3.6 STAR CITY INTERSECTION

3.6.1 Background of intersection plan and Additional F / S plan, Thilawa Access road plan

3.6.1.1 Background of intersection plan

Adjacent to Thanlyin Side of Bago Bridge, there are 3 major housing development projects, Thiri Han Thar Housing.

Project with 70 houses, Thanlyin Yadanar Housing Project with 350 houses and Star City Project with 9000 houses(4000 houses will be completed by 2022)

In addition to logistic traffic from Thilawa Port and Thilawa SEZ, the corresponding person trips are expected to be added to the traffic volume along Bago Bridge.

In the following sub-sections, the situations of traffic at this intersection after completion of Bago Bridge is shown.

Source: The Supplemental Survey for the Project for Construction of Bago River Bridge

Figure 3.6.1 Housing Development Projects adjacent to Thanlyin Side of Bago Bridge

The following Figure 3.6.2 shows the intersection adjacent to the starting point of Bago Bridge.

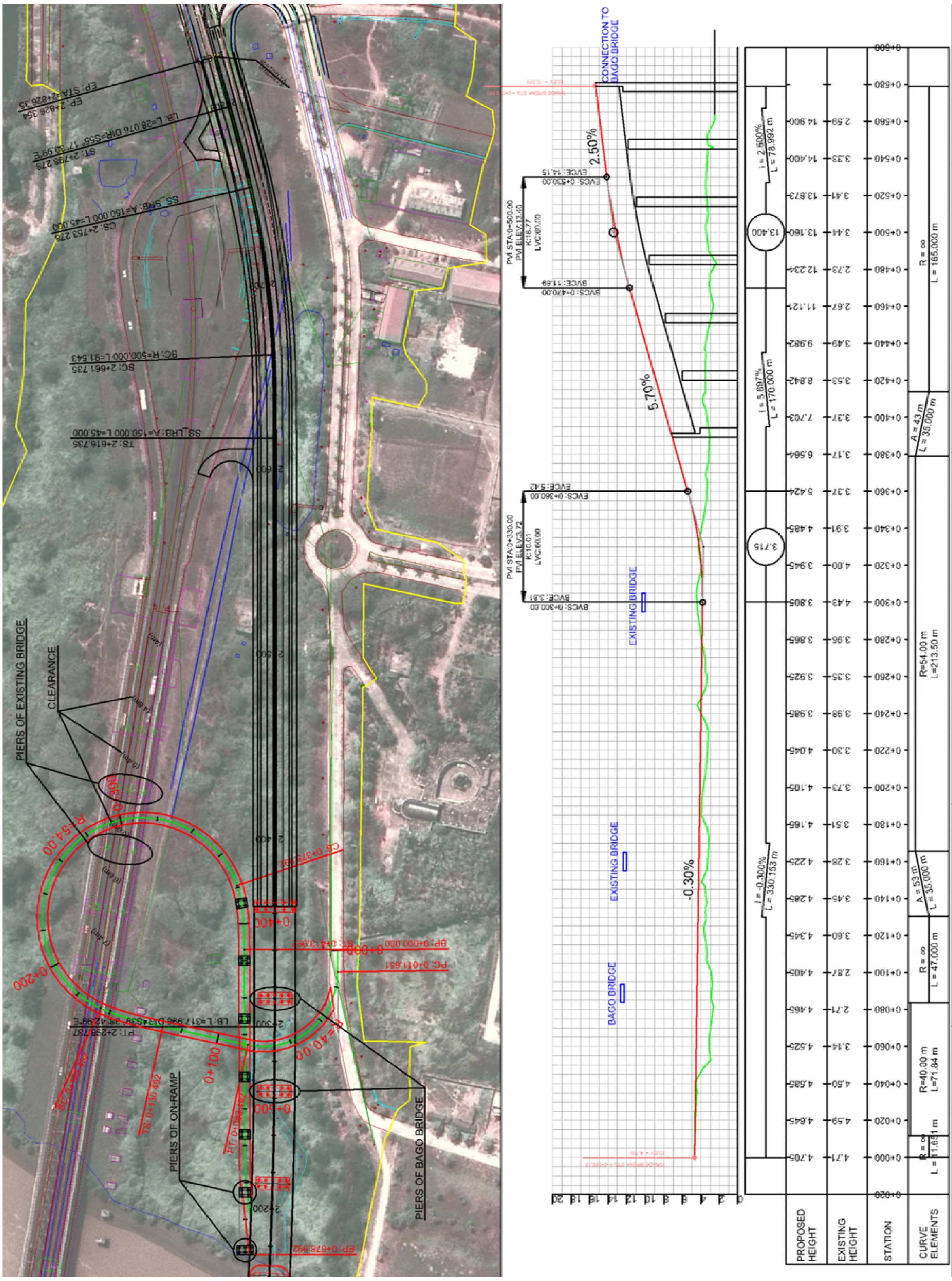
Source: The Supplemental Survey for the Project for Construction of Bago River Bridge

Figure 3.6.2 Intersection adjacent to the starting point of Bago Bridge

3.6.1.2 Additional F / S plan and Thilawa Access road plan

(1) Additional F / S plan

The plan for the additional F / S is the plan shown in Figure 3.6.3, which is consistent with the intersection plan planned in the Thilawa Access Road shown in Figure 3.6.4.

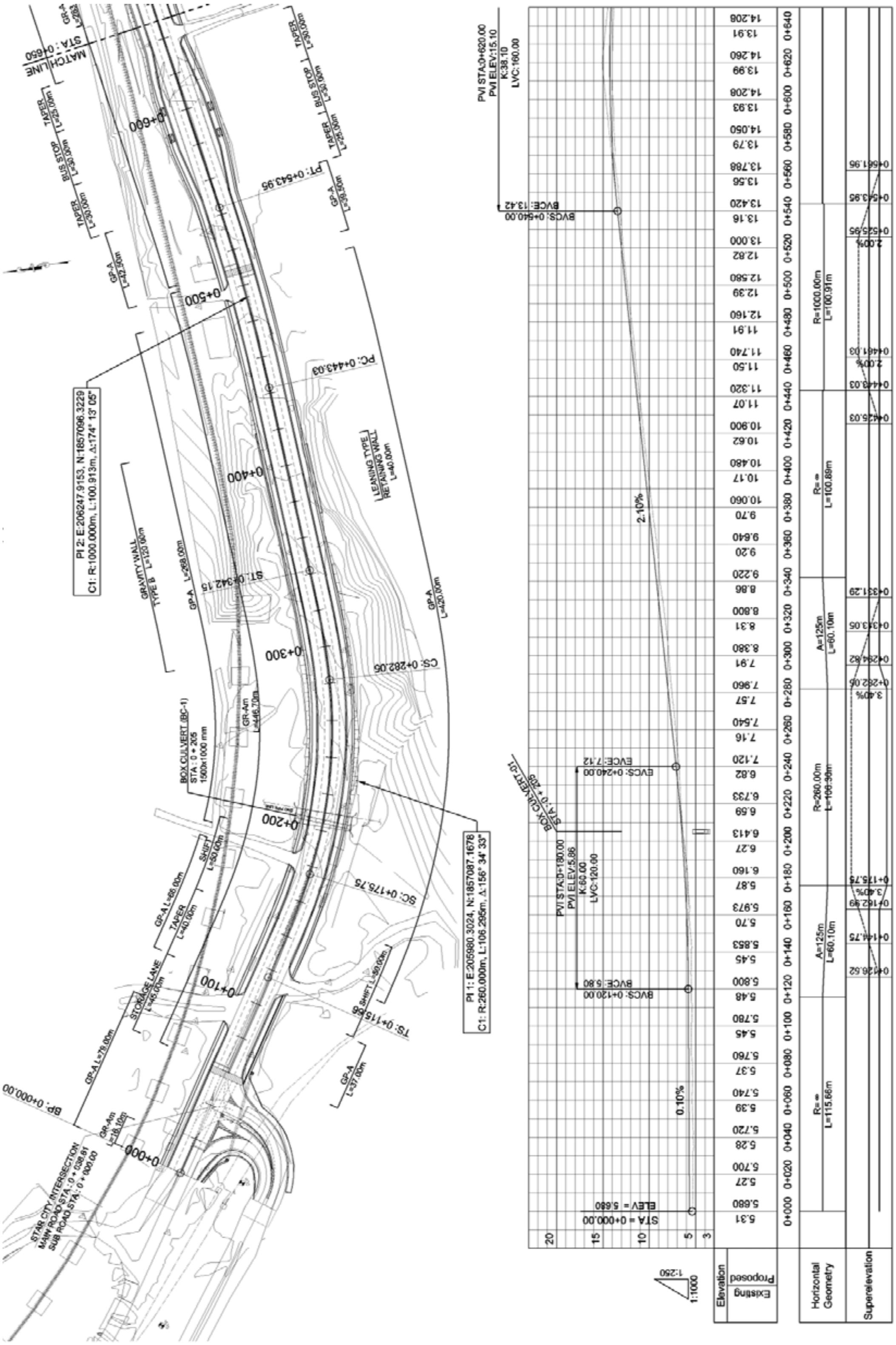


Source: The Supplemental Survey for the Project for Construction of Bago River Bridge

Figure 3.6.3 Additional F / S plan

(2) Thilawa Access road plan

The plan of the Tillaway Access Road is the plan of Figure 3.6.4.



Source: INFRASTRUCTURE DEVELOPMENT PROJECT IN THILAWA AREA PHASE II

Figure 3.6.4 Thilawa Access road plan

3.6.2 Proposed Solution on Newly-built Intersection

3.6.2.1 Propose of study

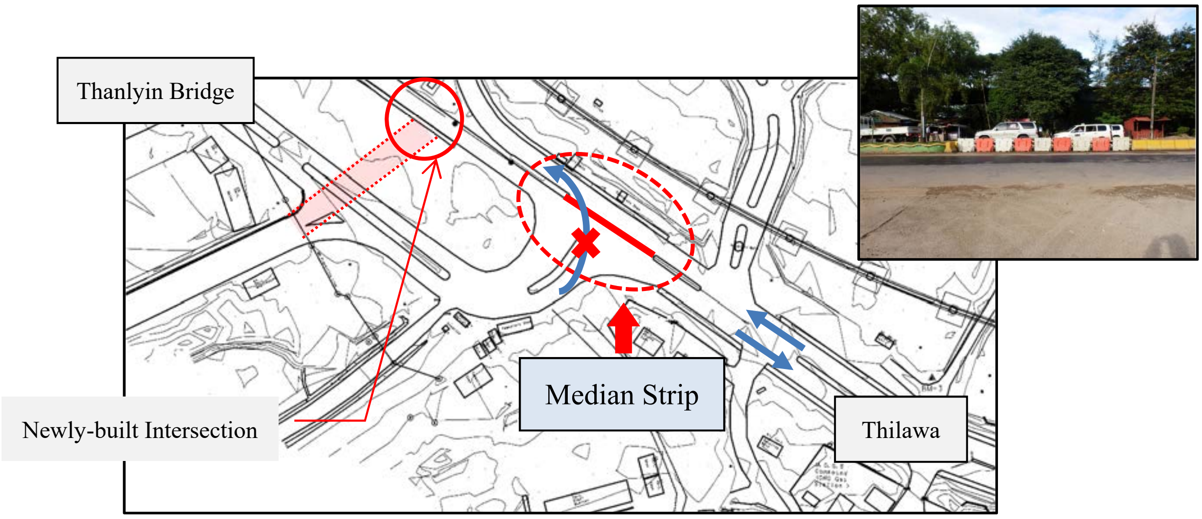
Around June 2016, since the Block was set up in the middle part of the main line of the T-junction road from the Thilawa Access Road, the car going from Star City to Thanlyin Bridge cannot enter the main line directly by turning left, 1 km after turning right and U-turn at the SEZ side There was inconvenience / dissatisfaction caused by going to Thanlyin Bridge.

Therefore, Star City began constructing an access road to the main line in order to improve convenience. There was no plan to install traffic lights at the connection, and removal of high steel columns started and steadily proceeded with construction.

The intersection plan at the Star City side is a temporary connection to the last, and if the T-junction of the Thilawa Access Road is converted to a signal junction, the connecting road will be closed.

Source: Google

Figure 3.6.5 Location of Newly-built Intersection

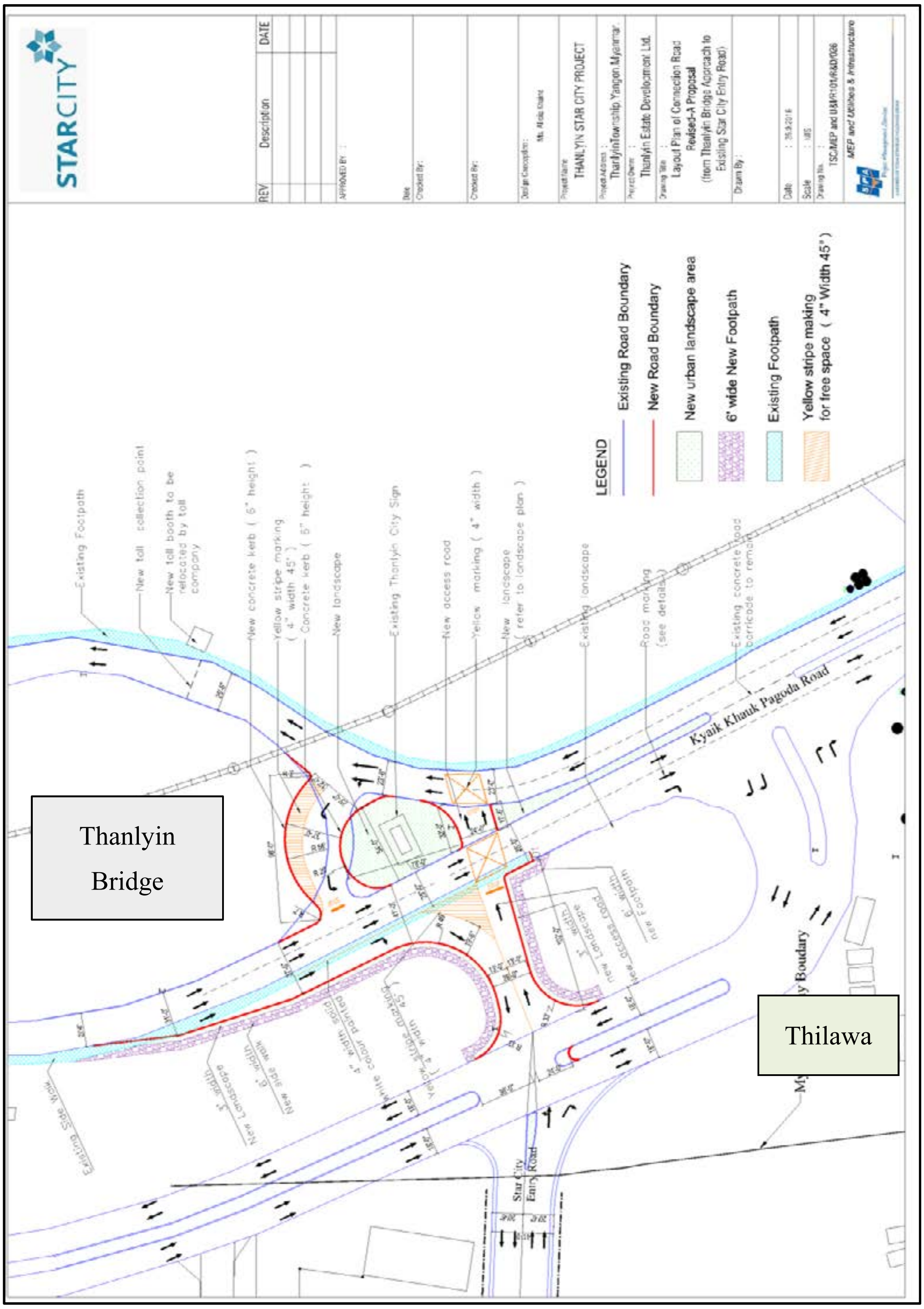


Source: Google

Figure 3.6.6 Outline of Newly-built Intersection

3.6.2.2 Intersection on the Star City side Overview of the project

- Project Name: Thanlyin Star City Project
- Project Owner: Thanlyin Estate Development Ltd.
- Approved by: Yangon Divisional Gov. (Prime Minister of YDG)
- Designed by: Star City



Source: Thanlyin Star City Project

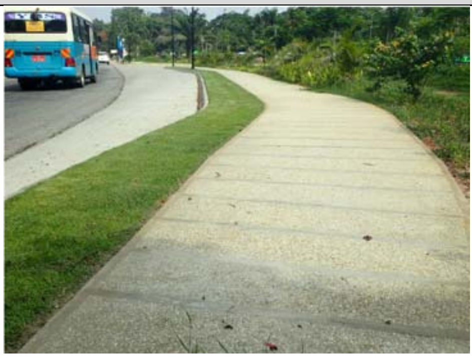
Figure 3.6.7 Intersection on the Star City side Overview of the project

Table 3.6.1 Photos of Under Construction

No.1	No.2
	

Source: JICA Study Team

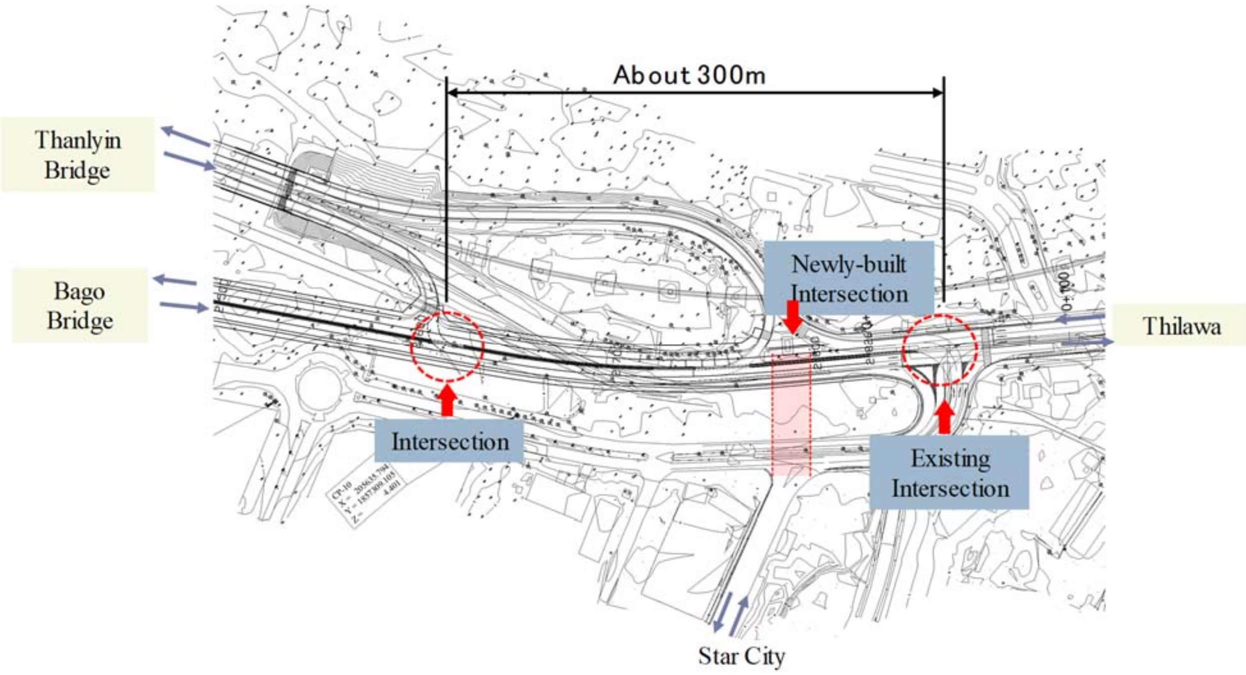
Table 3.6.2 Photos of Newly-built Intersection

No.1	No.2
	
No.3	No.4
	
No.5	No.6
	

Source: JICA Study Team

3.6.2.3 Problems of Newly-built Intersection

- Too Close to Existing Intersection and Planned Intersections.
- Conflict with Traffic from/to Thilawa and Bago Bridge.

