5. JICA/DULTBDA-005-D
19 May 2015

JICA Experts on Bengaluru Peripheral Ring Road Project

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To **Commissioner, DULT**
Engineer Member, BDA

Your Ref.: Our Ref.: JICA/DULTBDA-005-D Date: 19 May 2015

SUBJECT: Submission of Record of Discussions

Dear Sirs,

We would like to submit herewith the record of the following technical discussions regarding the Project.

1) Record of Discussion on 11 May 2015
2) Record of Discussion on 13 May 2015
3) Record of Discussion on 18 May 2015

Thanking you for your kind attention on the above.

Takaaki TANAKA
Team Leader, JICA Experts

Encl.: 1) Record of Discussions as mentioned above
2) Discussion Paper R02 (Road)
3) Discussion Paper R03 (Road)
4) Discussion Paper S02 (Structure)
5) Discussion Paper C01 (Cost Estimate)
6) Discussion Paper R04 (Road)
7) Discussion Paper S03 (Structure)
6) Discussion Paper E01 (Economic/Financial Analysis)
8) Discussion Paper T01 (Traffic Analysis)

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Record of Discussion

Number	RD-PRR-DP-005
Objection	Technical Discussion based on Discussion Paper No. R02 & R03
Date	11th May 2015 15:00~20:30
Venue	Meeting Room in DULT
Attendance	DULT : Mr. Shamanth K, Mr. Sivasubramaniam J BDA : Mr. Srinivask, Mr. H.C Ramendra, Mr. B Nagendra , Mr. Ajithkumar S.M STUP : Mr. T.V.Rajeev , Mr. Srivathsa B K JICA Experts: Mr. T. Tanaka, Mr. N. Kondo, Mr. S. Yamada
Handout	-Discussion Paper R02 (Road : Cross Sections, Vertical Alignment) -Discussion Paper R03 (Road : Junction/Toll Plaza/Rest Area)
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"Overall regarding Land Acquisition"

Horizontal alignment will be reviewed based on the technical review by JICA Experts on DP R01 which technically required for fulfilling the design speed of 80km/h to accommodate within available ROW of BPRR. Final Decision will be taken by BDA after the revision in the detailed design.

(It has to be confirmed by engineer member)

"DISCUSSION PAPER R02 (Road: Cross Sections, Vertical Alignment)"

1. Cross Sections

1.1 General regarding Cross Sections

Typical cross sections were updated in Final DPR with outer shoulder and edge strip but JICA Experts found that some earlier version of the drawings in DPR still used the old cross sections. STUP informed that the updated cross sections will be applied in the detailed design.

1.2 Typical Cross Sections of Mainline

1.2.1 Lane Width

It was confirmed that 3.5m of the lane width of BPRR was fixed based on IRC 86 (urban road).

1.2.2 Width of Shoulder and Edge Strip

Width of outer shoulder (min.=2.0m) and edge strip (min.=0.5m) of BPRR was determined based on IRC SP-99 based on earlier discussions with JICA. JICA Experts understand the basis of the determination and 0.25m of the narrow edge strip is only at the section with gantry facility of ITS. Accordingly, no change will be required for the detailed design.

1.2.3 Cross Fall (Camber)

JICA Experts found differences regarding the cross fall between DPR Report (2.0%) and Drawings (2.5% in some drawings). It was agreed to apply 2.0% of the standard cross fall of BPRR with rigid pavement. At toll plaza section and its approaches, cross fall/camber can be reduced to 1.7% with provision of cross drain at toll plaza central location.

1.3 Typical Cross Sections of Service Road

1.3.1 Cross Sections of Service Road

The lane configuration (i.e. number of lanes) of the service road is not mentioned in DPR. It was confirmed that the current width of carriageway (W=9.0m) is derived based on available width of 75m ROW for development of formation with other cross section elements firmed up. In principle, the number of lanes of the service road is 2-lane with wider shoulder as proposed by JICA Experts in the Discussion Paper. The final lane configuration will be further discussed and determined during the detailed design stage with proper lane markings.

(It has to be confirmed by engineer member)

1.3.2 Unnecessary Cross Sectional Bottleneck of Service Road

In DPR, the width of service roads is getting narrower toward the entry/exit of VUP and PUP as pointed out in the Discussion Paper. It was confirmed by STUP that compliance is already given to JICA 3rd Mission comments that the end of underpass will be flared (6m x 6m at VUP and 3m x 3m at PUP) in the detailed design stage to get sight distance and also to avoid narrowing of road section at approaches. Planning appropriate structure considering the turning radius of large-sized vehicles will be incorporated in the detailed design.

(It has to be confirmed by engineer member)

2. Vertical Alignment of BPRR (Mainline)

2.1 Gradient

It was agreed that application of 4.0% for maximum gradient and 0.3% for minimum gradient would be considered in accordance with the requirement of IRC SP 23.

BDA/STUP explained the requirement of the railway-crossing which will be based on the results of discussions with railway authorities providing 2.5% of the maximum gradient.

(It has to be confirmed by engineer member)

2.2 Length of Curve

BDA/STUP explained the length was determined using an abbreviated application table (Table 6) in IRC SP 23 and JICA Experts confirmed there are not major differences between figures in the table and the calculated value by formula in IRCs. Accordingly, the length of curves is not necessary to be changed.

2.3 Clearance for Intersections

It was agreed to modify the drawings properly reflecting the required clearance height for the overpass locations.

2.4 Maximum Height of Retaining Wall

It was basically agreed it would be better to avoid such tall retaining wall concerning the following demerits.

- Stability and future deformation by tall height *need special analysis such as FEM, etc.
- Requirement of high-performance costly material such as steel reinforcement sheet, strictly selected backfill, etc)
- Less accessibility across BPRR under the retaining wall
- Construction difficulties

- Time for construction
- Operation and maintenance of huge fill

Limitation of the height and the span layout of bridges will be further discussed in the next structural meeting on 13 May 2015 (am11:00-).

(It has to be confirmed by engineer member)

2.5 Example of Modification for Vertical Alignment

2.5.1 Modification for VUP

Vertical alignment will be designed as mentioned in 2.3 above during the detailed design stage.

2.5.2 Modification for flat section

Vertical alignment will be designed as mentioned in 2.1 above during the detailed design stage.

2.5.3 Modification for filling (high embankment)

As mentioned in 2.4 above, the height limitation of the retaining wall will be further discussed.

2.5.4 Modification for Toll Plaza

It was agreed to apply 2.0% for the maximum vertical gradient for the toll plaza section.

"DISCUSSION PAPER R03 (Road : Junction/Toll Plaza/Rest Area)"

1. Design Concept of Ramp Terminal

1.1 Ramp Design Speed

It was agreed to apply 40km/h for the design speed of ramps.

1.2 Design Speed of Acceleration/Deceleration Lanes

Suggestions from JICA Experts will be considered in the detailed design.

1.3 Transition Section of Main Carriageway and Ramp

Suggestions from JICA Experts will be considered in the detailed design.

1.4 Measures enable minimize the accident at section which connecting main carriageway and ramp

Suggestions from JICA Experts will be considered in the detailed design.

STUP informed that the length of acceleration and deceleration lane lengths in the interchange layout drawings are more than those required for 40km/h. Rumble strip/speed breakers, raised pavement markers, chevron markings, luminous water barricades will be proposed during the detailed design stage.

2. Design Concept of Toll Plaza Area

2.1 Alignment of Toll Plaza Area

As discussed by Discussion Paper R02, 2% of the maximum vertical gradient was agreed. Other suggestions in this section will be considered in the detailed design.

2.2 Toll Island

DULT, BDA , STUP agreed following suggestions from JICA Experts regarding toll plaza area, subject to no change in centerline of the main road and increase in land requirement beyond what is envisaged by BDA in land acquisition plan.

- Minimum radius of horizontal curve shall be 200m.
- Minimum radius of vertical curve shall be 700m
- Vertical gradient shall be not more than 2.0%

- Cross fall shall be between 1.7% to 2.0%
- Crossing drainage system for both side of toll island will be considered in the detail design to protect toll lane from water immersion
- Unifying width of toll lane width (3.2m) were agreed for considering future increase of ETC usage ratio.
- Unifying length of toll island (35m) were agreed for the same reason above.

BDA/STUP informed that the toll plaza layout has been revised and the layout drawings at Tumkur end submitted based on earlier discussion with JICA.

3. Rest Area

JICA Experts enquired about provision of rest areas for the Project. BDA informed that the rest area is not envisaged in the present scope of work.

Record of Discussion

Number	RD-PRR-DP-006
Objection	Technical Discussion based on Discussion Paper No. S02
Date	13th May 2015 12:00~17:00
Venue	Meeting Room in DULT
Attendance	DULT : Mr. Sivasubramaniam J BDA : Mr. H.C Ramendra, Mr. B Nagendra , Mr. Ajithkumar S.M STUP : Mr. A.T. Samuel, Mr. K.N. Saravanan, Mr. T.V.Rajeev JICA Experts: Mr. T. Tanaka, Mr. S. Yamada, Mr. T. Maeda
Handout	-Discussion Paper S02 (Structure)

Contents

1. Structure

1.1 Bridge

1.1.1 Bridge Planning Criteria and Conditions (Additional)

1.1.1.1 Pier Locations of VOP/POP

It was confirmed that most of existing Metro lines were constructed by high-elevated structures.

Moreover, maximum gradient of future Metro line on the median of BPRR will be smaller than BPRR and it is difficult to follow same profile of BPRR at the underpass sections. Therefore, the future Metro line will be planned by elevated structures at least in the underpass sections of BPRR.

Accordingly, it was confirmed that piers of VOP/POP at the median of BPRR will not be affected to the planning of future Metro line.

(It has to be confirmed by engineer member)

1.1.1.2 Maximum Height of Retaining Wall

It was confirmed that geotechnical survey/structural analysis were not conducted in the DPR stage.

DULT, BDA and STUP agreed to reduce the retaining wall height appropriately by setting back the abutment locations (by extending the bridge length) in this JICA's Technical Review stage.

Final conclusions will be decided in the D/D stage with geotechnical survey/structural analysis results.

(It has to be confirmed by engineer member)

1.1.2 Bridge Planning

1.1.2.1 Superstructure Type

DULT, BDA and STUP agreed the proposed superstructure type by the JICA Experts.

Notes:

- It was confirmed that other superstructure types such as RC-I Girder, PC Hollow Slab (Pre-tension) etc. are also common by 20m span length in India.
- JICA Experts recommended applying PC Void Slab at VOPs/POPs to reduce girder height; however, it was confirmed non-existence of critical profile locations on the main road. Therefore, it was agreed to apply PC-I Girder at VOPs/POPs for ensuring quality of construction works.
- It was confirmed that PC Box Girder by cast-in-place (CIP) method is appropriate from 40m span length instead of pre-cast method by reason of non-existence of long bridges in the Project.

1.1.2.2 Substructure Type

JICA Experts confirmed appropriateness of substructure types in the Final DPR.

Notes:

- It was confirmed that abutment type at VOP/POP is not MSE Wall but RC Retaining Wall.
- RC Retaining Wall Abutment will be applied authorized types by IRC.

1.1.2.3 Foundation Type

It was confirmed that CIP RC Bored Pile and Spread Foundation are common types in India.

Note:

- Possible Diameter of Bored Pile: 1.0m, 1.2m, 1.5m and 2.0m (1.0m and 1.2m are common).
- Maximum Pitch between Bored Piles: 3D (for Rock), 2D (for Soil)

1.1.2.4 Skew Angle

DULT, BDA and STUP agreed to improve bridge skew angles in the D/D stage.

Note:

- Small bridge skew angle is not common in India (exceptional case only).
- It is necessary to avoid extension of bridge length by improving bridge skew angles.

1.1.2.5 Bridge Planning

DULT, BDA, STUP and JICA Experts discussed bridge plan based on the proposal by JICA Experts and agreed it as shown in Attachment 1.

Main Revision Points from the Proposal by JICA Experts:

- According to the opinion by DULT, BDA and STUP, piers on service roads were considered for applying typical girder types as much as possible.
- According to the past experiences by DULT, BDA and STUP, it was assumed that temporary support structures inside railway ROW with reduced speed operation would be allowed by railway operator.
- In consideration of high railway embankment, it is difficult to apply temporary support structures inside railway ROW and 3 spans steel box girder with rapid erection method were planned at Chennai and Hosur Railway Lines.

(It has to be confirmed by engineer member)

Note:

- DULT, BDA and STUP will discuss with the national highway and railway operators and obtain approvals about clearance structure type and erection method by them.
- Superstructure plan at Chennai and Hosur Railway Lines may revise to ordinal structure plan in the D/D stage in case of verifying technical validity and obtaining approval by the railway operator.
- Other superstructure plan may also revise in the D/D stage in case of verifying economical and technical validity in accordance with geotechnical investigations/structural analysis results.

1.1.2.6 Bridge Accessory Planning

It was confirmed appropriateness of expansion joint and bearing types in the Final DPR.

- Expansion Joint: Modular Joint
- Bearing: Pot Bearing

1.1.3 Box Culvert

1.1.3.1 VUP

DULT, BDA and STUP explained that box culvert: (2@9m) with widening of both entrances (3m*3m) at VUP can be ensured turn movement of heavy vehicles. JICA Experts again proposed to modify into single span bridge (i.e. span length=30m) instead of box culvert to ensure u-turn movement for heavy vehicles. Updated cost due to this modification will be referred by JICA loan appraisal mission and will be able to accommodate possible design changes during the detailed design stage.

(It has to be confirmed by engineer member)

Attachment 1: Bridge Plan

No.	Station	Bridge Category	Location	Cross Object	Width1)	Clearance (under BR)		Bridge Length2)	Span Arrange.	Superstructure	Erection Method	Substructure		Remarks
						Vertical	Horizontal					Abutment	Pier	
1	KM30+000	Flyover	Main Road	NH-4	4m	5.5m	Existing BR	60m	2@30m	PC-I	Truck Crane	Mixed	Round	Widening of Existing Bridge at Tumkur Road JCT
2	KM33+560	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Truck Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
3	KM34+212	ROB, Flyover	Main Road, Service Road	Bangalore-Tumkur Railway Line, SH39	8.5m,2@15m,8.5m	Rail: TBC Road: 5.5m	Rail: 60m Road: 40m	195m	1@60m+3@45m	PC Box (Constant)	CIP (Staging)	Mixed	Main Road: Y Service Road: Round	Assumed to allow temporary support structure inside railway ROW with reduced speed operation by railway operator
4	KM14+435	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@12m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Y or Alternatives	Planned Piers on Median of BPRR Planned Piers on Service Road
5	KM14+800	POP	To be confirmed by STUP											
6	KM15+800	POP	Existence of Discrepancy among Drawings (Plan and Profile DWG: Mentioned, Junction DWG: Not Mentioned)											
7	KM23+400	VOP	Cross Road (SH104)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
8	KM25+304	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Round	Planned Piers on Median of BPRR Planned Piers on Service Road
9	KM27+145	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
10	KM29+770	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
11	KM36+323	Flyover	Main Road	NH-4	12m,2@15m,12m	5.5m	NH-4: 60m	60m	1@60m	PC Box (Constant)	CIP (Staging)	Mixed	-----	Assumed to allow temporary support structure inside NH-4 ROW with detour roads by national highway operator
12	KM37+750	VOP	Cross Road (SH35)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
13	KM38+769	Flyover	Main Road	Cross Road (SH35) (Underpass)	2@16m	5.5m	Cross Road	140m	40m+60m+40m	PC Box (Constant)	CIP (Staging)	Mixed	Y or Alternatives	Planned Piers on Service Road of Cross Road
14	KM43+125	ROB	Main Road,	Bangalore-Chennai Railway Line	8.5m,2@16m,8.5m	Rail: TBC	Rail: 70m	150m3)	40m+70m+40m	Steel Box	Rapid Erection	Mixed	Main Road: Y Service Road: Round	Planned steel box girder by reason of difficulty for applying temporary support structure inside railway ROW.
15	KM49+430	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
16	KM53+221	Flyover	Main Road	Cross Road (SH35) (Underpass)	2@15m	5.5m	Cross Road	90m	3@30m	PC-I	Track Crane	Mixed	Y or Alternatives	Planned Piers on Service Road of Cross Road
17	KM54+580	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
18	KM55+911	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Round	Planned Piers on Median of BPRR Planned Piers on Service Road
19	KM59+198	ROB	Main Road, Service Road	Bangalore-Hosur Railway Line	8.5m,2@17.5m,8.5m	Rail: TBC	Rail: 60m	130m3)	35m+60m+35m	Steel Box	Rapid Erection	Mixed	Main Road : Y or Alternatives Service Road: Round	Planned steel box girder by reason of difficulty for applying temporary support structure inside railway ROW.
20	KM64+751	Flyover	Main Road	NH-7	4m	5.5m	Existing BR	60m	2@30m	PC-I	Truck Crane	Mixed	Round	Widening of Existing Bridge at Hosur Road JCT

1) Road Width in the Final DPR (To be followed discussion result in DP-R02)
2) Approximate Bridge Length (It is necessary to determine in detail in the D/D stage)
3) Bridge length (abutment locations) will be extended by appropriate height of MSE Wall in this JICA Technical Review Stage (see 1.1.1.2 in the main text).
Red: To be confirmed with Railway Operator
Blue: To be confirmed with Road Operator

Record of Discussion

Number	RD-PRR-DP-007
Objection	Technical Discussion based on Discussion Papers
Date	18th May 2015 15:00~19:30
Venue	Meeting Room in DULT
Attendance	DULT : Mr. Sivasubramaniam J BDA : Mr. H.C Ramendra, Mr. B Nagendra , Mr. Ajithkumar S.M STUP : Mr. A.T. Samuel, Mr. T.V.Rajeev , Mr. Srivathsa B K JICA Experts: Mr. Tanaka, Mr. Kondo, Mr. Maeda, Mr. Oikawa, Mr. Ueno, Mr. Yamada
Handout	-Discussion Paper C01 (Cost Estimate) -Discussion Paper R04 (Road) -Discussion Paper S03 (Structure) -Discussion Paper E01 (Economic/Financial Analysis) -Discussion Paper T01 (Traffic Analysis)

Contents

"DISCUSSION PAPER C01 (Cost Estimate)"

1. Re-confirmation of Conditions of Cost Estimate

1.1 Final Version of Bill of Quantity and Cost Estimate (BOQC)

It was confirmed the final version of the civil works is BOQC Rev R(3). The items except the civil works was updated in DPR Report R(5).

1.2 Earth Spill out beyond 75 ROW

It was confirmed the design consultant that the marginal earth spill out mentioned in DP C01 is correct.

1.3 RUB Structure at Doddabalapur and Chikkaballapura Railway

It was confirmed the design consultant (temporary relocation of railway tracks) mentioned in BOQC is correct and the further detailed discussion will be made with the railway authorities during the detailed Design stage.

(It has to be confirmed by engineer member)

1.4 Box Culvert Structures for BPRR under National Highways

It was confirmed the design condition (temporary diversion of NHs) mentioned in BOQC is correct and the further detailed discussion will be made with the concerned authorities during the detailed Design stage.

(It has to be confirmed by engineer member)

1.5 Quantity of RE (Reinforced Earth) Wall

It was reported by JICA Experts that there is difference between the quantity calculation by JICA Experts and the quantity in BOQC on RE wall area. JICA will share the worksheet to STUP. STUP will check the quantity calculation by JICA Experts and will give feedback later.

2. General Question/Request form JICA Experts

It was confirmed no IRC was referred for the cost estimation, except referring the specification of works as per MORTH (Ministry of Road Transport and Highway) guidelines.

STUP will provide JICA Experts PDFs files of the followings.

1) KPWD SR Bangalore 2014-14

2) NH SR Bangalore Circle

"DISCUSSION PAPER R04 (Road: JCT Interval, Junction, Toll Gate Facilities)"

1. Maximization of BPRR Use

1.1 JCT intervals

There are three sections having long interval of JCTs more than 10km. JICA Experts recommended to reconsider the provision of ON/OFF Ramps with only 2-3 lanes of toll gates for each ON/OFF Ramp. BDA will reconsider the above during the detailed design stage depending on the usage.

(It has to be confirmed by engineer member)

1.2 Cancellation of ROB and VOP for service road

JICA Experts proposed to omit the railway overpass for the service roads. BDA informed the railway authorities will not accept at-graded railway crossing by any roads. JICA Experts agreed on this.

(It has to be confirmed by engineer member)

2. Design Concept of Ramp Terminal

2.1 Ramp Design Speed

It was agreed to adopt 40km/h as the design speed for ramps.

2.2 Design Speed from Toll Gate to Nose

It was agreed to adopt 40km/h as the design speed of nose position on taper.

2.3 Required Length for Acceleration/deceleration Lane

DPR is not using IRC:SP99 for design but using IRC:SP:41, since BPRR is not the expressway and these lengths are satisfying IRC:SP:41. However, to avoid any risk of accident, BDA/STUP will check the drawings and if extension of length of acceleration/deceleration lane is possible, it will be reconsidered within ROW during the detailed design stage. As of now, the length of acceleration and deceleration lane are more than required length given in IRC:SP:41.

2.4 Transition Section of Main Carriageway and Ramp

2.4.1 DPR is using IRC:SP:23 instead of IRC:SP:99, since BPRR is not the expressway. As per IRC:SP:23, minimum radius of vertical summit curve is 2200m and all vertical summit curves are satisfying IRC:SP:23. However, to avoid any risk of accident, BDA/STUP will check the drawings and if changing more moderate curve is possible, it will be reconsidered within ROW during the detailed design stage.

2.4.2 Since length of taper to exit gate of Whitefield JCT, BDA/STUP will reconsider about extension of length within ROW at D/D stage

3. Weaving

3.1 The weaving length between margining point of ramp and service road to entry toll plaza to Hosur direction should be longer since driver need to change the lane at least three times. BDA/STUP will reconsider the above as much as possible within the available land.

4. Toll Gate

4.1 Toll Gate Facilities

4.1.1 Ladder

JICA Experts pointed out the danger of ladder for toll booth to tunnel and explained Gurugaon toll plaza adopted steps as an Indian example. However, BDA/STUP said that toll plaza nearby Bengaluru constructed ladder instead of steps. It was agreed that further discussion would be necessary while designing tunnel.

(It has to be confirmed by engineer member)

4.1.2 Crash Barrier

JICA Experts proposed no provision of crash barrier for protecting toll booth. BDA/STUP introduced that there are many accident reported on National Highway toll booths resulting in damage to toll booth and injuries / fatalities . It was agreed to retain crash barrier.

4.1.3 Canopy

JICA Experts pointed out that canopy is not in same line for oversized lane and cantilever structure for large sized vehicle lane should be avoided. Figure of IRC:SP:99 has column and avoiding cantilever structure. BDA/STUP agreed to provide toll canopy in same line throughout the toll plaza but would review requirement of providing column for oversized lane to avoid cantilever based on the designs.

4.2 Width for Large Sized Vehicle Lane

JICA Experts pointed out that width of large sized vehicle lane should be 4.5m comply with IRC:SP:99. Adopting 4.5m can have 1m extra space also. BDA, STUP informed that there are vehicles with consignment with much wider width be safe passage at toll plaza area. . It was agreed to retain 5.5m for large sized vehicle for safety reason under Indian condition.

4.3 Capacity of Toll Lane by Each Systems

JICA Experts mentioned that IRC:SP:99 is shown only 240v/h for manual lane capacity but it is missing capacity of manual lane for exit gate. In exit gate, there is many more steps compare with entry gate as followings.

- Driver passes transit card to toll collector
- Toll collector check his travel fee
- Driver pays his travel fee to toll collector

JICA Experts recommended 130v/h for the capacity of exit lane.

BDA, STUP informed that the capacity of 240 v/h includes cash transaction and hence the capacity of toll booth if only token is given will be more than 240 v/h. JICA Experts will do calculation with using both processing capacity and discuss this issue with BDA, STUP again. JICA, BDA and DULT will discuss and finalize the toll fee operation strategy at entry and exit.

"DISCUSSION PAPER S03 (Structure)"

1. Structure

1.1 Bridge

1.1.1 Bridge Planning (Additional)

1.1.1.1 Structure of Approach Section at ROBs

DULT, BDA and STUP agreed to set back the abutment location by 5m height at 2 ROBs (Chennai and Hosur Railway Lines) to reduce the height of MSE Wall at swamp areas.

However, DULT, BDA and STUP suggested to revised the unit price of approach bridge (PC-I Girder) from INR80,000/m2 to INR50,000/m2 in consideration of construction prices in India.

JICA Experts agreed revising the unit price and re-estimated the preliminary cost evaluation as follows:

Revised Preliminary Cost Evaluation (Approach Sections at Chennai Railway Line)

Item	1: DPR	2: h=8m	3: h-=5m (Agreed)
1.PC-I Girder	0	INR1,286Mil.	INR1,733Mil.
2.MSE Wall	INR804Mil.	INR246Mil.	INR117Mil.
3.Soft Soil Treatment	INR214Mil.	INR123Mil.	INR91Mil.
Total	INR1,018Mil.	INR1,655Mil.	INR1,941Mil.

Bridge Width: Main Rd: w=2@17.75m, Service Rd: w=2@8.5m, Unit Price: INR50,000/m2
Red: Revised

Note:

This is a temporary solution in this JICA Technical Review stage to ensure project budget in safe side.

Final conclusion will be decided in the D/D stage with geotechnical survey/structural analysis results.

(It has to be confirmed by engineer member)

1.1.1.2 Cross Sections (Bridge Width)

JICA Experts confirmed the bridge width of service road at flyover sections with DULT, BDA and STUP and it was planned as 8.5m width in the Final DPR.

Accordingly, the bridge plan concluded in the last meeting (S02) was revised as shown in Attachment1.

1.1.1.3 Cross Sections (Structural Dimension)

JICA Experts confirmed with DULT, BDA and STUP that the detail of bridge cross sections would be determined in the beginning of D/D stage in accordance with general practices in India.

Therefore, JICA Experts confirmed expected structural dimensions on main points with DULT, BDA and STUP while referring to relevant project data.

Structural dimensions on main points confirmed during this Technical Discussion are in the followings:

Superstructure

PC-I Girder

- Slab Thickness: 22cm
- Girder Height: 1.45m (Span Length = 20m)

PC Box Girder (Constant Height)

- Structure Height: 2.1m (Span Length = 35m), 2.4m (Span Length = 60m)
- Cantilever Length: 3.5 to 4.0m (Bridge Width = 17.75m)
- Web Angle: 47 Degrees (acceptable from 42 to 47 Degrees)
- Width of Bottom Slab: 6m (Bridge Length: 17.75m)

Substructure

Wall (Y) Shape Pier

- Column Width at Bottom: 1.85m (Transverse Axis)*2.25m (Bridge Axis) (Bridge Width: 17.75m)

Foundation

CIP RC Bore Pile

- Pile Arrangement: 2 nos. on transverse axis in case of influence to local road

  (4 nos. on transverse axis are also acceptable in this Project, if required)

Note:

DULT, BDA and STUP agreed to provide reference drawings as requested by JICA Experts, if required.

1.2 Box Culvert

1.2.1 Plan of Box Culvert

JICA Experts confirmed the plan of box culvert with DULT, BDA and STUP.

Accordingly, the following points were revised:

Inner Width of Underpass (Main Road): 16.5m

Inner Width of Underpass (Service Road): 7.5m

1.2.2 Construction Method

DULT, BDA and STUP explained the construction method of underpass as follows:

- 2 RUBs (at Chikkaballapur and Doddaballapur Railwat Lines): Box Pushing
- Other Locations including at NH-7: Open and Cut with Detour Road

Note:

- DULT, BDA and STUP explained that box pushing were applied to many projects in India even dimension of underpass is larger than BPRR.
- DULT, BDA and STUP explained that box pushing were original developed in the UK (Skanska) and exported to Thailand (ITD) and it was simplified by IRC.
- DULT, BDA and STUP explained that reduced speed operation of railway would be required during construction in case of applying box pushing method.
- DULT, BDA and STUP explained that box pushing has no conflict in patent.
- DULT, BDA and STUP explained that underpass structure in case of applying box pushing is same as standard box culverts.
- DULT, BDA and STUP agreed to provide more technical information as requested by JICA Experts.

