Link Road

6.5.2 Design Quantity

Since design quantities are presented in a summarized manner and detailed quantities of each structure are not available in the DPR reports, preliminary check on major items was conducted in this Study. As a result, no fatal errors were found in the design quantities of major items. Therefore, in the cost estimate in this Study, design quantities presented in the DPR are to be utilized while unit prices are to be updated.

6.5.3 Recommendation on Detailed Design of Section 1

Based on the review results above, suggestions to be noted at the detailed design stage of Section 1 are as follows. In general, further examination is recommended on the contents of the DPR which were provided after conducting the review of the JICA Study Team.

(1) Suggestion on Road Design

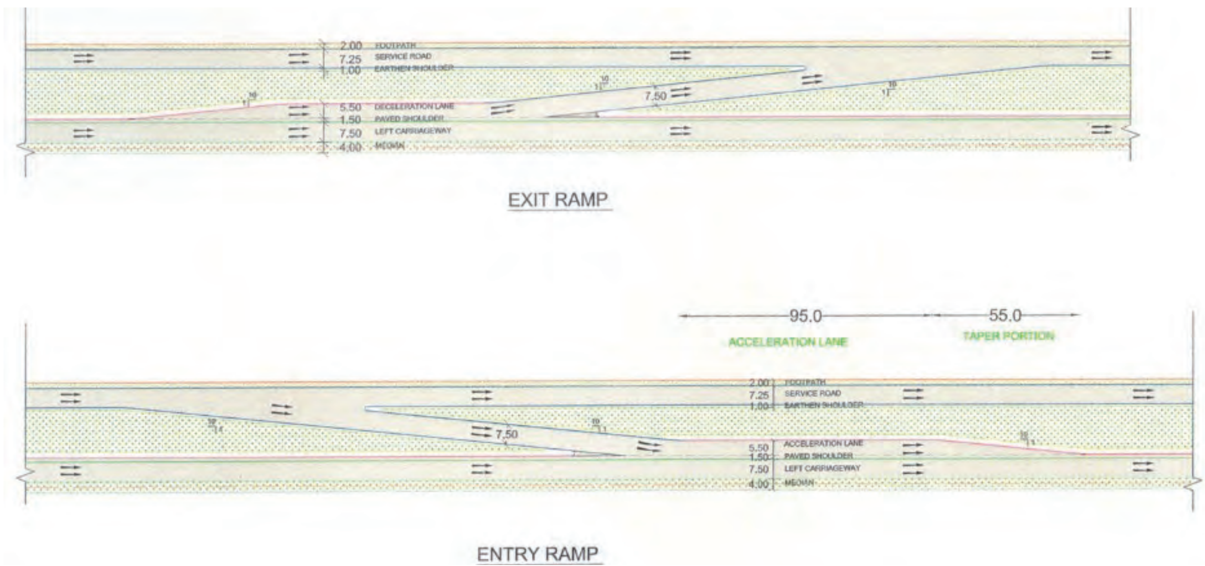
1) Road Alignment

Vertical alignment was corrected by the JICA Study Team because some vertical curve length of the main road (CPRR) did not satisfy the design standard (IRC73-1980).

2) Connection of Main Road and Service Road

The connection between acceleration and deceleration lane of main road and service road with small radius curve was changed to rampway type by the JICA Study Team. Therefore, traffic safety will improve because vehicles can wait on the rampway. Moreover, it is necessary to add traffic signs in the detailed design because the visibility of connecting point becomes worse with the small intersecting angle, although the safety will increase by changing to a one-way road.

Layout of entry and exit is shown in Figure 6.5.10 below.



Source: JICA Study Team

Figure 6.5.10 Layout Plan of Entrance and Exit

3) Improvement on IC-1 (NH5)

The service road was changed to one-way traffic according to the JICA Study Team. The box culverts were installed under the main road and H5 in order to connect each service road within the interchange area.