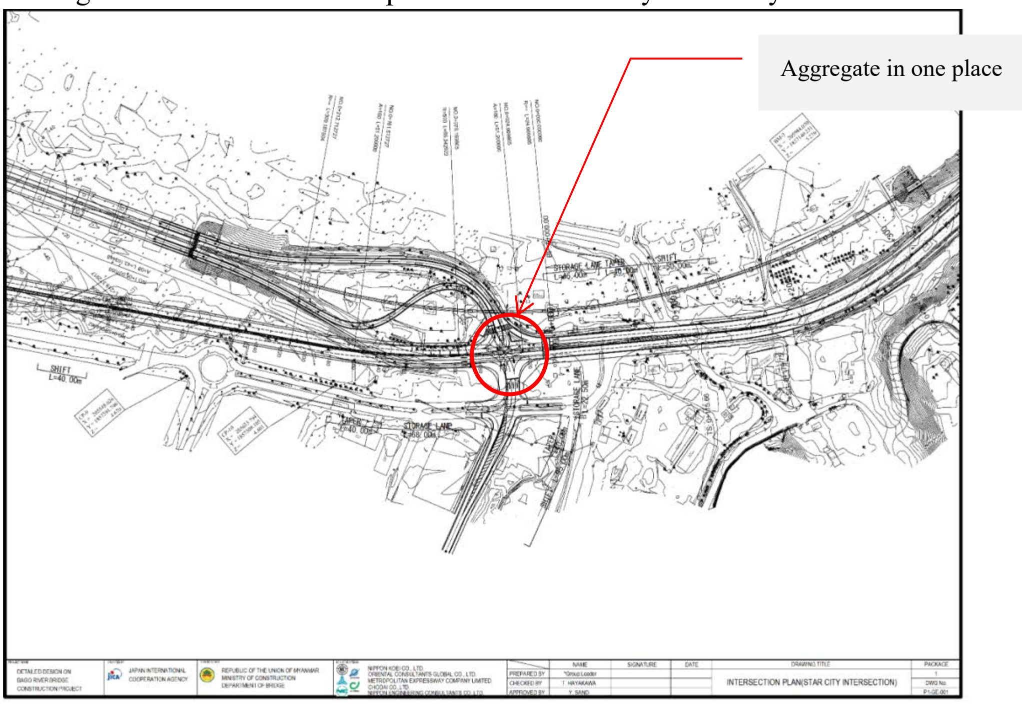


Source: JICA Study Team

Figure 3.6.8 Problems of Newly-built Intersection

3.6.2.4 Proposed Solution

- One Integrated Intersection will improve traffic efficiency and safety.

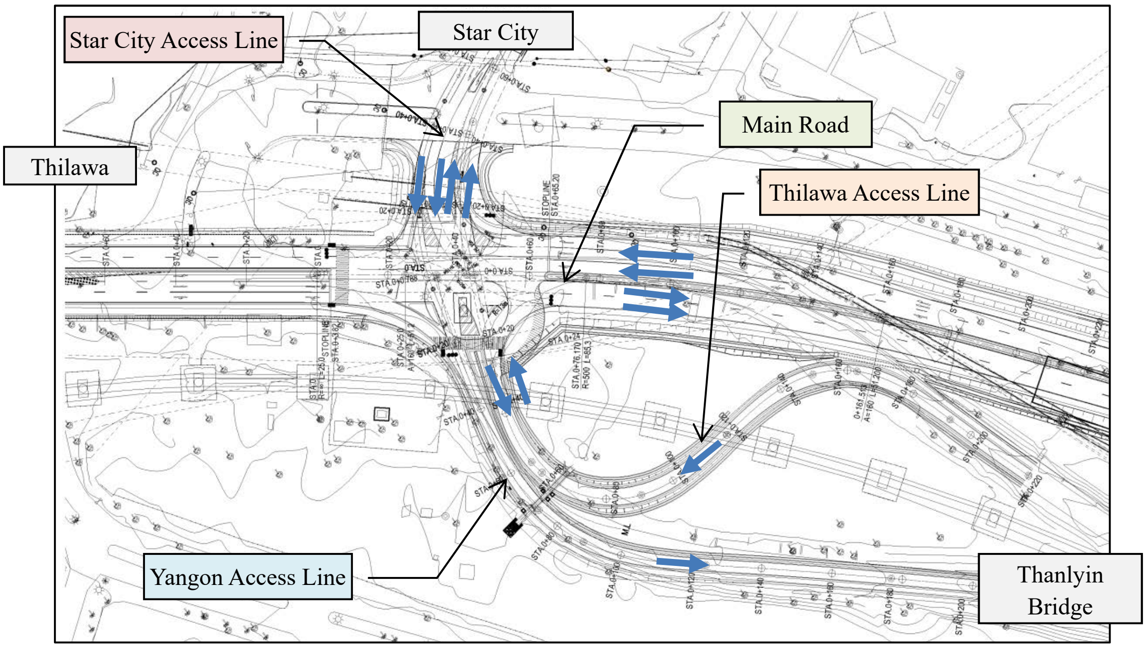


Source: JICA Study Team

Figure 3.6.9 Proposed Solution

3.6.3 Design Conditions

The name of each route is shown in Figure 3.6.10



Source: JICA Study Team

Figure 3.6.10 Name of each route

3.6.3.1 Design Criteria for the Main Road at intersection

Geometric design criteria for the main road design at intersection (STA.0 to STA.0 + 177) are shown in Table 3.6.3, which was prepared based on the ASEAN Highway Standards and Japanese Road Design Criteria.

Table 3.6.3 Geometric Design Criteria for the Main Road Design at intersection

Item	Criteria			Adopted Value	Remark
	Desirable	Standard	Absolute		
Design Speed		60 km/h		60 km/h	
Min. Horizontal Curve Radius (m)	200	150	120	500	
Min. Horizontal Curve length (m)		700/ø	100	187.743	
Min. Transition Curve Length (m)		50		51.200	
Min. Radius without Transition Curve (m)		1000	500	-	
Min. Radius without Superelevation (m)		2000		-	Straight section:2%
Max. Grade (%)		5.0	7.0	0.1	
Min. Vertical Curve Length (m)		50		240	
Min. K value (Crest)	20	14		-	
Min. K value (Sag)	15	10		92	
Max. Superelevation (%)		6.0		6.0	
Superelevation to Horizontal Curve (%)		6.0		-	R=270-330m
		5.0		-	R=330-420m
		4.0		-	R=420-560m
		3.0		-	R=560-800m
		2.0		-	R=800-2000m

Max. Ratio for Superelevation Development		1/125		1/125	
Stopping Sight Distance (m)		75		>75	

Source: JICA Study Team

3.6.3.2 Design Criteria for the Yangon / Thilawa Access Line

Geometric design criteria for the Yangon / Thilawa Access Line design are shown in Table 3.6.4, which was prepared based on the ASEAN Highway Standards and Japanese Road Design Criteria.

As for the vicinity of the intersection, we decided to plan down at a design speed of 30 km / h by lowering the design speed by 10 to 20 km / h, since it is a linear form avoiding the piers of Myanmar Railway.

Table 3.6.4 Geometric Design Criteria for the Yangon / Thilawa Access Line

Item	Criteria			Adopted Value		Remark
	Desirable	Standard	Absolute	Yangon	Thilawa	
Design Speed		30 km/h		30 km/h		
Min. Horizontal Curve Radius (m)	65	30		45	30	
Min. Horizontal Curve length (m)		350/ø	50	52	73	
Min. Transition Curve Length (m)		25		36	30	
Min. Radius without Transition Curve (m)			130	-	-	
Min. Radius without Superelevation (m)		350		-	-	Straight section:1.5%
Max. Grade (%)		8.0		2.65	3.40	
Min. Vertical Curve Length (m)		25		25	25	
Min. K value (Crest)	4	2.5		-	-	
Min. K value (Sag)	4	2.5		10.73	9.69	
Max. Superelevation (%)		6.0		2.0	6.0	
Superelevation to Horizontal Curve (%)		6.0		-	-	R=60-80m
		5.0		-	-	R=80-110m
		4.0		-	-	R=110-150m
		3.0		-	-	R=150-220m
		2.0		-	-	R=220-500m
		1.5		-	-	R=350m
Max. Ratio for Superelevation Development		1/75		1/326	1/214	
Stopping Sight Distance (m)		30		>30	>30	

Source: JICA Study Team

3.6.3.3 Design Criteria for the Star City Access Line

Geometric design criteria for the Star City Access Line design are shown in Table 3.6.5, which was prepared based on the ASEAN Highway Standards and Japanese Road Design Criteria.

For the vicinity of the intersection, we decided to design the plan at a design speed of 40 km / h by lowering the design speed by 10 km / h.

Table 3.6.5 Geometric Design Criteria for the Star City Access Line

Item	Criteria			Adopted Value	Remark
	Desirable	Standard	Absolute		
Design Speed		40 km/h		40 km/h	
Min. Horizontal Curve Radius (m)	100	60	50	55	
Min. Horizontal Curve length (m)		500/ø	70	39.249	Site constraint
Min. Transition Curve Length (m)		35		-	
Min. Radius without Transition Curve (m)		500	250	-	
Min. Radius without Superelevation (m)		800		-	Straight section:2.0%
Max. Grade (%)		7.0	10.0	2.48	
Min. Vertical Curve Length (m)		35		35	
Min. K value (Crest)	7	4.5		14.87	
Min. K value (Sag)	7	4.5		15.38	
Max. Superelevation (%)		6.0		6.0	
Superelevation to Horizontal Curve (%)		6.0		-	R=270-330m
		5.0		-	R=330-420m
		4.0		-	R=420-560m
		3.0		-	R=560-800m
		2.0		-	R=400-600m
		1.5		-	-
Max. Ratio for Superelevation Development		1/100		1/181	
Stopping Sight Distance (m)		40		>40	

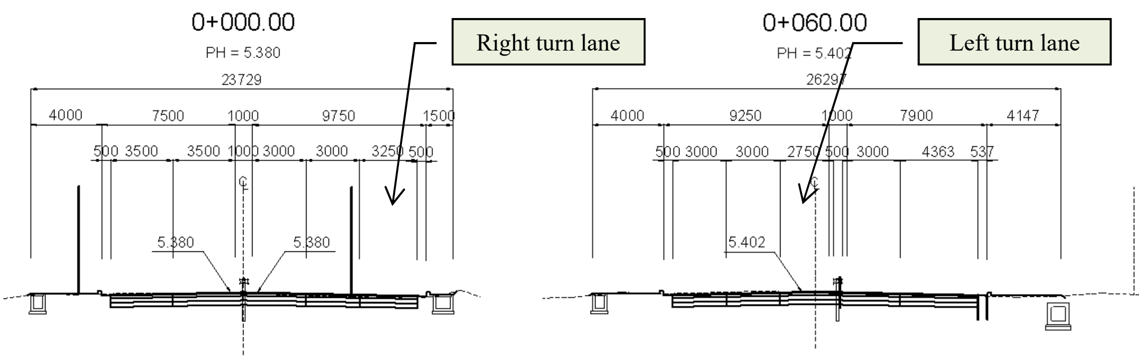
Source: JICA Study Team

3.6.3.4 Typical Cross Section

(1) Main Road

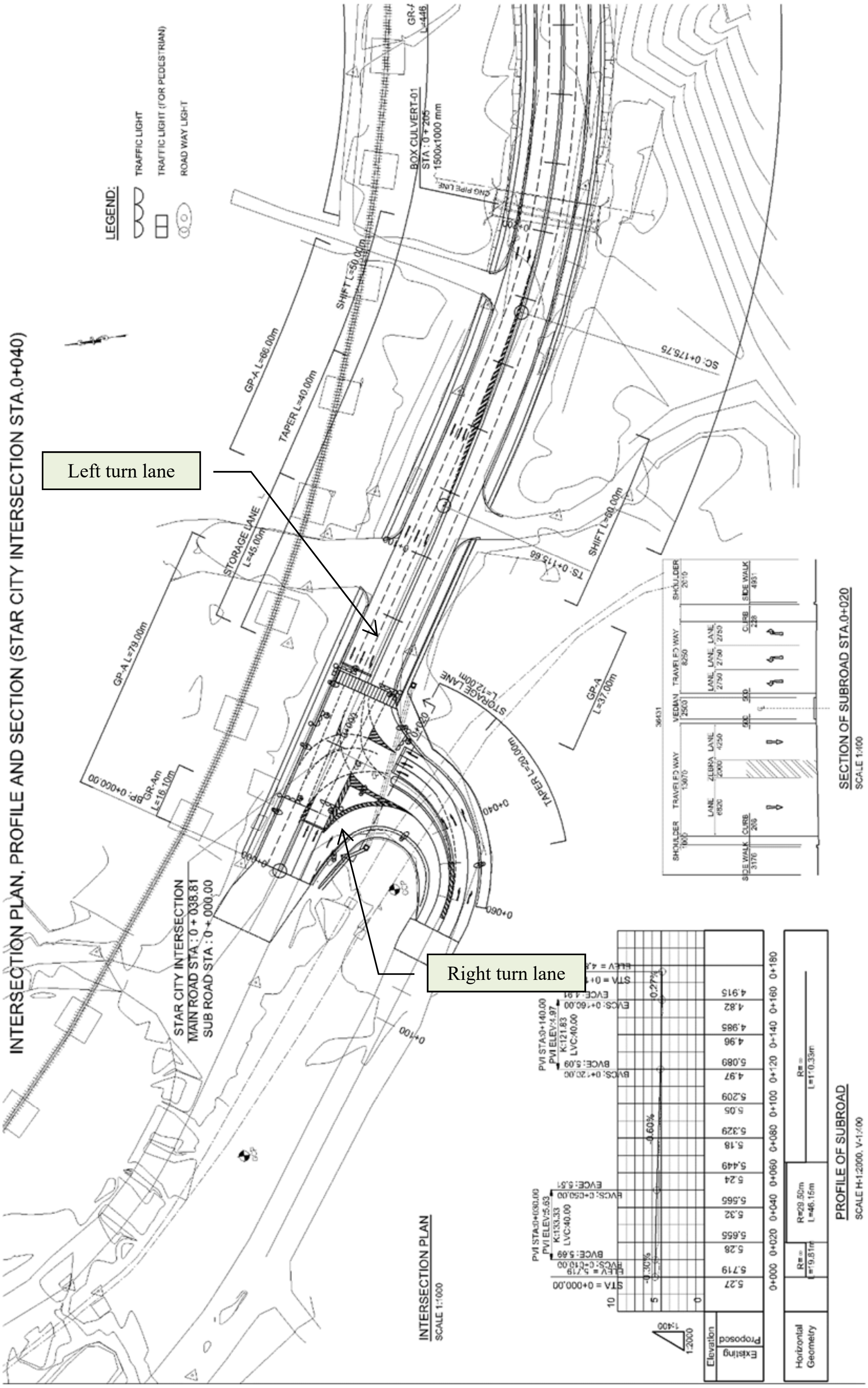
The width of the main line's right / left turn lane was planned based on the width of the already planned Thilawa Access Road.

- Right turn lane : 3.25m
- Left turn lane : 2.75m



Source: INFRASTRUCTURE DEVELOPMENT PROJECT IN THILAWA AREA PHASE II

Figure 3.6.11 Cross Section of Thilawa Access road plan



Source: INFRASTRUCTURE DEVELOPMENT PROJECT IN THILAWA AREA PHASE II

Figure 3.6.12 Intersection Plan of Thilawa Access road plan

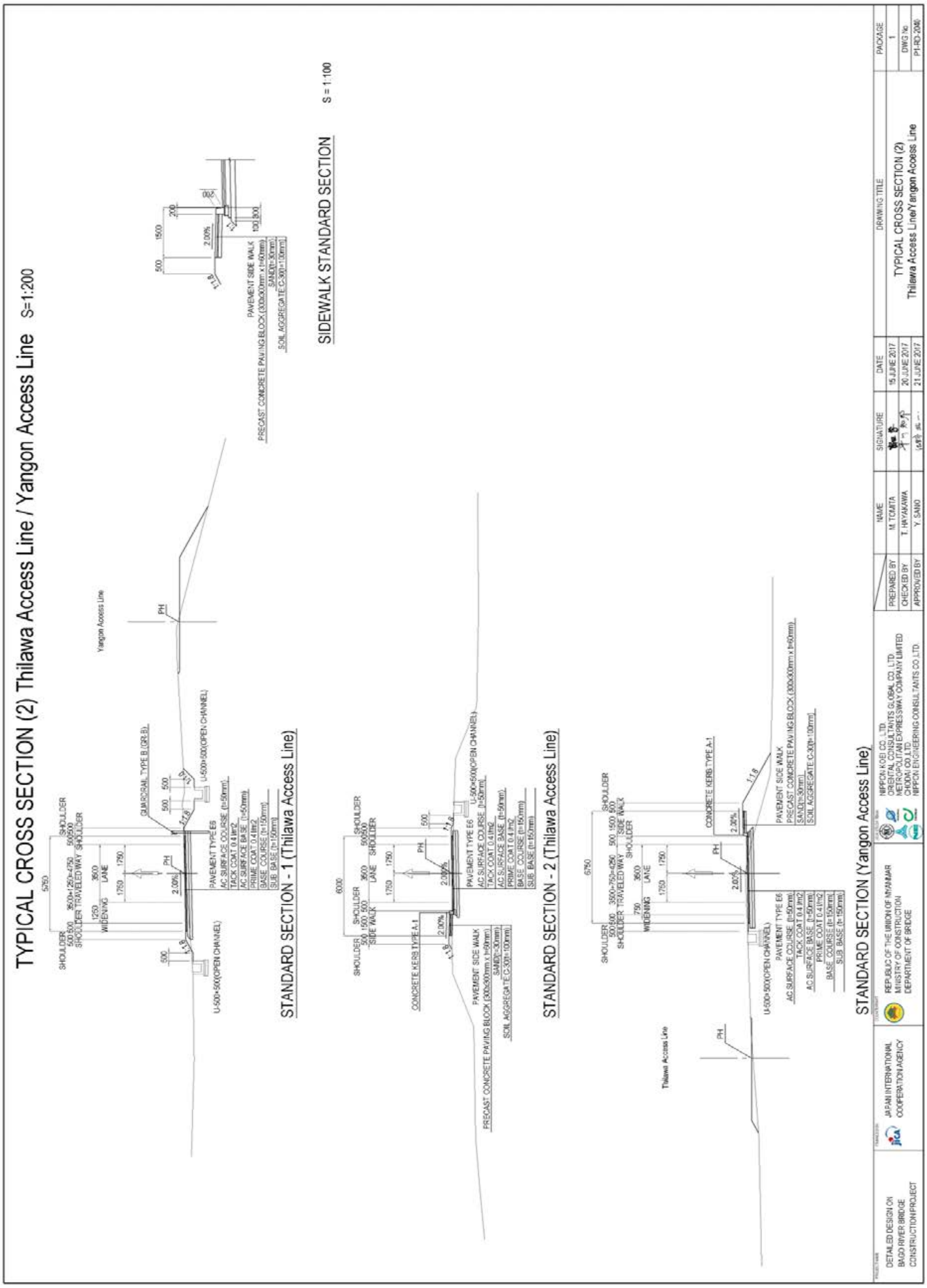
(2) Yangon / Thilawa Access Line

The lane width of the Yangon / Thilawa Access Line was planned with the same width as the Thanlyin Bridge, 0.5 m of road shoulder, 3.5 m of lane, 0.5 m of road shoulder and 1.5 m of sidewalk.