(It has to be confirmed by engineer member)

1.2.3 Thickness of Box Culvert

JICA Experts confirmed with DULT, BDA and STUP that the detail of box culvert sections would be determined in the beginning of D/D stage in accordance with general practices in India.

Therefore, JICA Experts confirmed expected structural dimensions on main points with DULT, BDA and STUP while referring to relevant project data.

Structural dimensions on main points confirmed during this Technical Discussion are in the followings:

Thickness of Box Culvert (2@12.5m)

- Upper Slab: 40cm
- Bottom Slab: 45cm
- Outer Wall: 35cm
- Intermediate Wall: 30cm

Note:

DULT, BDA and STUP agreed to provide reference drawings as requested by JICA Experts, if required.

1.2.4 Drainage Pump at Underpass

DULT, BDA and STUP explained general practices of drainage system at underpass in the followings:

- At Plain (i.e. Chennai): Drainage Pump
- At Hilly Area (i.e. Bengaluru): Gravity Drain with plumbing for terminal treatment of drainage water, manhole: 30m pitch with dia. 1.2m for maintenance works.

Accordingly, the drainage pump was not planned in the Final DPR as natural drainage is facilitated.

"DISCUSSION PAPER E01 (Economic Analysis and Financial Analysis)"

1. Economic Analysis

1.3 Project Cost

JICA Experts mentioned that the project cost for economic analysis have not included the Land Acquisition Cost.

STUP informed that similar highway projects in India were conducted for an economic evaluation utilizing the construction cost as a project cost. If a land acquisition cost were included in the project cost, it may not be feasible in economic point of view. This matter was already explained to the JICA mission last December 2014. This project was already approved by the government.

1.4 Economic Benefit

JICA Experts commented that the economic benefit calculated the Vehicle Operation Cost (VOC) only, it did not calculate the Travel Time Cost (TTC) Saving. STUP explained that the TTC unit was mentioned in the "Manual on Economic Evaluation of Highway Project in India". JICA Expert mentioned that the VOC and TTC as economic evaluation items will be estimated.

1.5 Economic Evaluation Period

JICA Experts recommended that the economic evaluation period will be assumed as 25 years based on the "Manual on Economic Evaluation of Highway Project in India".

1.6 Provision of Soft Copy

STUP provided the soft copy of the economic evaluation sheet to the JICA Experts.

2. Financial Analysis

2.1 Provision of Financial Evaluation Sheet

STUP informed that the financial evaluation sheet will be discussed with BDA before sending it to JICA.

2.2 O&M Operator

Road maintenance for 2 years only will be done by contractors initially. BDA will decide to select contract type for operation at a later date.

"DISCUSSION PAPER T01 (Traffic Analysis)"

DP T01 was explained by JICA Experts and STUP will provide necessary information to JICA Experts.

(END)

Attachment 1: Revised Bridge Plan regarding Discussion Paper S03

No.	Station	Bridge Category	Location	Cross Object	Width1)	Clearance (under BR)		Bridge Length2)	Span Arrange.	Superstructure	Erection Method	Substructure		Remarks
						Vertical	Horizontal					Abutment	Pier	
1	KM00+000	Flyover	Main Road	NH-4	4m	5.5m	Existing BR	60m	2@30m	PC-I	Truck Crane	Mixed	Round	Widening of Existing Bridge at Tumkur Road JCT
2	KM03+560	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Truck Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
3	KM04+212	ROB, Flyover	Main Road, Service Road	Bangalore-Tumkur Railway Line, SH39	8.5m,2@17.75m,8.5m	Rail: 6.14 Road: 5.5m	Rail: 60m Road: 40m	195m	1@60m+3@45m	PC Box (Constant)	CIP (Staging)	Mixed	Main Road: Y Service Road: Round	Assumed to allow temporary support structure inside railway ROW with reduced speed operation by railway operator
4	KM14+435	VOP	Cross Road (Local Road)	Main Road (Underpass), Service Road	2@12m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Y or Alternatives	Planned Piers on Median of BPRR Planned Piers on Service Road
5	KM14+800	POP	Cross Road (Local Road)	Main Road, Service Road (Underpass, TP Section)	2@8.5m	5.5m	Service Road	80m	2@40m	PC Box (Constant)	CIP (Staging)	RC Retaining Wall	Oval	Temporary Plan To be updated in the beginning of D/D stage with the taper design at toll plaza section
6	KM15+600	POP	Cross Road (Local Road)	Main Road, Service Road (Underpass, TP Section)	2@8.5m	5.5m	Service Road	120m	2@60m	PC Box (Constant)	CIP (Staging)	RC Retaining Wall	Oval	
7	KM23+400	VOP	Cross Road (SH104)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
8	KM25+604	VOP	Cross Road (Local Road)	Main Road (Underpass), Service Road	2@8.5m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Round	Planned Piers on Median of BPRR Planned Piers on Service Road
9	KM27+145	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
10	KM29+770	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
11	KM35+323	Flyover	Main Road	NH-4	8.5m,2@17.75m,8.5m	5.5m	NH-4: 60m	60m	1@60m	PC Box (Constant)	CIP (Staging)	Mixed	-----	Assumed to allow temporary support structure inside NH-4 ROW with detour roads by national highway operator
12	KM37+750	VOP	Cross Road (SH35)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
13	KM38+739	Flyover	Main Road	Cross Road (SH35) (Underpass)	2@17.75m	5.5m	Cross Road	140m	40m+60m+40m	PC Box (Constant)	CIP (Staging)	Mixed	Y or Alternatives	Planned Piers on Service Road of Cross Road
14	KM43+125	ROB	Main Road,	Bangalore-Chennai Railway Line	8.5m,2@17.75m,8.5m	Rail: 6.14	Rail: 70m	810m3)	11@30m 40m+70m+40m, 11@30m	PC-I, Steel Box, PC-I	Truck Crane, Rapid Erection, Truck Crane	Mixed	Main Road: Y Service Road: Round	Planned steel box girder by reason of difficulty for applying temporary support structure inside railway ROW.
15	KM49+430	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
16	KM53+221	Flyover	Main Road	Cross Road (SH35) (Underpass)	2@17.75m	5.5m	Cross Road	90m	3@30m	PC-I	Track Crane	Mixed	Y or Alternatives	Planned Piers on Service Road of Cross Road
17	KM54+580	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
18	KM56+911	VOP	Cross Road (Local Road)	Main Road (Underpass), Service Road	2@8.5m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Round	Planned Piers on Median of BPRR Planned Piers on Service Road
19	KM59+188	ROB	Main Road, Service Road	Bangalore-Hosur Railway Line	8.5m,2@17.75m,8.5m	Rail: 6.14	Rail: 60m	790m3)	11@30m, 35m+60m+35m, 11@30m	PC-I, Steel Box, PC-I	Truck Crane, Rapid Erection, Truck Crane	Mixed	Main Road : Y or Alternatives Service Road: Round	Planned steel box girder by reason of difficulty for applying temporary support structure inside railway ROW.
20	KM64+751	Flyover	Main Road	NH-7	4m	5.5m	Existing BR	60m	2@30m	PC-I	Truck Crane	Mixed	Round	Widening of Existing Bridge at Hosur Road JCT

1) Road Width in the Final DPR (To be followed discussion result in DP-R02)

2) Approximate Bridge Length (It is necessary to determine in detail in the D/D stage)

3) Bridge length (abutment locations) is temporary extended by 5m height of MSE Wall in this JICA Technical Review Stage

Red: To be confirmed with Railway Operator

Blue: To be confirmed with Road Operator

Directorate of Urban Land Transport, Government of Karnataka
Bangalore Development Authority

JICA Experts on
Bengaluru Peripheral Ring Road Project

DISCUSSION PAPER R02

regarding

- ✓ *Cross Sections*
- ✓ *Vertical Alignment of BPRR (Mainline)*

11 May 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

TABLE OF CONTENTS

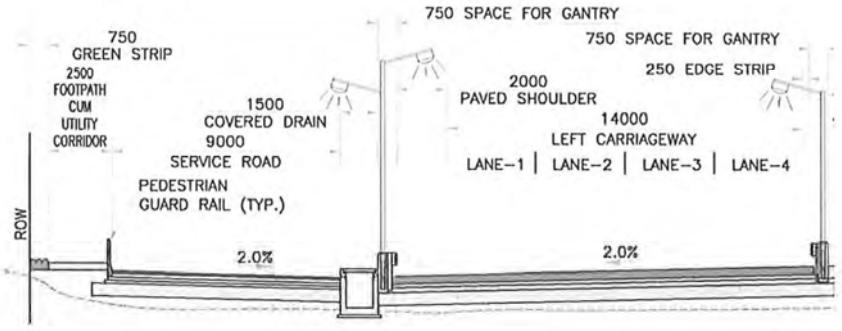
1 Cross Sections

1.1 General

Comments on DPR:
Cross sections on the junction drawings have not been updated. Old sections (without shoulders) are still used in these drawings.
Suggestion from JICA Experts:
Agreed cross sections shall be used properly in the detailed design.

Based on the review by JICA Experts in 2012/13, provision of the shoulders for the mainline was agreed. Figure 1.1 shows the updated cross section in the drawings of "Typical Cross Sections" in Final DPR. Main modifications from Draft DPR are listed below.

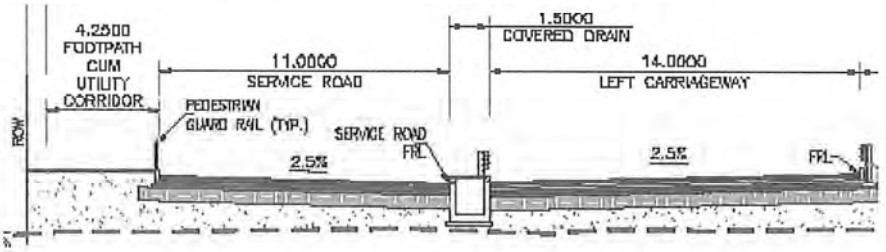
- Provision of "outer shoulder (2.0m)"
- Provision of "inner shoulder (0.25m) as an edge strip"
- Provision of 0.75m width at inner/outer carriageway for gantry's space
- Reduction of carriageway and footpath width of service road



Source: Final DPR, 2014

Figure 1.1 Cross Section in Final DPR

However JICA Experts found the old cross sections (without shoulders) in the drawings of interchanges and junctions.



Source: Final DPR, 2014

Figure 1.2 Old Cross Section in Draft DPR

JICA Experts would like to request BDA and STUP to conduct the detailed design using only the agreed cross sections.

1.2 Typical Cross Sections of Mainline

1.2.1 Lane Width

The lane width of BPRR is 3.5m based on IRC 86 (design standard of "urban road"). For reference, the lane width of "expressway" is 3.75m in plain and rolling terrains and 3.5m only in mountainous terrains.

JICA Experts has no objection on the above after the consensus to apply 80km/h of the design speed for BPRR (consensus based on DP R01 on 6 May 2015).

1.2.2 Shoulder and Edge Strip Width

Comments on DPR:
Width of the inner shoulder (edge strip) is too narrow for high speed traffic.
Suggestion from JICA Experts:
Provision of 1.5m width for "Outer Shoulder" and 0.75m width for "Edge Strip/Inner Shoulder"

BPRR is not designed as "expressway" but "urban road" allowing 80km/h high speeding. BPRR might be defined as "semi-expressway". Necessity of shoulders is not mentioned in IRC 86 which specify the design guideline of "urban road".

Necessity of shoulder was mutually agreed between DULT/BDA/STUP and JICA in 2012/2013. Therefore Guidelines for Expressway (hereinafter IRC-E) has been referred to finalize the dimension of the shoulders for BPRR.

Table 1.1 presents the required width of edge trips according to IRC-E.

Table 1.1 Width of Edge Strips in IRC

Terrain	Width of Edge Strip	
	Left (outer side)	Right (median side)
Plain	0.5m	0.75m
Rolling	0.5m	0.75m

Source: Guidelines for Expressways, IRC, 2010

According to IRC-E, *"edge strips should provide lateral support to the carriageway properly and will also accommodate the edge markings and edge strip shall provided so as to enhance the delineation effect to drivers and to constitute a part of lateral clearance for the safety of vehicles".*

The width of edge strip in Final DPR of BPRR is 0.25m only and not fulfill the above requirement. Provision of 0.75m width of edge strip (inner shoulder) is recommended by JICA Experts.

Table 1.2 presents the required width of shoulders (outer shoulder) according to IRC-E.

Table 1.2 Width of Shoulders in IRC

Terrain	Paved Shoulder
Plain	3.0m
Rolling	3.0m

Source: Guidelines for Expressways, IRC, 2010

Provision of the above width is actually quite difficult for BPRR due to the fixed available land. However the concept of the outer shoulder stipulated in IRC-E shall be considered as much as technically practical.

IRC-E stated the following important functions regarding the provision of shoulders.

i) Space is provided for stopping of vehicle and make the through traffic lane free from obstruction because of mechanical difficulty, a flat tyre, or othr emergency;

ii) Space is provided for the occasional driver who is required to stop, to decide road ramps, service areas, or for other reasons;

iii) Space is provided to escape potential accidents or reduce their severity;

iv) The sense of openness created by shoulders of adequate width contributes much to driving ease and freedom from strain;

v) Sight distance is improved in cut sections, thereby improving safety;

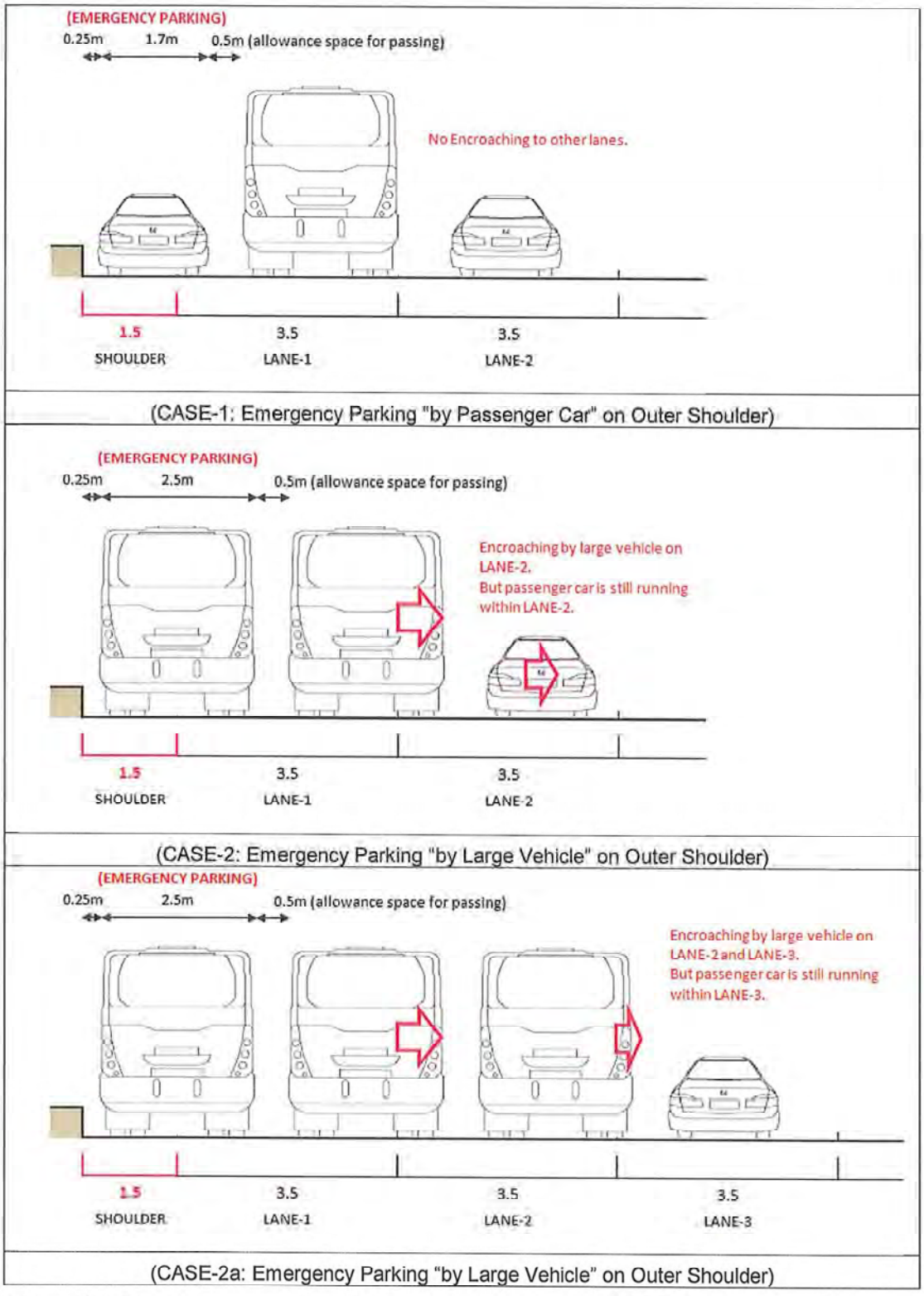
vi) Space is provided for road maintenance, operation and security.

Accordingly, JICA Experts introduces "Partial Shoulder" concept which is well-known in other developed countries' design guidelines (AASHTO, etc) and propose 1.5m width of the outer shoulder for BPRR.

> Although it is desirable that a shoulder be wide enough for a vehicle to be driven completely off the traveled way, narrower shoulders are better than none at all. For example, when a vehicle making an emergency stop can pull over onto a narrow shoulder such that it occupies only 0.3 to 1.2 m [1 to 4 ft] of the traveled way, the remaining traveled way width can be used by passing vehicles. Partial shoulders are sometimes used where full shoulders are unduly costly, such as on long (over 60 m [200 ft]) bridges or in mountainous terrain.

Source: A Policy on Geometric Design of Highways and Streets, AASHTO

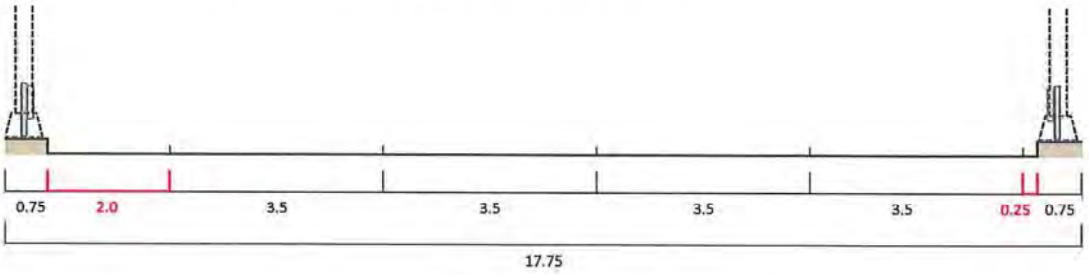
The concept of the proposal of JICA Experts is shown in Figure 1.3. JICA Experts propose 1.5m width of the partial outer shoulder.



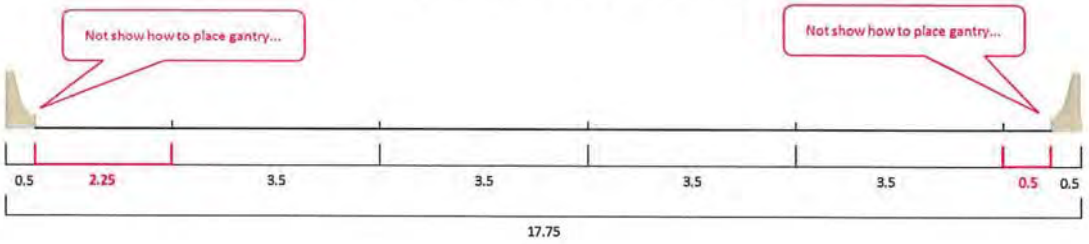
Source: JICA Experts

Figure 1.3 Proposed Concept of Partial Outer Shoulder for BPRR

Figure 1.4 shows the cross sections designed in DPR.



(Cross Section of At-grade Section)

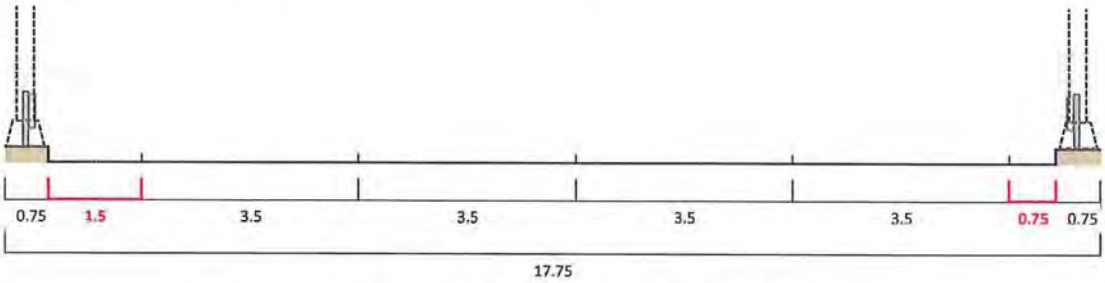


(Cross Section of Elevated Section)

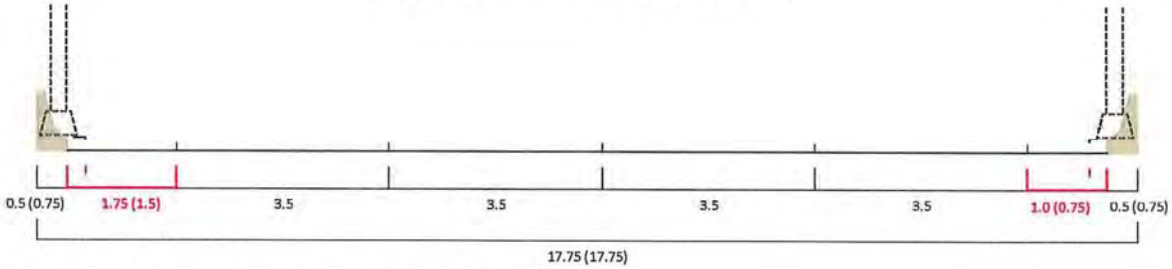
Source: Draft DPR

Figure 1.4 Cross Sections of Mainline of BPRR (Draft DPR)

JICA Experts propose the definitive cross sections as shown in Figure 1.5. It is noted that no change has been made to ROW fixed by DPR.



(Cross Section of At-grade Section)



Note: Figure in parentheses shows the width with gantry pole for ITS.

(Cross Section of Elevated Section)

Source: JICA Experts

Figure 1.5 Cross Sections of Mainline of BPRR (Proposed)

1.2.3 Cross fall (Camber)

Comments on DPR:
DPR modified the cross fall from 2.5% to 2.0%. However there are still descriptions of 2.5% in the drawings.
Suggestion from JICA Experts:
Need to be modified in the detailed design

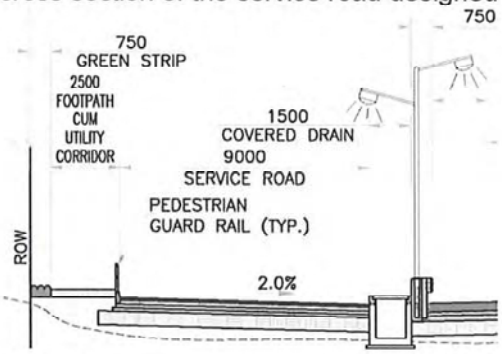
As stated above.

1.3 Typical Cross Sections of Service Road

1.3.1 Cross Section of Service Road

Comments on DPR:
Number of lanes for service road is not clearly mentioned in DPR.
Suggestion from JICA Experts:
Each direction of the service road can accommodate 2-lane with "partial shoulder" and "edge strip.

Figure 1.6 shows the cross section of the service road designed in DPR.



Source: Final DPR, 2014

Figure 1.6 Cross Section of Service Road in Final DPR

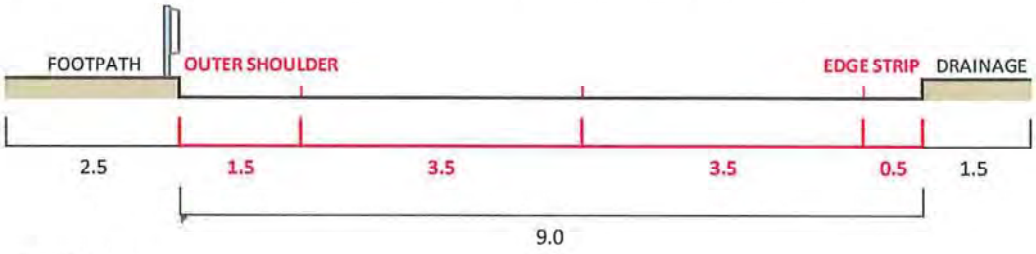
According to IRC-86, 3-lane roads require 10.5m of the carriageway width. Therefore 9.0m of the carriageway width for BPRR can accommodate only 2-lane.

Figure 1.7 shows the cross section of the service road designed in DPR. Lane configuration of the service road is not shown on the drawing.

Source: Draft DPR

Figure 1.7 Cross Sections of Mainline of BPRR (Draft DPR)

JICA Experts propose the lane configuration as shown in Figure 1.8.



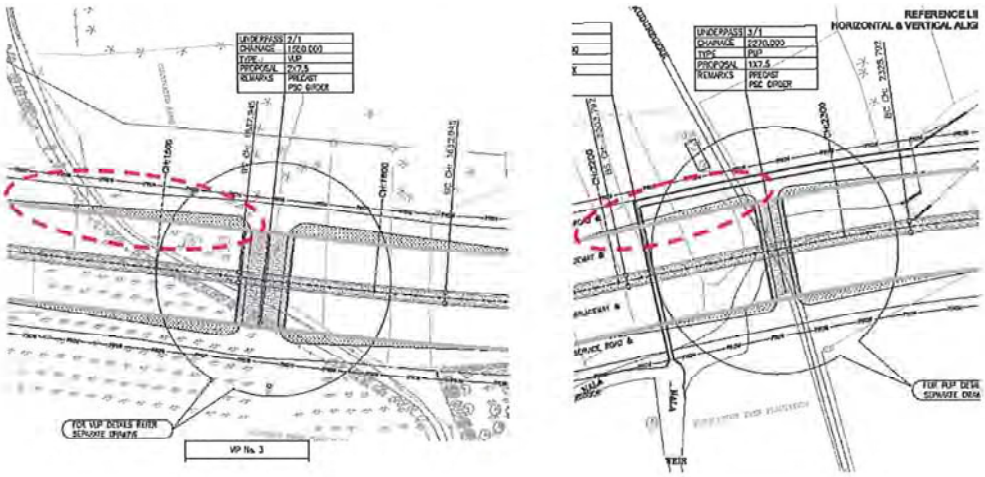
Source: JICA Experts

Figure 1.8 Cross Sections of Mainline of BPRR (Proposed)

1.3.2 Unnecessary Cross Sectional Bottleneck of Service Road

Comments on DPR:
Width of carriageway of the service road is narrowed at the approach to VUP and PUP.
Suggestion from JICA Experts:
Flyovers or bridges shall be studied instead of box-culverts.

Figure 1.9 shows the narrowed carriageway of the service roads.