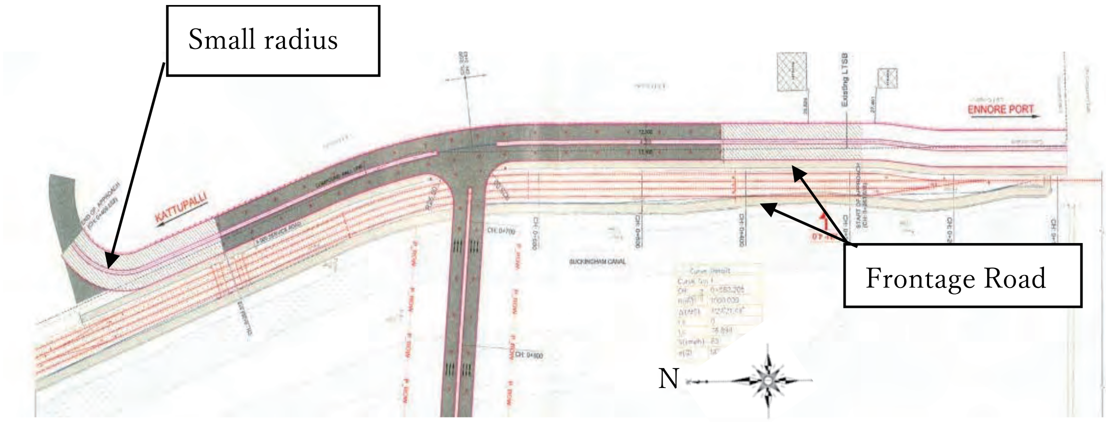
As a result of this, the connectivity was improved, but it became difficult to guide to destination.

The left-turning traffic from CPRR main road to NH5 passes through the service road (it is not direct connection ramp). Therefore, increase of travel time and decrease of traffic safety are expected because of the increase of future traffic volume. Refer to the plan of IC-1 (See Figure 6.5.2).

4) Improvement on JCT-1 (Beginning Point)

In the Interim Report, north-south direction traffic at the beginning point was suggested to pass on the ground instead of the flyover (frontage road is provided for north-south direction). However, afterwards, the direction of the alignment of the north side was changed from the north direction to the east direction. Therefore, it became dangerous because the small radius curve continues after the straight and steep alignment at the north side of the beginning point. Consequently, it is necessary to improve safety by enlarging the radius of curve and installing traffic sign in the detailed design.

Plan of JCT-1 is shown in Figure 6.5.11.



Source: JICA Study Team

Figure 6.5.11 Plan of JCT-1

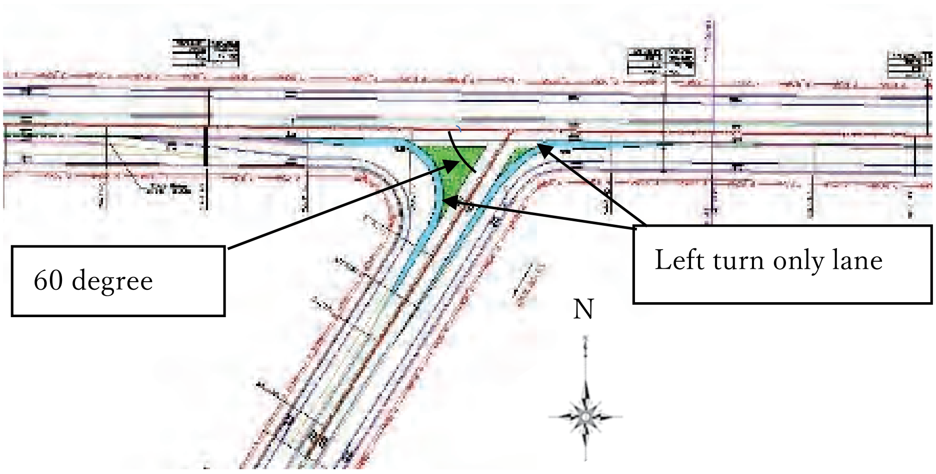
5) Improvement on JCT-2 (Connect with TPP Link Road)

It is recommended again to add the left turn only lane in order to increase traffic safety and the traffic capacity of the left turn traffic from the main road to TPP Link Road.