Figure 3.6.14 shows the standard section.

Source: JICA Study Team

Figure 3.6.13 Width of Thanlyin Bridge



Source: JICA Study Team

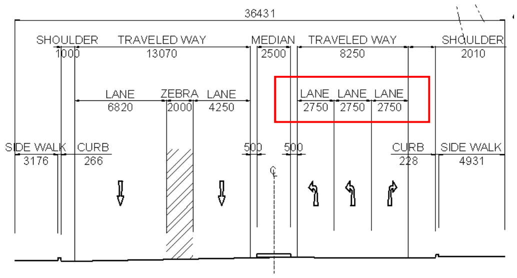
Figure 3.6.14 Typical Cross Section of Yangon / Thilawa Access Line

(3) Star City Access Line

The lane width of the Star City Access Line was planned based on the width of the planned Thilawa Access Road.

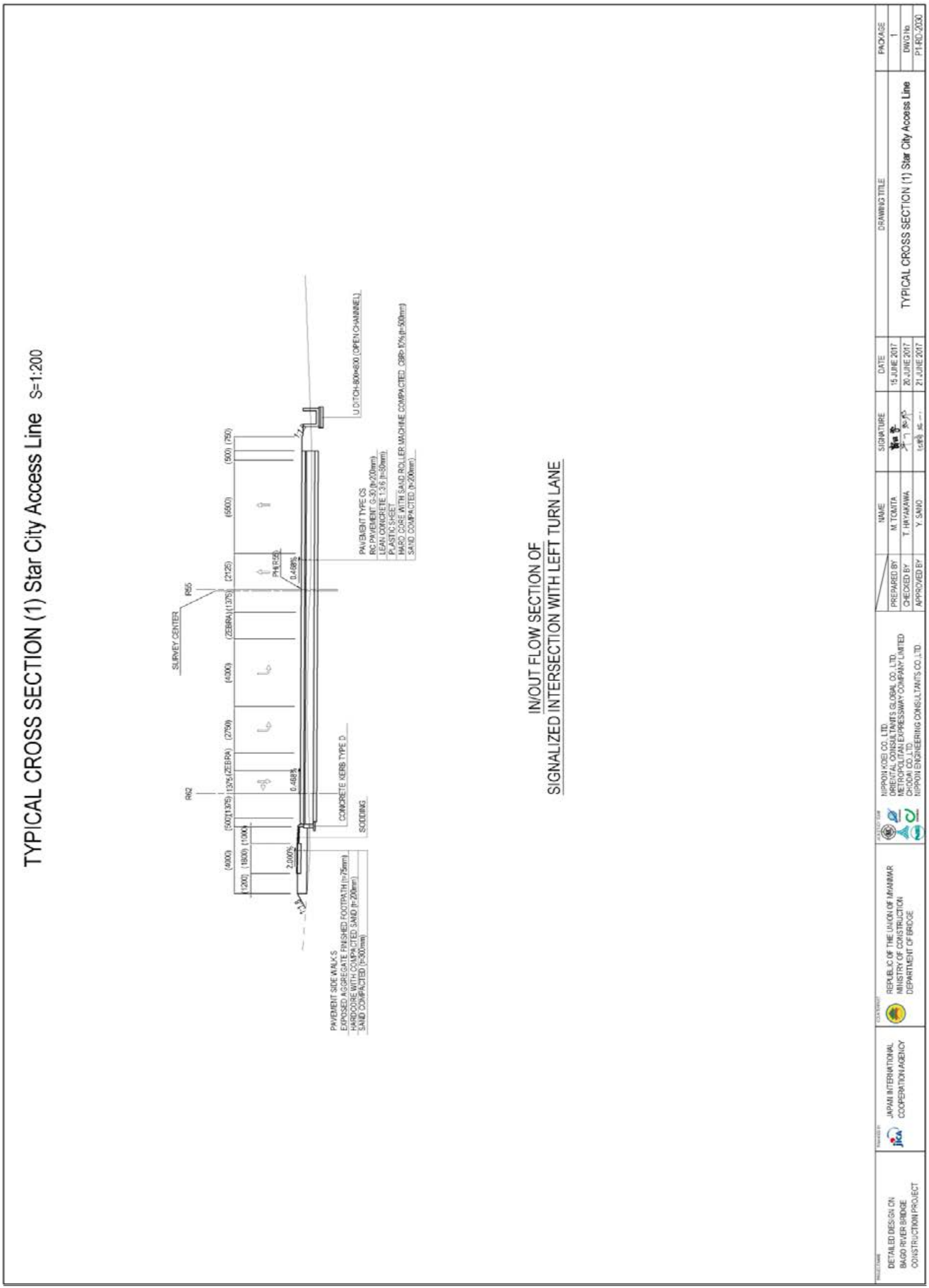
- straight ahead, turn right, turn left lane: 2.75 m

Figure 3.6.16 shows the standard section of Star City Access Line.



Source: INFRASTRUCTURE DEVELOPMENT PROJECT IN THILAWA AREA PHASE II

Figure 3.6.15 Typical Cross Section of Thilawa Access road plan(Star City side)



Source: JICA Study Team

Figure 3.6.16 Typical Cross Section of Star City Access Line

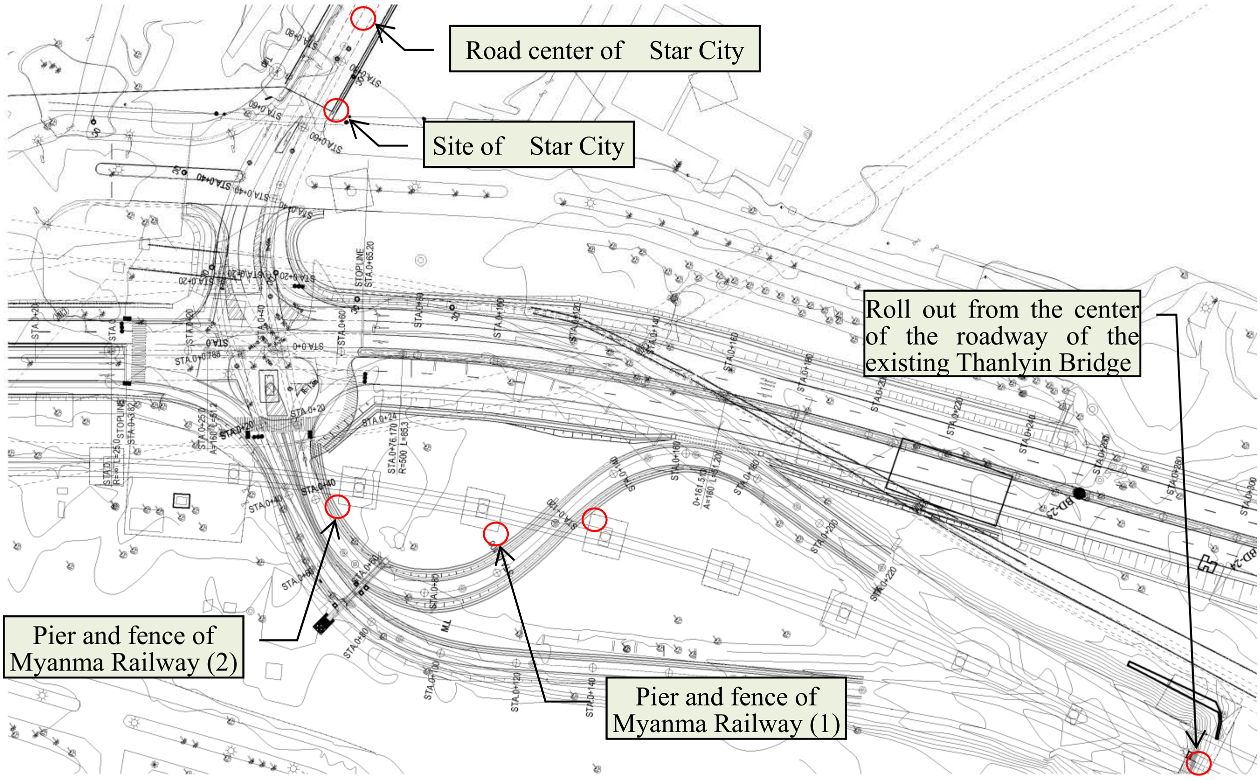
3.6.4 Alignment of the Intersection

3.6.4.1 Horizontal Alignment

Horizontal alignment of the Intersection was determined taking into account the following conditions.

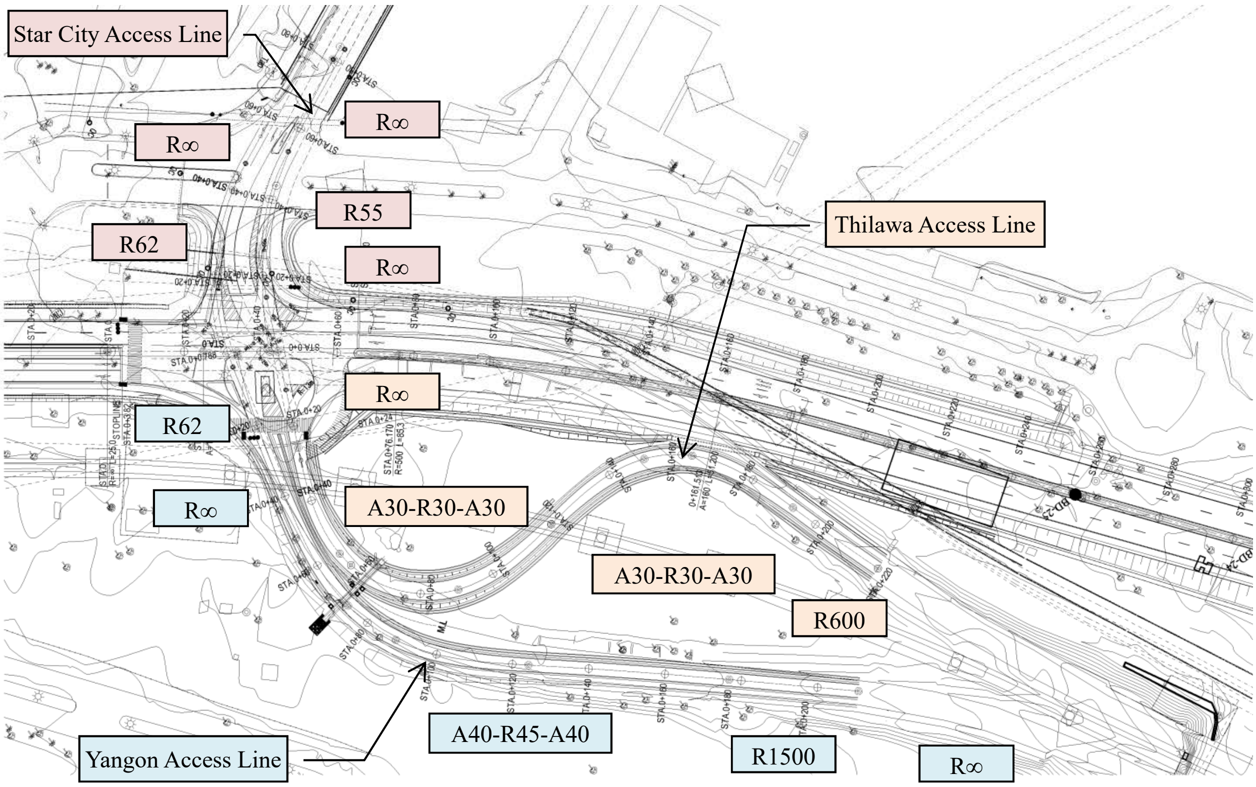
Table 3.6.6 Control point of Horizontal Alignment

Control Point	
Roll out from the center of the roadway of the existing Thanlyin Bridge	
Pier and fence of Myanma Railway (1)	
Pier and fence of Myanma Railway (2)	
Road center of Star City	



Source: JICA Study Team

Figure 3.6.17 Control point of Horizontal Alignment



Source: JICA Study Team

Figure 3.6.18 Horizontal Alignment of the intersection

(1) Horizontal alignment of Yangon Access Line

Table 3.6.7 Horizontal Alignment of Yangon Access Line (Survey)

STA	POSITION	EAST	NORTH	ELEV.
BC 1	0+000.000	205761.768	1857238.539	5.168
KE 1-1	0+001.033	205762.185	1857239.484	5.032
No.1	0+020.000	205768.338	1857257.408	4.997
KA 2-1	0+037.628	205772.507	1857274.534	4.766
No.2	0+040.000	205773.034	1857276.847	4.732
No.3	0+060.000	205776.338	1857296.551	5.089
KE 2-1	0+073.183	205775.782	1857309.691	5.044
No.4	0+080.000	205774.121	1857316.296	5.084
KE 2-2	0+088.695	205770.591	1857324.228	5.120
No.5	0+100.000	205763.964	1857333.361	5.133
No.6	0+120.000	205749.138	1857346.743	4.993
KA 3-1	0+124.251	205745.786	1857349.356	5.033
No.7	0+140.000	205733.398	1857359.082	5.140
No.8	0+160.000	205717.816	1857371.620	5.310
EC 3	0+176.829	205704.835	1857382.329	5.487
No.9	0+180.000	205702.400	1857384.361	5.545
No.10	0+200.000	205687.044	1857397.175	5.992
EP	0+210.781	205678.767	1857404.083	6.278

Source: JICA Study Team

Table 3.6.8 Horizontal Alignment of Yangon Access Line (Plan)

No.	Position	North	East	Horizontal Curve Radius	Parameters	Horizontal Curve length	Tangential Direction Angle
1	-0+00.787842	1,857,237.118390	205,763.814216	-62.000000		4.296547	16-49-40.907
2	0+03.508705	1,857,241.270741	205,764.914630	0.000000		34.118843	12-51-26.932
3	0+37.627548	1,857,274.534108	205,772.506983	0.000000	40.000000	35.555556	12-51-26.932
4	0+73.183103	1,857,309.691405	205,775.782269	-45.000000		15.511997	350-13-19.601
5	0+88.695100	1,857,324.227545	205,770.590988	-45.000000	40.000000	35.555556	330-28-17.846
6	1+24.250656	1,857,349.356460	205,745.785733	1,500.000000		52.577967	307-50-10.515
7	1+76.828622	1,857,382.329225	205,704.835076	0.000000		33.952786	309-50-40.504
8	2+10.781409	1,857,404.083024	205,678.766629				309-50-40.504

Source: JICA Study Team

(2) Horizontal alignment of Thilawa Access Line

Table 3.6.9 Horizontal Alignment of Thilawa Access Line (Survey)

STA	POSITION	EAST	NORTH	ELEV.
BP	0+000.000	205752.986	1857244.676	5.099
No.1	0+020.000	205760.737	1857263.112	5.057
KA 1-1	0+025.800	205762.985	1857268.459	4.975
No.2	0+040.000	205767.994	1857281.738	4.811
KE 1-1	0+055.800	205769.798	1857297.334	4.776
No.3	0+060.000	205769.079	1857301.469	4.755
No.4	0+080.000	205758.397	1857317.940	4.586
KE 1-2	0+090.053	205749.591	1857322.689	4.021
No.5	0+100.000	205739.834	1857324.460	4.202
No.6	0+120.000	205719.975	1857322.501	4.357
KA 2-1	0+120.053	205719.923	1857322.492	4.363
No.7	0+140.000	205700.117	1857320.519	4.232
KE 2-1	0+150.053	205690.256	1857322.295	4.319
No.8	0+160.000	205681.532	1857326.980	5.174
KE 2-2	0+062.708	205679.468	1857328.732	5.306
No.9	0+180.000	205669.930	1857343.008	5.376
EC 3	0+192.708	205665.553	1857354.934	5.586
No.10	0+200.000	205663.204	1857361.837	5.551
EP	0+220.000	205656.333	1857380.618	6.225

Source: JICA Study Team

Table 3.6.10 Horizontal Alignment of Thilawa Access Line (Plan)

No.	Position	North	East	Horizontal Curve Radius	Parameters	Horizontal Curve length	Tangential Direction Angle
1	0+00.000000	1,857,244.675512	205,752.986039	0.000000		25.800000	22-48-12.244
2	0+25.800000	1,857,268.458988	205,762.985353	0.000000	30.000000	30.000000	22-48-12.244
3	0+55.800000	1,857,297.334289	205,769.797584	-30.000000		34.252518	354-09-19.841
4	0+90.052518	1,857,322.689346	205,749.590770	-30.000000	30.000000	30.000000	288-44-16.875
5	1+20.052518	1,857,322.492113	205,719.923437	0.000000	30.000000	30.000000	260-05-24.472
6	1+50.052518	1,857,322.294880	205,690.256105	30.000000		12.655924	288-44-16.875
7	1+62.708442	1,857,328.731740	205,679.468250	30.000000	30.000000	30.000000	312-54-32.600
8	1+92.708442	1,857,354.933818	205,665.552768	-600.000000		27.291557	341-33-25.003
9	2+19.999999	1,857,380.618386	205,656.333024				338-57-02.856

Source: JICA Study Team

(3) Horizontal aligrument of Star City Access Line

Table 3.6.11 Horizontal Alignment of Star City Access Line (Survey)

STA	POSITION	EAST	NORTH	ELEV.
BC 1	0+000.000	205754.765	1857243.426	5.083
No.1	0+020.000	205744.947	1857226.049	4.651
No.2	0+040.000	205731.541	1857211.262	4.732
KE 1-1	0+043.763	205728.669	1857208.831	4.748
No.3	0+060.000	205715.311	1857199.626	4.534
No.4	0+080.000	205697.670	1857190.213	4.537
KA 1-1	0+083.763	205694.298	1857188.543	4.540
No.5	0+100.000	205679.743	1857181.347	4.439
No.6	0+120.000	205661.814	1857172.483	4.416
No.7	0+140.000	205643.886	1857163.618	4.392
No.8	0+160.000	205625.958	1857154.754	4.443
EP	0+180.000	205608.030	1857145.890	4.401

Source: JICA Study Team

Table 3.6.12 Horizontal Alignment of Star City Access Line (Plan R55)

No.	Position	North	East	Horizontal Curve Radius	Parameters	Horizontal Curve length	Tangential Direction Angle
1	0+00.000000	1,857,244.675512	205,752.986039	0.000000		14.530066	202-48-12.244
2	0+14.530066	1,857,231.281114	205,747.354617	55.000000		39.249048	202-48-12.244
3	0+53.779114	1,857,203.294657	205,721.030274	0.000000		30.501544	243-41-26.741
4	0+84.280658	1,857,189.775893	205,693.688234				243-41-26.741

Source: JICA Study Team

Table 3.6.13 Horizontal Alignment of Star City Access Line (Plan R62)