(Bottleneck for VUP) (Bottleneck for PUP)

Source: Final DPR

Figure 1.9 Bottleneck of Carriageway

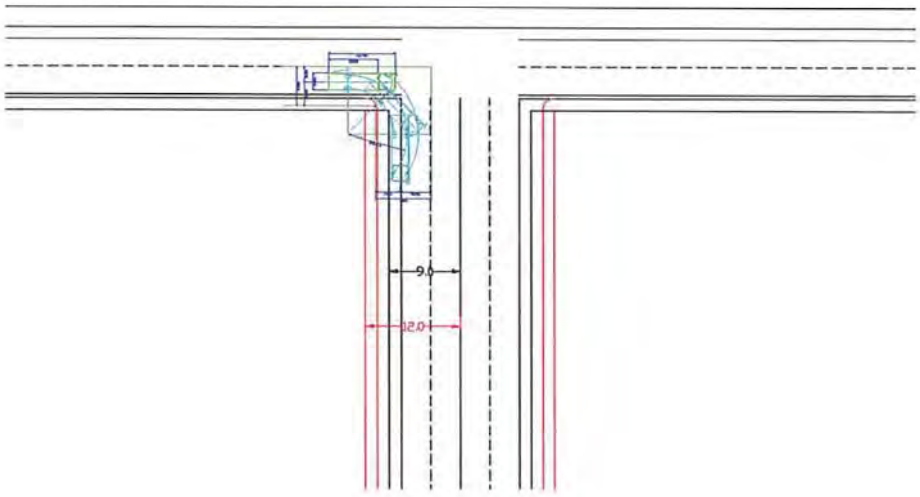
The narrowed carriageway will induce traffic congestion and the width of the carriageway shall keep the original width (9.0m).

Figure 1.10 present the vehicle motion path of 30 ton truck and semi-trailer on the proposed VUP of BPRR.

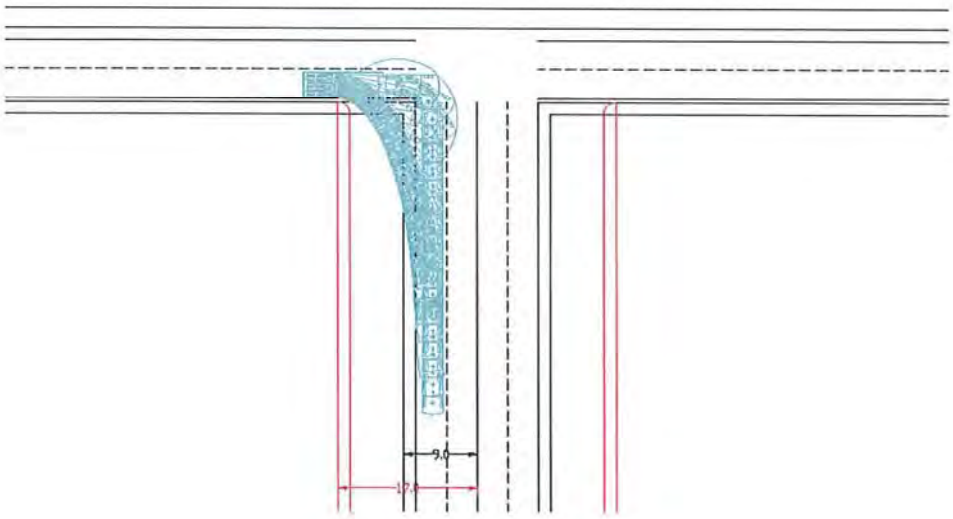
The proposed width of box-culvert cannot manage the traffic flow properly. In order to secure the minimum turning movement of these vehicle, width of the box culvert shall be much larger as suggested in Figure 1.10.

The development along the proposed BPRR will be rapidly accelerated after the completion of the road. Concurrently, traffic volume of heavy vehicles to/from the newly developed premises/enterprises will be increased.

It is quite essential to consider heavy vehicle's turning movement into the design of the VUP.



(30 ton Truck)



(Semi-trailer)

Source: JICA Experts

Figure 1.10 Vehicle Motion Path at VUP

According to the result of the motion path presented in above figure, size of box-culvert shall be changed to much larger one. JICA Experts recommend flyovers or bridges instead of box culvert for VUP.

2 Vertical Alignment of BPRR (Mainline)

2.1 Gradient

Comments on DPR:
Minimum gradient of the vertical alignment does not fulfill IRC 23.
Maximum gradient of the vertical alignment is set as 3.33% based on IRC 23.
Suggestion from JICA Experts:
Minimum gradient = 0.3%.
Maximum gradient = 4.0%

According to IRC SP 23-1983, the specified minimum gradient is 0.3% and 3.33% as maximum gradient. However the vertical alignment of DPR does not fulfill the requirement of IRC.

JICA Experts reviewed the vertical alignment of DPR based on "IRC 86-1983" and "IRC-SP 23-1983". IRC 86-1983 also specifies the absolute minimum gradient as 0.3% and 4.0% as a maximum gradient.

JICA Experts have pointed out there are many sections do not fulfill the requirement for minimum/maximum gradient as summarized in Table 2.1 in the next page.

The modifications of the vertical alignment shall be required at 19 curves as a respect of minimum gradient and 8 curves as a respect of maximum gradient.

However 8 curves required to modify regarding the maximum gradient might be canceled in case of applying IRC 86 (max gradient=4.0%).

Table 2.1 Review on Gradient of Vertical Alignment of BPRR (Mainline)

Elements on DPR											Check			
Tangent 1		VCR				Tangent 2		Gradient			Gradient (max)		Gradient (min)	Gradient (min)
		Start		End							IRC 86	IRC-sp23	IRC 86 (desirable)	IRC 86 (absolute)
Ch.	Elev	Ch.	Elev	Ch.	Elev	Ch.	Elev	i1	i2	i1-i2	(i1<4%)	(i1<3.3%)	(i1>0.5%)	(i1>0.3%)
0+100.000	669.528	0+470.000	850.045	0+570.000	849.885	1+400.000	868.504	-2.563%	2.243%	4.806%	OK	OK	OK	OK
0+570.000	649.885	1+400.000	868.504	1+700.000	868.876	2+165.000	859.597	2.243%	-1.995%	-4.238%	OK	OK	OK	OK
1+700.000	668.876	2+165.000	859.597	2+265.000	858.676	2+339.898	858.790	-1.995%	0.152%	2.148%	OK	OK	OK	OK
2+265.000	668.676	2+339.898	858.790	2+439.898	860.142	2+700.000	868.775	0.152%	2.550%	2.398%	OK	OK	[redacted]	[redacted]
2+439.898	860.142	2+700.000	868.775	3+000.000	871.282	3+079.087	871.642	2.550%	0.455%	-2.095%	OK	OK	OK	OK
3+000.000	871.282	3+079.087	871.642	3+179.087	872.301	3+510.000	875.161	0.455%	0.864%	0.409%	OK	OK	[redacted]	OK
3+179.087	872.301	3+510.000	875.161	3+610.000	875.495	4+245.000	874.253	0.864%	-0.196%	-1.060%	OK	OK	OK	OK
3+610.000	875.495	4+245.000	874.253	4+345.000	872.473	4+416.000	870.086	-0.196%	-3.362%	-3.166%	OK	OK	[redacted]	[redacted]
4+345.000	872.473	4+416.000	870.086	4+516.000	867.830	4+711.214	865.588	-3.362%	-1.148%	2.213%	OK	[redacted]	OK	OK
4+516.000	867.830	4+711.214	865.588	4+811.214	865.173	5+650.000	867.841	-1.148%	0.318%	1.467%	OK	OK	OK	OK
4+811.214	865.173	5+650.000	867.841	5+750.000	867.208	5+822.574	866.058	0.318%	-1.585%	-1.903%	OK	OK	[redacted]	OK
5+750.000	867.208	5+822.574	866.058	5+922.574	866.636	6+600.000	885.191	-1.585%	2.739%	4.324%	OK	OK	OK	OK
5+922.574	866.636	6+600.000	885.191	6+900.000	886.816	7+099.992	883.503	2.739%	-1.657%	-4.396%	OK	OK	OK	OK
6+900.000	886.816	7+099.992	883.503	7+199.992	882.319	7+413.975	880.795	-1.657%	-0.712%	0.944%	OK	OK	OK	OK
7+199.992	882.319	7+413.975	880.795	7+513.975	881.610	7+696.355	885.891	-0.712%	2.347%	3.060%	OK	OK	OK	OK
7+513.975	881.610	7+696.355	885.891	7+795.355	889.022	8+046.072	898.799	2.347%	3.915%	1.568%	OK	OK	OK	OK
7+795.355	889.022	8+046.072	898.799	8+245.072	899.558	8+602.202	888.321	3.915%	-3.155%	-7.071%	OK	[redacted]	OK	OK
8+245.072	899.558	8+602.202	888.321	8+752.202	887.239	8+760.000	887.323	-3.155%	1.077%	4.233%	OK	OK	OK	OK
8+752.202	887.239	8+760.000	887.323	8+960.000	885.538	9+110.000	880.216	1.077%	-3.548%	-4.625%	OK	OK	OK	OK
8+960.000	885.538	9+110.000	880.216	9+210.000	879.541	9+890.799	890.111	-3.548%	2.198%	5.745%	OK	[redacted]	OK	OK
9+210.000	879.541	9+890.799	890.111	9+890.799	889.063	9+919.287	888.138	2.198%	-3.247%	-5.445%	OK	OK	OK	OK
9+890.799	889.063	9+919.287	888.138	10+019.287	886.820	10+288.757	888.464	-3.247%	0.610%	3.857%	OK	OK	OK	OK
10+019.287	886.820	10+288.757	888.464	10+388.757	889.895	10+560.000	893.749	0.610%	2.251%	1.641%	OK	OK	OK	OK
10+388.757	889.895	10+560.000	893.749	10+760.000	898.641	11+128.000	908.359	2.251%	2.641%	0.390%	OK	OK	OK	OK
10+760.000	898.641	11+128.000	908.359	11+328.000	908.784	11+368.239	907.893	2.641%	-2.214%	-4.855%	OK	OK	OK	OK
11+328.000	908.784	11+368.239	907.893	11+518.239	908.535	11+735.000	915.193	-2.214%	3.072%	5.286%	OK	OK	OK	OK
11+518.239	908.535	11+735.000	915.193	12+035.000	922.749	12+435.000	930.812	3.072%	1.966%	-1.106%	OK	OK	OK	OK
12+035.000	922.749	12+435.000	930.812	12+635.000	930.278	12+864.224	925.005	1.966%	-2.300%	-4.266%	OK	OK	OK	OK
12+635.000	930.278	12+864.224	925.005	12+964.224	923.838	13+965.914	923.504	-2.300%	-0.033%	2.267%	OK	OK	OK	OK
12+964.224	923.838	13+965.914	923.504	14+125.914	920.773	14+230.000	917.254	-0.033%	-3.381%	-3.348%	OK	OK	[redacted]	[redacted]
14+125.914	920.773	14+230.000	917.254	14+390.000	913.480	15+570.000	897.694	-3.381%	-1.338%	2.043%	OK	[redacted]	OK	OK
14+390.000	913.480	15+570.000	897.694	15+730.000	895.196	16+100.000	888.594	-1.338%	-1.784%	-0.447%	OK	OK	OK	OK
15+730.000	895.196	16+100.000	888.594	16+260.000	889.845	16+505.000	898.050	-1.784%	3.349%	5.133%	OK	OK	OK	OK
16+260.000	889.845	16+505.000	898.050	16+665.000	901.752	17+260.000	909.361	3.349%	1.279%	-2.070%	OK	[redacted]	OK	OK
16+665.000	901.752	17+260.000	909.361	17+360.000	908.663	17+695.000	899.702	1.279%	-2.675%	-3.954%	OK	OK	OK	OK
17+360.000	908.663	17+695.000	899.702	17+795.000	899.371	18+296.223	909.455	-2.675%	2.012%	4.687%	OK	OK	OK	OK
17+795.000	899.371	18+296.223	909.455	18+496.223	909.472	18+520.000	908.998	2.012%	-1.994%	-4.005%	OK	OK	OK	OK

2.2 Length of Vertical Curve

Comments on DPR:
The minimum length of curve adopted in design is 100m.
Suggestion from JICA Experts:
Length of vertical curves shall be determined by formulae.

In DPR, the minimum length of curve adopted in design is 100m. In the drawings, all of the length is designed over 100m. But, to keep stopping site distance, JICA Experts recommend determining length of vertical curves based on formulae.

According to IRC SP 23-1983, length of vertical curves shall be determined as below.

Summit Curve

1) When the length of the curve exceeds the required sight distance

$$L = \frac{NS^2}{4.4}$$

S= stopping sight distance in metres (120m for the speed 80km/h)
N=deviation angle, i.e. the algebraic difference between the two grades

2) When the length of the curve is less than the required sight distance

$$L = 2S - \frac{4.4}{N}$$

Valley Curve

1) When the length of the curve exceeds the required sight distance

$$L = \frac{NS^2}{1.5 + 0.035S}$$

2) When the length of the curve is less than the required sight distance

$$L = 2S - \frac{1.50 + 0.035S}{N}$$

JICA Experts reviewed the drawings based on above formulae. JICA Experts have pointed out there are many sections do not fulfill the requirement for length of vertical curves as presented in Table 2.2 in the next page.

Table 2.2 Review on Vertical Curves of Vertical Alignment of BPRR (Mainline)

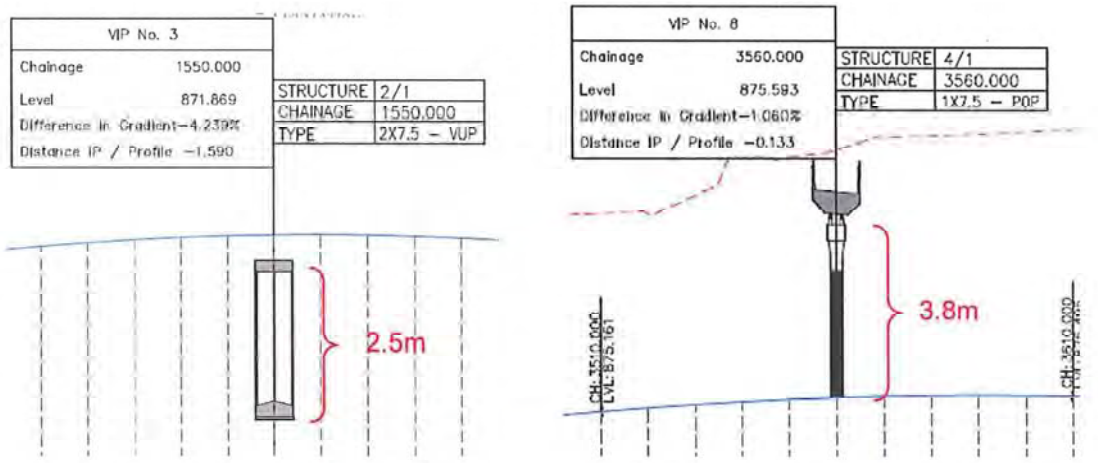
Elements on DPR													Check				
Tangent 1		VCR				Tangent 2		Tangent		VCR			Min. L	VCR Stopping Sight Distance			
		Start		End									IRC 86	Required L by IRC 86		Check	
Ch.	Elev	Ch.	Elev	Ch.	Elev	Ch.	Elev	L1	L2	L	R	K	(L>50m)	Summit VCR	Valley VCR	Summit VCR	Valley VCR
0+100.000	859.528	0+470.000	850.045	0+570.000	849.885	1+400.000	868.504	370	830	100.000	2,081	20.896	OK	-	121.404	-	[illegible]
0+570.000	849.885	1+400.000	868.504	1+700.000	868.875	2+165.000	859.597	830	465	300.000	7,078	70.776	OK	138.722	-	OK	-
1+700.000	868.876	2+165.000	859.597	2+265.000	858.676	2+339.898	858.790	465	75	100.000	4,656	46.562	OK	-	-25.401	-	OK
2+265.000	858.676	2+339.898	858.790	2+439.898	860.142	2+700.000	866.775	75	260	100.000	4,170	41.702	OK	-	2.297	-	OK
2+439.898	860.142	2+700.000	866.775	3+000.000	871.282	3+079.087	871.642	260	79	300.000	14,320	143.201	OK	68.562	-	OK	-
3+000.000	871.282	3+079.087	871.642	3+179.087	872.301	3+510.000	875.161	79	331	100.000	24,445	244.451	OK	-	-1153.368	-	OK
3+179.087	872.301	3+510.000	875.161	3+610.000	875.495	4+245.000	874.253	331	635	100.000	9,435	94.352	OK	-175.147	-	OK	-
3+610.000	875.495	4+245.000	874.253	4+345.000	872.473	4+416.000	870.086	635	71	100.000	3,158	31.582	OK	101.040	-	[illegible]	-
4+345.000	872.473	4+416.000	870.086	4+516.000	867.830	4+711.214	865.588	71	195	100.000	4,518	45.178	OK	-	-17.512	-	OK
4+516.000	867.830	4+711.214	865.588	4+811.214	865.173	5+650.000	867.841	195	839	100.000	6,819	68.187	OK	-	-148.664	-	OK
4+811.214	865.173	5+650.000	867.841	5+750.000	867.208	5+822.574	866.058	839	73	100.000	5,256	52.553	OK	8.746	-	OK	-
5+750.000	867.208	5+822.574	866.058	5+922.574	865.636	6+600.000	885.191	73	677	100.000	2,313	23.129	OK	-	108.166	-	[illegible]
5+922.574	865.636	6+600.000	885.191	6+900.000	885.816	7+099.992	883.503	677	200	300.000	6,625	66.250	OK	143.856	-	OK	-
6+900.000	885.816	7+099.992	883.503	7+199.992	882.319	7+413.975	880.795	200	214	100.000	10,589	105.892	OK	-	-363.583	-	OK
7+199.992	882.319	7+413.975	880.795	7+513.975	881.610	7+696.355	885.891	214	182	100.000	3,269	32.685	OK	-	53.695	-	OK
7+513.975	881.610	7+696.355	885.891	7+796.355	889.022	8+046.072	893.799	182	250	100.000	6,378	63.778	OK	-	-123.535	-	OK
7+796.355	889.022	8+046.072	893.799	8+246.072	899.558	8+602.202	883.321	250	356	200.000	2,829	28.286	OK	231.400	-	[illegible]	-
8+246.072	899.558	8+602.202	883.321	8+752.202	887.239	8+760.000	887.323	356	8	150.000	3,544	35.440	OK	-	106.927	-	OK
8+752.202	887.239	8+760.000	887.323	8+960.000	885.538	9+110.000	880.216	8	150	200.000	4,324	43.241	OK	151.370	-	OK	-
8+960.000	885.538	9+110.000	880.216	9+210.000	879.541	9+690.799	890.111	150	481	100.000	1,740	17.402	OK	-	140.808	-	[illegible]
9+210.000	879.541	9+690.799	890.111	9+890.799	889.063	9+919.287	888.138	481	28	200.000	3,673	36.728	OK	178.213	-	OK	-
9+890.799	889.063	9+919.287	888.138	10+019.287	886.820	10+288.757	888.464	28	269	100.000	2,593	25.926	OK	-	92.219	-	OK
10+019.287	886.820	10+288.757	888.464	10+388.757	889.895	10+560.000	893.749	269	171	100.000	6,096	60.956	OK	-	-107.452	-	OK
10+388.757	889.895	10+560.000	893.749	10+760.000	898.641	11+128.000	908.359	171	368	200.000	51,261	512.613	OK	-	9.857	-	OK
10+760.000	898.641	11+128.000	908.359	11+328.000	908.784	11+368.239	907.893	368	40	200.000	4,119	41.194	OK	158.892	-	OK	-
11+328.000	908.784	11+368.239	907.893	11+518.239	908.535	11+735.000	915.193	40	217	150.000	2,838	28.378	OK	-	133.537	-	OK
11+518.239	908.535	11+735.000	915.193	12+035.000	922.749	12+435.000	930.612	217	400	300.000	27,129	271.288	OK	36.191	-	OK	-
12+035.000	922.749	12+435.000	930.612	12+635.000	930.278	12+864.224	925.005	400	229	200.000	4,688	46.881	OK	139.618	-	OK	-
12+635.000	930.278	12+864.224	925.005	12+964.224	923.838	13+965.914	923.504	229	1002	100.000	4,411	44.111	OK	-	-11.431	-	OK
12+964.224	923.838	13+965.914	923.504	14+125.914	920.773	14+230.000	917.254	1002	104	160.000	4,780	47.797	OK	109.555	-	OK	-
14+125.914	920.773	14+230.000	917.254	14+390.000	913.480	15+570.000	897.694	104	1180	160.000	7,831	78.314	OK	-	51.614	-	OK
14+390.000	913.480	15+570.000	897.694	15+730.000	895.196	15+100.000	888.594	1180	370	160.000	35,832	358.320	OK	14.614	-	OK	-
15+730.000	895.196	16+100.000	888.594	16+260.000	889.845	15+505.000	898.050	370	245	160.000	3,117	31.169	OK	-	129.683	-	OK
16+260.000	889.845	16+505.000	898.050	16+655.000	901.752	17+260.000	909.361	245	595	160.000	7,729	77.289	OK	67.751	-	OK	-
16+665.000	901.752	17+260.000	909.361	17+360.000	908.663	17+695.000	899.702	595	335	100.000	2,529	25.292	OK	128.713	-	[illegible]	-
17+360.000	908.663	17+695.000	899.702	17+795.000	899.371	18+296.223	909.455	335	501	100.000	2,134	21.336	OK	-	118.382	-	[illegible]
17+795.000	899.371	18+298.223	909.455	18+498.223	909.472	18+520.000	908.998	501	24	200.000	4,993	49.933	OK	131.086	-	OK	-

2.3 Clearance for intersection

Comments on DPR:
Vertical clearance of 5.5m for vehicular underpasses, 4.5m for pedestrian underpasses
Suggestion from JICA Experts:
Vertical clearance of 5.5m for vehicular underpasses, 4.5m for pedestrian underpasses

Vertical clearance shall be determined as 5.5 m for vehicular underpasses and 4.5m for pedestrian underpasses in the final DPR. However, several underpasses in the drawing are not kept the clearance as written in final DPR.

JICA Experts reviewed the drawings based on above standard. JICA Experts have pointed out there are many sections do not fulfill the requirement for clearance as presented in the Table 2.3



Source: JICA Experts

Figure 2.1 Insufficient Lateral Clearance for VUP/POP

Table 2.3 Review on Vertical Clearance of VUP, VOP, PUP and POP (Mainline)

Chainage	Type	Clearance (m)	IRC86 5.5m vehicular road 4.5m pedestrian road
1+550.000	VUP	2.5	error
2+270.000	PUP	2.1	error
3+560.000	POP	3.8	error
4+950.000	PUP	4.0	error
5+700.000	PUP	3.5	error
6+750.000	VUP	4.5	error
8+860.000	VUP	5.5	OK
10+700.000	VUP	4.4	error
11+700.000	PUP	3.1	error
12+550.000	VUP	4.8	error
14+800.000	POP	3.9	error
15+600.000	POP	4.1	error
17+310.000	VUP	4.4	error
20+269.000	VUP	5.5	OK
21+200.000	PUP	3.0	error
23+400.000	VOP	5.3	error
27+145.000	POP	4.5	error
28+080.000	VUP	4.4	error
29+700.000	VOP	5.5	OK
31+500.000	VUP	5.5	OK
33+620.000	VUP	4.4	error
37+760.000	VOP	3.9	error
41+344.000	PUP	3.7	error
44+382.000	VUP	5.0	error
45+445.000	VUP	4.6	error
49+430.000	POP	2.1	error
50+360.000	VUP	5.0	error
51+430.000	VUP	5.5	OK
54+580.000	POP	3.7	error
61+370.000	PUP	3.5	error
62+900.000	VUP	3.8	error

2.4 Maximum Height of Retaining Wall

Comments on DPR:
Very tall MSE retaining wall is planned in DPR.
Suggestion from JICA Experts:
It is better to set the limitation of the height of MSE. Otherwise, detailed analysis, such as FEM analysis, will be required for the tall wall.

Mechanical Stabilized Earth (MSE) Wall is planned in the sections of embankment slope of mainline and service road including the following high embankment locations:

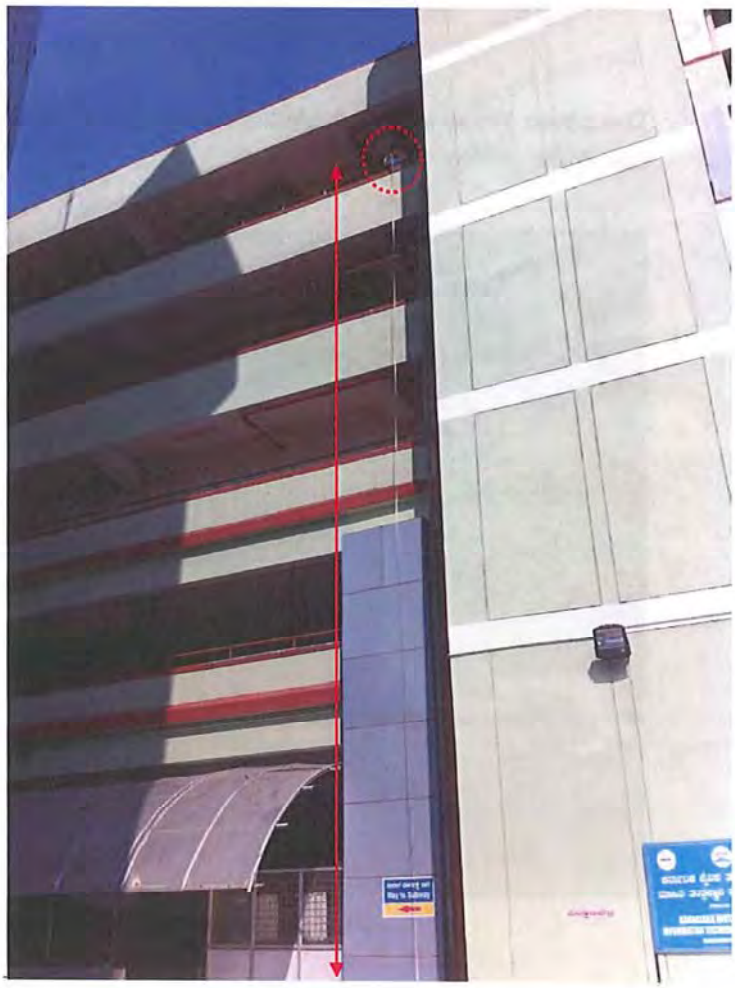
- KM43+100 (ROB at Chennai Railway Line): 16m on the centerline
- KM59+200 (ROB at Hosur Railway Line): 15m on the center line

It is noted that the above height is scaled on the centerline and actual maximum height of MSE at the both edges of the road might be <u>further increased such as 18m-20m height.</u>

(EXAMPLE OF H-18m)

This photo indicate 18m height at the office building of DULT.

18m will reach to 4th floor (actually 5-storey height) of DULT office.



Actually there are some cases in the world constructing tall MSE as listed below. However certain settlement of MSE was observed even using high- performance filling material (strictly selected granular or soil) and inextensible reinforcement (steel reinforcement).