Plan of JCT-2 is shown in Figure 6.5.12.

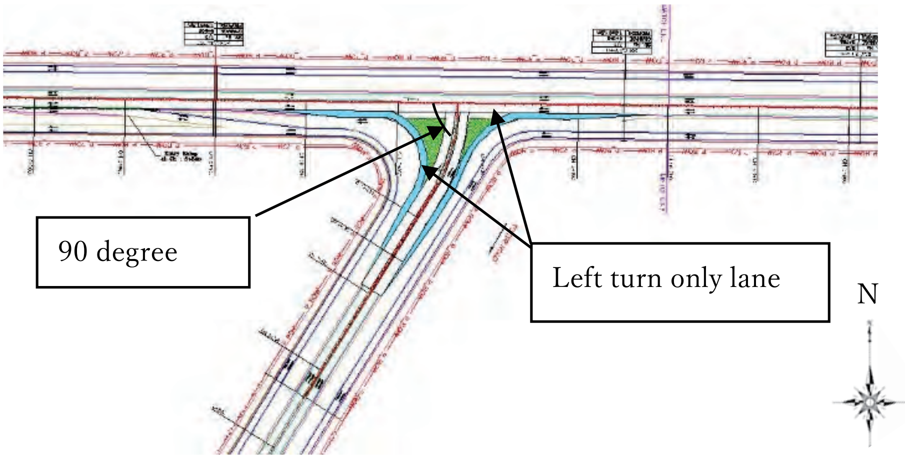
It is proposed as an alternative to change the intersection angle from 60 degrees to 90 degrees between the main road and the TPP Link Road. It can increase the capacity by reducing the intersection area and increase the safety by improving the visibility.

Alternative plan of JCT-2 is shown in Figure 6.5.13.



Source: JICA Study Team

Figure 6.5.12 Plan of JCT-2



Source: JICA Study Team

Figure 6.5.13 Traffic Control Center on CPRR Ch.8+600

(2) Suggestion on Structure Design

1) Inclusion of the Railway Plan (MJB101)

HMPD states that MJB101 is planned to be connected by railroad in the north and south, but it has no detailed plan as of now and it is also not considered in the final DPR.

Details of MJB101 railroad plan such as clearances, determination of bridge type based on construction limits, span arrangement and others must be reflected in the detailed design. The railway company must be involved in the confirmation process as well.

2) River Conditions (MJB, MNB)

Although the cross section and water level (FWL) are shown in the final DPR (drawing), it could not be verified on site. Verification of the cross section and water level by means of tests must be done prior to the detailed design. The water level during construction must be checked as well.

3) Abutment Type (MJB101, 202, 301)

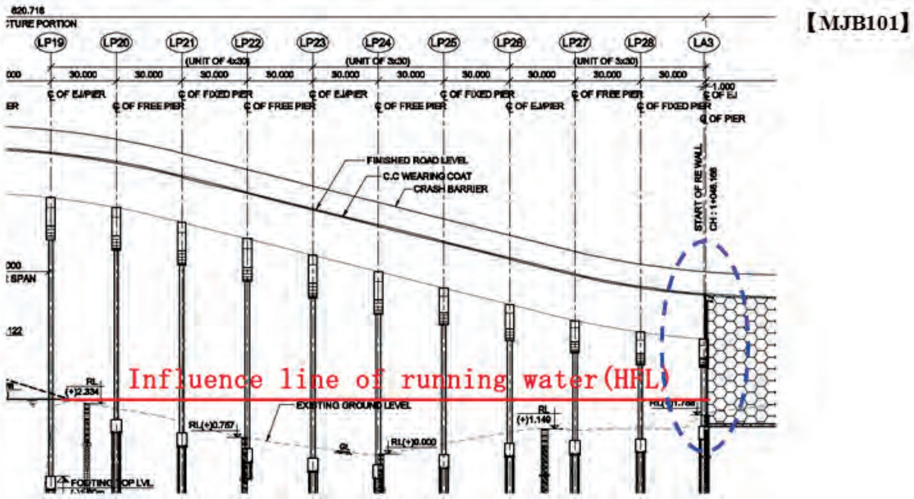
The structure of some river bridge abutments is not found to be a common abutment structure but a combined structure of reinforced earth wall and pier.