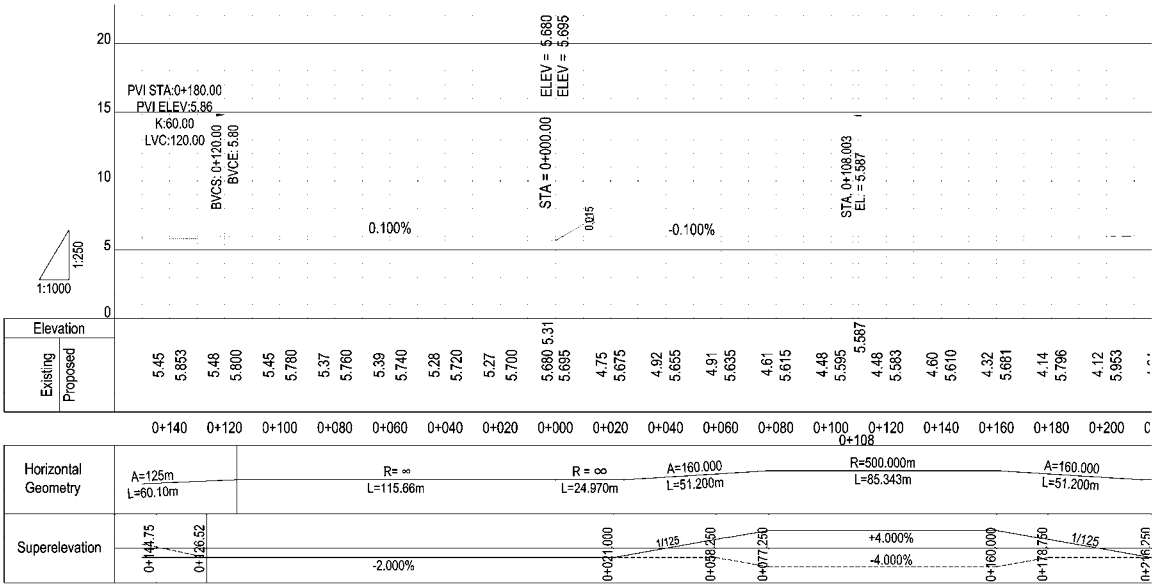
No.	Position	North	East	Horizontal Curve Radius	Parameters	Horizontal Curve length	Tangential Direction Angle
1	0+00.000000	1,857,237.118390	205,763.814216	62.000000		50.710349	196-49-40.932
2	0+50.710349	1,857,199.489674	205,731.948558	0.000000		8.100885	243-41-26.744
3	0+58.811234	1,857,195.899235	205,724.686804				243-41-26.744

Source: JICA Study Team

3.6.4.2 Vertical Alignment

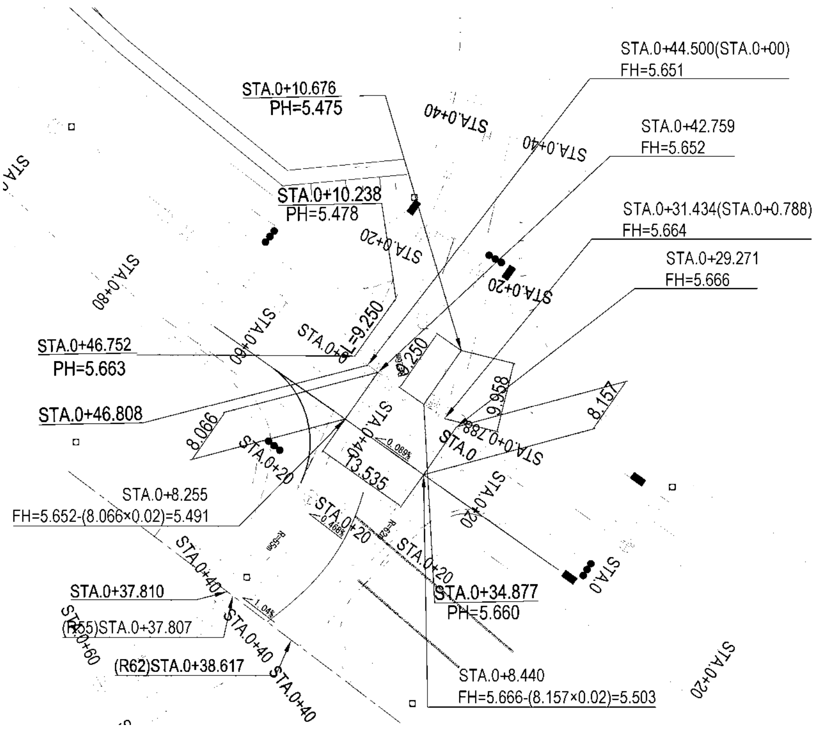
Vertical alignment of the Intersection was determined taking into account the following conditions.

- Raise gradient from main road longitudinal
- Adjust to the height of the existing road
- Ensuring 5.0m of vertical clearance at Myanmar Railway



Source: JICA Study Team

Figure 3.6.19 Vertical Alignment of the intersection

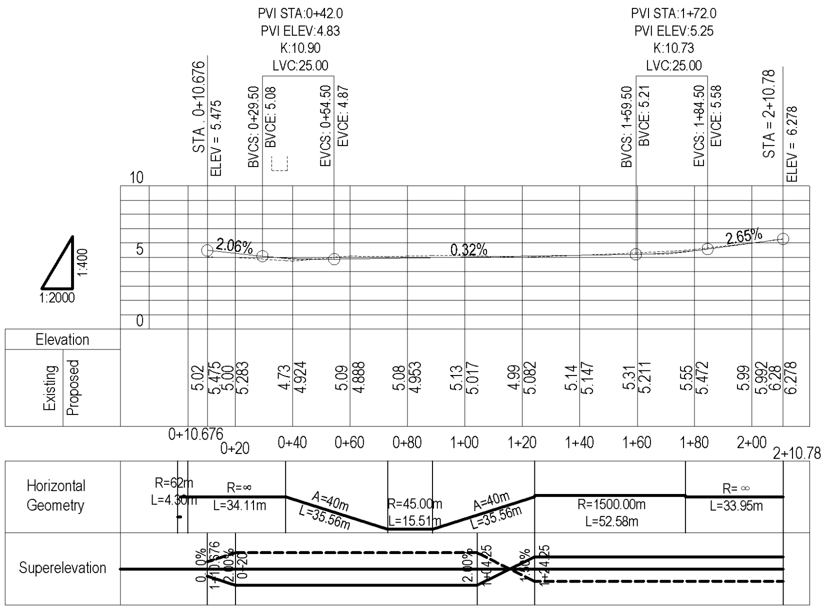


Source: JICA Study Team

Figure 3.6.20 Raise gradient from main road longitudinal

(1) Vertical alignment of Yangon Access Line

The vertical alignment of Yangon Access Line is shown in Figure3.6.21

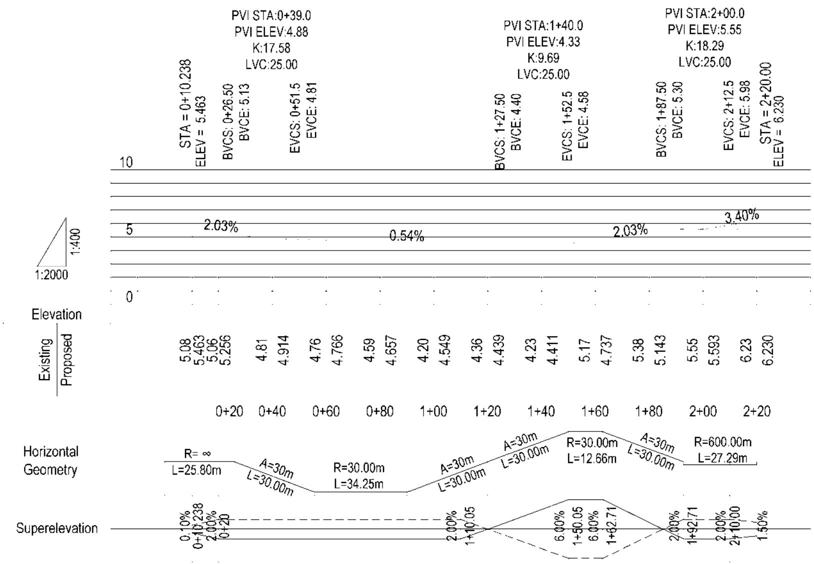


Source: JICA Study Team

Figure 3.6.21 Vertical alignment of Yangon Access Line

(2) Vertical alignment of Thilawa Access Line

The vertical alignment of Thilawa Access Line is shown in Figure3.6.22

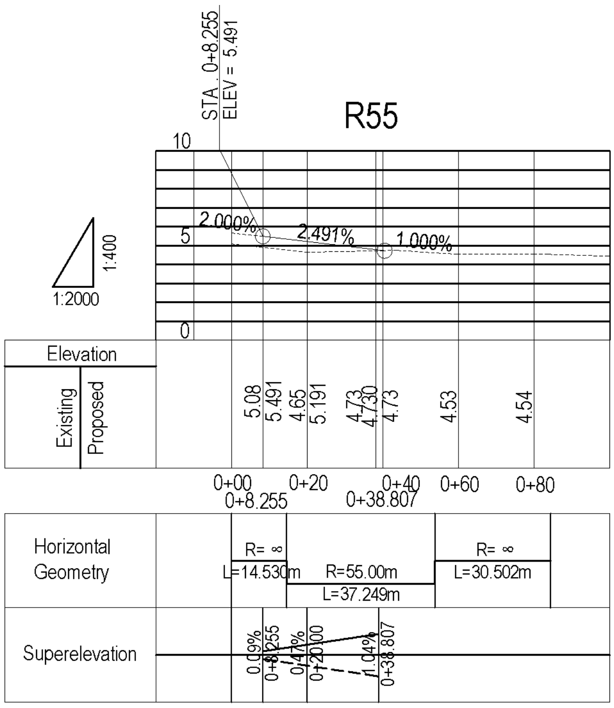


Source: JICA Study Team

Figure 3.6.22 Vertical alignment of Thilawa Access Line

(3) Vertical alignment of Star City Access Line

The vertical alignment of Star City Access Line is shown in Figure3.6.23



Source: JICA Study Team

Figure 3.6.23 Vertical alignment of Star City Access Line

3.6.5 Storage length of Intersection

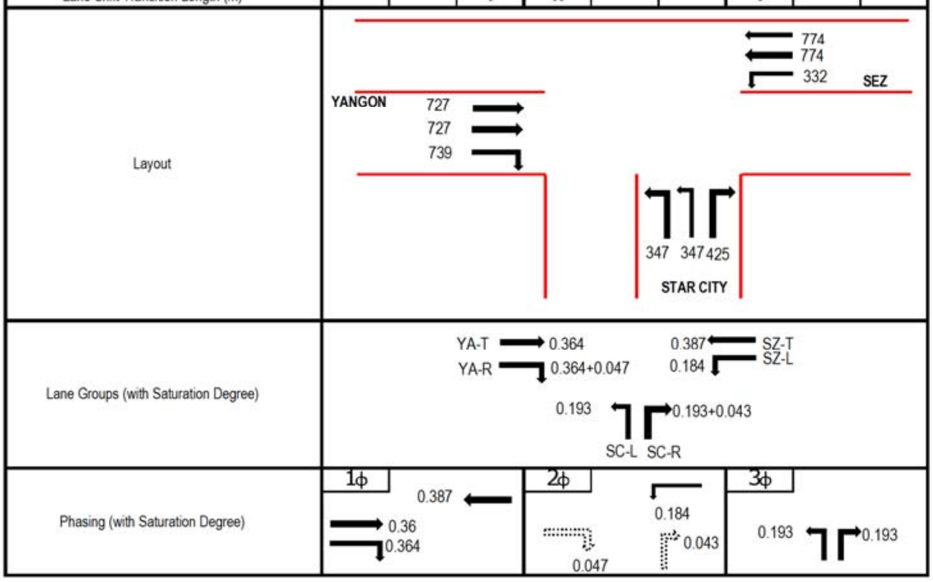
In order to plan consistency with the Thilawa Access Road, the storage length of the intersection conducted an intersection plan using the crossing analysis analyzed on the Thilaway Access Road.

Figure 3.6.24 shows the result of intersection analysis calculated by the Thilawa Access Road Plan.

The adoption year is 2023 years.

Analysis of Major Intersection
01-Star City Intersection (KM 0+040) FORECAST YEAR 2023

Approach	YANGON			SEZ			STAR CITY				
Lane	L	T	R	L	T	R	L	T	R		
Code	YA-L	YA-T	YA-R	SZ-L	SZ-T	SZ-R	SC-L	SC-T	SC-R		
Volume pcu/hr	-	1454	739	332	1548	-	694	-	425		
Check for Left Turn Protection Requirement				482728							
LT x Opposing TH > 50000 (1L), 90000 (2L)				YES							
Input for Volume Adjustment											
Number of Lanes, N		2	1	1	2		2		1		
Lane Width		≥3.0	≥2.75	≥2.75	≥3.0		≥2.75		≥2.75		
Vertical Grade		0.04	0.04	-0.04	-0.04		0		0		
Percentage of RT	-	-	-	-	-	-	-	-	-		
Percentage of LT	-	-	-	-	-	-	-	-	-		
Base Saturation Flow S_0 (pcu/hr/lane)		2000	1800	1800	2000		1800		1800		
Heavy vehicle adjustment factor, f_{HV}		1	1	1	1		1		1		
Lane width adjustment factor, f_w		1	1	1	1		1		1		
Vertical grade adjustment factor, f_g		1	1	1	1		1		1		
Right-turn adjustment factor, f_{RT}		1	1	1	1		1		1		
Left-turn adjustment facotr, f_{LT}		1	1	1	1		1		1		
Adjusted Saturation Flow pcu/hr		4000	1800	1800	4000		3600		1800		
Left Turn Volume Adjustment for Turn at Transition											
No. of vehicles turning Left at transition/cycle				2							
Initial Assumed Cycle time (sec)				90							
Volume to be Adjusted				80							
Adjusted Volume pcu/hr	-	1454	739	252	1548	-	694	-	425		
Flow Ratio		0.364	0.411	0.140	0.387		0.193		0.236	λ_i	λ
Phase Ratio 1φ		0.364	0.364		0.387					0.387	
Phase Ratio 2φ			0.047	0.140					0.043	0.140	0.720
Phase Ratio 3φ							0.193		0.193	0.193	
Total Lost time (L) (Sec)											11
Approximate Cycle Time (1.5xL+5)/(1-λ)											77
Minimum Cycle Time (0.9L/(0.9-λ)											55
Applied Cycle Time (Sec)										80	
Green Time (Sec) 1φ										37	
Green Time (Sec) 2φ										14	
Green Time (Sec) 3φ										18	
Storage Length (m)			68	45			45				
Taper Length (m)			40	40			40				
Lane Shift Transition Length (m)			0	60			0				



Source: INFRASTRUCTURE DEVELOPMENT PROJECT IN THILAWA AREA PHASE II

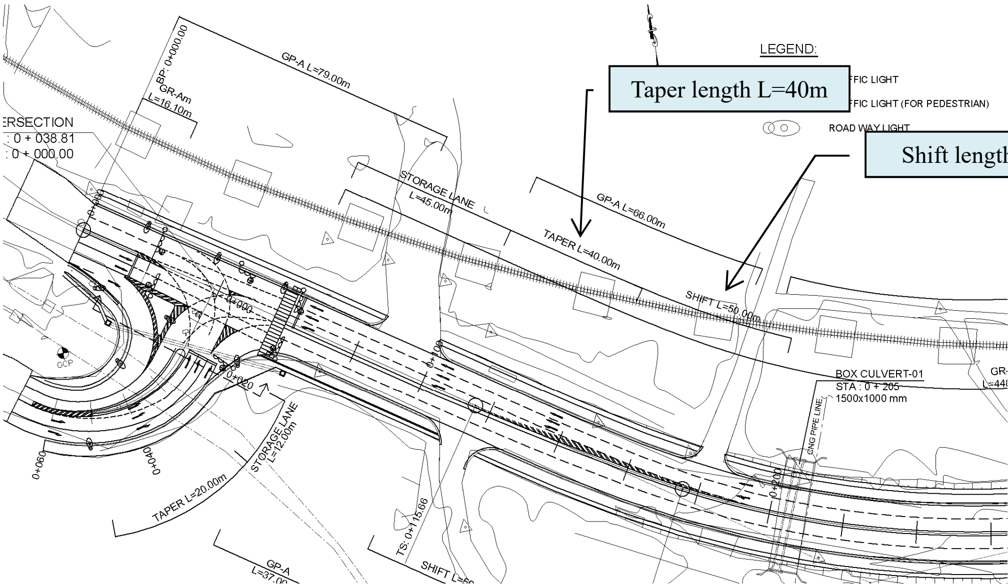
Figure 3.6.24 Major intersection analysis of Thilawa Access Road Plan

3.6.6 Intersection Design

3.6.6.1 Taper length and Shift length

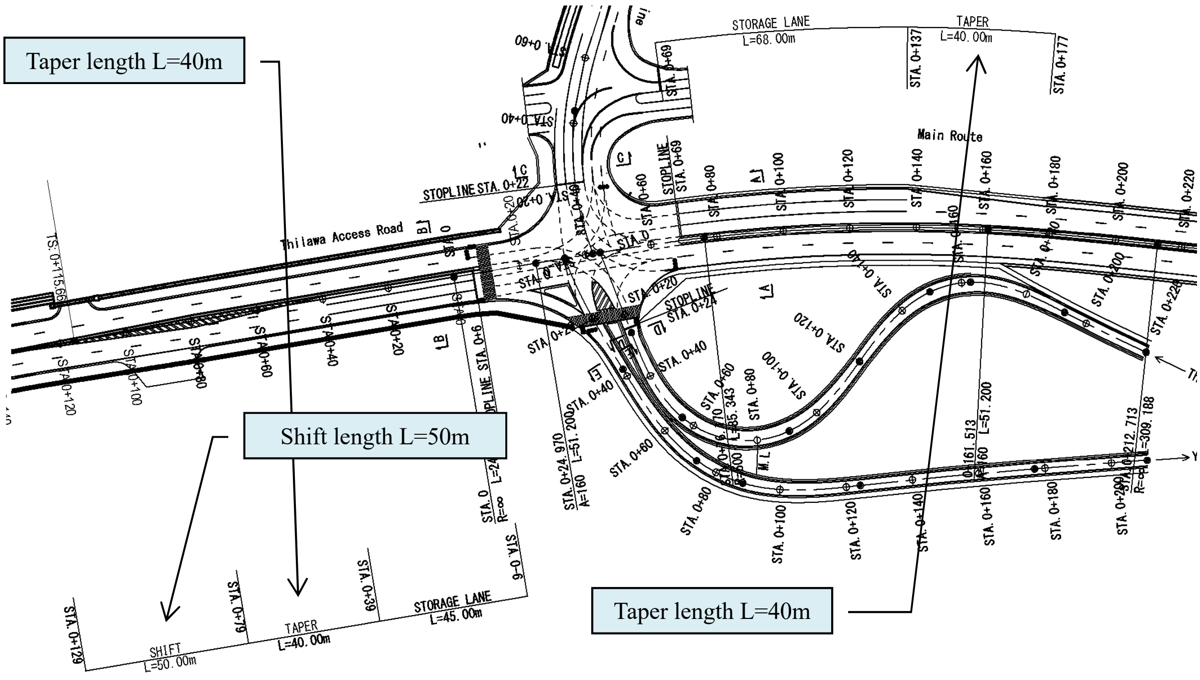
(1) Main Road

The taper length of the main road and the shift length of the main road were planned to secure the taper length L = 40 m and the shift length L = 50 m in order to match with the Thilawa Access Road.