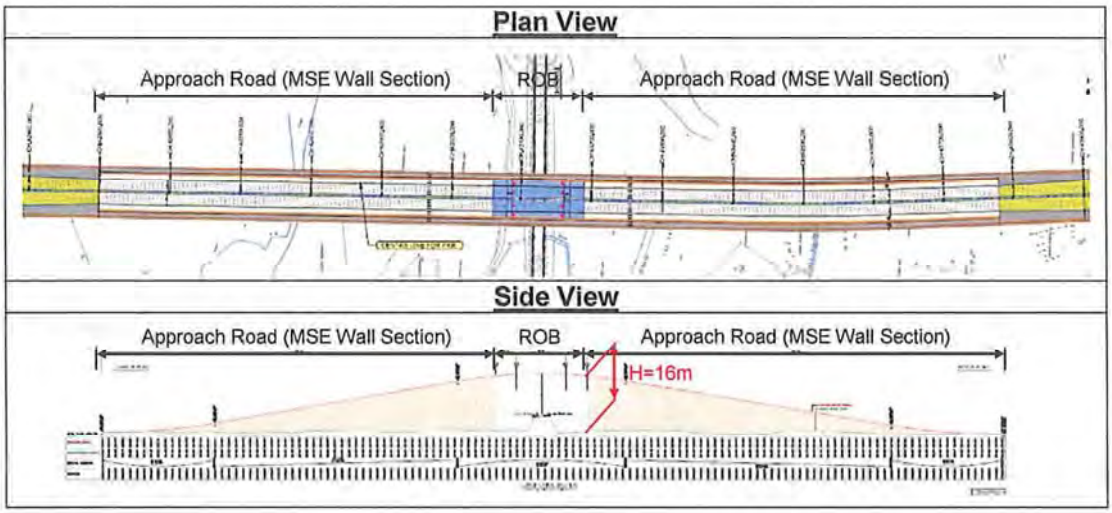
Location	*Max. Height(m)*	*No. of Tiers*	*Year Complete*	*Comments (Supplier)*
Crushing System Expansion, Victor, Colorado USA	32	1	2001	Mine wall supporting bridge crane. (Hilfiker)
Route 288, Richmond, Virginia USA	24	2	2002	High friction (gravel) backfill. (RECo)
Springfield Interchange, Virginia USA	20	1	2002	High friction (gravel) backfill. (RECo)
Hartsfield Airport Runway, Georgia USA	20	1	2003	Maximum total settlement of 600 mm during construction. (RECo)

Source: www.reinforcedearth.com

The photo below shows the actual deformation (settlement) of the 6m height MSE wall in Bangalore.

(Deformation at MSE Wall of NH-7 in Bangalore)

These exceed an experimental standard height (maximum 12m in general); therefore, structural measures or optional structure type are necessary to be considered.



Source: Final DPR

Figure 1.12 Height of MSE Wall at Chennai Railway Line (KM43+100)

JICA Experts recommend applying the standard height of MSE Wall by setting back the abutment locations (extending of ROB length) to assure structural aspects.

In case of applying tall MSE Wall, following technical measures are necessary to assure structural aspects during design life:

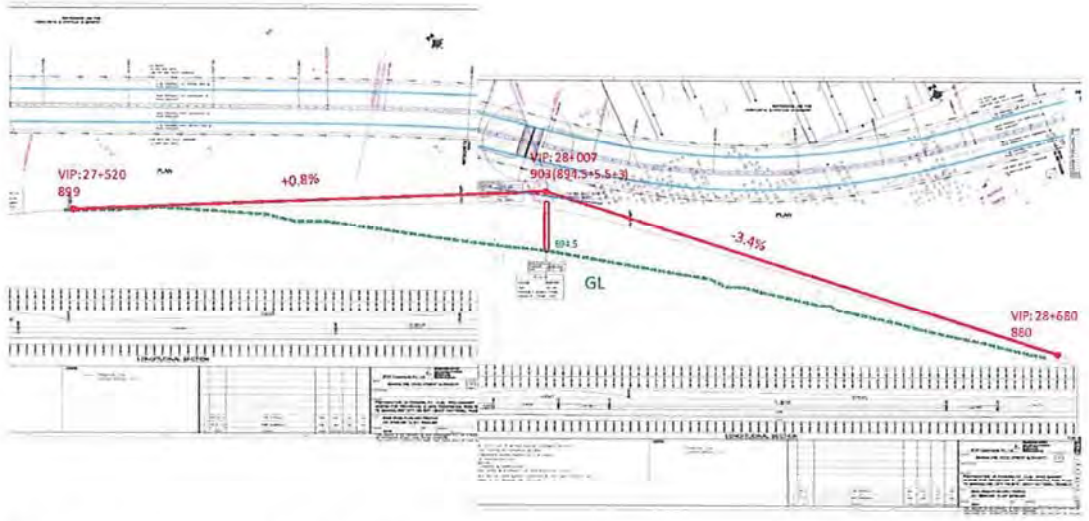
- Considering as critical structure during design life,
- Conducting detail geotechnical investigations at the planned locations,
- Conducting stability/deformation analyses by FEM in static/seismic conditions,
- Conducting consolidation analysis in detail,
- Using specific reinforcing such as metallic/geosynthetic reinforcing, etc.
- Conducting deformation and settlement monitoring during construction and operation periods.

Furthermore, in case of applying high MSE Wall, environmental and social conditions are significantly changed; therefore, it is necessary to agree with neighborhood.

2.5 Example of modification for vertical alignment

2.5.1 VUP

JICA Experts shows an example of modification for drawings including VUP. VUP shall be revised to keep minimum vertical clearance.

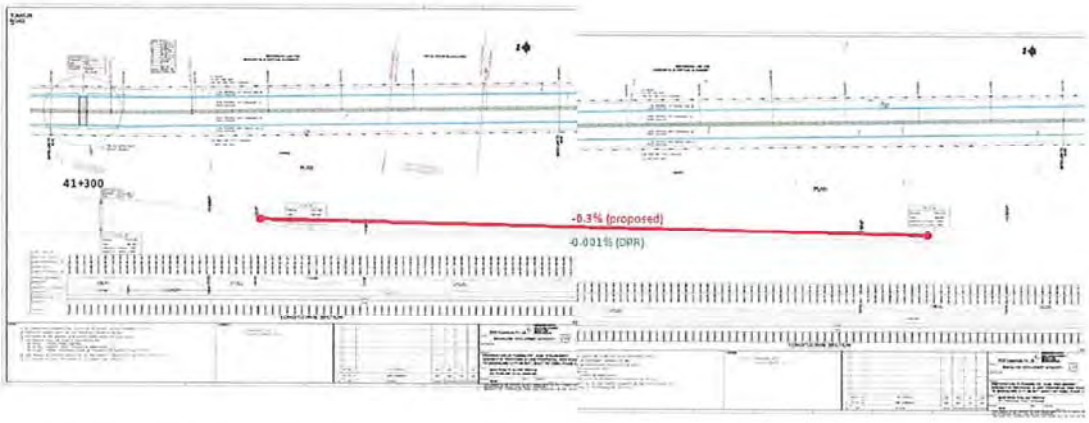


Source: JICA Experts based on Final DPR

Figure 1.13 Draft Modifications for Vertical Alignment (1)

2.5.2 Flat

Some drawings do not fulfill the requirement for minimum gradient. JICA Experts shows example of modification as below.



Source: JICA Experts based on Final DPR

Figure 1.14 Draft Modifications for Vertical Alignment (2)

2.5.3 Filling

Filling landscape shall be applied 4 per cent gradient. JICA Experts shows example that modified from 2.5 per cent to 4 per cent gradient. Therefore, filling can be minimize than existing drawing as below.

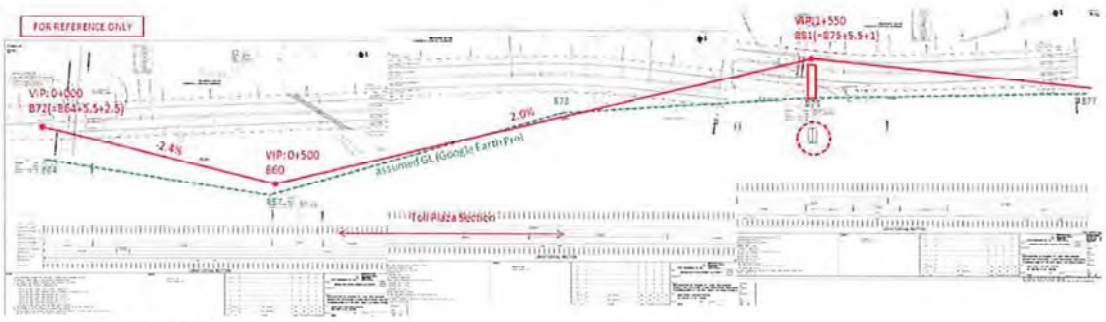
Source: JICA Experts based on Final DPR

Figure 1.15 Draft Modifications for Vertical Alignment (3)

2.5.4 Sections of Toll Plaza

IPC-86 does not specify about the limitation of vertical gradient around toll plaza. Queuing vehicles toward toll booths are sometime stopping on the toll plaza. To avoid minor accident "face to rear hitting" by stopping vehicle due to unintended releasing of brake, the vertical gradient on the toll plaza shall be smaller. Japanese Toll Road Guideline (NEXCO) specifies 2.0% for desirable maximum gradient to avoid the incidents mentioned above.

JICA Experts propose minor modification of the vertical alignment of BPRR as introduced below.



Source: JICA Experts based on Final DPR

Figure 1.16 Draft Modifications for Vertical Alignment (4)

Directorate of Urban Land Transport, Government of Karnataka
Bangalore Development Authority

JICA Experts on
Bengaluru Peripheral Ring Road Project

DISCUSSION PAPER R03

regarding

- ✓ *Design Concept of Ramp Terminal*
- ✓ *Design Concept of Toll Plaza Area*
- ✓ *Rest Area*

11 May 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

TABLE OF CONTENTS

1 Design Concept of Ramp Terminal

1.1 Ramp Design Speed

Comments on DPR:
No description on DPR
Suggestion from JICA Experts:
Below suggestion need to be consider.

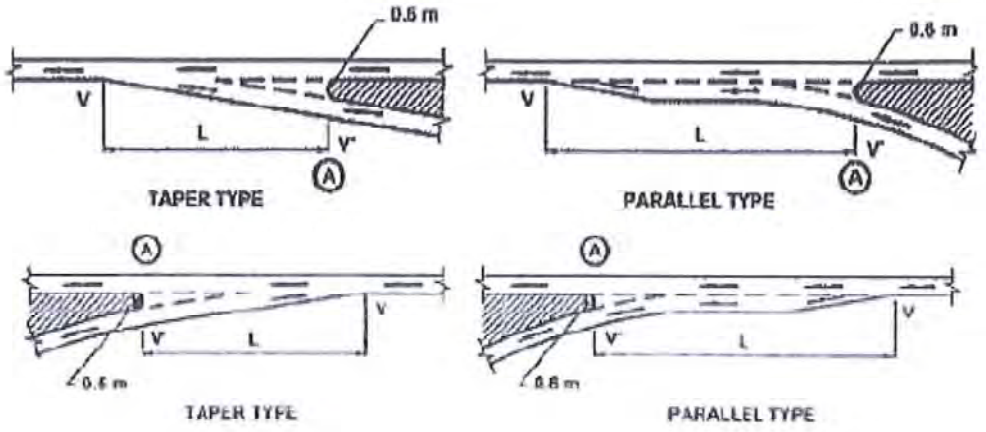
According to "Manual of Specification and Standard for Expressways" (IRC:SP:99-2013), ramp speed of BPRR is the range of 60-80 (km/h). JICA Experts recommend 60(km/h) for ramp speed since most of the car need to accelerate from stopping position at tool booth except ETC.

1.2 Design Speed of Acceleration/deceleration lanes

Comments on DPR Drawings:
No description on OPR drawings about taper Type and ramp speed
Suggestion from JICA Experts:
Acceleration lane length shall be 65m and deceleration lane length shall be 80m.
Structure type of acceleration and deceleration lane shall be taper type

In principle, parallel type is adopted for acceleration lane and taper type is adopted for deceleration lane. However, BPRR adopt the **taper type** for both accelerate and deceleration because of following reasons.

- Since the design speed of main carriageway is 80km/h, long length for acceleration lane is not requires.
- Vehicle can enter main carriageway without too much handling.



(Soure: IRC:SP:99-2013)

Minimum acceleration/deceleration lengths for exit by IRC:SP:99-2013.are shown below.(Under the condition of 80km/h for expressway design speed and 60km/h for ramp design speed.)

Acceleration Length: 65m (Minimum)

Deceleration Length: 80m (Minimum)

1.3 Transition Section of Main Carriageway and Ramp

Comments on DPR Drawings:
Alignment of connecting section of main carriageway with ramp is not considered visibility
Suggestion from JICA Experts:
Any possible measures shall be conducted

Even not description of IRC:SP:99-2013, alignment of connecting section of main carriageway with ramp, need to ensure the driver's visibility since this accident tends to occur in this section. To avoid accident in this section, driver need to recognize interchange from a long distance.

Descriptions below are shown alignment of main carriageway needed to be considered at connecting section of main carriageway and ramp as per Japanese manual.

- Radius of Horizontal Curve (shall be more than 1100m (800m※))
- Radius of Vertical Curve 凸 type (shall be more than 12,000m (6,000m※))
- Radius of Vertical Curve 凹 type (shall be more than 8,000m (4,000m※))
- Vertical Gradient (3% (4%※))

※This is the value shall be follow under any conditions.

Many sections of BPRR are violating above. Since additional land acquisition to follow above values, any possible measures shall be conducted as much as possible.

Besides, operational control for the vehicle speed and recognition of merging/diverging points toward interchanges shall be taken by proper road sign board system. DPR does not provide any drawings of traffic control devices including road signs. This shall be carefully considered in the detailed design.

1.4 Measures enable minimize the accident at section which connecting main carriageway and ramp

Comments on DPR Drawings:
No detail design

Suggestion from JICA Experts:

Some possible measures shall be considered in this stage

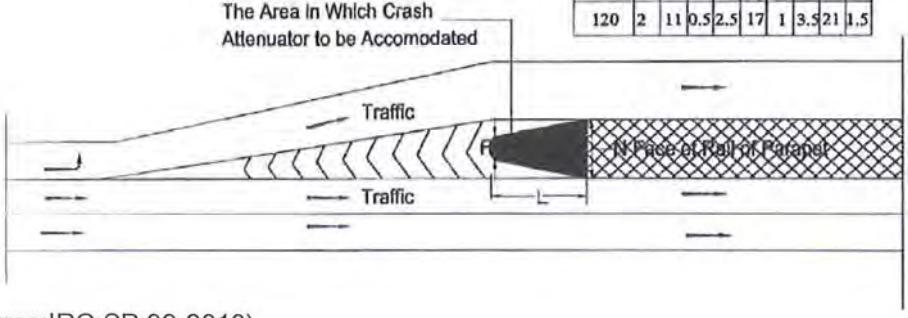
Every measure needs to focus on that improvement of recognition of interchanges for drivers coming from upstream from a long distance.

- Improvement of radius of vertical curve (especially at crest section)
- Expansion of margining/separating length
- Clear segregation between main carriageway and ramp

  (Wide dot marking, Arrow marking, Lettering marking, Colored pavement, Grooving pavement, Cat eye, etc.)
- Warning Signs (2km, 1km, 500m)
- Nose protection

Minimum Space Required For Crash Attenuators i.e. Reserve Area (In meter

Speed of Main Highway (kmph)	Minimum Space						Preferred Space		
	Restricted Conditions			Unrestricted Conditions					
	N	L	F	N	L	F	N	L	F
50	2	2.5	0.5	2.5	3.5	1	3.5	5	1.5
80	2	5	0.5	2.5	7.5	1	3.5	10	1.5
100	2	8.5	0.5	2.5	3.5	1	3.5	17	1.5
120	2	11	0.5	2.5	17	1	3.5	21	1.5



(Source:IRC:SP:99-2013)

2 Design Concept of Toll Plaza Area

2.1 Alignment of Toll Plaza Area

Comments on DPR Drawings:

No finalized drawings are submitted

Suggestion from JICA Experts:

Radius of horizontal curve should be more than 200m and gradient of tool plaza area should not be more than 2%

To design toll plaza area, followings shall be considered.

- Strait line is the best for toll plaza area but if horizontal curve is impossible to avoid, minimum radius of horizontal curve shall be 200m.
- Minimum radius of vertical curve shall be 700m
- Gradient of toll plaza area shall be not more than 2%.
- Crossfall of toll plaza area shall be not more than 2%

2.2 Toll Island

Comments on DPR Drawings:
No finalized drawings are submitted
Suggestion from JICA Experts:
Width of toll lane should be uniformed

As per IRC:SP:99-2013, width of ETC lane is 3.5m and others are 3.2m. However, considering increasing ETC users in future, width should be unformed as 3.2m.

IRC also described 25m for toll island length and not described about ETC lane length. ETC lane need longer island than manual lane since ETC lane requires communication zone between antenna and OBU. Therefore, all lane shall be 30m.(+5m for communication zone)

3 Rest Area

3.1 Recommendation of Rest Area

Comments on DPR/Drawings:
No description about rest area
Suggestion from JICA Experts:
Building rest area along the BPRR is recommended for releasing the call for nature and fatigue.

Total length of peripheral ring road (including NICE) will be 110 km. If some freight trucks drive from Mysore road to Old Madras road, it will drive about half of entire stretch. In order to consider driver's mental fatigue, call for nature and refueling petroleum, having a rest area along the BPRR can improve driver's convenience.

Facilities for rest area are shown below.

- Parking lots (minimum requirement)
- Toilet (minimum requirement)
- Petroleum stand
- Restaurant

- Food court
- Shopping area

Except parking lots and toilet, tenant fee for other facilities will be additional income for road administrator.

Directorate of Urban Land Transport, Government of Karnataka
Bangalore Development Authority

JICA Experts on
Bengaluru Peripheral Ring Road Project

DISCUSSION PAPER S02 (Structure) Regarding

- ✓ *Bridge Planning Criteria and Conditions (Additional)*
- ✓ *Bridge Planning*

13 May 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

TABLE OF CONTENTS
(STRUCTURE_S01_060515)

1 Structure

1.1 Bridge

1.1.1 Bridge Planning Criteria and Conditions (Additional)

1.1.1.1 Pier Locations of VOP/POP

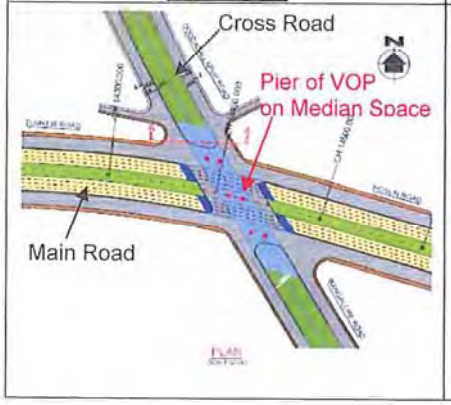
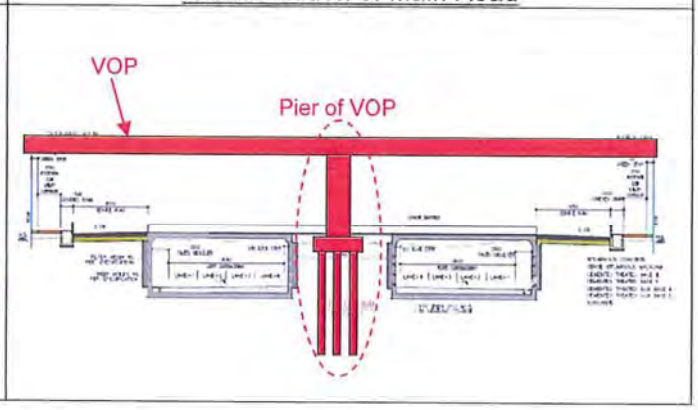
(1) Comments

Median of BPRR (w=12m) is planned utilizing to BRT or Metro in the future.

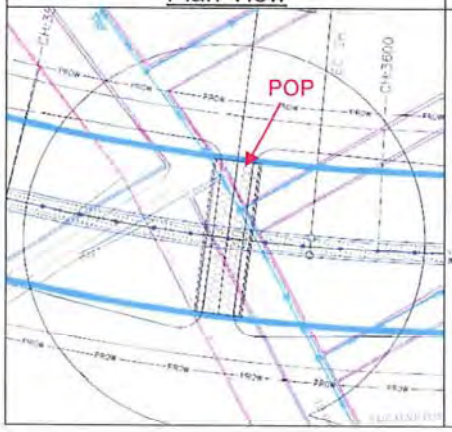
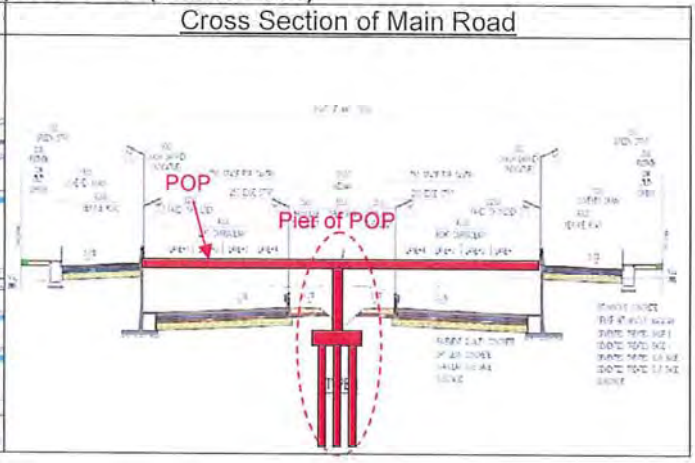
However, piers of VOP are planned on the median space in the Final DPR.

Moreover, it seems that piers of POP are also planned on the median space.

Example of Pier on the Median Space (VOP at KM14+400)

Plan View	Cross Section of Main Road
	

Example of POP (at KM3+600)

Plan View	Cross Section of Main Road
	

(2) Suggestions

JICA Experts recommend to decide the possibility of pier planning at the median space of main road in consideration of the following aspects.

VOP

In case of planning piers on the median space, construction cost may be reasonable by applying shorter span length; however, BRT and Metro should be arranged above VOP in the future.

Moreover, in case of planning piers on the median space, practical construction method and procedures including neighboring construction between the piers and underpass of main road should be carefully studied.

POP

In case of planning piers on the median space, construction cost may be reasonable by applying typical girders with low girder depth (i.e. PC-I Girder, PC Void Slab); however, BRT and Metro should be arranged above VOP or beside the piers on the ground in the future.

(3) Conclusions

1.1.1.2 Maximum Height of Retaining Wall

Comments on DPR:
Very tall MSE retaining wall is planned in DPR.
Suggestion from JICA Experts:
It is better to set the limitation of the height of MSE. Otherwise, detailed analysis, such as FEM analysis, will be required for the tall wall.

Mechanical Stabilized Earth (MSE) Wall is planned in the sections of embankment slope of mainline and service road including the following high embankment locations:

- KM43+100 (ROB at Chennai Railway Line): 16m on the centerline
- KM59+200 (ROB at Hosur Railway Line): 15m on the center line

It is noted that the above height is scaled on the centerline and actual maximum height of MSE at the both edges of the road might be further increased such as 18m-20m height.

(EXAMPLE OF H-18m)

This photo indicate 18m height at the office building of DULT.

18m will reach to 4th floor (actually 5-storey height) of DULT office.

Actually there are some cases in the world constructing tall MSE as listed below. However certain settlement of MSE was observed even using high- performance filling material (strictly selected granular or soil) and inextensible reinforcement (steel reinforcement).

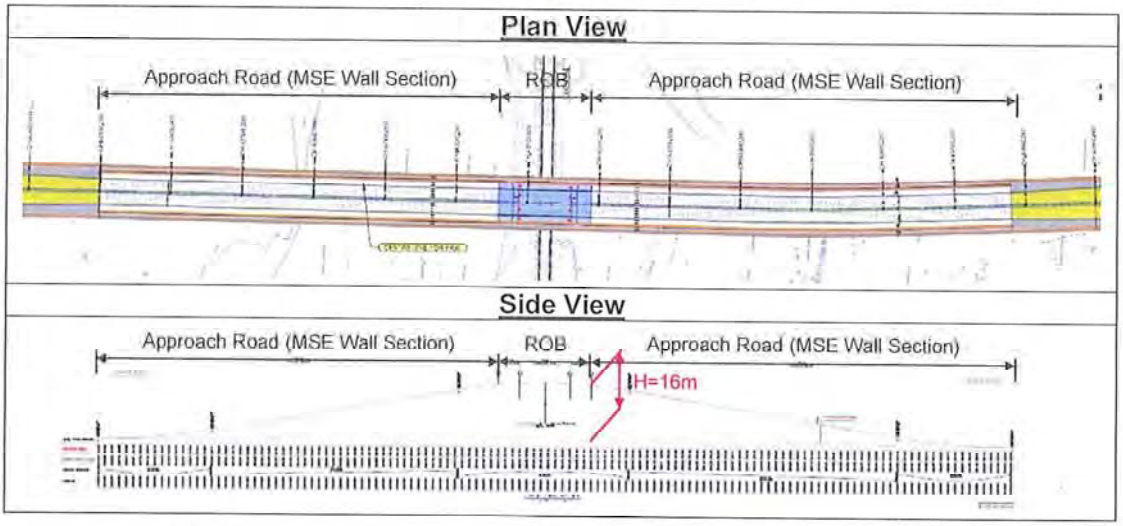
Location	*Max. Height(m)*	*No. of Tiers*	*Year Complete*	*Comments (Supplier)*
Crushing System Expansion, Victor, Colorado USA	32	1	2001	Mine wall supporting bridge crane. (Hilfiker)
Route 288, Richmond, Virginia USA	24	2	2002	High friction (gravel) backfill. (RECo)
Springfield Interchange, Virginia USA	20	1	2002	High friction (gravel) backfill. (RECo)
Hartsfield Airport Runway, Georgia USA	20	1	2003	Maximum total settlement of 600 mm during construction. (RECo)

Source: www.reinforcedearth.com

The photo below shows the actual deformation (settlement) of the 6m height MSE wall in Bangalore.

(Deformation at MSE Wall of NH-7 in Bangalore)

These exceed an experimental standard height (maximum 12m in general); therefore, structural measures or optional structure type are necessary to be considered.



Source: Final DPR

Height of MSE Wall at Chennai Railway Line (KM43+100)

JICA Experts recommend applying the standard height of MSE Wall by setting back the abutment locations (extending of ROB length) to assure structural aspects.

In case of applying tall MSE Wall, following technical measures are necessary to assure structural aspects during design life:

- Considering as critical structure during design life,
- Conducting detail geotechnical investigations at the planned locations,
- Conducting stability/deformation analyses by FEM in static/seismic conditions,
- Conducting consolidation analysis in detail,
- Using specific reinforcing such as metallic/geosynthetic reinforcing, etc.
- Conducting deformation and settlement monitoring during construction and operation periods.

Furthermore, in case of applying high MSE Wall, environmental and social conditions are significantly changed; therefore, it is necessary to agree with neighborhood.

Note: JICA Experts discussed the above issue with DULT/BDA/STUP in the last road design meeting on 11th May (DP-R02). Road engineers of STUP understood the necessity of reducing the MSE Wall height at the above locations and it was decided to ask to the structural engineers of STUP in this meeting (DP-S02).

1.1.2 Bridge Planning

1.1.2.1 Superstructure Type

(1) Comments

Span length is planned from 30m to 70m in the Final DPR; however, superstructure type is applied Pre-cast PC Box Girder (Constant Height Type) only.

In consideration of economy, reducing girder height and dead load, plural superstructure types are necessary by span length and erection conditions.

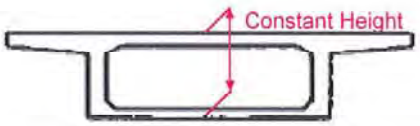
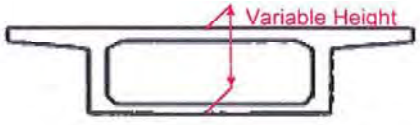
(2) Suggestions

JICA Experts conducted site investigations to the existing bridges in Bengaluru City.

In consideration of general practices in Bengaluru City, JICA Experts recommend applying the following superstructure type in the Project.

However, ROBs, flyovers at national highway should be separately planned.

Superstructure Type (Recommended)

Span Length	Sections (Image)	Erection Method
By 35m	PC-I Girder 	Pre-cast (Truck Crane) 
By 35m (Locations where need to reduce girder height)	PC Void Slab 	CIP (Staging) 
From 40m to 60m	PC Box Girder (Constant Height) 	CIP (Staging) 
Over 60m	PC Box Girder (Variable Height) 	CIP (Balanced Cantilever) 

(3) Conclusions

1.1.2.2 Substructure Type

(1) Comments

Plural type of concrete piers is planned by locations and road width in the Final DPR.