Although HMPD stated that these structures are not affected by the water current, it would be better to adopt the abutment structure and hydraulic force countermeasures because the common reinforced earth wall is weak against hydraulic force. During the detailed design, it is necessary to review and study the abutment structures upon conducting hydrologic surveys and upon checking the water level.

Table 6.5.1 Suggestion on the Abutment Type (MJB101)

Sec.	No.	STRUCTURE CODE	Location	Revision Suggestion			
				Plan of DPR	Affected by running water	Suggestion	
Sec.1	1	MJB101-1 Str.No.1/1	A1(Start point)	Pier + RE Wall	No (land)	→	No change
			A3 End point	Pier + RE Wall	Yes	→	Change from pier to Abutment
		MJB101-2 Str.No.1/1	A2(End point)	Pier + RE Wall	No (land)	→	No change

Source: JICA Study Team



Source: JICA Study Team based on DPR (Drawing)

Figure 6.5.14 Abutment of MJB101

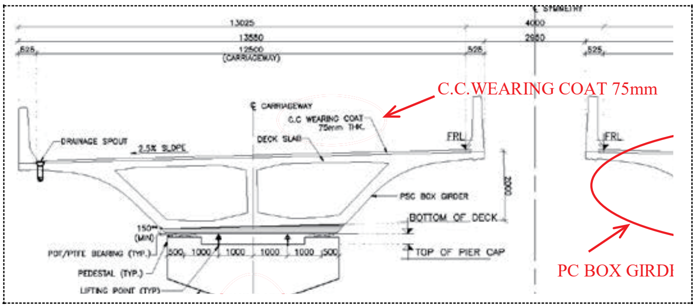
4) Reduction of Substructures on River (MJB, MNB)

The bridge plan in the final DPR is based on the minimum span of concrete bridges excluding ROBs.

Although the ease of superstructure construction could be the major consideration in the plan, constructability becomes inferior by placing several piers due to the increase of path obstruction rate and cost of temporary construction equipment particularly in MNBs on narrow rivers. The current plan is considered economical by HMPD as opposed to the opinion of the JICA Study Team. This is an important matter that must be reviewed in the detailed design.

5) Type of Pavement (All Bridges)

In the final DPR, the planned bridge pavement material is concrete. However, asphalt pavement is used in the vicinity of earthworks section as well as ORR, while concrete asphalt is used in the already constructed bridge at the end of Section 4. Although material procurement could be the main consideration, others such as consistency must also be considered in the determination of pavement material during the detailed design.



Source: JICA Study Team based on DPR (Drawing)

Source: JICA Study Team

Figure 6.5.15 Cross Section of MJB101 and Constructed Bridge in Section 4 (Concrete Pavement)

6) Consultation with the Railway Company (ROB)

The ROBs design condition, construction limits, and bridge plan must be confirmed during the consultation with the railway company. Since there is no record of consultation in the DFR, the railway company must be consulted to confirm details such as the sequence and the bridge plan and to obtain approval.

7) Further Investigation About Superstructure and Substructure Type (VUP)