Source: INFRASTRUCTURE DEVELOPMENT PROJECT IN THILAWA AREA PHASE II

Figure 3.6.25 Thilawa Access road plan



Source: JICA Study Team

Figure 3.6.26 Intersection Plan

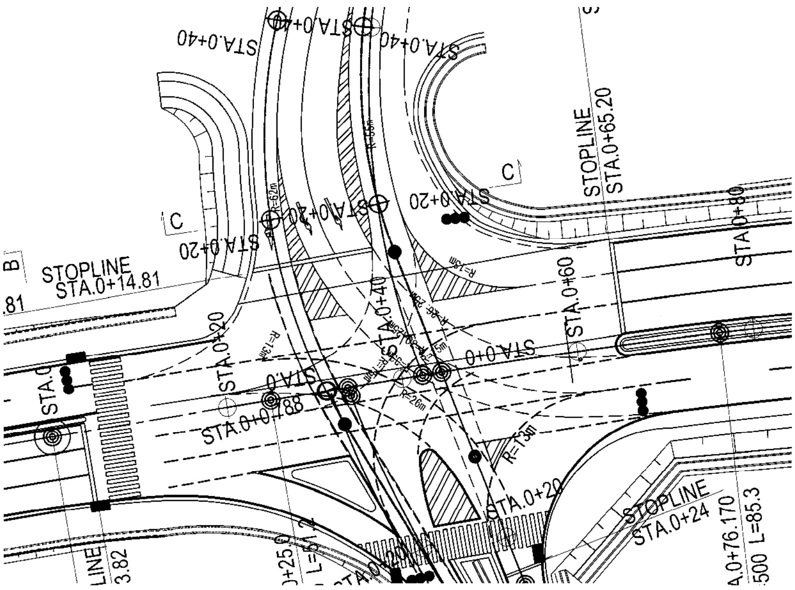
3.6.6.2 Channel

The channel planned for regular vehicle same as the Thilawa Access Road

Table 3.6.14 Channel of regular vehicle

Design vehicle / Outer radius		regular vehicle
more than 13	less than 14	5. 5
14	15	
15	16	5. 0
16	17	
17	19	
19	21	4. 5
21	25	
25	30	4. 0
30	40	
40	60	3. 5
60		

Source: Japan Standard



Source: JICA Study Team

Figure 3.6.27 Channel Plan

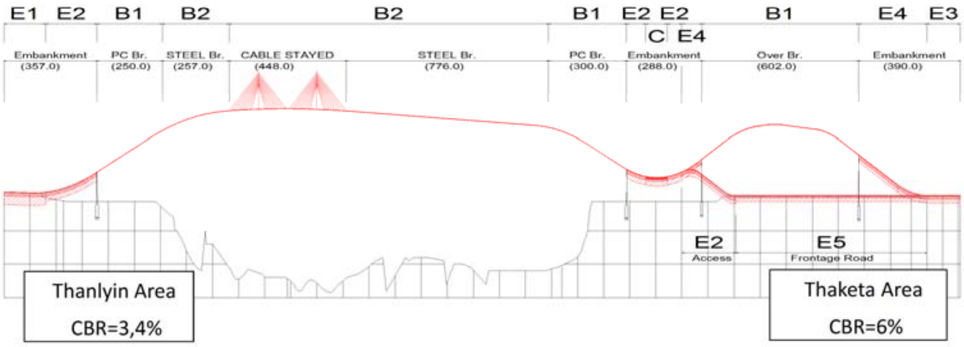
3.6.6.3 Pavement Design

(1) Pavement Design of Yangon / Thilawa Access Line

Figure3.6.29 shows the pavement composition table of the earthwork section.

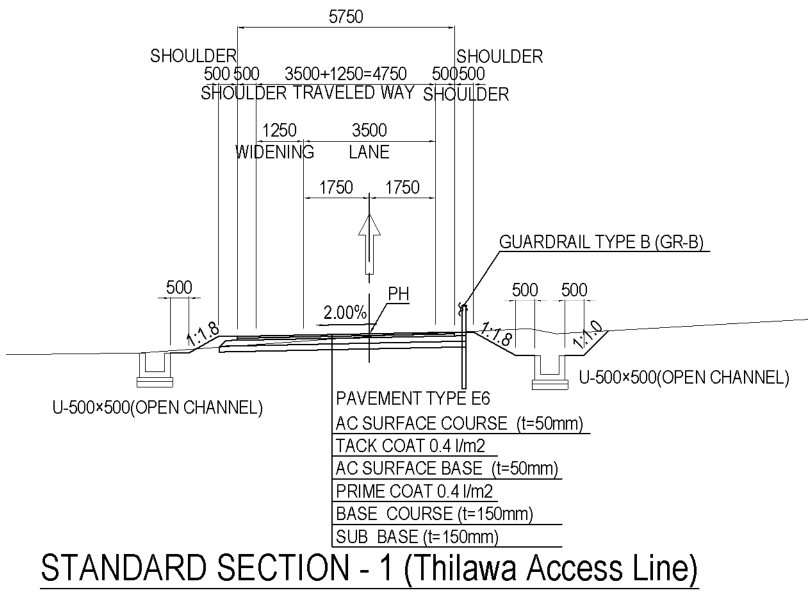
When the Bago Bridge was constructed, there was hardly any traffic passing through the Thanlyin Bridge, so we planned with Type-E6 which is the minimum pavement thickness

Location	Thanlyin Approach		Thanlyin Ramp	Thaketa Toll	Thaketa Ov Approach	Thaketa Access Ramp	Thaketa Ov Approach	Thaketa Widenning	Thaketa Frontage Road
	E1	E2	E6	E2	E4	E4	E4	E3	E5
DesignCBR	4.0 -	6.0 -	3.0 -			6.0 -		6.0 -	6.0 -
M_R (psi)	6000.0	9000.0	4500.0			9000.0			
a_1					0.440				
a_2					0.134				
a_3					0.109				
m					1.000				
Traffic	29,344,839	29,344,839	526,952	29,344,839	13,899,717	15,445,122	13,899,717	19,033,241	3,588,119
SN	5.028	4.503	3.061	4.503	4.014	4.081	4.014	4.216	3.222
Thickness of Pavemnet Structures									
As	10	10	10	10	10	10	10	10	10
Base Course	25	25	15	25	25	25	25	25	15
SubBase	50	35	15	35	25	25	25	30	25
SubGrade	-	-	-	-	-	-	-		-
Totall	85	70	40	70	60	60	60	65	50



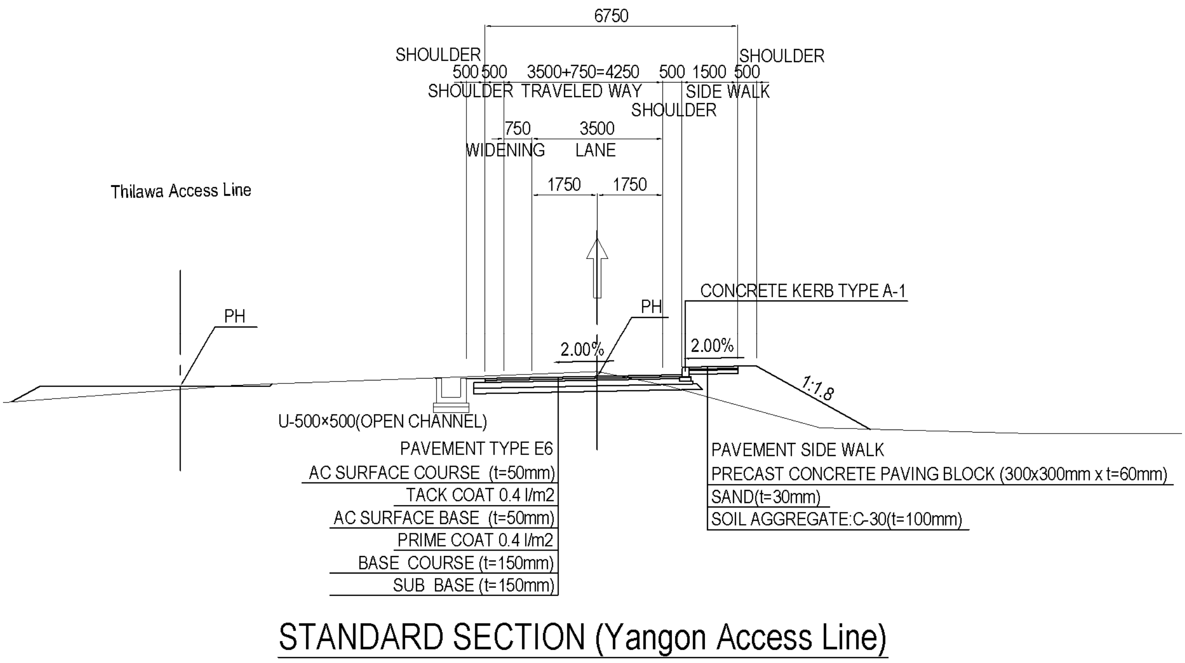
Source: JICA Study Team

Figure 3.6.28 Pavement composition table of the earthwork section



Source: JICA Study Team

Figure 3.6.29 Pavement Design of Thilawa Access Line



Source: JICA Study Team

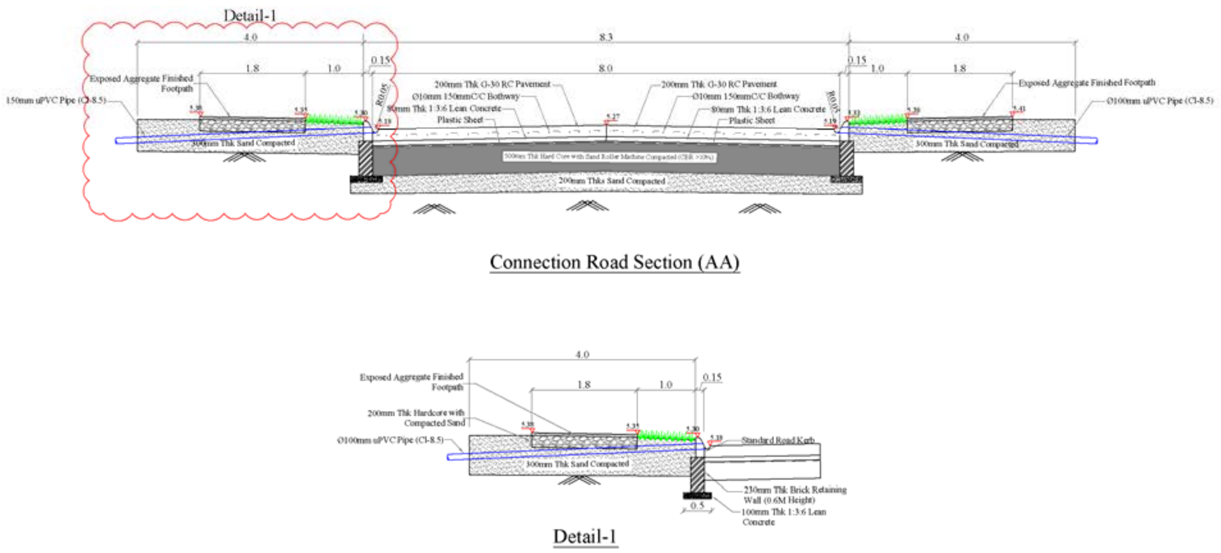
Figure 3.6.30 Pavement Design of Yangon Access Line

(2) Pavement Design of Star City Access Line

The pavement of the Star City Access Line was planned similar to the pavement construction (RC pavement) constructed at the intersection project of Star City.

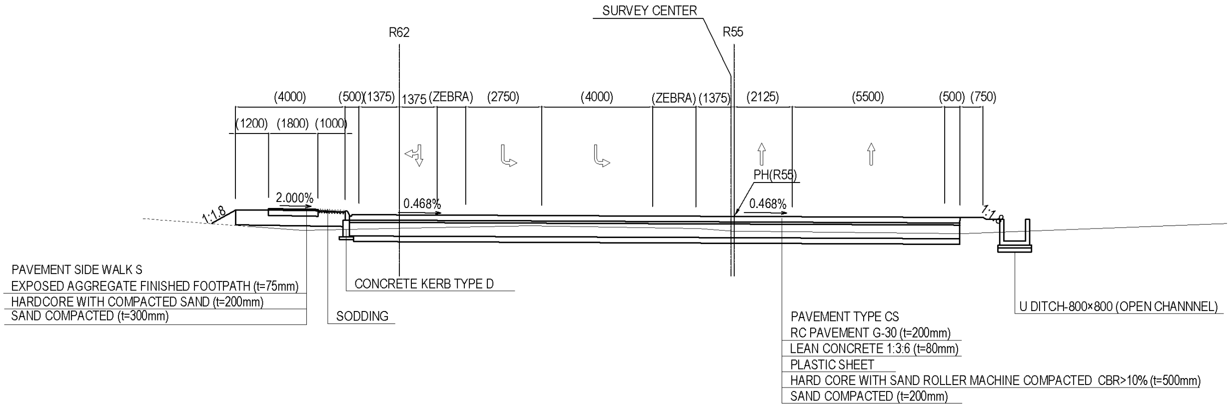
Sidewalk pavement is also the same.

Figure 3.6.32 shows the pavement constructed by the intersection project of Star City.



Source: Thanlyin Star City Project

Figure 3.6.31 Intersection on the Star City side Overview of the project

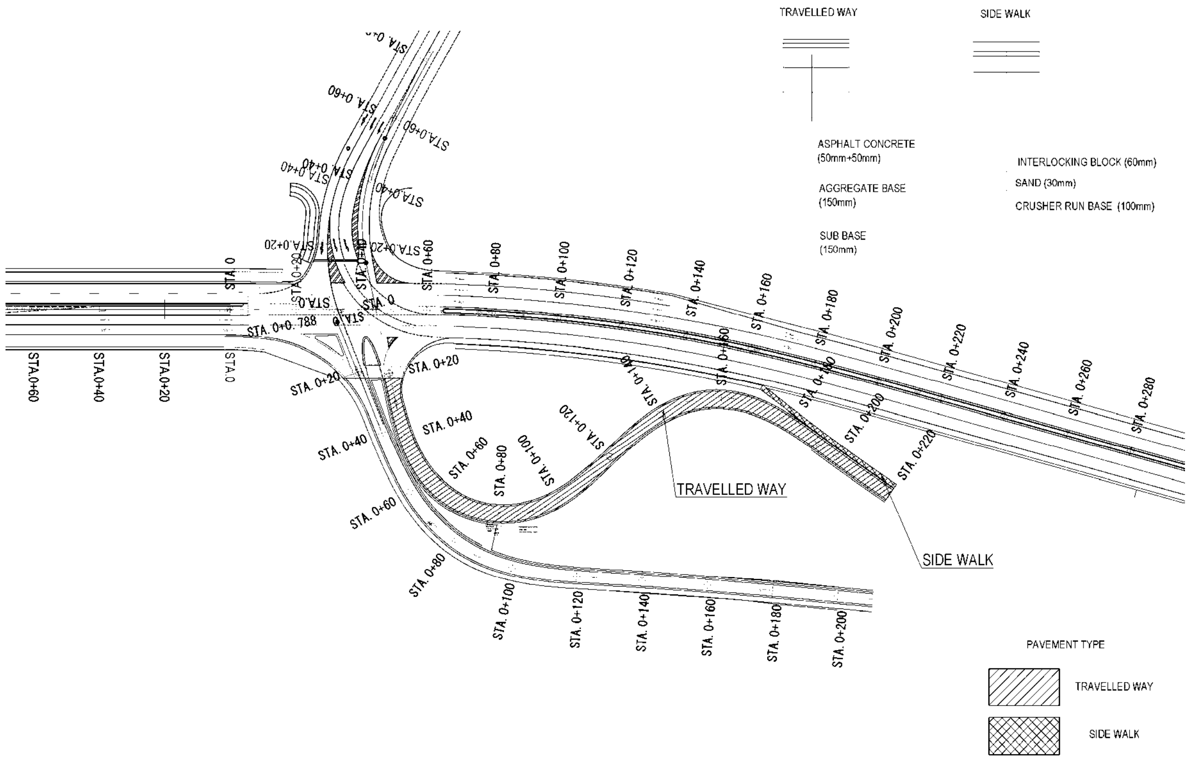


Source: JICA Study Team

Figure 3.6.32 Pavement Design of Star City Access Line

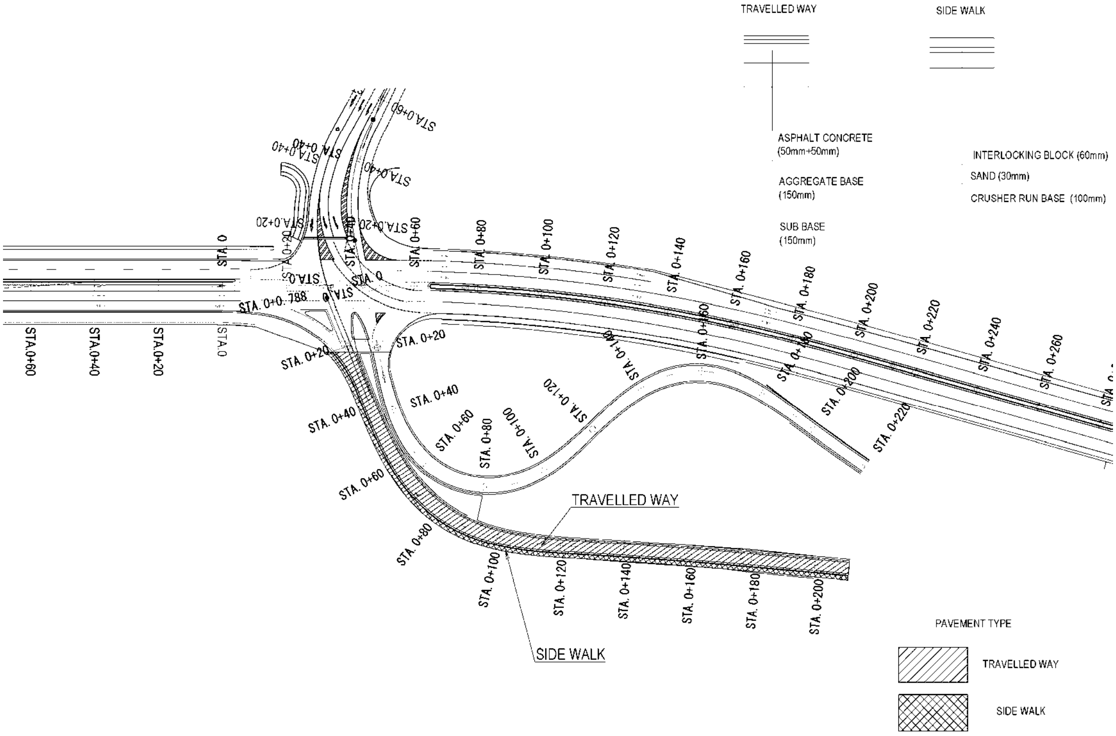
(3) Classification of pavement

The division of pavement is shown in Figure 3.6.34 to Figure 3.6.36.