Abutment types are not clearly mentioned in the Final DPR; however, it seems that MSE Wall Abutment (VOP/POP) and Mixed Abutment (other bridges) are planned.

Image of Piers

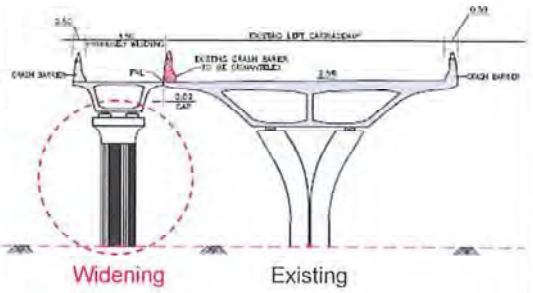
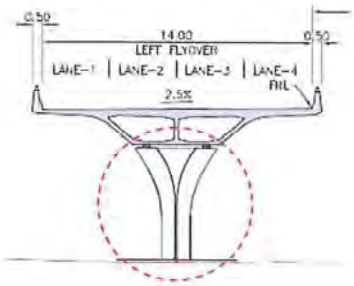
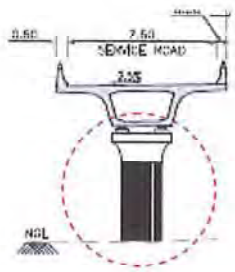
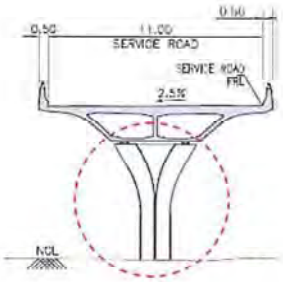
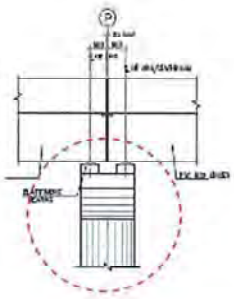
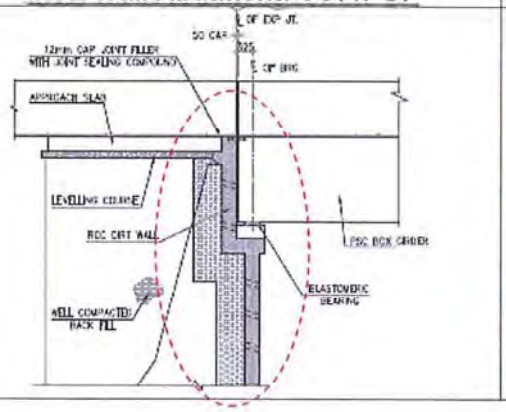
Main Road	
Widening: Round Shape	Typical: Y Shape
	
Service Road	
Road Width≤8.5m: Round Shape	Road Width>8.5m: Y Shape
	
VOP/POP	
Oval Shape	
Side View	Plan View
	

Image of Abutments

MSE Wall Abutment: VOP/POP	Mixed Abutment: Other bridges
	

(2) Suggestions

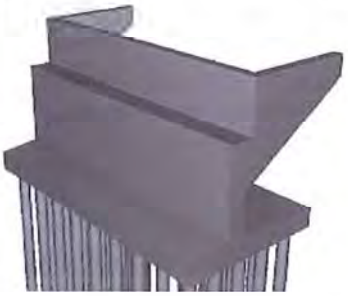
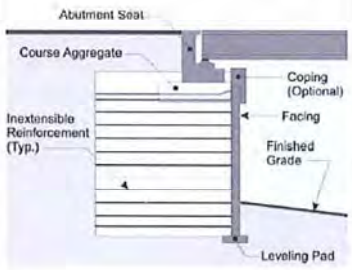
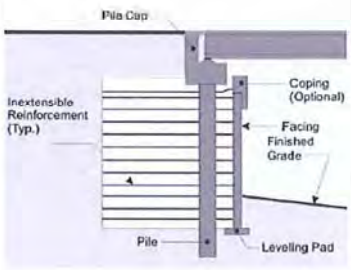
Pier types in the Final DPR are reasonable by economy and general practices in Bengaluru City; however, the column width of Y Shape Piers is necessary to analyze in consideration of the design loads (to be discussed in the next meeting (DP-S03)).

As for the abutment types, JICA Experts recommend applying Inverted T Shape.

In case of applying the MSE Wall Abutment and Mixed Abutment, JICA Experts recommend the following solutions:

- Applying MSE Wall Abutment at cutting location (POP and some VOP) only by reason of avoiding settlement at bridge structure.
- Applying True MSE Wall Abutment or Modified Mixed Abutment instead of MSE Wall Abutment to avoid influence of settlement/deformation to bridge structure.
- Applying Mixed Abutment at embankment locations.

Image of Alternative Abutment Types

Inverted T Shape Abut.	True MSE Wall Abut.	Modified Mixed Abut.
		

(3) Conclusions

1.1.2.3 Foundation Type

(1) Comments

Foundation types are not mentioned in the Final DPR.

It may be not planned in the DPR stage by reason of luck of geotechnical information.

However, variation of foundation type and size will be huge affected to the project cost in the implementation stage; therefore, it is necessary to plan before the JICA Appraisal in relation to the existing geotechnical information at/around BPRR.

(2) Suggestions

Existing geotechnical information will be provided through DULT/BDA; therefore, in this discussion, JICA Experts confirm common foundation types in Bengaluru City.

JICA Experts assume that the following are common foundation types:

- Cast in Place RC Bore Pile (to be confirmed common dia. in Bengaluru City)
- Spread Foundation (at shallow depth of bearing layer (i.e. by 5m))

However, in case of applying the above common foundation types, it is necessary to consider appropriate countermeasures at neighboring construction locations (near existing houses and structures, etc.).

(3) Conclusions

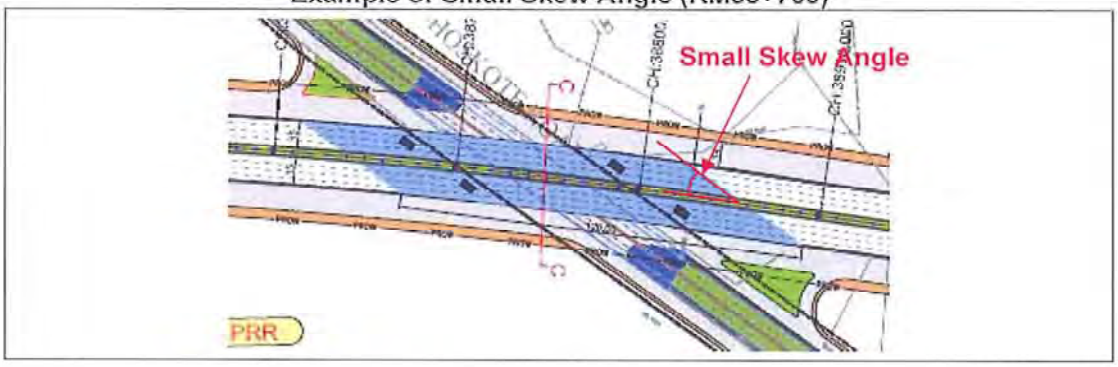
1.1.2.4 Skew Angle

(1) Comments

Some bridges are planned with quite small skew angles in the Final DPR.

Bridge with small skew angle has several technical issues in design and durability.

Example of Small Skew Angle (KM38+700)



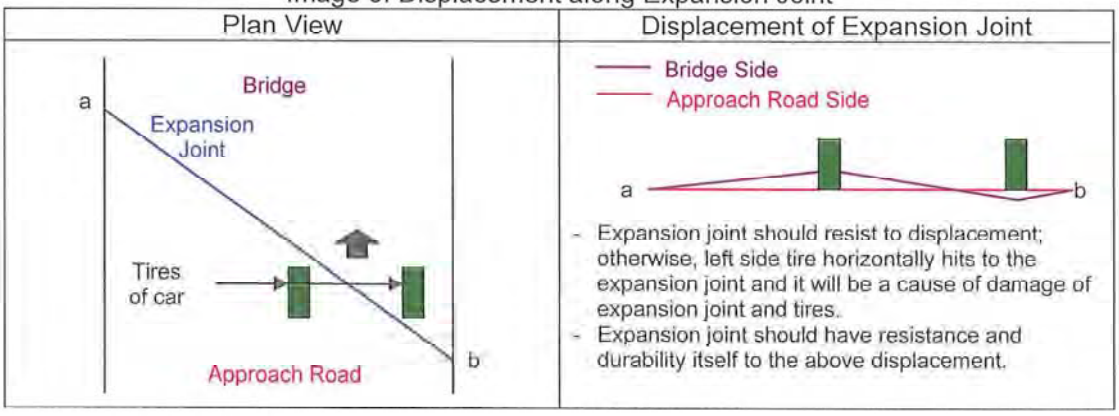
(2) Suggestions

JICA Experts recommend improving the skew angle to 90 degrees (at least minimum 70 degrees) to avoid torsional force, unsymmetrical earth pressure at abutment.

In case of applying small skew angles (less than 70 degrees), the following technical issues are necessary to solute in the design stage.

- Considering torsional force in structural design.
- Considering unsymmetrical earth pressure in abutment design.
- Applying durable expansion joint to resist displacement along expansion joint

Image of Displacement along Expansion Joint



(3) Conclusions

1.1.2.5 Bridge Planning

(1) Comments

Bridge planning is not clearly mentioned in the Final DPR.

Variation of bridge type and length will be huge affected to the project cost in the implementation stage; therefore, it is necessary to plan before the JICA Appraisal in accordance with Sections 1.1.2.1 to 1.1.2.4 in this Discussion Paper.

(2) Suggestions

JICA Experts conducted the preliminary bridge planning as shown in the next page.

Based on this bridge planning, JICA Experts will discuss and conclude the bridge planning with DULT/BDA/STUP.

As for the bridges at National Highway and Railways, those are necessary to discuss and agree with the Operators.

In case of the Operators will request short erection period at cross locations; it shall be considered applying rapid erection method with steel structures.

(3) Conclusions

Bridge Plan (Preliminary Planning Results by JICA Experts)

No	Station	Bridge Category	Location	Cross Object	Width(1)	Clearance (under BR)		Priority	Bridge Length(2)	Span Arrange	Superstructure	Erection Method	Substructure		Remarks
						Vertical	Horizontal						Abutment	Pier	
1	KM00+000	Flyover	Main Road	NH-7	4m	5.5m	Existing BR	—	60m	2@30m	PC-I	Truck Crane	Mixed	Round	Widening of Existing BR (Both Sides). Existing BR: PC-I Girder
2	KM03+660	POP	Cross Road (Local Road)	Main Road (Underpass)	8.6m	5.5m	Main Road	Priority	46.5m	2@23.25m	PC Void	CIP (Staging)	MSE Wall	Oval	It depends on pier at median of main road is allowed or not.
								Alternative		1@46.5m	PC Box (Constant)	CIP (Staging)	MSE Wall	—	
3	KM04+212	ROB, Flyover	Main Road, Service Road	Bangalore-Tumkur Railway Line, SH-33	8.5m,2@15m,8.5m	Rail: TBC, Road: 5.5m	Rail: 40m, Road: 40m	Priority	200m	1@60m+1@40m	Steel Box	Erection Girder	Mixed	Main: Y, Service: Round	Erection from Approach Span/Road by Erection Girder. Maximum 3 days for Erection Works.
								Alternative 1			PC Box (Constant)	CIP (Staging)			
											PC Box (Constant)	Erection Girder (Precast)	Mixed	Main: Y, Service: Round	Alternative: Apply PC Box (Constant) at railway cross location. Not economical by short BR length, long period heavy weight.
						(Rail: 5m/Road: 28m)		Alternative 2	175m	5@35m	PC-I	Erection Girder (Rail: Road)	Mixed	Main: Y, Service: Round	In case of allowed by railway and road operators
4	KM14+435	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@12m	5.5m	Service Road	Priority	120m	2@60m	PC Box (Constant)	CIP (Staging)	Mixed	Y/Alternatives	It depends on pier at median of main road is allowed or not.
								Alternative	220m	60m+100m+60m	PC Box (Variable)	CIP (Cant'lever)	Mixed	Y/Alternatives	It is recommended applying 50 degrees of skew angle.
5	KM14+800	FOP	To be confirmed (Toll Plaza Section)												
6	KM15+600	FOP	(Plan and Profile DWG: Mentioned, Junction DWG: Not Mentioned)												
7	KM20+400	VOP	Cross Road (Service Road)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	Priority	46.5m	2@23.25m	PC Void	CIP (Staging)	MSE Wall	Oval	It depends on pier at median of main road is allowed or not.
								Alternative		1@46.5m	PC Box (Constant)	CIP (Staging)	MSE Wall	—	
8	KM26+683	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	6.6m	Service Road	Priority	120m	2@60m	PC Box (Constant)	CIP (Staging)	Mixed	Round	It depends on pier at median of main road is allowed or not.
								Alternative	220m	60m+100m+60m	PC Box (Variable)	CIP (Cant'lever)	Mixed	Round	
9	KM27+145	FOP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	Priority	46.5m	2@23.25m	PC Void	CIP (Staging)	MSE Wall	Oval	It depends on pier at median of main road is allowed or not.
								Alternative		1@46.5m	PC Box (Constant)	CIP (Staging)	MSE Wall	—	
10	KM29+770	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	Priority	46.5m	2@23.25m	PC Void	CIP (Staging)	MSE Wall	Oval	It depends on pier at median of main road is allowed or not.
								Alternative		1@46.5m	PC Box (Constant)	CIP (Staging)	MSE Wall	—	
11	KM36+923	Flyover	Main Road	NH-4	12m,2@15m,12m	5.5m	NH-4: 40m	Priority	60m	1@60m	Steel Box	Erection Girder	Mixed	—	It depends on staging at NH-4 is allowed or not.
								Alternative			PC Box (Constant)	CIP (Staging)			
12	KM37+760	VOP	Cross Road (SH-33)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	Priority	46.5m	2@23.25m	PC Void	CIP (Staging)	MSE Wall	Oval	It depends on pier at median of main road is allowed or not.
								Alternative		1@46.5m	PC Box (Constant)	CIP (Staging)	MSE Wall	—	
13	KM39+789	Flyover	Main Road	Cross Road (NH-209) (Underpass)	2@15m	5.5m	Cross Road	—	180m	60m+60m+60m	PC Box (Variable)	CIP (Cant'lever)	Mixed	Y/Alternatives	It is recommended applying 50 degrees of skew angle.
14	KM43+125	ROB	Main Road	Bangalore-Chennai	10m,2@15m,10m	6m	Rail: 100m	Priority	160m	40m+70m+40m	Steel Box	Erection Girder	Mixed	Main: Y	Erect on from Approach Span/Road by Erection Girder. Maximum 3 days for Erection Works.
								Alternative			PC Box (Variable)	Erection Girder (Precast)			Not economical by short BR length, long period heavy weight.
15	KM49+430	POP	Cross Road (Local Road)	Main Road (Underpass)	8.6m	5.5m	Main Road	Priority	93.5m	2@23.25m	PC Void	CIP (Staging)	MSE Wall	Oval	It depends on pier at median of main road is allowed or not.
								Alternative		1@46.5m	PC Box (Constant)	CIP (Staging)	MSE Wall	—	
16	KM56+211	Flyover	Main Road	Cross Road (SH-91) (Underpass)	2@15m	5.5m	Cross Road	—	130m	35m+60m+35m	PC Box (Constant)	CIP (Staging)	Mixed	Y/Alternatives	
17	KM61+650	POP	Cross Road (Local Road)	Main Road (Underpass)	8.6m	5.5m	Main Road	Priority	46.5m	2@23.25m	PC Void	CIP (Staging)	MSE Wall	Oval	It depends on pier at median of main road is allowed or not.
								Alternative		1@46.5m	PC Box (Constant)	CIP (Staging)	MSE Wall	—	
18	KM65+211	VOP	Cross Road (Local Road)	Main Road (Underpass)	10m,2@15m,10m	5.5m	Service Road	Priority	120m	2@60m	PC Box (Constant)	CIP (Staging)	Mixed	Round/Alternatives	It depends on pier at median of main road is allowed or not.
								Alternative	220m	60m+100m+60m	PC Box (Variable)	CIP (Cant'lever)	Mixed	Round/Alternatives	
19	KM69+198	RCB	Main Road, Service Road	Bangalore-Hosur Railway Line	3.5m,2@17.5m,8.5m	6m	Rail: 60m	Priority	130m	35m+1@+35m	Steel Box	Erection Girder	Mixed	Main: Y/Others: Service: Round	Erection from Approach Span/Road by Erection Girder. Maximum 3 days for Erection Works.
								Alternative 1			PC Box (Constant)	Erection Girder (Precast)			Not economical by short BR length, long period heavy weight. Steel box is more safety by reason of curve bridge.
							Rail: 60m	Alternative 2	105m	3@35m	PC-I	Truck Crane			In case of allowed by railway operator.
20	KM84+751	Flyover	Main Road	NH-7	4m	5.5m	Existing BR	—	60m	2@30m	PC-I	Truck Crane	Mixed	Round	Widening of Existing BR (Both Sides). Existing BR: PC-I Girder

1) Road Width in the Final DPR (To be followed discussion result in DP-R02)
2) Approximate Bridge Length (It is necessary to determine in detail in the D/D stage)
Red: To be confirmed with Railway Operator
Blue: To be confirmed with Road Operator

1.1.2.6 Bridge Accessory Planning

(1) Comments

Bridge accessories plan is not clearly mentioned in the Drawings, Final DPR; however, plan of bridge bearings and expansion joint is described in the Main Report.

Bridge Bearings: Pot Bearings

Expansion Joint: Modular Joints

(2) Suggestions

JICA Experts understand that Pot Bearings and Modular Joints are appropriate by reason of high performance and durability.

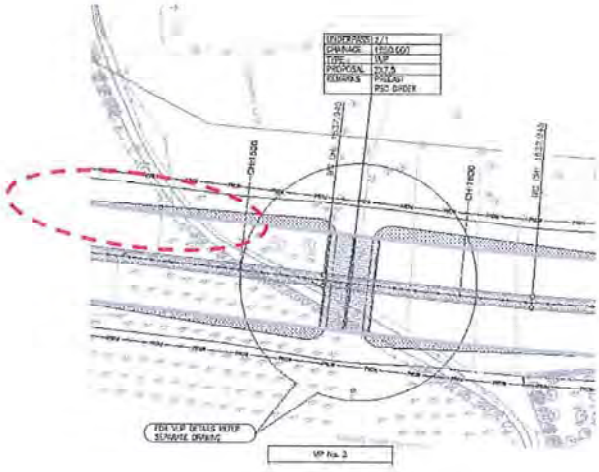
(3) Conclusions

1.1.3 Box Culvert

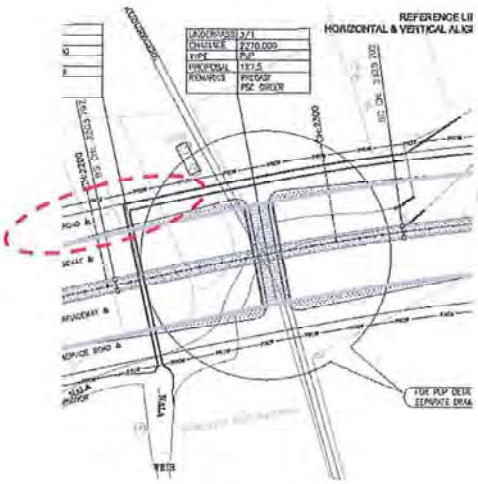
1.1.3.1 VUP

Comments on DPR:
Width of carriageway of the service road is narrowed at the approach to VUP and PUP.
Suggestion from JICA Experts:
Flyovers or bridges shall be studied instead of box-culverts.

Following figure shows the narrowed carriageway of the service roads.



(Bottleneck for VUP)



(Bottleneck for PUP)

Source: Final DPR

Bottleneck of Carriageway

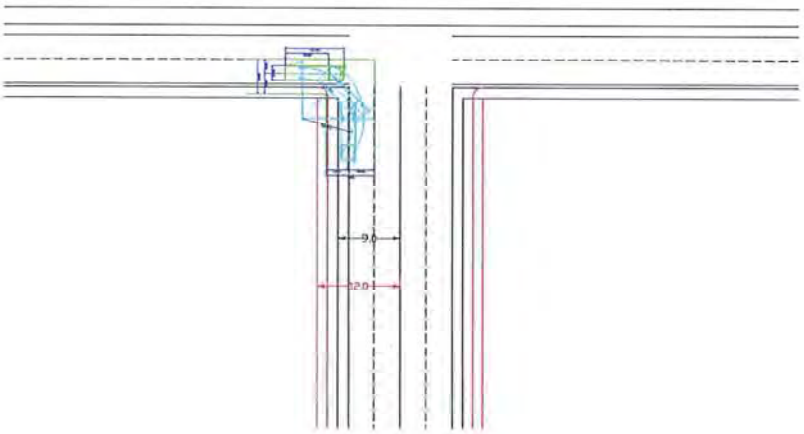
The narrowed carriageway will induce traffic congestion and the width of the carriageway shall keep the original width (9.0m).

Figure in the next page presents the vehicle motion path of 30 ton truck and semi-trailer on the proposed VUP of BPRR.

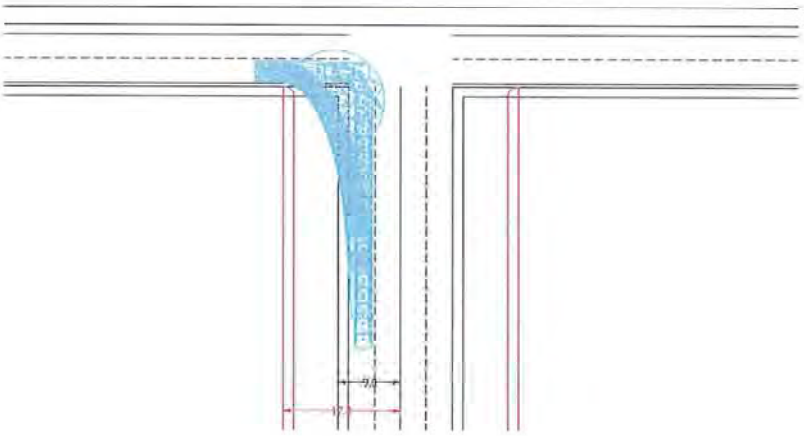
The proposed width of box-culvert cannot manage the traffic flow properly. In order to secure the minimum turning movement of these vehicle, width of the box culvert shall be much larger as suggested in the figure in the next page.

The development along the proposed BPRR will be rapidly accelerated after the completion of the road. Concurrently, traffic volume of heavy vehicles to/from the newly developed premises/enterprises will be increased.

It is quite essential to consider heavy vehicle's turning movement into the design of the VUP.



(30 ton Truck)



(Semi-trailer)

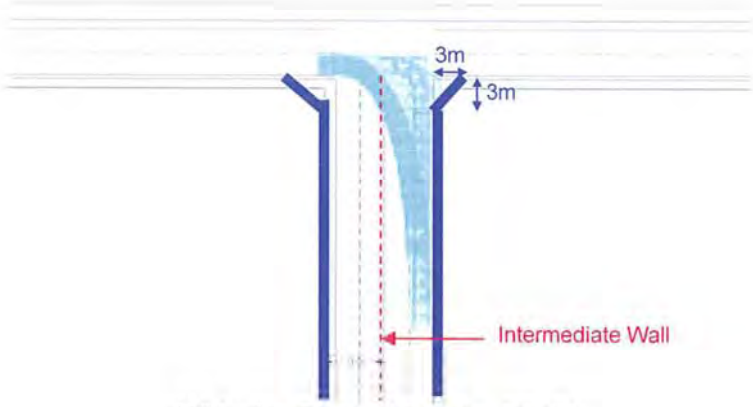
Source: JICA Experts

Vehicle Motion Path at VUP

According to the result of the motion path presented in above figure, size of box-culvert shall be changed to much larger one. JICA Experts recommend flyovers or bridges instead of box culvert for VUP.

Note: JICA Experts discussed the above issues with DULT/BDA/STUP in the road design meeting on 11th May. Road engineers of STUP explained that it will plan widening of box culvert at the both entrances as shown in the figure in the next page. However, it has still issues in the followings; therefore, JICA Experts ask to structural engineers of STUP in this meeting.

- Turn Movement: Not ensured by Intermediate Wall
- Width of VUP: Very Wide (More than 2@12m)



Widening Plan of VUP (by STUP)

Directorate of Urban Land Transport, Government of Karnataka
Bangalore Development Authority

JICA Experts on
Bengaluru Peripheral Ring Road Project

DISCUSSION PAPER C01

(COST ESTIMATE)

regarding

✓ ***Cost Estimate***

18 May 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

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1 Re-confirmation of Conditions of Cost Estimate

1.1 Final Version of "Bill of Quantities and Cost Estimate (BOQC)"

Comments on DPR and BOQC:
Amount differences between .BOQC and DPR Report
Suggestion from JICA Experts:
Need to be confirmed.

BDA provided JICA "Bill of Quantities and Cost Estimate (BOQC)", Rev R(3).

JICA Experts obtained from BDA/STUP the Final DPR Report, Rev R(5) on 7 May 2015 and found there were significant differences on figures of the estimation between BOQC and Final DPR. Table 1.1 shows an example of the differences.

Table 1.1Amout Differences between BOQC and DPR (Example)

Item	Bill of Quantities Rev R(3)	Final DPR Report Rev R(5)
Grand Total for the Project Construction	3,220 Crores	3,750 Crores

Source: BOQC, Rev R(3) and Final DPR, Rev R(5)

1.2 Earth Spill out beyond 75m ROW

Comments on DPR and BOQC:
It was assumed earthen embankment or cutting less than 1.0m height would be beyond 75m ROW.
Suggestion from JICA Experts:
Need to be confirmed.

JICA Experts have briefly reviewed DPR and BOQC (Bill of Quantities and Cost Estimate).

DPR does not explain in detail about the type of retaining wall and the drawings only indicate RE Wall (Reinforces Earth Retaining Wall = MSE: Mechanically Stabilized Earthen) wall structure.

On the other hand, BOQC, Rev R(3), stated the following conditions for the cost estimation.

4) Retaining wall is considered as follows:
   i) No wall if the level difference between road top edge and NGL is less than 1m.
   ii) RCC wall if the level difference between road top edge and NGL is between 1m and 2.5m.
   iii) RE wall if the level difference is more than 2.5m.
   iv) RCC wall is considered for RUB portion.

5) The cost of retaining wall is approximately 300 Cr which is due to restriction in earthen spill at end of ROW hence necessitating retaining wall at ROW edges. It is presumed that BDA will permit earthen spill beyond 75m ROW into development zone.

JICA Experts would like to confirm BDA regarding the condition without retaining wall (height less than 1.0m) whether the spilled out embankment or cutting is accepted or not.

1.3 RUB Structures at Doddaballapur and Chikkaballapura Railways

Comments on DPR and BOQC:
BOQC assumes railway track shifting during the construction of RUB.
Suggestion from JICA Experts:
Need to be confirmed.

BOQC (Bill of Quantities and Cost Estimate) stated the following.

RUB is proposed for Doddaballapur and Chikkaballapur railway crossing. The cost includes temporary diversion of existing tracks, construction of RUB (cut and cover) and restoring the track back.

JICA Experts would like to confirm the above condition to BDA. When the track shifting is not accepted by the railway authority, the alternative construction method such as "box pushing" will be selected and will induce an certain large additional cost.

1.4 Box Culvert Structures for BPRR under National Highways

Comments on DPR and BOQC:
Construction method of the large sized box culverts is not mentioned in DPR.
Suggestion from JICA Experts:
Need to be confirmed.

It shall be confirmed the cost estimate condition of the construction method of the large-sized box culverts to underpass the National Highways.

JICA Experts assume the "open and cut" method is applied in the construction method for the cost estimation as well as the RUB (See 1.3 above.).