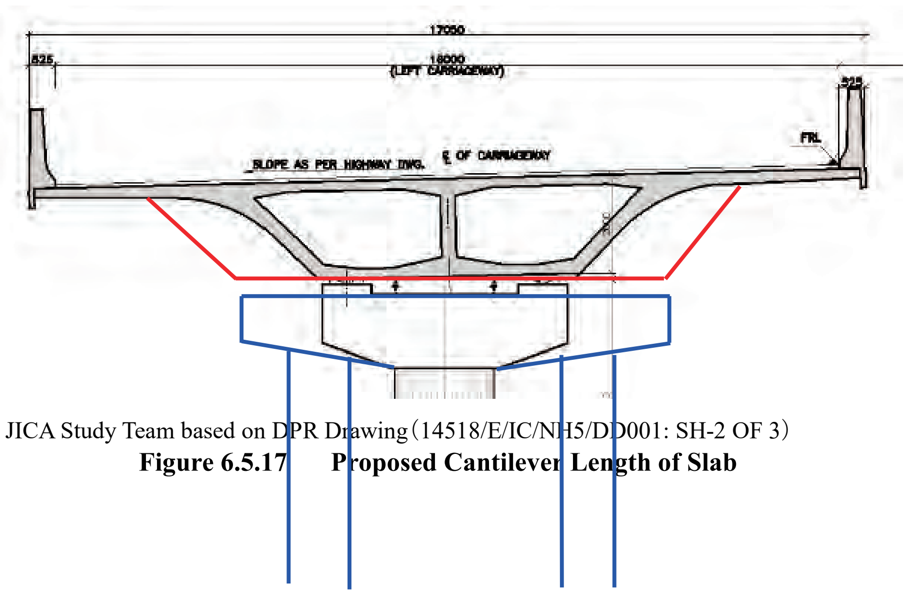
In the final DPR, the adopted structure is a reinforced concrete girder with minimum span while in ORR, a simply supported box girder bridge is adopted. The type of structure must be finalized in the detailed design considering economy and constructability. In addition, by adopting a box girder bridge, expansion joint and bearing may be omitted resulting to ease of maintenance.

Source: JICA Study Team

Figure 6.5.16 VUP in the Outer Ring Road（Box, Block Wall）

8) Slab Cantilever Length (IC/NH5)

The deck cantilever is about 4.5 m. Although this design is valid in HMPD, it is preferable not to set the length to maximum considering deterioration and unexpected loadings. Adjustment of edge curvature or box girder width in order to attain the preferable length is advised.

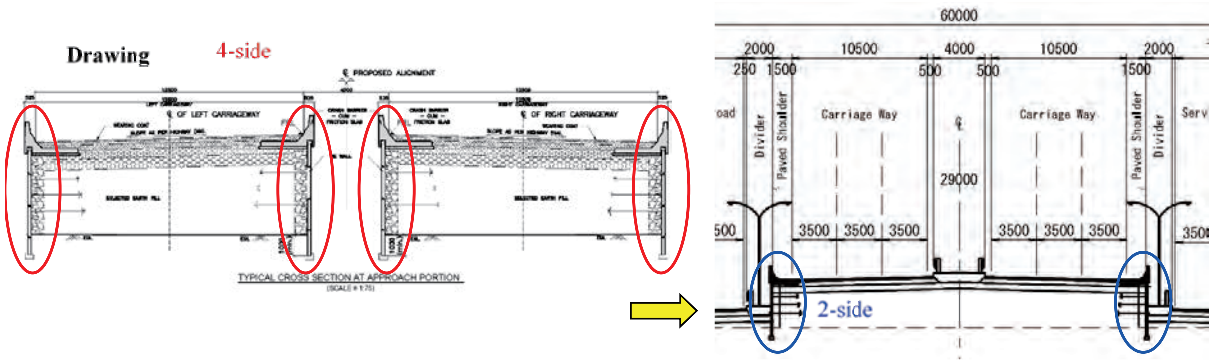


Source: JICA Study Team based on DPR Drawing（14518/E/IC/NH5/DD001: SH-2 OF 3）

Figure 6.5.17 Proposed Cantilever Length of Slab

9) Number of Face of Reinforced Earth Walls (IC)

Reinforced earth walls are placed between each gap of the upper and lower lanes of IC. The total number of faces is four. The said gap is about 3 m high if it is filled with soil. There will be two installation faces of reinforced earth wall which in turn will be economical. For bridges other than IC, there are two faces, but this should be reviewed in the detailed design.