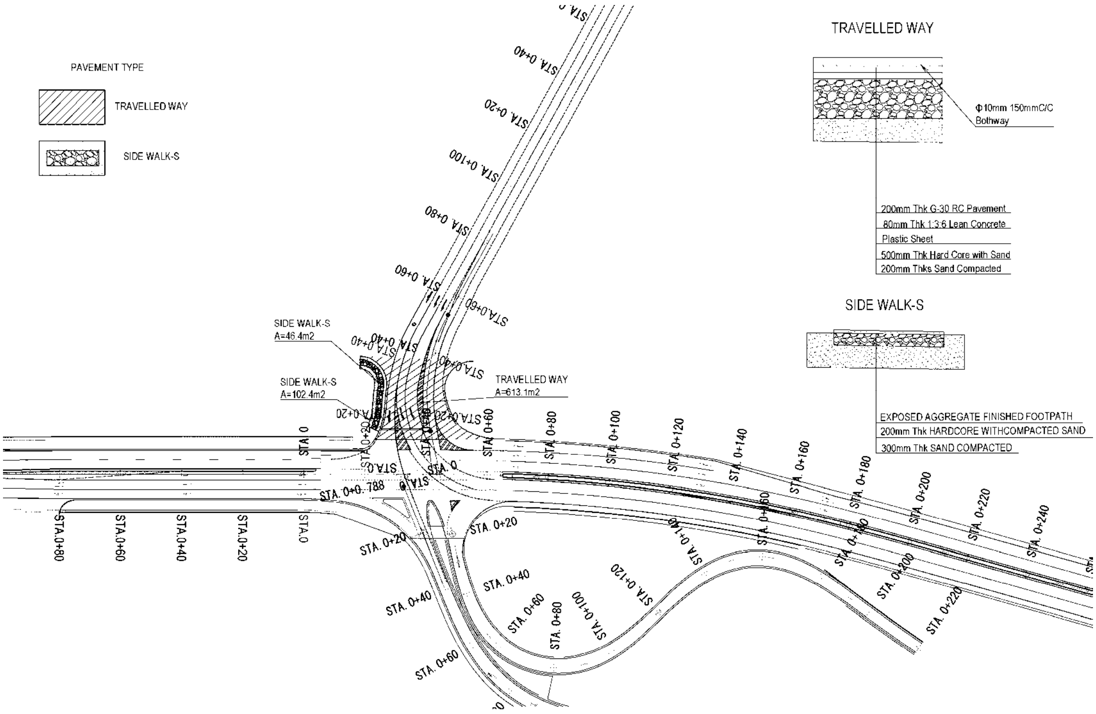
Source: JICA Study Team

Figure 3.6.33 Classification of pavement (1)



Source: JICA Study Team

Figure 3.6.34 Classification of pavement (2)



Source: JICA Study Team

Figure 3.6.35 Classification of pavement (3)

3.7 TRAFFIC SIGNS AND ROAD MARKINGS

3.7.1 Design Conditions

Traffic signs required for the Project consist of the following:

- Roadside traffic signs attached to the signboard post
- Informatory signboard to guide the road crossing layout ahead with each road's destination
- Road markings such as separation of traffic lanes, stop line, arrow marks, etc.

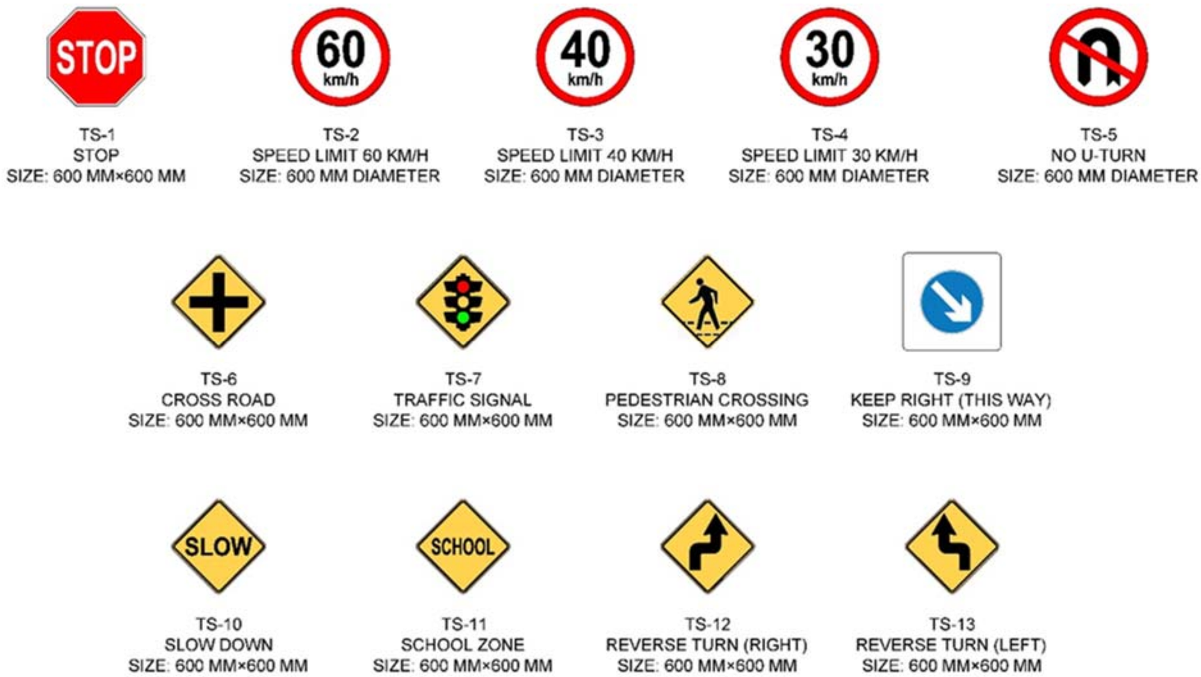
In addition to the above, as the Project has the toll plaza to collect the toll charge, it was considered necessary to provide drivers a signboard which will inform the toll facility ahead. Thus, the toll information was provided on informatory signboard and by road markings on the road surface.

Further description of each type of traffic sign is given in the following subsections.

3.7.2 Traffic Signs

The Project will deploy traffic signs including warning signs, regulatory signs, and information signs as given in Figure 3.7.1.

In addition to the traffic signs, informatory signboards which will guide drivers on road destinations will be introduced as given in Figure 3.7.2. These signboards shall be installed at appropriate locations before the driver's entry into the major intersections.



Source: JICA Study Team

Figure 3.7.1 Traffic Signs

Source: JICA Study Team

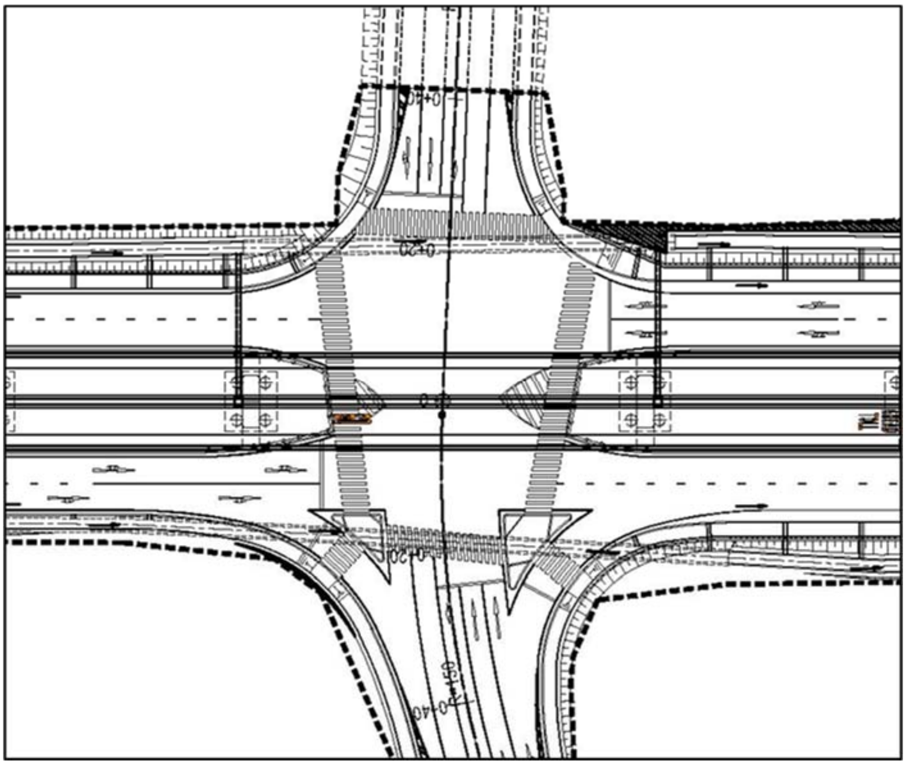
Figure 3.7.2 Informatory Signboards

3.7.3 Road Marking

In order to establish traffic safety and secure smooth traffic flow, the following road markings, among others, will be deployed in the Project:

- Arrow mark
- Zebra zone
- Stop line
- Crosswalk lines
- Lane lines
- Holding lines
- Give way lines

Figure 3.7.3, which is the plan drawing of Thanlyin Chin Kat Road - Yadanar Road Intersection, shows the example of road marking deployment in the Project.



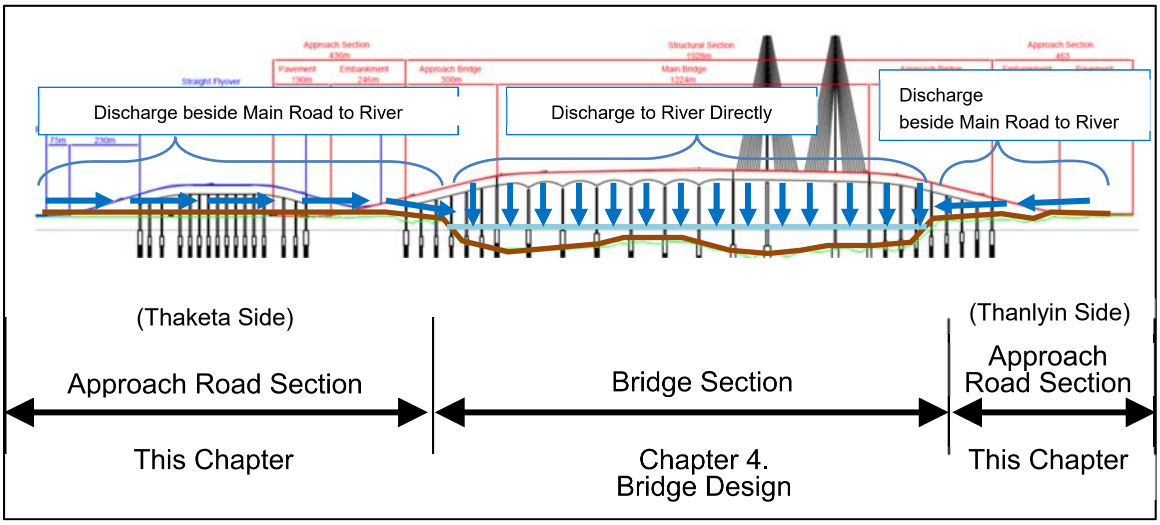
Source: JICA Study Team

Figure 3.7.3 Example of Road Markings

3.8 DRAINAGE DESIGN

3.8.1 General

Rainfall water inside the Project site will discharge to Bago River. Figure 3.8.1 shows the overall concept for drainage design. The rainfall water around approach road area will discharge through drainage structures along the Project road. In the bridge section on the river, the water will discharge directly to the river. This chapter will cover the drainage design of the approach road section only consisting of right and left river bank section and will exclude the bridge section on Bago River. Details for the drainage in bridge section will be mentioned in Chapter 4.



Source: JICA Study Team

Figure 3.8.1 Demarcation and Concept of Drainage Design

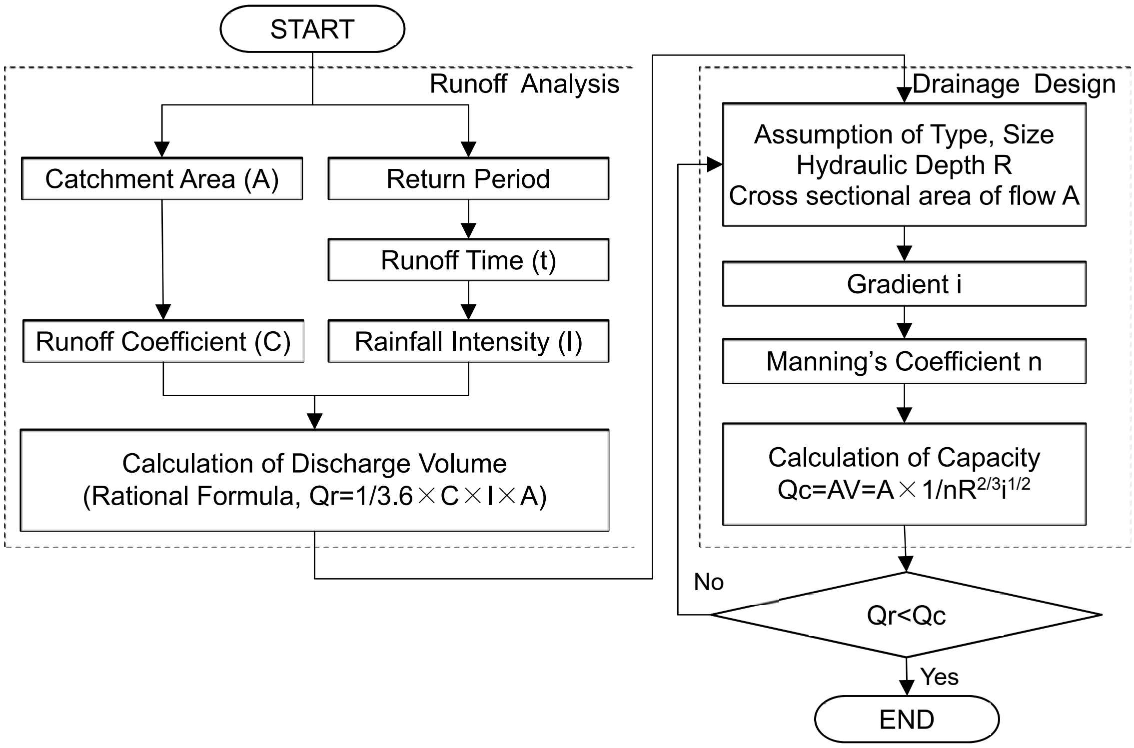
3.8.2 Flow of Hydrological Analysis and Drainage Design

The drainage design consists of the following three components:

i) Hydrological analysis (flood return period, runoff time and rainfall intensity)

ii) Discharge volume estimation by Rational Formula from catchment area and runoff coefficient

iii) Discharge capacity checking by Manning's formula as illustrated in the following drainage design flow diagram



Source: JICA Study Team

Figure 3.8.2 Flow of Hydrological Analysis and Drainage Design

3.8.3 Return Period and Rainfall Intensity

The flood return period (flood frequency) used to design drainage structures is determined by the type, size, location, and importance of the structure. The JICA Study Team adopted the following return periods for the design of the drainage structures of the Project.

Table 3.8.1 Return Period for Drainage Structure Design

Type of Drainage	Return Period
Roadside Open Ditches	3 years
Culverts (Pipe and Box Type)	

Source: JICA Study Team

In Section 2.4 (River and Hydrological Survey), the JICA Study Team estimated the following rainfall intensity curve with reference to Mononobe's equation in each runoff time. This curve, with three year return period, is applied to the drainage design of the Project as shown in following equation and Table 3.8.2.

$$I = R_{24} / 24 \times (24/t)^m$$

Where,

m = 2/3

I: Rainfall intensity (mm/hr)

R_{24}: 24 hour rainfall

t: Runoff time (Rainfall duration) (min)

Table 3.8.2 Estimated Rainfall Intensity Curve

Return Period (Probability) (Year, %) Kaba Aye		Dairy Rainfall: R_{24} (mm/day)	Rainfall intensity each rainfall duration (mm/hr): $It = R_{24}/24*(24/t)^m$, m=2/3											
		24 hour	24	12	8	6	3	2	1.5	1	0.75	0.5	0.333	0.167
		1,440 min.	1,440	720	480	360	180	120	90	60	45	30	20	10
2	50.0%	112.9	4.7	7.5	9.8	11.9	18.8	24.7	29.9	39.1	47.4	62.1	81.4	129.2
3	33.3%	130.1	5.4	8.6	11.3	13.7	21.7	28.4	34.4	45.1	54.6	71.6	93.8	148.9
5	20.0%	152.1	6.3	10.1	13.2	16.0	25.4	33.2	40.2	52.7	63.9	83.7	109.7	174.1
10	10.0%	184.3	7.7	12.2	16.0	19.4	30.7	40.3	48.8	63.9	77.4	101.4	132.9	211.0
20	5.0%	220.4	9.2	14.6	19.1	23.1	36.7	48.1	58.3	76.4	92.6	121.3	158.9	252.3
25	4.0%	233.0	9.7	15.4	20.2	24.5	38.8	50.9	61.6	80.8	97.9	128.2	168.0	266.7
30	3.33%	243.7	10.2	16.1	21.1	25.6	40.6	53.2	64.5	84.5	102.3	134.1	175.7	279.0
50	2.0%	275.5	11.5	18.2	23.9	28.9	45.9	60.2	72.9	95.5	115.7	151.6	198.7	315.4
80	1.25%	307.3	12.8	20.3	26.6	32.3	51.2	67.1	81.3	106.5	129.1	169.1	221.6	351.8
100	1.0%	323.4	13.5	21.4	28.0	34.0	53.9	70.6	85.6	112.1	135.8	178.0	233.2	370.2
150	0.667%	354.1	14.8	23.4	30.7	37.2	59.0	77.3	93.7	122.8	148.7	194.9	255.4	405.3
200	0.5%	377.1	15.7	24.9	32.7	39.6	62.9	82.4	99.8	130.7	158.4	207.5	271.9	431.7
300	0.33%	411.4	17.1	27.2	35.7	43.2	68.6	89.8	108.8	142.6	172.8	226.4	296.7	470.9
400	0.25%	436.9	18.2	28.9	37.9	45.9	72.8	95.4	115.6	151.5	183.5	240.4	315.1	500.1
500	0.2%	457.5	19.1	30.3	39.7	48.0	76.3	99.9	121.0	158.6	192.1	251.8	329.9	523.7
		Calculation formula of Probable rainfall = Generalized extreme value distribution												

Source: JICA Study Team based on the data from DMH (See Section 2.4)

Because the calculated high water level of Bago River by the hydrological study in Section 2.4 considers the tidal effect which has dominant value, the design high water level for drainage design shall exclude the tidal effect and consider the case of mean tidal level with flood effect in three year return period rainfall.

Table 3.8.3 shows the calculation result of design high water level for drainage design.