DPR and BOQC does not explain about the above and JICA Experts need to clarify this issue.

1.5 Quantity of RE (Reinforced Earth) Wall

Comments on DPR and BOQC:
The total quantity of the RE Wall in BOQC is <u>176,175 m2</u>.
Suggestion from JICA Experts:
JICA Experts tentatively calculated the quantity of RE Wall as <u>339,680 m2</u>.

Below table is derived from the "Bill of Quantity and Cost Estimate (BOQC)" in DPR.

The amount of the quantity of RE Wall is estimated as 176,175 m2.

Table 1.2Amout Differences between BOQC and DPR (Example)

CONSTRUCTION OF 8 LANE PERIPHERAL RING ROAD IN BENGALURU - COST ESTIMATE

BILL NO 25: RE WALL

Item	Stretch / Structures	Unit	VUP 1	VUP 2	VUP 3	ROP 1	ROP 2	ROP 3	Flyover 1	Flyover 2	Flyover 3	ROB 1	ROB 2	ROB 3	TOTAL QTY	RATE	1 Amount in	2 Amount in	3 Amount in	TOTAL AMOUNT
	RE PANEL																			
25.01	Area of RE wall + RE Panel	Sqm	29265	31462	41262	13889	2232	5786	15933	11406	21529	0	0	12531	176175	5,500	[illegible]	[illegible]	[illegible]	[illegible]
25.02	Area of RE wall - (Friction slab, Crash barrier, Filter media, HDPE pipe etc.)	Sqm	29265	31462	41262	13889	2232	4786	15933	11406	21529	0	0	12531	176175	3,500	206,349,500	122,050,000	237,413,000	[illegible]
	RCC WALL																			
	Length		1952	1431	2751	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1275	0	0	[illegible]	[illegible]					
25.03	[illegible]	Cum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.04	Back fill	Cum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.05	PCC	Cum	[illegible]	[illegible]	[illegible]	[illegible]	71	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.06	RCC - M35	Cum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.07	Steel	MT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.08	Weep holes	Nos	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.09	Filter media	Cum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.10	Painting	Sqm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Sub Total																[illegible]	[illegible]	[illegible]	1,770,266,280
	Grand Total																	1,770,266,280		

Source: BOQC, Rev R(3)

JICA Experts independently calculated the quantity based on the available information. (Please see "EXCEL Sheet" as distributed by e-mail prior to the meeting on 18 May 2015.).

<u>The quantity calculated by JICA Experts is 339,680 m2 and this figure is approximately 200% of BOQC (176,175 m2).</u>

Table 1.3 summarizes differences between BOQC and JICA Experts' calculation.

Table 1.3 Quantity Differences on RE Wall

Sections	DPR (BOQC, Rev (R3))	JICA Experts' Calculation
Section 1	58,957 m2 (100%)	102,157 m2 (173%)
Section 2	35,100 m2 (100%)	60,348 m2 (172%)
Section 3	82,118 m2 (100%)	177,175 m2 (216%)
Total	**176,175 m2 (100%)**	**339,680 m2 (193%)**

Source: BOQC, Rev R(3), JICA Experts

<u>The cost differences on the above will be at least 164 crores and this issue need to be clarified.</u>

Possibility of the above difference is BOQC counts only the edge of the road and JICA Experts counts the edge of the both direction of the road as shown in below figure.

(Wall on Road Edge only) (Wall on Edge of Both Direction)

Figure 1.1 Differences of Quantity?? (Need to be confirmed soon)

1.6 Coordination with NICE

Comments on DPR and BOQC:
According to BOQC and also hearing from DULT/BDA, the scope demarcation between BDA and NICA is still under negotiation.
Suggestion from JICA Experts:
Need to be confirmed.

BOQC (Bill of Quantities and Cost Estimate) stated the following.

Details and extent of integration required at Tumkur road and Hosur road with existing NICE road is assumed in absence of conformation on type, extent of integration and scope of work between BDA and NICE.

JICA Experts would like to confirm the above condition to BDA. It might be recommended to include the cost of these junctions in the Project cost if the negotiation is not concluded before the appraisal mission by JICA in July 2015.

2 General Question/Request from JICA Experts (Cost Estimate)

Request 1:
Pease provide us the final "Bill of Quantities and Cost Estimate".

Request 2:
Please share the source of cost estimate such as below documents. 1) KPWD SR Bangalore2013-14 2) NH SR Bangalore Circle 3) Referred IRC for the cost estimate, if any

Directorate of Urban Land Transport, Government of Karnataka
Bangalore Development Authority

JICA Experts on
Bengaluru Peripheral Ring Road Project

DISCUSSION PAPER R04

(ROAD/JUNCTION/TOLL FACILITY)

regarding

- ✓ *Maximization of BPRR Use*
- ✓ *Design Concept of Ramp Terminal*
- ✓ *Weaving*
- ✓ *Toll Gate*

18 May 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

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1 Maximization of BPRR Use

1.1 Interval of JCTs and Recommendation of Additional JCTs

Comments on DPR/Drawings:
There are 3 sections having long interval of JCTs more than 10km.
Suggestion from JICA Experts:
To maximize the utilization of BPRR, it is highly recommended to provide additional ON/OFF Ramps.

Since BPRR is a ring road of Bengaluru Metropolitan Area, the interval of adjacent Junctions (JCTs) should not be too long in terms of user's convenience and maximization of toll revenue.

Table 1.1 shows IC interval of three ring roads which are BPRR, Tokyo PRR and Tokyo ORR. Average radius of Tokyo PRR is around 50km from center of Tokyo, but none of IC interval exceeds 10km. On the other hands, three section of IC interval of BPRR exceed 10km.

Table 1.1 Comparison of IC Interval of Three Ring Road

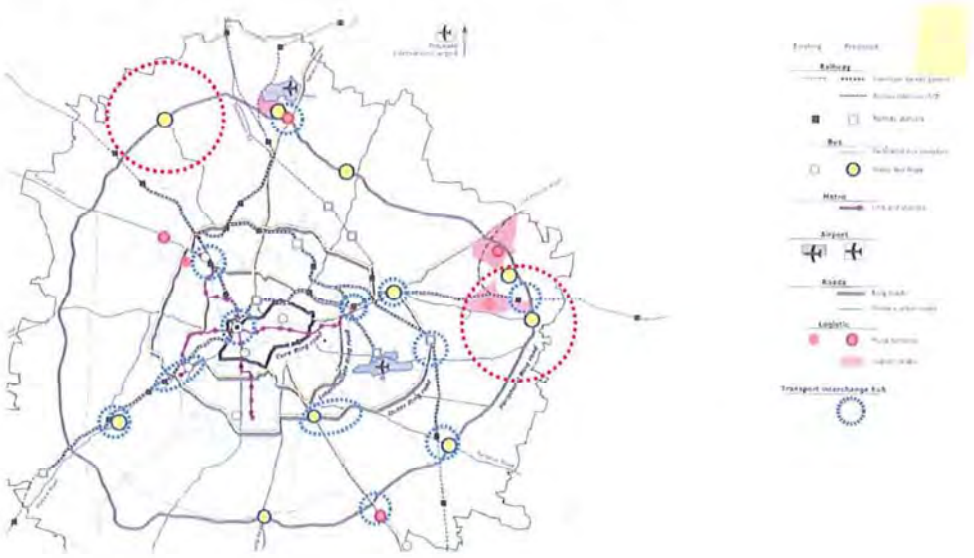
BPRR(106km ring)		Tokyo PRR(300km ring) 220km is on service		Tokyo ORR(85km ring)c 34km is on service	
IC Name	Distance	IC Name	Distance	IC Name	Distance
Tumkur		Ebina		Oizumi	
	4.34		4.9		3.4
Hessarghatta		Kenouatsugi		Wako	
	10.08		5.2		2.1
Doddaballapura		Sagamiwara-aikawa		Wako-kita	
	4.22		8.9		2.1
Bellary		Sagamiwara		Toda-nishi	
	6.96		5.9		2.3
Hennur		Takaosan		Toda-higashi	
	10.64		6.4		2.4
Old Madras		Hachiouji-nishi		Gaikan-urawa	
	2.33		5.2		1.7
Whitefield		Akiruno		Kawaguchi-nishi	
	15.47		2.0		2.8
Hoskote-Anekal		Hinode		Kawaguchi-cyuo	
	2.69		8.7		2.2
Sajapur		Oume		Kawaguchi-higashi	
	8.83		4.8		3.4
Hosur		Iruma		Souka	
			6.0		6.0
		Sayamahidaka		Misato-nishi	
			6.8		5.3
		Kenou-tsurugashima		Misato-miinami	
			7.4		
		Sakato			
			2.5		
		Kawashima			
			5.7		
		Okegawa-kitamoto			
		Tsukuba-cyuo			
			5.8		
		Tsukuba-ushiku			
			6.1		
		Ushilku-ami			
			5.9		
		Ami-higashi			
			6.0		
		Inashiki			
			6.0		
		Inashiki-higashi			
			4.6		
		Kanzaki			

This section is under construction

Construction of new interchanges for above three sections which have more than 10km interval of JCTs, should be considered in the detail design stage.

The interval between Whitefield JCT and Hoskote-Anekal JCT is more than 15km distance and Whitefield is one of the most chronically congested area in Bengaluru.

According to "Bengalore Master Plan- 2015 Vision", Whitefield area is strategically selected as "Logistic Center" and "Public Bus Node".



Source: Bangalore RCDP 2015

Figure 1.1 Bangalore Master Plan

Area of Chansandra will be best location to provide additional ON/OFF Ramps to ensure accessibility to Whitefield Road.

Similarly, the interval between Hesarghatta JCT and Doddaballapura JCT is also more than 10km distance. In the master plan, the road between these JCTs is identified as "Public Bus Node". It will be recommended to provide additional ON/OFF Ramps to ensure accessibility to this strategic road.

Furthermore, JICA Experts recommend BDA/DULT to consider an additional ON/OFF Ramps between Hennur JCT and Old Madras JCT which interval is also more than 10km long.

To construct additional ON/OFF Ramp, 25m vacant spaces along the BPRR could be utilized for installing 2 or 3 toll gates at both sides.

※Required width of toll gate for 2 lanes

$2 \times (2m+3.2m+2m+4.5m) = 23.4m < 25m$

1.2 Cancellation of ROB and VOP for Service Road

Comments on DPR/Drawings:
Overpass structure (bridge) is designed for the service road to across the railways and National Highways.
Suggestion from JICA Experts:
To encourage the usage of BPRR as a toll road, it is recommended not to provide overpass structure for the service road. Service road could be connected with existing secondary road network to across the railway and main roads.

In the design of DPR, the service road can be also across the railway lines and National Highways by the proposed new bridges in parallel with BPRR mainline.

Such convenient configuration will encourage the usage of the service road without any toll fee and the toll revenue of BPRR will be reduced.

The road network of the service road shall ensure certain convenience to premises/enterprises along BPRR but the network shall be strategically minimum.

Otherwise, the road user will chose the service road easily because of no toll change and the toll revenue of BPRR will be reduced.

In this review study by JICA Experts, several cost increased modification have been proposed. To absorb these increases of the cost, the cancellation of the overpass structure for the service road will be effective.

2 Design Concept of Ramp Terminal

2.1 Ramp Design Speed

Comments on DPR:
No description on DPR
Suggestion from JICA Experts:
Ramp speed : 40km/h.

According to "Manual of Specification and Standard for Expressways" (IRC:SP:99-2013), ramp speed of BPRR is the range of 60-80 (km/h). However, AS a result of discussion among DULT, BDA, STUP and JICA Experts, 40km/h which is a minimum ramp design speed as per IRC:SP 99-2013, was decided as ramp speed.

In BPRR, only clover leaf type IC has ramps which connecting access toad to service road. Since speed limit of service road is 30km/h, minimum design speed (40km/h) is sufficient for ramp.

2.2 Design Speed from Toll Gate to Nose

Comments on DPR:
No description on DPR
Suggestion from JICA Experts:
Design speed : 40km/h.

To select the length of acceleration/deceleration lane, design speed of V' need to be decided as per IRC:SP:99-2013. Since the most of the cars except ETC users have to stop at toll gate, design speed of V' also decided as 40km/h.

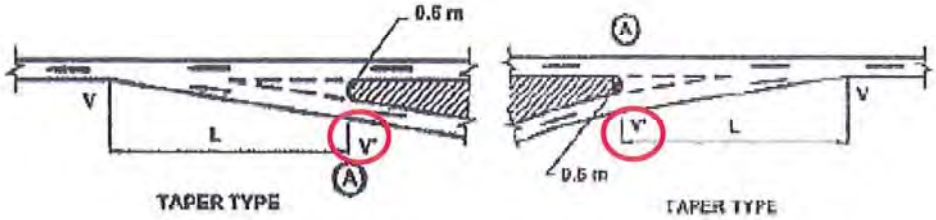


Figure 2.1 Taper Length in IRC

Source: IRC SP-99

2.3 Required Length for Acceleration/deceleration Lane

Comments on DPR Drawings:
Some of ICs do not have sufficient length for acceleration/deceleration lane.
Suggestion from JICA Experts:(All are minimum length)
Acceleration lane length : 145m
Deceleration lane length : 100m

In last meeting (11th May), JICA Experts proposed minimum length for acceleration and deceleration lane as followings.

Acceleration Length: 65m (Minimum)

Deceleration Length: 80m (Minimum)

However, DULT, BDA, STUP and JICA Experts agreed 40km/h for ramp speed. In this case, ramp speed will be longer as per IRC:SP:99-2013 as below.

Acceleration Length: 145m (Minimum)

Deceleration Length: 100m (Minimum)

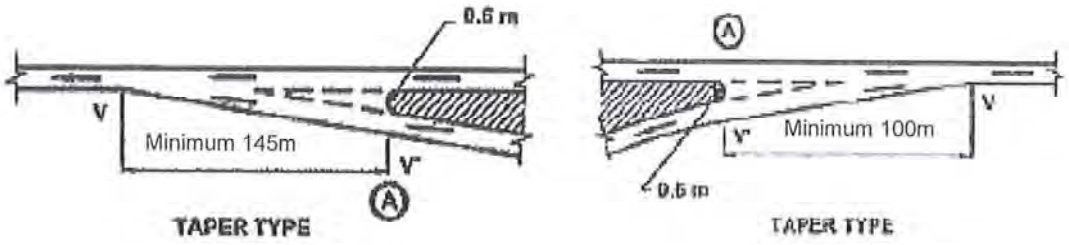


Figure 2.2 Taper Types in IRC

Source: IRC SP-99

As minimum acceleration/deceleration length is used for mainline gradient is not more than 2%. If the gradient of mainline exceeds 2%, JICA Experts recommend to adopt correction factors are shown table below.

Table 2.1 Correction Factor of Acceleration/deceleration Lane Length by Gradient

Average gradient of mainline	0< i ≦2	2< i ≦3	3< i ≦4	4< i
Up-grade for acceleration lane	1.00	1.20	1.30	1.40
Down-grade for deceleration lane	1.00	1.10	1.20	1.30

As per above table, minimum ramp length of some interchange will be changes as the table below.

Table 2.2 Corrected Acceleration/deceleration Length Based on DPR Drawings

IC Name	Toward to	Entry/Exit	Gradient (DPR) (%)	Required Gradient
Ballary	Tumukur	Entry	2.7	145m × 1.2 = 174m
	Hosur	Exit	-2.7	100m × 1.1 = 110m
Hoskote-Anekal	Hosur	Entry	2.6	145m × 1.2 = 174m
	Tumukur	Exit	-2.6	100m × 1.1 = 110m
Sarjapur	Hosur	Entry	2.9	145m × 1.2 = 174m
	Tumukur	Exit	-2.9	100m × 1.1 = 110m

2.4 Transition Section of Main Carriageway and Ramp

Comments on DPR Drawings:
Alignment of connecting section of mainline with ramp is not considered visibility
Suggestion from JICA Experts:
Alignment shall compile with criteria described below.

Even not description of IRC:SP:99-2013, alignment of connecting section of mainline with ramp, need to ensure the driver's visibility since this accident tends to occur in this section. To avoid accident in this section, driver need to recognize interchange from a long distance.

JICA Experts indicate alignment criteria of "fully access controlled highways for Tokyo Metropolitan Expressway" for the section which connects mainline and ramp for merging/diverging below. (Speed of mainline: 80km/h)

- Radius of Horizontal Curve (shall be more than 500m※)
- Radius of Vertical Curve 凸 type (shall be more than 4,500m※)
- Radius of Vertical Curve 凹 type (shall be more than 3,000m※)
- Vertical Gradient (4%※)

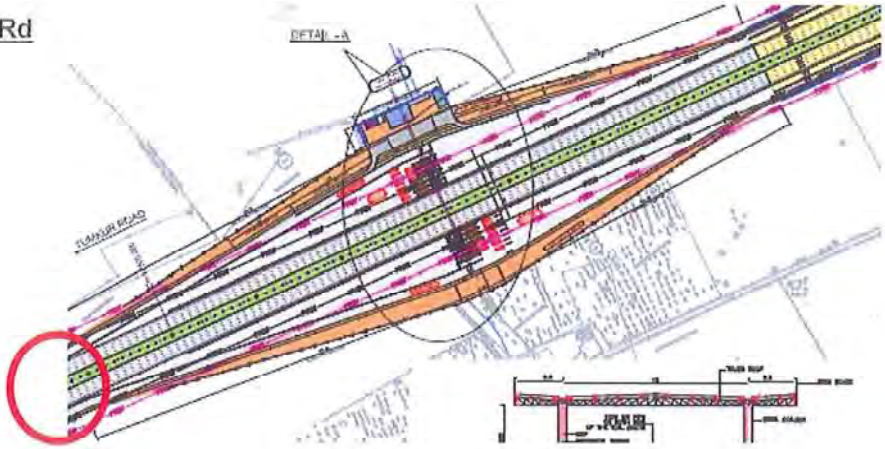
※This is the value shall be follow under any conditions for fully access controlled highways in Tokyo metropolitan expressways.

Table 2.1. Alignment which violating criteria of "fully access controlled highways for Tokyo Metropolitan Expressway"

IC Name	Toward to	Entry /Exit	Old Chainage	New Chainage	Chainage difference	Horizontal Curve Radius (500m)	Vertical Curve Radius ⌒ (4500m)	Vertical Curve Radius ⌓ (3000m)	Vertical Gradient (4%)	Remark
Hessarghatta	Hosur	Entry		5,500					0.3	
	Tumkur	Exit		5,500					-0.3	
	Tumkur	Entry								
	Hosur	Exit								
Doddaballapura	Hosur	Entry		15,900					-1.8	
	Tumkur	Exit		15,900					1.8	
	Tumkur	Entry		13,250			12,300			
	Hosur	Exit		13,250			12,300			
Ballary	Hosur	Entry		19,900		835			-1.9	
	Tumkur	Exit		19,900		835	5,100		1.9	There is a ⌒ at nose.
	Tumkur	Entry		17,450					2.7	
	Hosur	Exit		17,450			2,500		-2.7	There is a ⌒ at beginning of taper.
Hennur	Hosur	Entry		26,800			3,600		1.5	There is too sharp ⌒ at end of tapar.
	Tumkur	Exit		26,800			3,600		-1.5	There is too sharp ⌒ at beginning of tapar.
	Tumkur	Entry		24,200					-0.4	
	Hosur	Exit		24,200					0.4	
Old Madras	Hosur	Entry		37,400				10,000		
	Tumkur	Exit		37,400				10,000		
	Tumkur	Entry		34,700		785			-1.5	
	Hosur	Exit		34,700		785			1.5	
Whitefield	IC Center		~~38,747~~	~~38,663~~	~~-484~~					Corrected chainage seems wrong.
	Hosur	Entry		40,100		800	6,938			
	Tumkur	Exit		39,950					-1.9	Deceleration length is too short. Less than 200m
	Tumkur	Entry		37,650				3,000	-3.2	There is ⌓at end of taper.
	Hosur	Exit		38,000			3,500		-1.9	There is too sharp ⌒ before tapar. Deceleration length is less than 200m
Hoskote-Anekal	IC Center		53,200	54,014	814					
	Hosur	Entry	54,186	55,000	814		4,250		2.6	There is too sharp ⌒ at end of tapar.
	Tumkur	Exit	54,186	55,000	814		4,250		-2.6	There is too sharp ⌒ at beginning of tapar.
	Tumkur	Entry	51,986	52,800	814				1.5	
	Hosur	Exit	51,986	52,800	814				-1.5	
Sarjapur	IC Center		55,890	56,705	815					
	Hosur	Entry	57,285	58,100	815		21,209		2.9	
	Tumkur	Exit	57,285	58,100	815		20,209		-2.9	
	Tumkur	Entry	54,585	55,400	815	1,175			0.9	
	Hosur	Exit	54,585	55,400	815	1,175			-0.9	

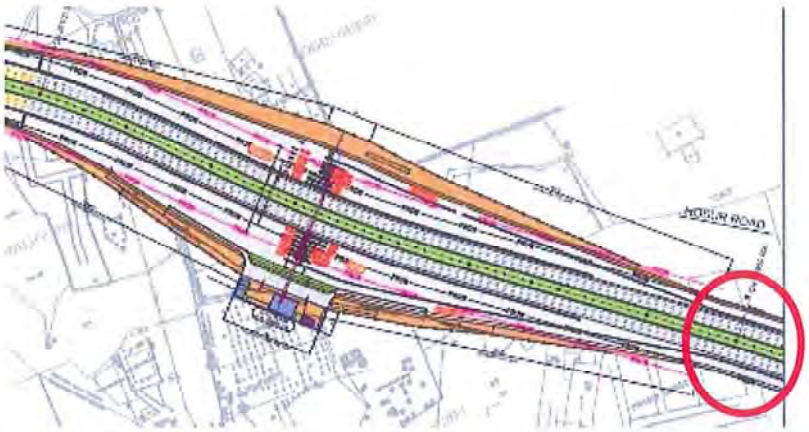
JICA Experts have not received Hessarghatta drawing which described entry to Tumukur and exit to Hosur.

Ballary Rd



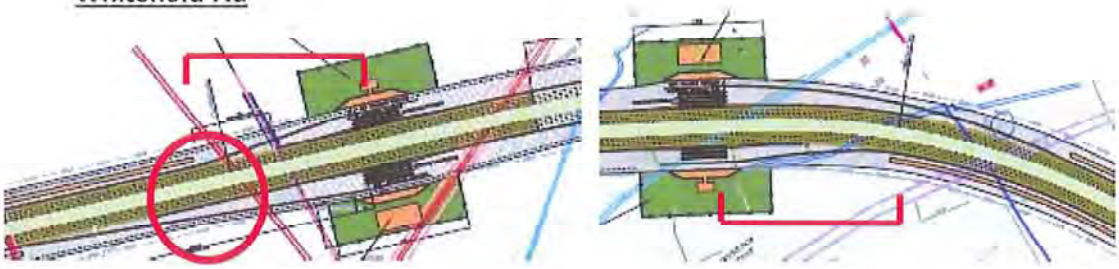
Sharp crest at chainage 17310 which cause poor visibility for car want to exit toward to Hosur.

Hennur JCT



Sharp crest at chainage 26934 which cause poor visibility for car want to entry toward to Hosur and exit toward to Tumkur

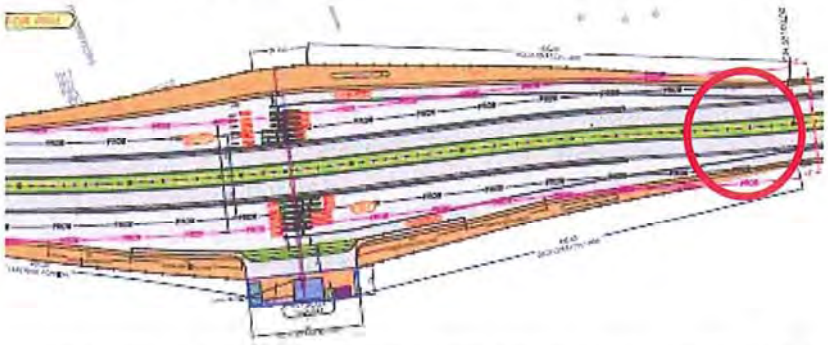
Whitefield Rd



Sharp crest at chainage 37987 which cause poor visibility for car want to exit toward to Hosur

Deceleration length of both exits is too short.

Hoskote-Anekal JCT



Sharp crest at chainage 54917 which cause poor visibility for car want to entry toward to Hosur and exit toward to Tumkur

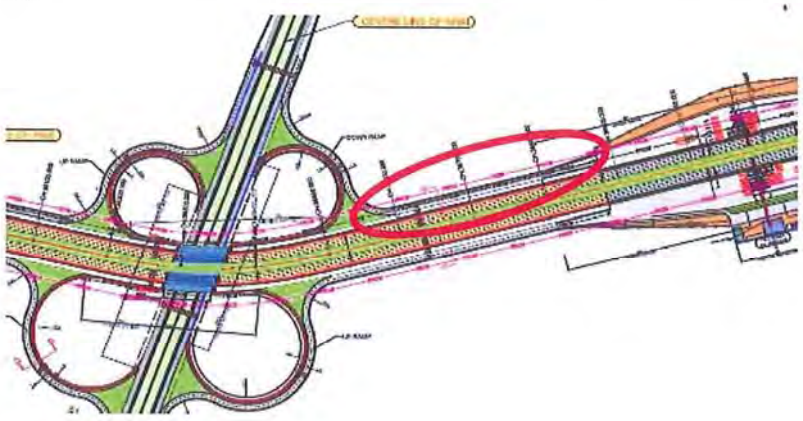
The problem sections which are violating criteria of "radius of vertical curve of crest" shall be changed to minimum 4500m.

3 Weaving

3.1 Weaving Length of Old Madras Rd IC

Comments on DPR Drawings:
Length is too short for weaving
Suggestion from JICA Experts:
Recommend maximum weaving length for Highway Capacity Manual

The car wants to enter the BPRR to Hosur direction by approaching from NH-4 Chennai side, needs to change the lane at least 3 times within short weaving section (around 200m).



It is easy to assume a large number of vehicles will keep coming since access is a major road (NH-4) and all drivers coming to entry lane at this IC need to change the lane maximum 4 times. JICA Experts recommend extending this portion within a limit of acquired land.

4 Toll Gate

4.1 Required Consideration of Toll Gate Facilities

Comments on DPR Drawings:
Some of toll gate facilities need to reconsider
Suggestion from JICA Experts:
Tunnel Stars, Crash barrier around toll booth, canopy etc.

Tunnel

Tunnel for toll management is required for all toll plazas. JICA Experts confirmed most of the toll plazas have a plan of tunnels except Whitefield IC and one of Doodabalapura IC. However, redder has planned for toll booth to tunnel. Redder may cause inflict injury on staffs working for toll management. Especially toll collector need to carry cash box from toll booth to cash room and redder will be difficult for up and down. Gurugaon toll plaza has a toll management tunnel and connecting booth to tunnel by stairs as well as Hyderabad ORR.