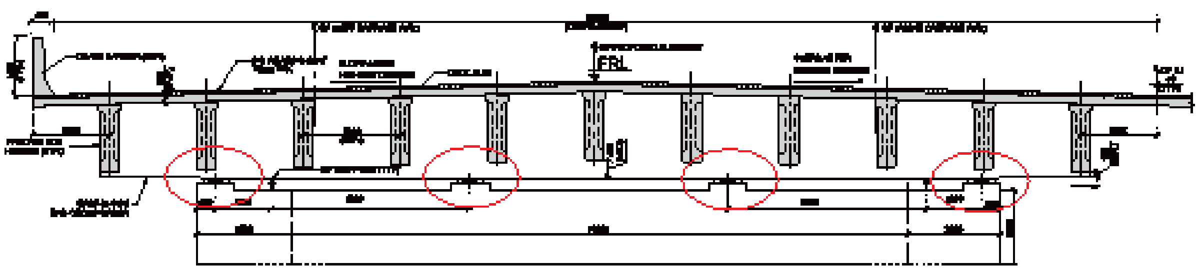


Source: JICA Study Team based on DPR Drawing（14518/E/IC/NH5/DD001: SH-2 OF 3）

Figure 6.5.18 Cross Section of Reinforced Earth Wall (IC)

10) Bearing Position and Width of Substructure (All Bridges)

The bearings are located under the end cross beams and as compared with the superstructure width, the coping width of some substructures is found to be extremely small. It is advised that the bearing position and the coping width be reviewed in order to be certain of the vertical support load and to ensure bridge fall prevention in case unexpected forces occur.



Source: JICA Study Team based on DPR Drawing

Figure 6.5.19 Proposed Bearing Position (MJB101)

(3) Suggestion on Operation and Management Plan

The O&M of the CPRR is still under examination and a concrete plan has not yet been formulated by the Highways Department of Tamil Nadu State. The JICA Study Team, therefore, exchanged views with people responsible in the Highways Department, studied current situations in the O&M of roads, and described its recommendations in Chapter 5 Highway Operations and Maintenance (O&M) Structure.

(4) Suggestion on Possible Adoption Measures Against Climate Change

1) Influence of Climate Change on Roads

In recent years, disasters caused by extreme meteorological phenomena such as strong typhoon, hurricane, local heavy rain, drought and heat wave have occurred and caused enormous damage all over the world. To address the influence of global climate change, adaptation measures against already surfaced impact and unavoidable effect in the medium to long term are required as well as mitigation measures, including reduction of greenhouse gas emissions.

Table 6.5.2 shows major influence of climate change on roads.

Table 6.5.2 Major Influence of Climate Change on Roads

Cause	Influence
Increase in Rainfall and Rainfall Intensity	・ Flood on roads ・ Inundation and wash away of roads ・ Destabilization of road structure and collapse of road embankment ・ Reduction in drainage capacity due to sediment runoff
Rise in Temperature	・ Deterioration and damage of pavement
Increase in Wind Force	・ Reduction of stability of bridges

Source: JICA Study Team

2) Possible Adaptation Measures in the Project

The CPRR, forming arterial road network in Chennai, is expected to play important roles such as emergency transport route, route for police and fire fighting, and others. To develop a safe and reliable road, it is desirable to undertake adaptation measures against climate change as shown in Table 6.5.3 during the detailed design and/or construction supervision stages.

Table 6.5.3 Adaptation Measures against Climate Change in the Project

Item	Adaptation Measures against Climate Change
Road Embankment	・ Setting out of the proposed elevation based on recent rainfall trend ・ Proper design of slope protection in inundation-prone areas ・ Design of embankment and soft ground treatment considering lowering of groundwater level
Drainage	・ Design of drainage facilities considering lowering of capacity due to sediment runoff
Pavement	・ Application of superelevation for drainage ・ Use of sound material for pavement
Bridge	・ Design of bridges based on recent rainfall trend and appropriate design discharge ・ Consideration of appropriate wind load

Source: JICA Study Team