Table 3.8.3 Determined Design High Water Level for Drainage Design

No.	Category of Water Level	Water Level (m)*	Assumed Influencing Factors
I.	Probable High Water Level at Monkey Point in case of 3-year Return Period (Flooding Effect is included)	4.22	a) Highest Water Level during Spring Tide & b) Highest Increase due to Flooding Effect
II.	Highest Water Level in Ordinary Spring Tide with No Flooding Effect (Recorded on 2005/2/11 AM 6:00 at Bago River)	3.18	a) Highest Water Level during Spring Tide
III.	**Determined Design High Water Level** for Drainage Design (III = I - II)	1.04	b) Highest Increase due to Flooding Effect It means that **This water level is the Highest Water Level during Mean Sea Level**

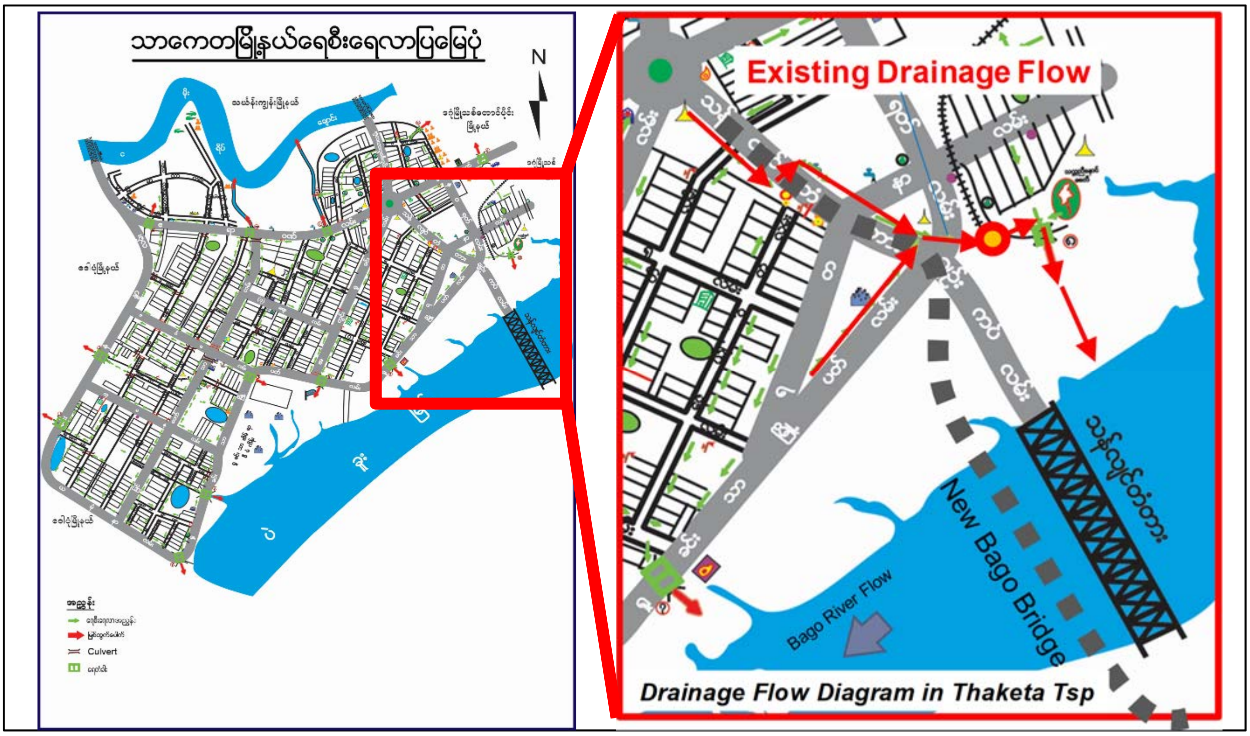
Source: JICA Study Team (Prepared with reference to above Section 2.4 (River and Hydrological Survey))

*Note: * Water Level based on Mean Sea Level*

3.8.4 Drainage System and Outlets

The JICA Study Team surveyed the existing drainage system by collecting related documents, conducting site inspection and topographic survey, and through interviews with engineers from YCDC and Thanlyin Township (YRDC). The existing drainage system in the right river bank is shown in Figure 3.8.3, as collected from YCDC. On the other hand, there is no data related to the existing drainage system in the left river bank authorized by Thanlyin Township, so the JICA Study Team determined the drainage flow. i.e., from and to where the drainage should discharge, based on joint site inspection with the engineers from

Thanlyin Township (YRDC).



Source: YCDC

Figure 3.8.3 Existing Drainage System In Right River Bank Prepared by YCDC

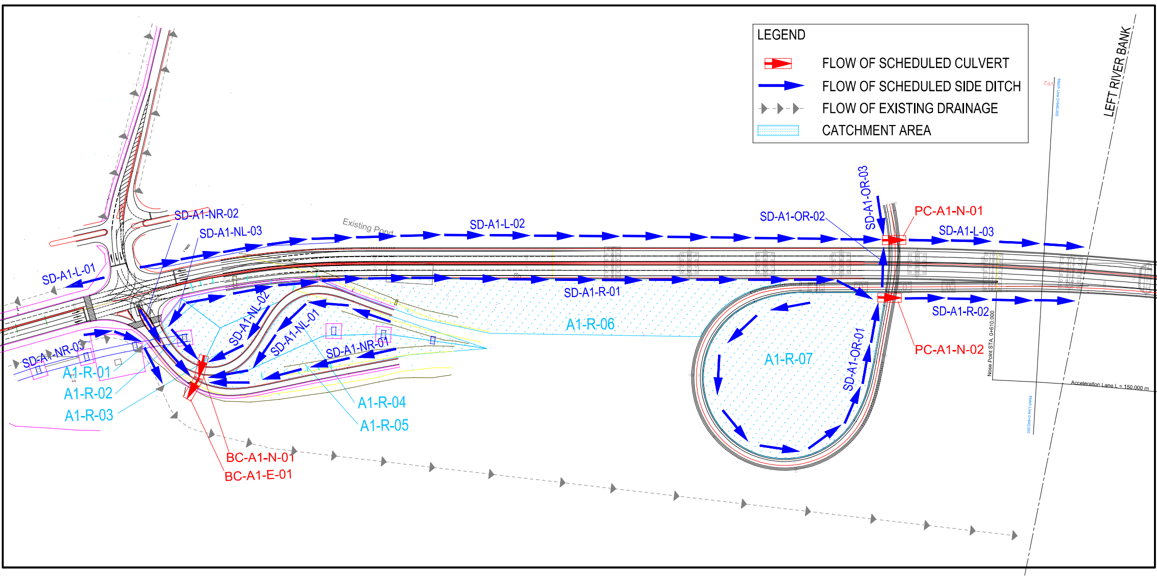
Based on these survey and considerations, drainage system are simulated in the left and right river bank.

The drainage outlet in the right river bank is partly replaced to the new outlets because of insufficient capacity of the existing drainage outlet.

3.8.5 Catchment Area and Runoff (Discharge) Estimation

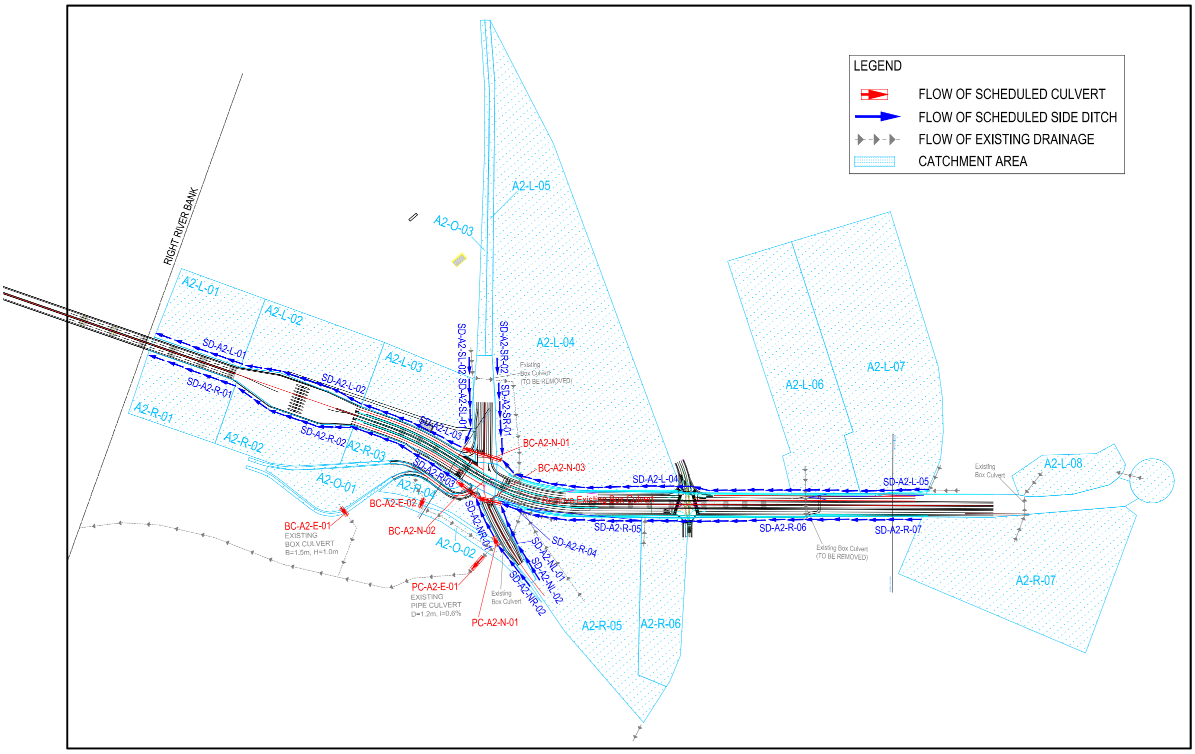
3.8.5.1 Catchment Area

The JICA Study Team estimated the catchment area for roadside drainage and culvert design using the existing drainage system obtained from YCDC with supplemental survey and data of topographic survey and joint site inspection with YCDC and Thanlyin Township. The estimated areas are shown in Figure 3.8.4, Figure 3.8.5, and Table 3.8.4.



Source: JICA Study Team

Figure 3.8.4 Catchment Area in Left River Bank (Package 1)



Source: JICA Study Team

Figure 3.8.5 Catchment Area in Right River Bank (Package 2 and 3)

Table 3.8.4 Catchment Area (Surrounding Area)

Left River Bank Side			Right River Bank Side		
No.	ID	Area (m^2)	No.	ID	Area (m^2)
1.	A1-R-01	1,254	1.	A2-L-01	8,384
2.	A1-R-02	956	2.	A2-L-02	10,722
3.	A1-R-03	827	3.	A2-L-03	9,613
4.	A1-R-04	2,558	4.	A2-L-04	116,343
5.	A1-R-05	2,508	5.	A2-L-05	5,079
6.	A1-R-06	8,267	6.	A2-L-06	42,161
7.	A1-R-07	10,269	7.	A2-L-07	67,980
			8.	A2-L-08	13,765
			9.	A2-R-01	15,479
			10.	A2-R-02	16,394
			11.	A2-R-03	6,507
			12.	A2-R-04	6,155
			13	A2-R-05	43,133
			14.	A2-R-06	17,946
			15.	A2-R-07	54,762
			16.	A2-O-01	9,179
			17.	A2-O-02	3,853
			18.	A2-O-03	4,865

Source: JICA Study Team
Note: A1: Left River Bank Side, A2: Right River Bank Side
L: Left Side of Main Road, R: Right Side of Main Road, O: On-ramp Section

Table 3.8.5 Catchment Area (Road Surface in Left River Bank Side)

ID of Road Surface Catchment	Runoff from Road Surface					
	Road ID	Road Width	Sta.		Length	Area
			From	To		
		m	-	-	m	km2
SD-A1-L-01	Main Road	9.000	0+000	0+040	40	0.00036
SD-A1-L-02	Main Road	13.750	0+040	0+557	517	0.00711
SD-A1-L-03	Main Road	11.350	0+557	0+668	111	0.00126
SD-A1-R-01	Main Road	14.350	0+040	0+557	517	0.00742
SD-A1-R-02	-	-	-	-	-	0.00197
	Main Road	10.350	0+557	0+668	111	0.00115
	On-ramp	7.450	0+470	0+580	110	0.00082
SD-A1-NL-01	Main Road	6.900	0+110	0+200	90	0.00062
SD-A1-NL-02	Main Road	6.900	0+065	0+110	45	0.00031
SD-A1-NL-03	Main Road	6.900	0+010	0+065	55	0.00038
SD-A1-NR-01	Main Road	6.900	0+065	0+211	146	0.00101
SD-A1-NR-02	Main Road	6.900	0+005	0+065	60	0.00041
SD-A1-NR-03	-	-	-	-	-	0.00148
	Main Road	11.250	-0+080	0+020	100	0.00113
	Yangon Access Line	6.900	0+000	0+050	50	0.00035
SD-A1-OR-01	On-ramp	9.872	0+060	0+470	410	0.00405
SD-A1-OR-02	On-ramp	8.250	0+030	0+060	30	0.00025
SD-A1-OR-03	On-ramp	8.250	0+000	0+030	30	0.00025

Source: JICA Study Team
Note: A1: Left River Bank Side, A2: Right River Bank Side
L: Left Side of Main Road, R: Right Side of Main Road, OR: On-ramp Section
NL: Left Side of Yangon and Thanlyin Access Line, NR: Right Side of Yangon and Thanlyin Access Line

Table 3.8.6 Catchment Area (Road Surface in Right River Bank Side)

ID of Road Surface Catchment	Runoff from Road Surface					
	Road ID	Road Width	Sta.		Length	Area
			From	To		
		m	-	-	m	km2
SD-A2-L-01	Main Road	10.350	2+250	2+400	150	0.00155
SD-A2-L-02	Main Road	21.900	2+400	2+600	200	0.00438
SD-A2-L-03	Main Road	13.462	2+600	2+860	260	0.00350
SD-A2-L-04	Main Road	13.708	2+860	3+340	480	0.00658
SD-A2-L-05	-	-	-	-	-	0.01027
	Main Road	20.477	3+340	3+540	200	0.00410
	Thanlyin Chin Kat Road	18.700	-	-	330	0.00617
SD-A2-R-01	Main Road	10.350	2+250	2+400	150	0.00155
SD-A2-R-02	Main Road	43.100	2+400	2+600	200	0.00862
SD-A2-R-03	-	-	-	-	-	0.00649
	Main Road	22.288	2+600	2+860	260	0.00579
	Thanlyin Access Line	8.000	0+000	0+087	87	0.00070
SD-A2-R-04	Main Road	30.000	2+860	2+900	40	0.00120
SD-A2-R-05	Main Road	28.639	2+900	3+080	180	0.00516
SD-A2-R-06	Main Road	24.423	3+080	3+340	260	0.00635
SD-A2-R-07	Main Road	19.188	3+340	3+520	180	0.00345
SD-A2-NL-01	Shukhinthar Road (North)	9.300	0+220	0+300	80	0.00074
SD-A2-NL-02	Shukhinthar Road (North)	9.300	0+300	0+382	82	0.00076
SD-A2-NR-01	Shukhinthar Road (North)	9.300	0+220	0+300	80	0.00074
SD-A2-NR-02	Shukhinthar Road (North)	9.300	0+300	0+382	82	0.00076
SD-A2-SL-01	Shukhinthar Road (South)	17.800	0+040	0+170	130	0.00231
SD-A2-SL-02	Shukhinthar Road (South)	17.800	0+000	0+040	40	0.00071
SD-A2-SR-01	Shukhinthar Road (South)	17.800	0+040	0+170	130	0.00231
SD-A2-SR-02	Shukhinthar Road (South)	17.800	0+000	0+040	40	0.00071

Source: JICA Study Team

Note: See Table 3.8.5

3.8.5.2 Runoff (Discharge Volume)

The runoff was estimated based on the following Rational Method:

Q=1/3.6 * C x I x A or Q=1/ (3.6*10^6) * C * I * a

Where,

Q: Runoff (m^3/sec)

C: Rational coefficient

I: Design rainfall intensity (mm/h)

A: Catchment area (km^2)

a: Catchment area (m^2)

3.8.5.3 Runoff Time

Runoff Time (t) = Flow-in time (t1) + Flow-down time (t2)

(If t < 10 minutes, use 10 minutes)

i) Flow-in time

- In case the length of inflow is equal or less than 370 m, the W.S. Kerby Method is applied as follows:

$$t_1 = 1.445 \left(\frac{N \cdot L}{\sqrt{S}} \right)^{0.467} \qquad L \leqq 370\text{m}$$

- In case the length of inflow is more than 370 m, the Kinematic Wave Method is applied as follows:

$$t_1 = 6.92 \left(\frac{n \cdot L}{\sqrt{S}} \right)^{0.6} i^{-0.4}$$

Where,

L: Length of inflow,

S: Slope

N: Roughness coefficient of W.S. Kerby

0.013:	For Asphalt & Concrete Surface	0.20:	Poor Grass, Cultivated Land
0.02:	Smooth Impervious Surfaces	0.40:	Dance Grass
0.10:	Compacted Soil Surface	0.60-0.80:	Forest
0.013:	For Asphalt & Concrete Surface	0.20:	Poor Grass, Cultivated Land

n: Manning's roughness coefficient

(n=0.013 for precast concrete products, 0.015 for cast in-place concrete)

ii) Flow-down Time (t_2)

$t_2 = L / V$

Where,

L: Length of inflow in drainage facility

V: Average velocity (m/s)

3.8.5.4 Runoff Coefficient (C)

The runoff coefficients used in the above formula are as follows:

Table 3.8.7 Runoff Coefficients (C) by Land Use

Land Use		Runoff Coefficient*	Applied for Design**
Road Surface	Paved area	0.70 – 0.95	0.90
Residential Area	Residential area with many gardens and vacant lots	0.30 – 0.50	0.50

*Source: *Land Use and Runoff Coefficients from Earthworks Manual, Japan Road Association, 2009*
*** Applied coefficient by the JICA Study Team for the design.*

3.8.5.5 Result of Estimated Runoff (Discharge) for Open Ditches and Culverts

The catchment area and estimated runoff (discharge volume) of each side ditch and culvert are shown in the following tables.