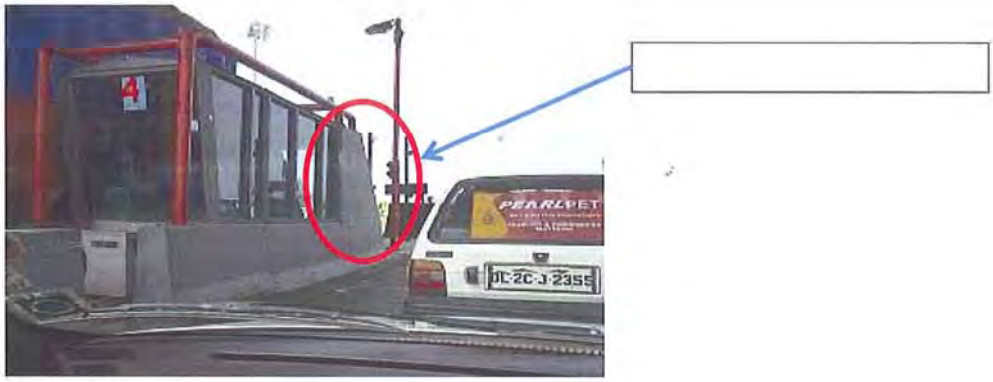


Figure 4.1 Stairs space of toll booth of Gurugaon toll plaza

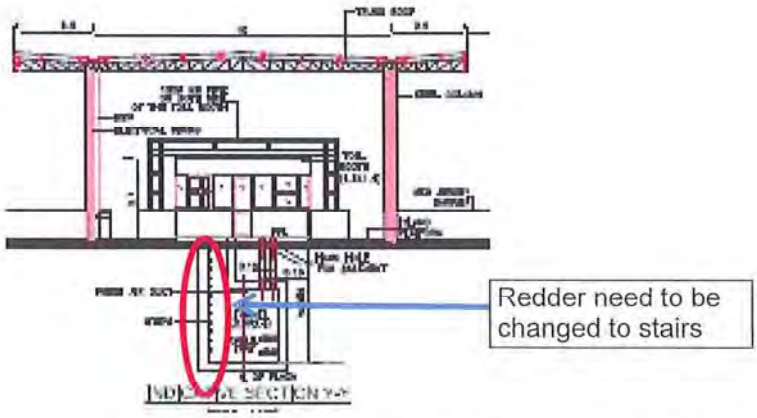


Figure 4.2 Redder of BPRR (current drawing)

Crash Barrier

Crash barrier is not necessary for protecting toll booth since vehicle runs strait line on the toll lane which will be restricted by toll island. Without crash barrier,

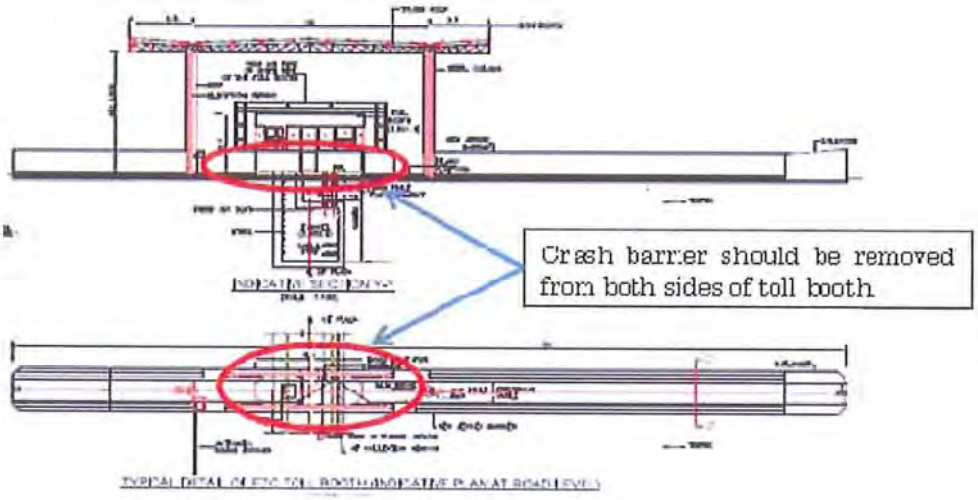


Figure 4.3 Crash barrier deployment plan of BPRR

Without crash barrier, clearance will be wider. Figure below shows an example of Japanese standard.

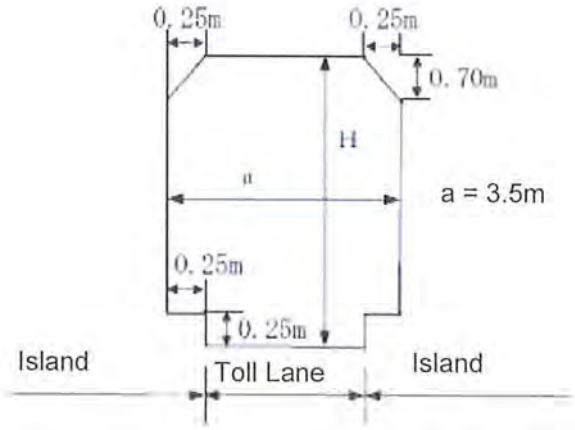


Figure 4.4 Clearance for ETC lane as per Japanese standard

Canopy

Canopy designed for BPRR is not consistent because clearance for large sized vehicle lane is bigger than other lanes. In addition, canopy for large sized vehicle was planned as cantilever. Since canopy has to be robust enough to bear overhead traffic light and VMS (it maybe require in future), cantilever should be avoided.

Figure 4.5 Canopy plan of BPRR

IRC:SP:99-2013 described regarding canopy as below

> **12.4.10** *Canopy*
>
> All the toll lanes and toll booths shall be covered with a canopy. The canopy shall be wide enough to provide weather protection to toll operators, drivers and facilities. The canopy shall be of aesthetically pleasing design with cylindrical support columns located at traffic island so that there is no restriction on visibility and traffic movement. The vertical clearance shall be as prescribed in this Manual.

4.2 Width for Large Sized Vehicle Lane

Comments on DPR Drawings:
Large sized vehicle lane is not compiled with IRC:SP:99-2013
Suggestion from JICA Experts:
Reduce the width of large sized vehicle lane will generate the space for required facilities such as canopy column.

Width of large sized vehicle lane is described as 4.5m in IRC:SP:99-2013. However, DPR drawings are described 5.5m. Since toll plaza has to be constructed very much restricted area (100m width is right of way), JICA Experts recommend to reduce 1m of width of large sized vehicle lane as per IRC:SP:99-2013.

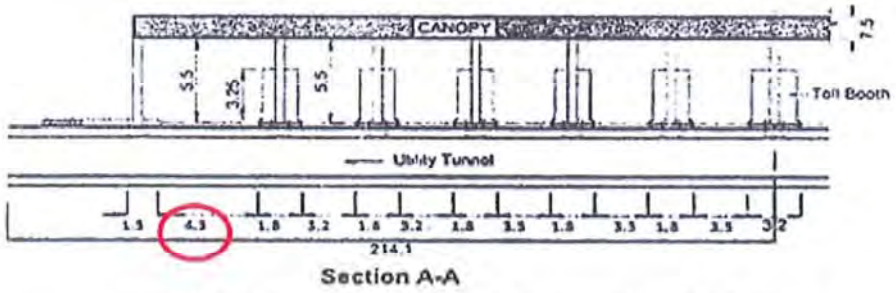


Figure 4.5 Typical Layout of Toll Plaza (IRC:SP:99-2013)

4.3 Capacity of Toll Lane by Each System

Comments on DPR Drawings:
Capacity of each fee collection system is not considered
Suggestion from JICA Experts:
Capacity of manual lane, smart card lane and ETC lane are compiled with IRC:SP:99-2013. However capacity of manual exit is not mentioned in IRC:SP:99-2013. Therefore, capacity of manual exit lane need to be considered in order to finalize the required number of toll lanes

As per IRC:SP:99-2013, capacity of lane of different system are described as below.

- Semi automatic toll lane (Manual money transaction) : 240v/h
- Smart card lane (T&G) : 360v/h
- ETC lane : 1200v/h

In the case of T&G and ETC, each of processing time of both entry and exit are same. However, processing time of entry and exit will be different for manual lane. When manual vehicle come to entry gate, driver receives transit card from toll collector and leave for mainline. On the other hand, when that vehicle come to exit gate, driver passes transit card to toll collector and pay his travel fee to toll collector after toll collector check the amount. Therefore processing time of exit lane takes more time than entry lane.

The capacity of manual lane which described in IRC:SP:99-2013 is the capacity of entry lane only since almost equal number (230v/h) is described in Japanese manual. Capacity of manual exit lane need to be considered and JICE Experts recommend utilizing 130v/h which normally use for toll plaza planning in Japan. Capacity of each system for both entry and exit are shown table below.

Table 4.1 Capacity of Entry/exit Lane by Each Systems

Lane Type	Manual	T & G	ETC
Entry	240v/h	360v/h	1200v/h
Exit	130v/h	360v/h	1200v/h

It is noted that the number of lane increase, the capacity of processing will be more than the capacity multiply number of lanes by the capacity of one lane, since coming vehicle can enter any vacant lane.

Directorate of Urban Land Transport, Government of Karnataka
Bangalore Development Authority

JICA Experts on
Bengaluru Peripheral Ring Road Project

DISCUSSION PAPER S03 (Structure)
Regarding

- ✓ *Bridge Planning (Structure of Approach Sections at ROBs)*
- ✓ *Bridge Planning (Cross Sections)*
- ✓ *Box Culvert*

18 May 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

TABLE OF CONTENTS
(STRUCTURE_S03_180515)

1 Structure

1.1 Bridge

1.1.1 Bridge Planning

1.1.1.1 Structure of Approach Section at ROBs

(1) Comments

In the last meeting on 11th May, 2015 (DP-R02), it was concluded that the abutment locations at 2 ROBs (Chennai and Hosur Railway Lines) would be set back to reduce the height of MSE Wall (DPR: 15-16m) at swamp areas.

This revision will have an impact to cost increase; therefore, it is necessary to agree on the revised abutment locations among DULT, BDA, STUP and JICA Experts.

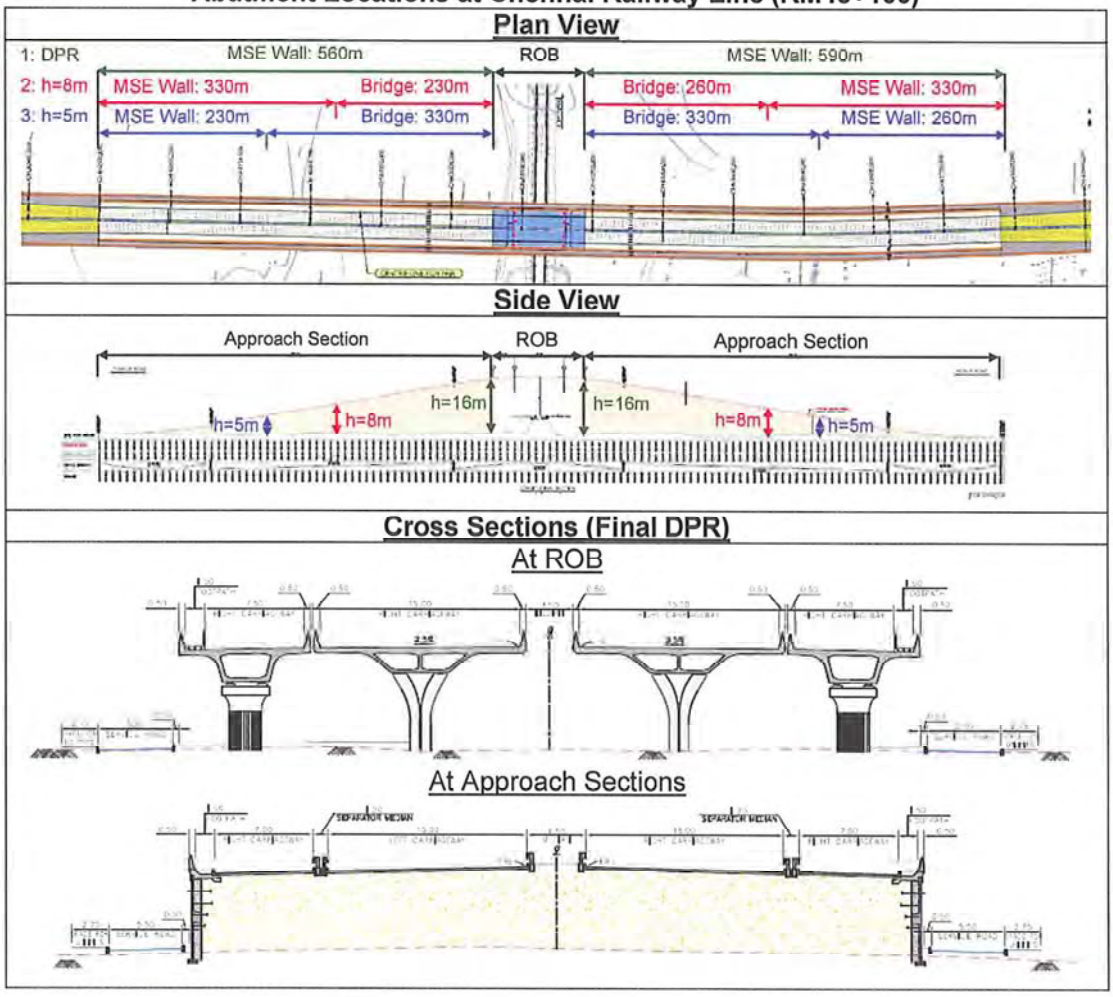
At present, the extent of geotechnical conditions is uncertain by lack of survey data; therefore, the abutment locations are necessary to decide in safety side to avoid cost overrun in the implementation stage.

(2) Suggestions

JICA Experts conducted a preliminary cost evaluation at the Chennai Railway Line (KM43+100) in case of the abutment height is reduced to 5m and 8m.

For avoiding cost overrun in the implementation stage, JICA Experts recommend applying 5m of abutment height at 2 ROBs in this JICA's Technical review stage.

Abutment Locations at Chennai Railway Line (KM43+100)



Preliminary Cost Evaluation (Approach Sections at Chennai Railway Line)

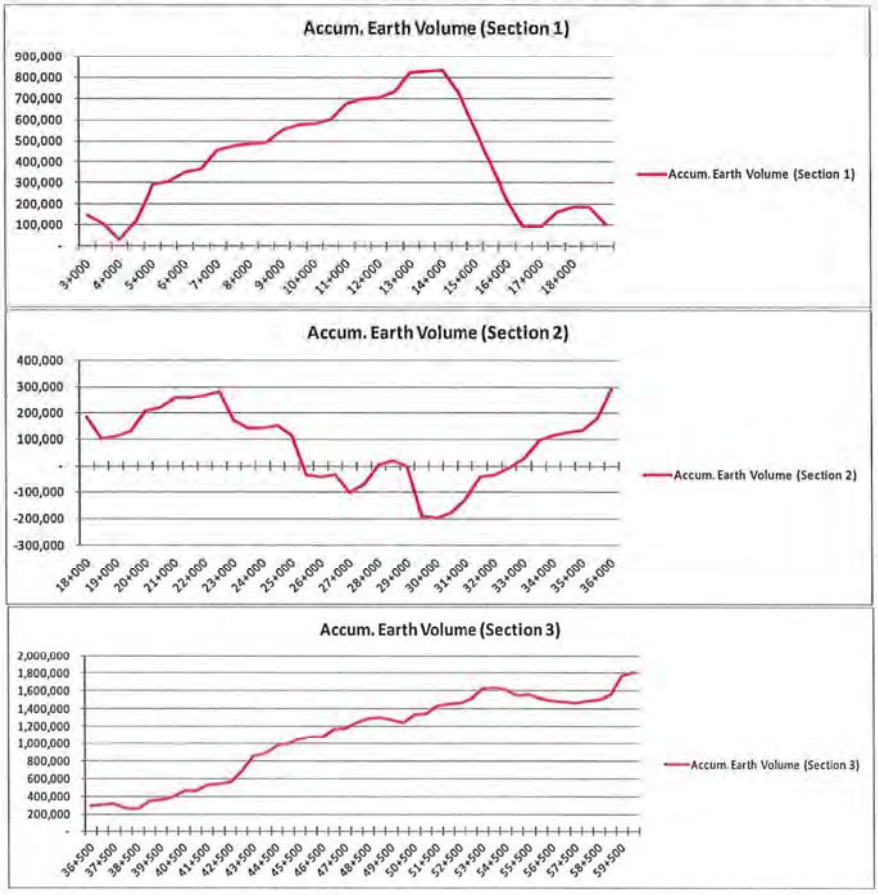
Item	1: DPR	2: h=8m	3: h=5m
Features of Approach Section	Approach Section L=1,150m BP Side MSE Wall: 560m Bridge: 0m EP Side MSE Wall: 590m Bridge: 0m	Approach Section L=1,150m BP Side MSE Wall: 330m Bridge (PC-I): 230m EP Side MSE Wall: 330m Bridge (PC-I): 260m	Approach Section L=1,150m BP Side MSE Wall: 230m Bridge (PC-I): 330m EP Side MSE Wall: 260m Bridge (PC-I): 330m
Preliminary Cost Evaluation (Mil. INR)			
1.PC-I Girder [1)]	0	2,332	3,142
2.MSE Wall [2)]	804	246	117
3.Soft Soil Treatment [3)]	214	123	91
Total	**1,018**	**2,701**	**3,350**

1) Bridge Width: Main Rd.: w=2@17.75m, Service Rd.: w=2@12m, Unit Rate: INR80,000/m2
2) Used Unit Rate of Final DPR
3) Not estimated in DPR, Assume Soil Replacement (D=5m), Unit Rate: INR500/m3

Also, from the "Earth Balance (Cut and Fill)" point of view, the volume of the earth filling in Section 3 shall be reduced.

Below figure indicate the earth balance of each section calculated by JICA Experts.

Huge amount of the borrowed earth filling shall be required for Section 3. On the other hand, the earth volume in Section 1 and Section 2 is well balanced.



Source: Calculation by JICA Experts

Earth Balance of Each Section

1.1.1.2 Cross Sections (Bridge Width)

(1) Comments

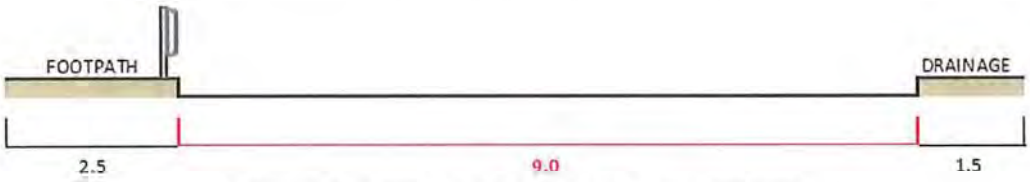
In the Final DPR, bridge plan of service road at flyover sections is different location by location as shown in table in the next page,

(2) Suggestions

JICA Experts will clarify the bridge plan of service road at flyover sections in the following points in this Technical Discussion (S03).

- Existence or non-existence of bridge on service road at flyovers
- Bridge width of bridge on service road at flyovers

Cross section of service road (road section) is shown below.



Cross Section of Service Road (Road Section)

(3) Conclusions

Bridge Plan

No.	Station	Bridge Category	Location	Cross Object	Width1)	Clearance (under BR)		Bridge Length2)	Span Arrange.	Superstructure	Erection Method	Substructure		Remarks
						Vertical	Horizontal					Abutment	Pier	
1	KM00+000	Flyover	Main Road	NH-4	4m	5.5m	Existing BR	60m	2@30m	PC-I	Truck Crane	Mixed	Round	Widening of Existing Bridge at Tumkur Road JCT
2	KM03+560	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Truck Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
3	KM04+212	ROB, Flyover	Main Road, Service Road	Bangalore-Tumkur Railway Line, SH39	[illegible] 2@15m, [illegible]	Rail: TBC Road: 5.5m	Rail: 60m Road: 40m	195m	1@60m+3@45m	PC Box (Constant)	CIP (Staging)	Mixed	Main Road: Y Service Road: Round	Assumed to allow temporary support structure inside railway ROW with reduced speed operation by railway operator
4	KM14+435	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@12m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Y or Alternatives	Planned Piers on Median of BPRR Planned Piers on Service Road
5	KM14+800	POP	To be confirmed by STUP											
6	KM15+600	POP	Existence of Discrepancy among Drawings (Plan and Profile DWG: Mentioned, Junction DWG: Not Mentioned)											
7	KM23+400	VOP	Cross Road (SH104)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
8	KM25+604	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Round	Planned Piers on Median of BPRR Planned Piers on Service Road
9	KM27+145	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
10	KM29+770	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
11	KM36+323	Flyover	Main Road	NH-4	[illegible] 2@15m, [illegible]	5.5m	NH-4: 60m	60m	1@60m	PC Box (Constant)	CIP (Staging)	Mixed	—	Assumed to allow temporary support structure inside NH-4 ROW with detour roads by national highway operator
12	KM37+760	VOP	Cross Road (SH35)	Main Road (Underpass)	2@8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Piers on Median of BPRR
13	KM38+769	Flyover	Main Road	Cross Road (SH35) (Underpass)	[illegible]	5.5m	Cross Road	140m	40m+60m+40m	PC Box (Constant)	CIP (Staging)	Mixed	Y or Alternatives	Planned Piers on Service Road of Cross Road
14	KM43+125	ROB	Main Road,	Bangalore-Chennai Railway Line	[illegible] 2@16m, [illegible]	Rail: TBC	Rail: 70m	150m3)	40m+70m+40m	Steel Box	Rapid Erection	Mixed	Main Road: Y Service Road: Round	Planned steel box girder by reason of difficulty for applying temporary support structure inside railway ROW.
15	KM49+430	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
16	KM53+221	Flyover	Main Road	Cross Road (SH35) (Underpass)	[illegible]	5.5m	Cross Road	90m	3@30m	PC-I	Track Crane	Mixed	Y or Alternatives	Planned Piers on Service Road of Cross Road
17	KM54+580	POP	Cross Road (Local Road)	Main Road (Underpass)	8.5m	5.5m	Main Road	46.5m	2@23.25m	PC-I	Track Crane	RC Retaining Wall	Oval	Planned Pier on Median of BPRR
18	KM55+911	VOP	Cross Road (Local Road)	Main Road (Underpass)	2@8.5m	5.5m	Service Road	120m	4@30m	PC-I	Track Crane	Mixed	Round	Planned Piers on Median of BPRR Planned Piers on Service Road
19	KM59+198	ROB	Main Road, Service Road	Bangalore-Hosur Railway Line	[illegible] 2@17.5m, [illegible]	Rail: TBC	Rail: 60m	130m3)	35m+60m+35m	Steel Box	Rapid Erection	Mixed	Main Road : Y or Alternatives Service Road: Round	Planned steel box girder by reason of difficulty for applying temporary support structure inside railway ROW.
20	KM64+751	Flyover	Main Road	NH-7	4m	5.5m	Existing BR	60m	2@30m	PC-I	Truck Crane	Mixed	Round	Widening of Existing Bridge at Hosur Road JCT

■: To be confirmed bridge plan of service road at flyovers

1.1.1.3 Cross Sections (Structural Dimension)

(1) Comments

Preliminary study of bridge cross sections is included in the scope of works in the Contract between JICA and JICA Experts; however, JICA Experts understand that detail of bridge cross sections will be determined in the beginning of D/D stage.

Therefore, JICA Experts confirm main points of bridge cross sections only in this Technical Discussion (S-03) based on IRC and general practices in Bengaluru.

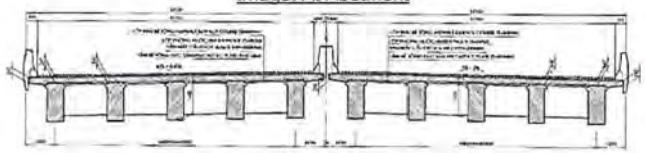
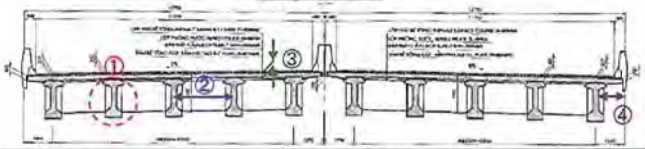
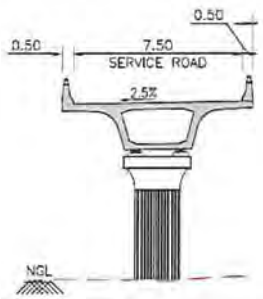
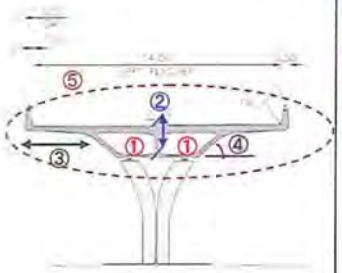
(2) Suggestions

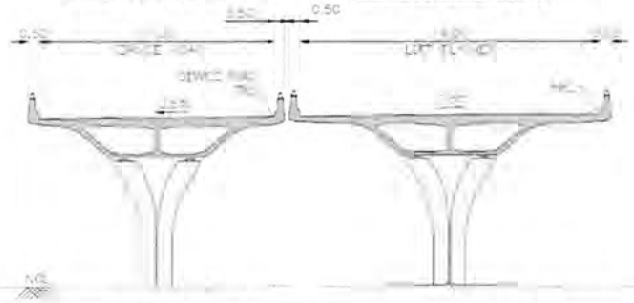
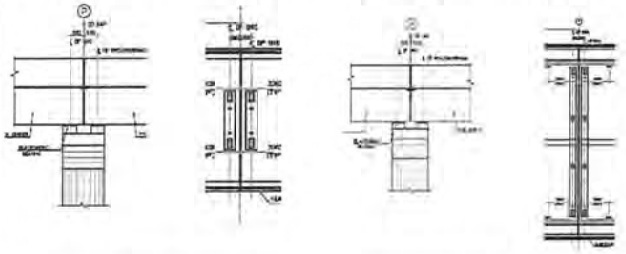
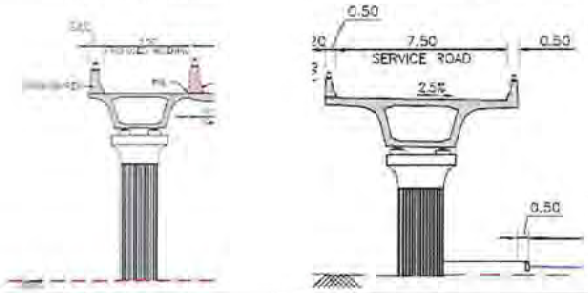
JICA Experts prepared inquiries on main points of bridge cross sections in the next page.

JICA Experts would like to ask kind cooperation by DULT/BDA/STUP in providing us with the answers and relevant materials during this Technical Discussion (S-03).

(3) Conclusions

Inquiries on Bridge Cross Sections

No.	Structure			Inquiries by JICA Experts
1	Superstructure	PC-I Girder	Image: At Abutment  Image: At Pier 	① Size of PC-I Girder by Girder Length ② Typical, Maximum and Minimum Distance between Girders ③ Typical and Minimum Thickness of Slab ④ Typical and Maximum Cantilever Length
2		PC Box Girder (Constant Height)	Bridge Width: 8.5m  Bridge Width: 12m, 17.75m 	① Nos. of Cell for Bridge Width of 8.5m, 12m and 17.75m ② Girder Height for Span Length of 40m, 45m and 60m ③ Typical and Maximum Cantilever Length for Bridge Width of 8.5m, 12m and 17.75m ④ Web Angle for Bridge Width of 8.5m, 12m and 17.75m ⑤ Typical and Minimum Thickness of Components for Bridge Width of 8.5m, 12m and 17.75m

No.	Structure			Inquiries by JICA Experts
3	Substructure	Wall (Y) Shape Pier	Bridge Width: 12m / Bridge Width: 17.75m 	Dimension of Substructure
4		Wall (Oval) Shape Pier	Bridge Width: 8.5m (Side View / Plan View) / Bridge Width: 19.6m (Side View / Plan View) 	
5		Round Shape Pier	Bridge Width: 4m / Bridge Width: 8.5m 	

1.2 Box Culvert

1.2.1 Plan of Box Culvert

(1) Comments

JICA Experts reviewed plan of box culvert based on the drawings of Final DPR.

List of box culvert structure is shown in table in the next page.

(2) Suggestions

JICA Experts will confirm the plan of box culverts with DULT, BDA and STUP in this Technical Discussion (S03).

(3) Conclusions

List of Box Culvert

No.	Category	Station	Location	Cross Objects	Length	Size (w*h)	Remark
1	DC	KM00+525	Main Road, Service Road	Waterway	75m+Skew	2@(3.0m*2.0m)	
2	VUP	KM01+550	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
3	DC	KM02+215	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
4	PUP	KM02+270	Cross Road	Main Road	46.5m	1@(10.5m*4.5m)	
5	DC	KM02+643	Main Road, Service Road	Waterway	75m+Skew	2@(2.0m*2.0m)	
6	VUP	KM02+850	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
7	DC	KM04+593	Main Road, Service Road	Waterway	75m+Skew	1@(3.0m*2.0m)	
8	PUP	KM04+950	Cross Road	Main Road	46.5m	1@(10.5m*4.5m)	
9	PUP	KM05+700	Cross Road	Main Road	46.5m	1@(10.5m*4.5m)	
10	DC	KM05+806	Main Road, Service Road	Waterway	75m+Skew	2@(2.0m*2.0m)	
11	VUP	KM06+750	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
12	DC	KM07+413	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
13	DC	KM08+720	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
14	VUP	KM08+850	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
15	DC	KM09+389	Main Road, Service Road	Waterway	75m+Skew	1@(3.0m*2.0m)	
16	DC	KM10+223	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
17	DC	KM10+636	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
18	VUP	KM10+700	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
19	PUP	KM11+700	Cross Road	Main Road	46.5m	1@(10.5m*4.5m)	
20	VUP	KM12+550	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
21	Underpass	KM14+435	Main Road	Cross Road	TBC	2@(14.0m*5.5m)	Doddaballapura JCT (SH-9)
22	RUB	KM15+158	Main Road, Service Road	Cross Railway	TBC	1@(7.5m*5.5m),	Chikkaballapur Railway
23	RUB	Km16+061	Main Road, Service Road	Cross Railway	TBC	2@(14.0m*5.5m), 1@(7.5m*5.5m)	Doddaballapur Railway
24	VUP	KM17+310	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
25	DC	KM17+786	Main Road, Service Road	Waterway	75m	1@(3.0m*2.0m)	
26	Underpass	KM18+651	Main Road, Service Road	Cross Road	TBC	1@(7.5m*5.5m), 2@(14.0m*5.5m), 1@(7.5m*5.5m)	Bellary JCT (NH-7)
27	VUP	KM20+260	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
28	PUP	KM21+200	Cross Road	Main Road	46.5m	1@(10.5m*4.5m)	
29	DC	KM22+213	Main Road, Service Road	Waterway	75m+Skew	1@(3.0m*2.0m)	
30	Underpass	KM25+604	Main Road	Cross Road	TBC	2@(14.0m*5.5m)	Hennur JCT
31	DC	KM26+520	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
32	VUP	KM28+080	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
33	DC	KM29+065	Main Road, Service Road	Waterway	75m+Skew	2@(3.0m*2.0m)	
34	DC	KM30+883	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
35	VUP	KM31+500	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
36	DC	KM31+703	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
37	DC	KM32+233	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
38	DC	KM32+480	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
39	DC	KM33+250	Main Road, Service Road	Waterway	75m+Skew	2@(3.0m*2.0m)	
40	VUP	KM33+620	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
41	DC	KM33+704	Main Road, Service Road	Waterway	75m	1@(3.0m*2.0m)	
42	DC	KM34+725	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
43	DC	KM35+732	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
44	Underpass	KM38+769	Cross Road	Main Road, Service Road	TBC	1@(19.2m*5.5m)	
45	DC	KM39+644	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
46	DC	KM39+993	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
47	VUP	KM40+060	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
48	DC	KM40+884	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
49	DC	KM41+060	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
50	PUP	KM41+344	Cross Road	Main Road	46.5m	1@(10.5m*4.5m)	
51	DC	KM42+783	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	

No.	Category	Station	Location	Cross Objects	Length	Size (w*h)	Remark
52	DC	KM43+525	Main Road, Service Road	Waterway	75m+Skew	3@(2.0m*2.0m)	
53	DC	KM44+356	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
54	VUP	KM44+382	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
55	DC	KM45+025	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
56	VUP	KM45+445	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
57	DC	KM46+056	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
58	DC	KM46+304	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
59	DC	KM46+719	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
60	VUP	KM46+815	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
61	DC	KM46+895	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
62	DC	KM47+244	Main Road, Service Road	Waterway	75m+Skew	3@(2.0m*2.0m)	
63	DC	KM47+832	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
64	DC	KM47+997	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
65	VUP	KM48+100	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
66	DC	KM48+890	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
67	DC	KM50+062	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
68	VUP	KM50+360	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
69	DC	KM50+539	Main Road, Service Road	Waterway	75m	1@(3.0m*2.0m)	
70	MB	KM51+165	Main Road, Service Road	Waterway	75m+Skew	2@(10.0m*5.0m)	
71	DC	KM51+410	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
72	VUP	KM51+430	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
73	DC	KM51+480	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
74	DC	KM51+990	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
75	DC	KM52+510	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
76	DC	KM52+608	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
77	Underpass	KM53+221	Cross Road	Main Road, Service Road	TBC	1@(19.2m*5.5m)	Hoskote - Anekal JCT
78	DC	KM53+420	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
79	DC	KM55+298	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
80	MB	KM55+460	Main Road, Service Road	Waterway	75m+Skew	2@(15.0m*5.0m)	
81	DC	KM55+780	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
82	Underpass	KM55+911	Main Road	Cross Road	TBC	2@(14.0m*5.5m)	Barjapur JCT
83	DC	KM56+610	Main Road, Service Road	Waterway	75m	1@(3.0m*2.0m)	
84	DC	KM58+515	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
85	DC	KM59+178	Main Road, Service Road	Waterway	75m+Skew	2@(3.0m*2.0m)	Bangalore - Hosur Railway
86	DC	KM60+600	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
87	PUP	KM61+370	Cross Road	Main Road	46.5m	1@(10.5m*4.5m)	
88	DC	KM61+637	Main Road, Service Road	Waterway	75m+Skew	1@(2.0m*2.0m)	
89	DC	KM61+796	Main Road, Service Road	Waterway	75m	1@(2.0m*2.0m)	
90	VUP	KM62+900	Cross Road	Main Road	46.5m	2@(9.0m*5.5m)	
91	DC	KM64+165	Main Road, Service Road	Waterway	75m+Skew	1@(3.0m*2.0m)	
92	DC	KM64+578	Main Road, Service Road	Waterway	75m	2@(2.0m*2.0m)	

DC: Drainage Culvert

VUP: Vehicular Underpass

PUP: Pedestrian Underpass

RUB: Railway Under Bridge

MB: Minor Bridge (Box Culvert)

1.2.2 Construction Method

(1) Comments

Construction method of box culvert is not clearly explained in the Final DPR.

At least, it is necessary to clarify at cross locations with national highway and RUBs.

(2) Suggestions

JICA Experts understand that construction method at cross locations with national highway and RUBs are planned in the followings:

- At Cross Locations with National Highway: Open and Cut Method with Detour
- At 2 RUBs: Box Pushing Method

For box pushing, it is necessary to confirm the following technical background:

- Technical Certification by IRC
- Maximum Pushing Length and Size (Possibility, Past Experience)
- Detail of Construction Method
- Structural Detail of Box Culvert

(3) Conclusions

1.2.3 Thickness of Box Culvert

(1) Comments

Some box culverts are planned as large size in the Final DPR.

It is necessary to confirm the thickness of component of large box culverts based on IRC or past experiences in this Technical Discussion (S03).

(2) Suggestions

JICA Experts will confirm the thickness of component of box culvert in the followings:

No.	Size (w*h)	Top Slab (mm)	Bottom Slab (mm)	Wall (Outside) (mm)	Wall (Intermediate) (mm)
1	1@(7.5m*5.5m)				
2	1@(10.5m*4.5m)				
3	1@(19.2m*5.5m)				
4	2@(9m*5.5m)				
5	2@(12m*5.5m)				
6	2@(14m*5.5m)				
7	2@(17.75m*5.5m)				
8	2@(15m*5m): Minor Bridge				
9	2@(10m*5m): Minor Bridge				

In case of planned size in a cell is not appropriate, nos. of cell will be reconsidered.

(3) Conclusions

1.2.4 Drainage Pump at Underpass

(1) Comments

It seems that drainage pump at underpass is not planned in the Final DPR.

It is necessary to clarify the plan of drainage pump in this Technical Discussion (S03).

(2) Suggestions

JICA Experts will confirm the capacity, pitch and installation space of drainage pump at underpass with DULT, BDA and STUP based on IRC and past experiences.

(3) Conclusions

Directorate of Urban Land Transport, Government of Karnataka
Bangalore Development Authority

JICA Experts on
Bengaluru Peripheral Ring Road Project

DISCUSSION PAPER E01

(ECONOMIC ANALYSIS AND FINANCIAL ANALYSIS)

regarding

- ✓ *Economic Analysis*
- ✓ *Financial Analysis*

18 May 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

TABLE OF CONTENTS

1 Economic Analysis

1.1 Economic Cost

Comments on DPR:
Project Cost was 32,200 Million Rs for economic evaluation.
Suggestion from JICA Experts:
Project Cost should include the Land Acquisition Cost of this project. Estimated Project cost will be 90,000 Million Rs,

According to the DPR (Detailed Project Report), the Project Cost was 33,876 Million Rs as utilized for the economic analysis. The Project Construction Cost was 37,500 Million Rs as shown in Table 9-1. If the land acquisition cost will be included, the Project Cost is 111,500 Million, excluding the ITS cost.

This proposed PPR is a green field project, thus the land acquisition cost should be included in the Project Cost. The estimated Project cost will be 111,500 Million Rs. The Project Cost will also update if the Construction Cost and/or other Costs will be changed.

1.2 Economic Benefits

Comments on DPR:
Only the Vehicle Operation Cost (VOC) Benefit was estimated. Travel Time Cost Saving was not mentioned.
Suggestion from JICA Experts:
Travel Time Cost (TTC) as well as VOC should be estimated as Benefits for the Economic Analysis.

For an expressway project, the benefit of travel time cost (TTC) saving is quiet big. Thus, travel time cost saving should be fully considered for this project

The benefits will be estimated as VOC and TTC based on the traffic assignment results.

- Without PPR Project Scenario
- With PPR Project Scenario
- Benefit of VOC (a) = VOC of "Without Project Scenario" - VOC of "With Project Scenario"
- Benefit of TTC (b) = TTC of "Without Project Scenario" - TTC of "With Project Scenario"
- Total Benefits = (a)+ (b)

1.3 Economic Evaluation Period

Comments on DPR:
No mention of Economic Evaluation Period.
Suggestion from JICA Experts:
Economic Evaluation Period will be assumed as 25 years (2015-2040)

The economic evaluation period should be written in the report. As shown in the IPC: SP:30-

2009 Guidelines, economic evaluation period will be assumed as 25 years (2015-2040). JICA Expert will estimate the economic cost and benefit for 25 years then evaluate the economic feasibility.

2 Financial Analysis

2.1 Toll Revenue

Comments on DPR:
Toll Revenue was not clearly mentioned.
Suggestion from JICA Experts:
JICA Expert will study the sensibility analysis among toll rate, traffic volume and toll revenue based on the Willingness-to-pay (WTP) survey results.

The toll rate was set as per toll notification issued by the Ministry of Road Transport and Highways, Government of India in December 2008.

As the Willingness-to-pay (WTP) survey was conducted by JICA Expert, the sensibility study of toll rate, traffic volume and toll revenue will be studied based on the result of the WTP survey.

3. General Question/Request from JICA Experts (Economic Analysis/Financial Analysis)

Economic Analysis

Request 1:

Provision of economic evaluation sheet Process for economic evaluation is not mentioned therefore, its appropriateness is uncertain. Can you provide us with the economic evaluation sheet?

Request 2:

Provision of the detailed O& M Cost estimate;

- Annual Maintenance Cost
- Periodic Maintenance Cost
- Operation Cost including toll collection

Financial Analysis

Question 1:

Who will conduct the O & M? Private Company or Public? If Private Company, how will you select the Private company? Concessionaire or Sub-contract?

Question 2:

How did you estimate the Equity IRR? What kinds of PPP scheme did you assume? BOT Scheme?

Request 3:

Provision of the financial evaluation sheet Process for financial evaluation is not mentioned; therefore, its appropriateness is uncertain. Can you provide us with the financial evaluation sheet?

Thank you for attending the meeting today.

Directorate of Urban Land Transport, Government of Karnataka
Bangalore Development Authority

JICA Experts on
Bengaluru Peripheral Ring Road Project

DISCUSSION PAPER T01

(TRAFFIC DEMAND FORECAST)

regarding

- ✓ ***Future traffic demand forecast***

18 May 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

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1 Target year of traffic demand forecast and design traffic volume

1.1 Target year of traffic demand forecast

Comments on DPR:

The target year is not decided. The demand forecast is carried out in order to identify when the traffic volume exceeds the design capacity of 8 lanes (160,000 PCU per day).

Suggestion from JICA Experts:

- The design traffic volume shall be set commonly for 20 years from the base year.
- The base year is the planning year (e.g.2015) or the time of construction completion. If the base year is 2015, the target year is 2035. If the time of construction completion, the target year is around 2040.

1.2 Design Traffic volume

Comments on DPR:

The unit of the design traffic volume is PCU per day. The traffic volume is calculated for 3 divided sections.

Suggestion from JICA Experts:

- The demand forecast will be conducted by the basis of PCU per day.
- The design traffic will be decided from the result of traffic demand forecast of all sections and of Inter Change (IC).

2 Method of traffic demand forecast and the input condition

2.1 Procedure of traffic demand forecast

Comments on DPR:

The step applied below in DPR is not familiar to JICA.

- Current OD Matrix
- Current traffic assignment
- Link traffic volume (Current)
- Growth rate
- Link traffic volume (Future) = Link traffic volume (Current) * Growth rate

Suggestion from JICA Experts:

The procedure followed by the 3 step modeling method is applied.

- Modeling of Generation / Attraction traffic volume (Growth rate per zone)
- Modeling of Distribution traffic volume
  - Current OD Matrix
  - Future OD Matrix
- Traffic assignment
  - Link traffic volume (Future)

2.2 OD Matrix

2.2.1 Zoning

Comments on DPR:

The zone of inside of PRR and the zone along the PRR are rough. But the zone of outside of PRR is detail.

BDA area is divided to into 13 zones.

The zoning area is not adjusted to planning district or ward area.

Suggestion from JICA Experts:

- The zoning along the PRR shall be divided into more detail to analyze future traffic flow between zones that are along PRR. Especially it is to analyze future traffic flow on service road of PRR.
- The zoning area shall be adjusted to planning district or ward area. Because these units have basic information such as population and land use plan that is important information for the future traffic demand forecast of Generation/Attraction traffic per zone.
- Total number of zone is 40 zones. BDA area is divided to into 23 zones. The outside of BDA area is integrated into 17 zones.

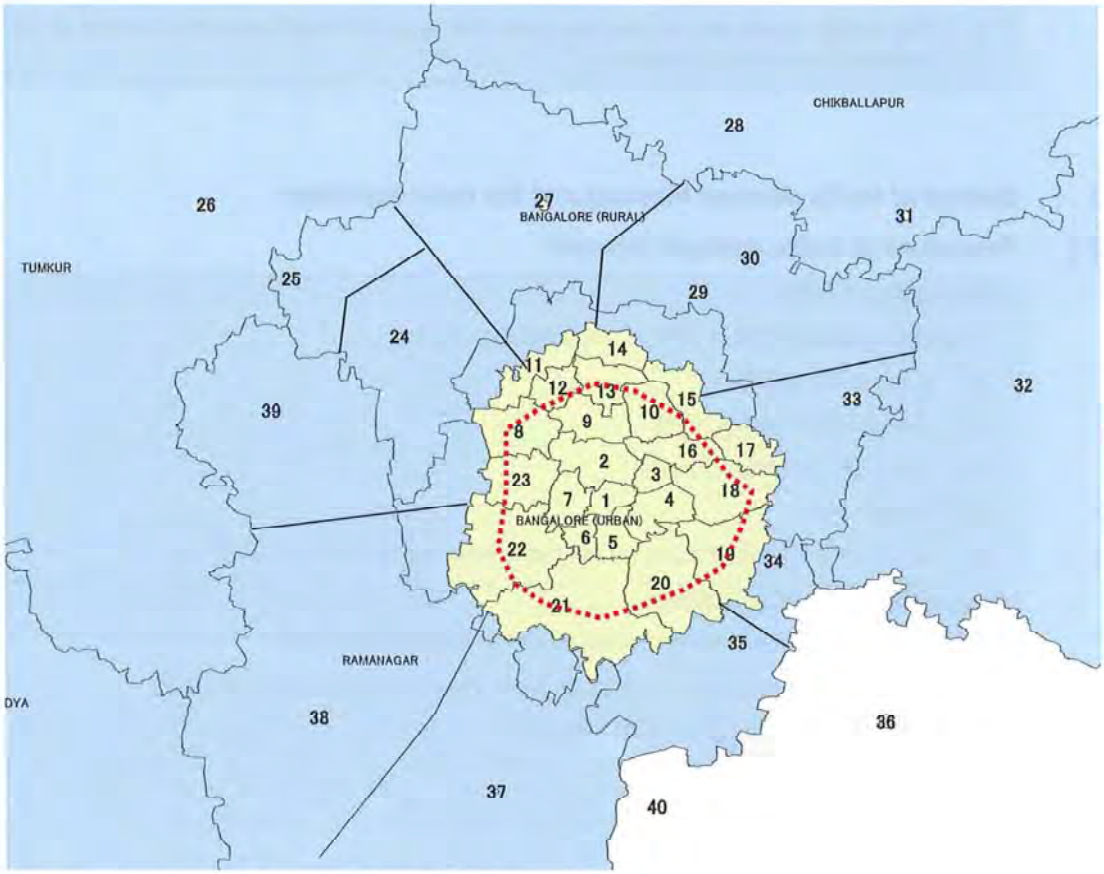


Figure1.1 Proposed traffic zone

2.2.2 Current OD Matrix

Comments on DPR:

The current OD Matrix in DPR is made from OD survey carried out on cordon line. This OD matrix is mainly focused on external traffic of PRR alignment.

It is not considered the traffic between the zones along PRR.

Suggestion from JICA Experts:

- The current OD matrix data created in DPR is essential for the review of the demand forecast of PRR.
- In the review, the traffic flow between the zones along PRR shall be considered. This traffic flow is considered in Bengaluru ITS Mater plan study by JICA (2014). That data was made based on the CTTP and CTTS.
- JICA expert will review the current OD matrix using the both data used in DPR and in ITS master plan. Moreover, the zoning is changed as mentioned above.

2.2.3 Generation traffic volume from development

Comments on DPR:

The key plan showing various planning district through which PRR pass is considered to examine the generation traffic. These plans are based on the revised master plan 2015.

Suggestion from JICA Experts:

- JICA expert follow the idea of DPR referring the district plan and the proposed layouts in and around PRR. The necessarily information shall be provided from BDA who is the authority of this kind of the development plan.
- The parameters and assumptions for the conversion from development plan to the generation traffic in will be reconsidered as necessary.

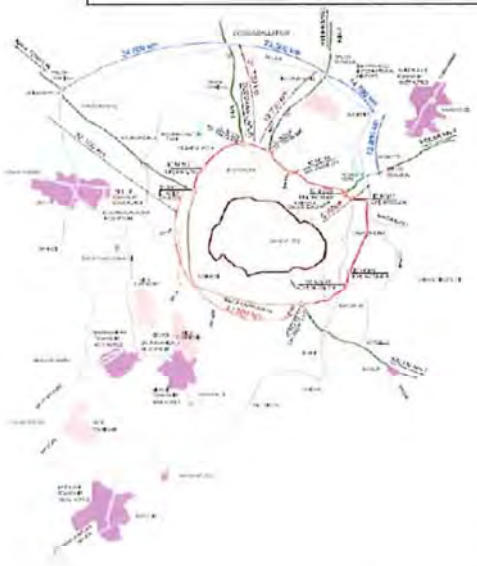


Table 2.1 Proposed development plan

2.2.4 Road network and traffic assignment

Comments on DPR:

The competitive road: The NH207 and NICE road is considered as the competitive road in the process of the traffic assignment in DPR.

The toll fee of PRR and the value of time were not considered based on technical specification of DPR.

The traffic assignment was carried out by the original way of the consultant.

Suggestion from JICA Experts:

- JICA expert will be made in accordance with DPR idea of the competitive road. However, in the review process, the traffic assignment will be considered using the road network of wide area and the traffic assignment method based on traffic engineering such as the user equilibrium assignment method or the incremental assignment method.
- The toll fee of PRR based on National highway or NICE road and the value of time based on opinion survey (SP survey) analysis will be considered.
- The SP survey is conducted to passenger car driver and trucker. The 500 samples will be taken to analyze using the logit model.

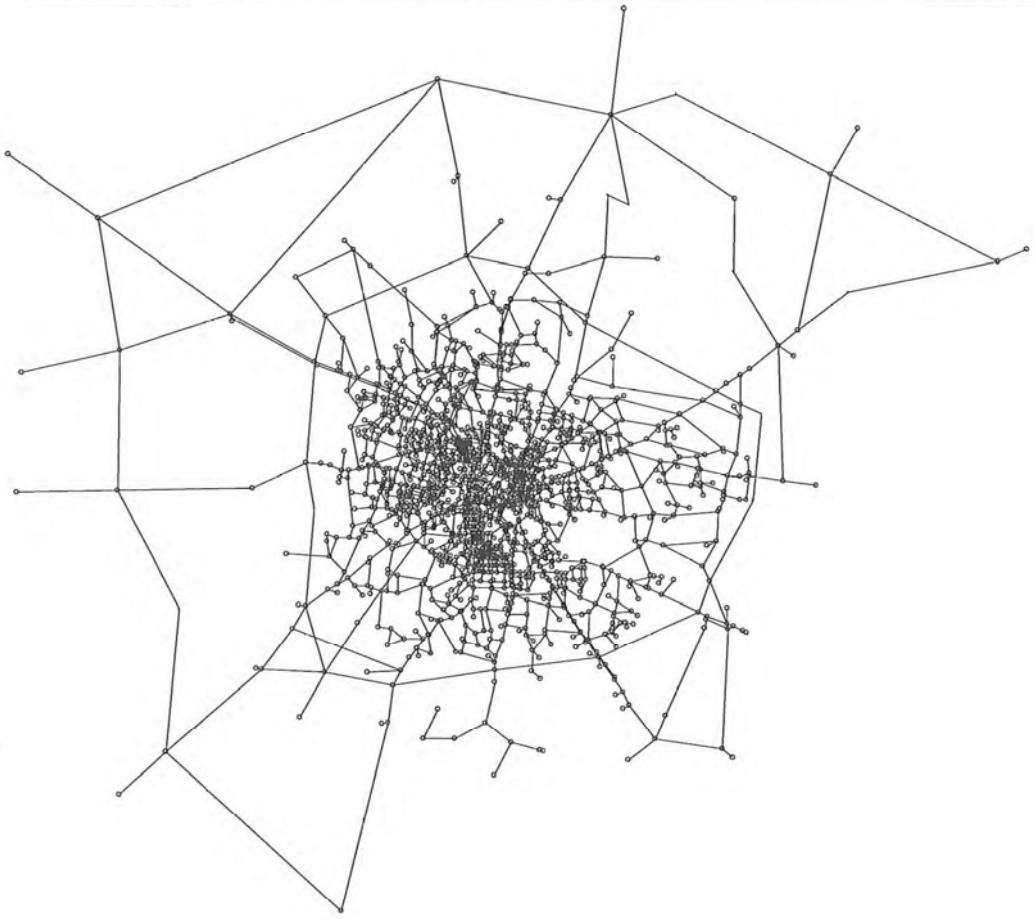
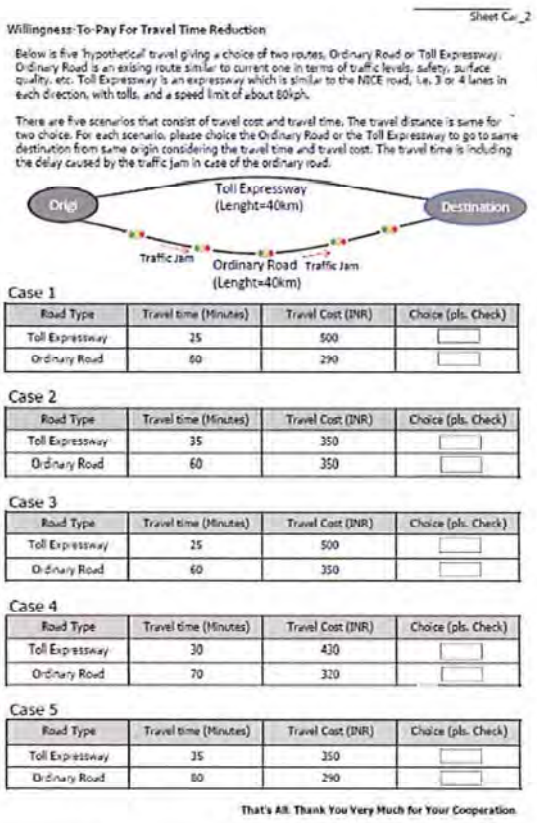


Figure 2.2 Road network for the traffic assignment



Sheet Car_2

Willingness-To-Pay For Travel Time Reduction

Below is five hypothetical travel giving a choice of two routes, Ordinary Road or Toll Expressway. Ordinary Road is an exising route similar to current one in terms of traffic levels, safety, surface quality, etc. Toll Expressway is an expressway which is similar to the NICE road, i.e. 3 or 4 lanes in each direction, with tolls, and a speed limit of about 80kph.

There are five scenarios that consist of travel cost and travel time. The travel distance is same for two choice. For each scenario, please choice the Ordinary Road or the Toll Expressway to go to same destination from same origin considering the travel time and travel cost. The travel time is including the delay caused by the traffic jam in case of the ordinary road.

Case 1

Road Type	Travel time (Minutes)	Travel Cost (INR)	Choice (pls. Check)
Toll Expressway	25	500	
Ordinary Road	60	290	

Case 2

Road Type	Travel time (Minutes)	Travel Cost (INR)	Choice (pls. Check)
Toll Expressway	35	350	
Ordinary Road	60	350	

Case 3

Road Type	Travel time (Minutes)	Travel Cost (INR)	Choice (pls. Check)
Toll Expressway	25	500	
Ordinary Road	60	350	

Case 4

Road Type	Travel time (Minutes)	Travel Cost (INR)	Choice (pls. Check)
Toll Expressway	30	430	
Ordinary Road	70	320	

Case 5

Road Type	Travel time (Minutes)	Travel Cost (INR)	Choice (pls. Check)
Toll Expressway	35	350	
Ordinary Road	80	290	

That's All. Thank You Very Much for Your Cooperation

Figure 2.3 Survey Form of Opinion Survey

2.2.5 PCU factor

Comments on DPR:

JICA point out the basis of the PCU factor of truck, 3.0 to 4.5, is large in comparison with the case of Japan or of other country one.

Suggestion from JICA Experts:

- JICA expert will make in accordance with the PCU factor in IRC.
- Because we have to follow the consistency between the design capacity and PCU factor in IRC.

Table 2.1 PCU Factors Considered

Type	PCU factor	Type	PCU factor
Two Wheeler	0.5	LCV	1.5
Auto Rikiswar	1.0	Truck	3.0
Passenger Car	1.0	Multi Axle Truck	4.5
Bus	3.0	-	-

Source: IRC 64-1990

3 Cases of Analysis

Comments on DPR:

It is estimated the case of "with BPR in the future" only.

It is estimated dividing into 3 sections only.

Suggestion from JICA Experts:

- It is conducted the following 3 cases:
  - ✓ Re-production of the existing traffic conditions
  - ✓ Future 1 (without BPRR)
  - ✓ Future 2 (with BPRR)
- Future cases are used to the economic and financial analyses.
- Traffic volume on the junctions (ICs) and between junctions of BPRR is estimated.