Table 3.8.8 Result of Estimated Runoff for Left River Bank Side (Package 1) (1/2)

Location of Drainage Structure	Estimated Runoff							
	Catchment ID	Area	Runoff Time		Coefficient	Rainfall Intensity	Estimated Runoff	
			Applied Formula	t	C	I	Qr	
				t=t1+t2			Each	Total
		km²		min		mm/h	m³/sec	m³/sec
SD-A1-L-01	SD-A1-L-01	0.00036	-	10.0	0.9	149	0.013	0.013
SD-A1-L-02	SD-A1-L-02	0.00711	-	10.0	0.9	149	0.265	0.265
SD-A1-L-03	SD-A1-L-02	0.00711	-	10.0	0.9	149	0.265	0.330
	SD-A1-L-03	0.00126	-	10.0	0.9	149	0.047	
	SD-A1-OR-02	0.00025	-	10.0	0.9	149	0.009	
	SD-A1-OR-03	0.00025	-	10.0	0.9	149	0.009	
SD-A1-R-01	SD-A1-R-01	0.00742	-	10.0	0.9	149	0.276	0.387
	A2-R-06	0.00800	Kerby	18.3	0.5	100	0.111	
SD-A1-R-02	SD-A1-R-01	0.00742	-	10.0	0.9	149	0.276	0.808
	SD-A1-R-02	0.00197	-	10.0	0.9	149	0.073	
	SD-A1-OR-01	0.00405	-	10.0	0.9	149	0.151	
	A2-R-06	0.00800	Kerby	18.3	0.5	100	0.111	
	A2-R-07	0.01000	Kerby	10.7	0.5	142	0.197	
SD-A1-NL-01	SD-A1-NL-01	0.00062	-	10.0	0.9	149	0.023	0.085
	A2-R-04	0.00300	Kerby	10.0	0.5	149	0.062	
SD-A1-NL-02	SD-A1-NL-02	0.00031	-	10.0	0.9	149	0.012	0.033
	A2-R-03	0.00100	Kerby	10.0	0.5	149	0.021	
SD-A1-NL-03	SD-A1-NL-03	0.00038	-	10.0	0.9	149	0.014	0.032
	A2-R-02	0.00100	Kerby	11.8	0.5	133	0.018	
SD-A1-NR-01	SD-A1-NL-01	0.00062	-	10.0	0.9	149	0.023	0.185
	SD-A1-NR-01	0.00101	-	10.0	0.9	149	0.038	
	A2-R-04	0.00300	Kerby	10.0	0.5	149	0.062	
	A2-R-05	0.00300	Kerby	10.0	0.5	149	0.062	
SD-A1-NR-02	SD-A1-NR-02	0.00041	-	10.0	0.9	149	0.015	0.015
SD-A1-NR-03	SD-A1-NR-03	0.00148	-	10.0	0.9	149	0.055	0.055
SD-A1-OR-01	SD-A1-OR-01	0.00405	-	10.0	0.9	149	0.151	0.348
	A2-R-07	0.01000	Kerby	10.7	0.5	142	0.197	
SD-A1-OR-02	SD-A1-OR-02	0.00025	-	10.0	0.9	149	0.009	0.009
SD-A1-OR-03	SD-A1-OR-03	0.00025	-	10.0	0.9	149	0.009	0.009

Source: JICA Study Team

Note: SD=Side Ditch, PC=Pipe Culvert, BC=Box Culvert
A1= Left River Bank Side, A2=Right River Bank Side
L=Left Side of Main Road, R=Right Side of Main Road, OR=On-ramp Section
NL=Left Side of Yangon and Thanlyin Access Line (P1) / of Thanlyin Chin Kat Road (P2&3)
NR=Right Side of Yangon and Thanlyin Access Line (P1) / of Thanlyin Chin Kat Road (P2&3)
N= New Culvert, E=Existing Culvert

Table 3.8.9 Result of Estimated Runoff for Left River Bank Side (Package 1) (2/2)

Location of Drainage Structure	Estimated Runoff							
	Catchment ID	Area	Runoff Time		Coefficient	Rainfall Intensity	Estimated Runoff	
			Applied Formula	t	C	I	Qr	
				t=t1+t2			Each	Total
		km^2		min		mm/h	m^3/sec	m^3/sec
PC-A1-N-01	SD-A1-L-02	0.00711	-	10.0	0.9	149	0.265	0.283
	SD-A1-OR-02	0.00025	-	10.0	0.9	149	0.009	
	SD-A1-OR-03	0.00025	-	10.0	0.9	149	0.009	
PC-A1-N-02	SD-A1-R-01	0.00742	-	10.0	0.9	149	0.276	0.735
	SD-A1-OR-01	0.00405	-	10.0	0.9	149	0.151	
	A2-R-06	0.00800	Kerby	18.3	0.5	100	0.111	
	A2-R-07	0.01000	Kerby	10.7	0.5	142	0.197	
BC-A1-N-01	SD-A1-NL-02	0.00031	-	10.0	0.9	149	0.012	0.065
	SD-A1-NL-03	0.00038	-	10.0	0.9	149	0.014	
	A2-R-02	0.00100	Kerby	11.8	0.5	133	0.018	
	A2-R-03	0.00100	Kerby	10.0	0.5	149	0.021	
BC-A1-E-01	SD-A1-NL-01	0.00062	-	10.0	0.9	149	0.023	0.265
	SD-A1-NL-02	0.00031	-	10.0	0.9	149	0.012	
	SD-A1-NL-03	0.00038	-	10.0	0.9	149	0.014	
	SD-A1-NR-01	0.00101	-	10.0	0.9	149	0.038	
	SD-A1-NR-02	0.00041	-	10.0	0.9	149	0.015	
	A2-R-02	0.00100	Kerby	11.8	0.5	133	0.018	
	A2-R-03	0.00100	Kerby	10.0	0.5	149	0.021	
	A2-R-04	0.00300	Kerby	10.0	0.5	149	0.062	
	A2-R-05	0.00300	Kerby	10.0	0.5	149	0.062	

Source: JICA Study Team

Note: See Table 3.8.8.

Table 3.8.10 Result of Estimated Runoff for Right River Bank Side (Package 2&3) (1/3)

SD-A2-L-01	Side Ditch A2-side Left No.1	SD-A2-L-01	0.00155	-	10.0	0.9	149	0.058	3.133
		SD-A2-L-02	0.00438	-	10.0	0.9	149	0.163	
		SD-A2-L-03	0.00350	-	10.0	0.9	149	0.130	
		SD-A2-L-04	0.00658	-	10.0	0.9	149	0.245	
		SD-A2-L-05	0.01027	-	10.0	0.9	149	0.383	
		SD-A2-SL-01	0.00231	-	10.0	0.9	149	0.086	
		SD-A2-SL-02	0.00071	-	10.0	0.9	149	0.026	
		SD-A2-SR-01	0.00231	-	10.0	0.9	149	0.086	
		SD-A2-SR-02	0.00071	-	10.0	0.9	149	0.026	
		A2-L-01	0.00800	Kerby	30.1	0.5	71	0.079	
		A2-L-02	0.01100	Kerby	31.7	0.5	69	0.105	
		A2-L-03	0.01000	Kerby	23.0	0.5	85	0.118	
		A2-L-04	0.11600	Kinematic wave	193.8	0.5	21	0.338	
		A2-L-05	0.00500	-	10.0	0.9	149	0.186	
		A2-L-06	0.04200	Kinematic wave	96.1	0.5	33	0.193	
		A2-L-07	0.06800	Kinematic wave	109.9	0.5	30	0.283	
		A2-L-08	0.01400	Kerby	24.3	0.5	82	0.159	
		A2-R-07	0.05500	Kinematic wave	82.3	0.5	37	0.283	
		A2-O-03	0.00500	-	10.0	0.9	149	0.186	
SD-A2-L-02	Side Ditch A2-side Left No.2	SD-A2-L-02	0.00438	-	10.0	0.9	149	0.163	2.996
		SD-A2-L-03	0.00350	-	10.0	0.9	149	0.130	
		SD-A2-L-04	0.00658	-	10.0	0.9	149	0.245	
		SD-A2-L-05	0.01027	-	10.0	0.9	149	0.383	
		SD-A2-SL-01	0.00231	-	10.0	0.9	149	0.086	
		SD-A2-SL-02	0.00071	-	10.0	0.9	149	0.026	
		SD-A2-SR-01	0.00231	-	10.0	0.9	149	0.086	
		SD-A2-SR-02	0.00071	-	10.0	0.9	149	0.026	
		A2-L-02	0.01100	Kerby	31.7	0.5	69	0.105	
		A2-L-03	0.01000	Kerby	23.0	0.5	85	0.118	
		A2-L-04	0.11600	Kinematic wave	193.8	0.5	21	0.338	
		A2-L-05	0.00500	-	10.0	0.9	149	0.186	
		A2-L-06	0.04200	Kinematic wave	96.1	0.5	33	0.193	
		A2-L-07	0.06800	Kinematic wave	109.9	0.5	30	0.283	
		A2-L-08	0.01400	Kerby	24.3	0.5	82	0.159	
		A2-R-07	0.05500	Kinematic wave	82.3	0.5	37	0.283	
		A2-O-03	0.00500	-	10.0	0.9	149	0.186	

Source: JICA Study Team, Note: See Table 3.8.8.

Table 3.8.11 Result of Estimated Runoff for Right River Bank Side (Package 2&3) (2/3)

SD-A2-L-03	Side Ditch A2-side Left No.3	SD-A2-L-03	0.00350	-	10.0	0.9	149	0.130	2.728
		SD-A2-L-04	0.00658	-	10.0	0.9	149	0.245	
		SD-A2-L-05	0.01027	-	10.0	0.9	149	0.383	
		SD-A2-SL-01	0.00231	-	10.0	0.9	149	0.086	
		SD-A2-SL-02	0.00071	-	10.0	0.9	149	0.026	
		SD-A2-SR-01	0.00231	-	10.0	0.9	149	0.086	
		SD-A2-SR-02	0.00071	-	10.0	0.9	149	0.026	
		A2-L-03	0.01000	Kerby	23.0	0.5	85	0.118	
		A2-L-04	0.11600	Kinematic wave	193.8	0.5	21	0.338	
		A2-L-05	0.00500	-	10.0	0.9	149	0.186	
		A2-L-06	0.04200	Kinematic wave	96.1	0.5	33	0.193	
		A2-L-07	0.06800	Kinematic wave	109.9	0.5	30	0.283	
		A2-L-08	0.01400	Kerby	24.3	0.5	82	0.159	
		A2-R-07	0.05500	Kinematic wave	82.3	0.5	37	0.283	
		A2-O-03	0.00500	-	10.0	0.9	149	0.186	
SD-A2-L-04	Side Ditch A2-side Left No.4	SD-A2-L-04	0.00658	-	10.0	0.9	149	0.245	1.546
		SD-A2-L-05	0.01027	-	10.0	0.9	149	0.383	
		A2-L-06	0.04200	Kinematic wave	96.1	0.5	33	0.193	
		A2-L-07	0.06800	Kinematic wave	109.9	0.5	30	0.283	
		A2-L-08	0.01400	Kerby	24.3	0.5	82	0.159	
		A2-R-07	0.05500	Kinematic wave	82.3	0.5	37	0.283	
SD-A2-L-05	Side Ditch A2-side Left No.5	SD-A2-L-05	0.01027	-	10.0	0.9	149	0.383	1.108
		A2-L-07	0.06800	Kinematic wave	109.9	0.5	30	0.283	
		A2-L-08	0.01400	Kerby	24.3	0.5	82	0.159	
		A2-R-07	0.05500	Kinematic wave	82.3	0.5	37	0.283	
SD-A2-R-01	Side Ditch A2-side Right No.1	SD-A2-R-01	0.00155	-	10.0	0.9	149	0.058	2.244
		SD-A2-R-02	0.00862	-	10.0	0.9	149	0.321	
		SD-A2-R-03	0.00649	-	10.0	0.9	149	0.242	
		SD-A2-R-04	0.00120	-	10.0	0.9	149	0.045	
		SD-A2-R-05	0.00516	-	10.0	0.9	149	0.192	
		SD-A2-R-06	0.00635	-	10.0	0.9	149	0.237	
		SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	
		SD-A2-NL-01	0.00074	-	10.0	0.9	149	0.028	
		SD-A2-NL-02	0.00076	-	10.0	0.9	149	0.028	
		SD-A2-NR-01	0.00074	-	10.0	0.9	149	0.028	
		SD-A2-NR-02	0.00076	-	10.0	0.9	149	0.028	
		A2-R-01	0.01500	Kerby	26.4	0.5	78	0.163	
		A2-R-02	0.01600	Kerby	30.6	0.5	71	0.158	
		A2-R-03	0.00700	Kerby	24.0	0.5	83	0.081	
		A2-R-05	0.04300	Kerby	41.3	0.5	58	0.346	
		A2-R-06	0.01800	Kerby	35.8	0.5	64	0.160	
SD-A2-R-02	Side Ditch A2-side Right No.2	SD-A2-R-02	0.00862	-	10.0	0.9	149	0.321	2.023
		SD-A2-R-03	0.00649	-	10.0	0.9	149	0.242	
		SD-A2-R-04	0.00120	-	10.0	0.9	149	0.045	
		SD-A2-R-05	0.00516	-	10.0	0.9	149	0.192	
		SD-A2-R-06	0.00635	-	10.0	0.9	149	0.237	
		SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	
		SD-A2-NL-01	0.00074	-	10.0	0.9	149	0.028	
		SD-A2-NL-02	0.00076	-	10.0	0.9	149	0.028	
		SD-A2-NR-01	0.00074	-	10.0	0.9	149	0.028	
		SD-A2-NR-02	0.00076	-	10.0	0.9	149	0.028	
		A2-R-02	0.01600	Kerby	30.6	0.5	71	0.158	
		A2-R-03	0.00700	Kerby	24.0	0.5	83	0.081	
		A2-R-05	0.04300	Kerby	41.3	0.5	58	0.346	
		A2-R-06	0.01800	Kerby	35.8	0.5	64	0.160	
SD-A2-R-03	Side Ditch A2-side Right No.3	SD-A2-R-03	0.00649	-	10.0	0.9	149	0.242	1.544
		SD-A2-R-04	0.00120	-	10.0	0.9	149	0.045	
		SD-A2-R-05	0.00516	-	10.0	0.9	149	0.192	
		SD-A2-R-06	0.00635	-	10.0	0.9	149	0.237	
		SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	
		SD-A2-NL-01	0.00074	-	10.0	0.9	149	0.028	
		SD-A2-NL-02	0.00076	-	10.0	0.9	149	0.028	
		SD-A2-NR-01	0.00074	-	10.0	0.9	149	0.028	
		SD-A2-NR-02	0.00076	-	10.0	0.9	149	0.028	
		A2-R-03	0.00700	Kerby	24.0	0.5	83	0.081	
		A2-R-05	0.04300	Kerby	41.3	0.5	58	0.346	
		A2-R-06	0.01800	Kerby	35.8	0.5	64	0.160	

Source: JICA Study Team, Note: See Table 3.8.8.

Table 3.8.12 Result of Estimated Runoff for Right River Bank Side (Package 2&3) (3/3)

SD-A2-R-04	SD-A2-R-04	0.00120	-	10.0	0.9	149	0.045	1.109
	SD-A2-R-05	0.00516	-	10.0	0.9	149	0.192	
	SD-A2-R-06	0.00635	-	10.0	0.9	149	0.237	
	SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	
	A2-R-05	0.04300	Kerby	41.3	0.5	58	0.346	
	A2-R-06	0.01800	Kerby	35.8	0.5	64	0.160	
SD-A2-R-05	SD-A2-R-05	0.00516	-	10.0	0.9	149	0.192	0.718
	SD-A2-R-06	0.00635	-	10.0	0.9	149	0.237	
	SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	
	A2-R-06	0.01800	Kerby	35.8	0.5	64	0.160	
SD-A2-R-06	SD-A2-R-06	0.00635	-	10.0	0.9	149	0.237	0.366
	SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	
SD-A2-R-07	SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	0.129
SD-A2-NL-01	SD-A2-NL-01	0.00074	-	10.0	0.9	149	0.028	0.056
	SD-A2-NL-02	0.00076	-	10.0	0.9	149	0.028	
SD-A2-NL-02	SD-A2-NL-02	0.00076	-	10.0	0.9	149	0.028	0.028
SD-A2-NR-01	SD-A2-NR-01	0.00074	-	10.0	0.9	149	0.028	0.056
	SD-A2-NR-02	0.00076	-	10.0	0.9	149	0.028	
SD-A2-NR-02	SD-A2-NR-02	0.00076	-	10.0	0.9	149	0.028	0.028
SD-A2-SL-01	SD-A2-SL-01	0.00231	-	10.0	0.9	149	0.086	0.149
	SD-A2-SL-02	0.00071	-	10.0	0.9	149	0.026	
	A2-O-03	0.00100	-	10.0	0.9	149	0.037	
SD-A2-SL-02	SD-A2-SL-02	0.00071	-	10.0	0.9	149	0.026	0.063
	A2-O-03	0.00100	-	10.0	0.9	149	0.037	
SD-A2-SR-01	SD-A2-SR-01	0.00231	-	10.0	0.9	149	0.086	0.112
	SD-A2-SR-02	0.00071	-	10.0	0.9	149	0.026	
SD-A2-SR-02	SD-A2-SR-02	0.00071	-	10.0	0.9	149	0.026	0.026
PC-A2-N-01	SD-A2-NR-01	0.00074	-	10.0	0.9	149	0.028	0.056
	SD-A2-NR-02	0.00076	-	10.0	0.9	149	0.028	
BC-A2-N-01	SD-A2-L-04	0.00658	-	10.0	0.9	149	0.245	2.182
	SD-A2-L-05	0.01027	-	10.0	0.9	149	0.383	
	SD-A2-SR-01	0.00231	-	10.0	0.9	149	0.086	
	SD-A2-SR-02	0.00071	-	10.0	0.9	149	0.026	
	A2-L-04	0.11600	Kinematic wave	193.8	0.5	21	0.338	
	A2-L-05	0.00500	-	10.0	0.9	149	0.186	
	A2-L-06	0.04200	Kinematic wave	96.1	0.5	33	0.193	
	A2-L-07	0.06800	Kinematic wave	109.9	0.5	30	0.283	
	A2-L-08	0.01400	Kerby	24.3	0.5	82	0.159	
	A2-R-07	0.05500	Kinematic wave	82.3	0.5	37	0.283	
BC-A2-N-02	SD-A2-R-04	0.00120	-	10.0	0.9	149	0.045	1.221
	SD-A2-R-05	0.00516	-	10.0	0.9	149	0.192	
	SD-A2-R-06	0.00635	-	10.0	0.9	149	0.237	
	SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	
	SD-A2-NL-01	0.00074	-	10.0	0.9	149	0.028	
	SD-A2-NL-02	0.00076	-	10.0	0.9	149	0.028	
	SD-A2-NR-01	0.00074	-	10.0	0.9	149	0.028	
	SD-A2-NR-02	0.00076	-	10.0	0.9	149	0.028	
	A2-R-05	0.04300	Kerby	41.3	0.5	58	0.346	
	A2-R-06	0.01800	Kerby	35.8	0.5	64	0.160	
BC-A2-N-03	SD-A2-R-04	0.00120	-	10.0	0.9	149	0.045	1.165
	SD-A2-R-05	0.00516	-	10.0	0.9	149	0.192	
	SD-A2-R-06	0.00635	-	10.0	0.9	149	0.237	
	SD-A2-R-07	0.00345	-	10.0	0.9	149	0.129	
	SD-A2-NL-01	0.00074	-	10.0	0.9	149	0.028	
	SD-A2-NL-02	0.00076	-	10.0	0.9	149	0.028	
	A2-R-05	0.04300	Kerby	41.3	0.5	58	0.346	
	A2-R-06	0.01800	Kerby	35.8	0.5	64	0.160	
PC-A2-E-01	A2-R-04	0.00600	Kerby	17.6	0.5	102	0.085	0.123
	A2-O-02	0.00400	Kerby	31.9	0.5	69	0.038	
BC-A2-E-01	A2-O-01	0.00900	Kerby	21.8	0.5	89	0.111	0.111
BC-A2-E-02	A2-R-04	0.00600	Kerby	17.6	0.5	102	0.085	0.085

Source: JICA Study Team, Note: See Table 3.8.8.

3.8.6 Type of Drainage Structures and Drainage Capacity Design

3.8.6.1 Type of Drainage Structures

The types of the drainage structures to be used for the Project are listed in Table 3.8.13.

Table 3.8.13 Types of Drainage Structures

Type	Drainage Structure	Purpose
Open Ditches	Side Ditch Type U Inside Width (mm): 300, 500, 800, 1000, 1500 Height (mm): 500~2500 (Vary)	Collection of rainfall water from gutter, sidewalk, vertical drain, culvert crossing roadway and U-ditch crossing sidewalk.
	U-Ditch Crossing Sidewalk Inside Width (mm): 300 Height (mm): 150~300	Collection of rainfall water from pavement surface and crossing sidewalk
	PVC Pipe Crossing Sidewalk Inside Dia. (mm): 150 mm	Ditto
Concrete Pipe Culverts	Reinforced Spun and Centrifugal RC Pipes (Class I, Precast) Inside Dia. (mm): 300, 900 Protection with 360 Degree Concrete for joint protection	Crossing the roadway and Discharge rainfall water from paved surface along roadway
Concrete Box Culverts	Box Culvert Type Inside Width & Height (mm): 1000x1000, 1500x1000, 1500x1500	Crossing roadway
Catch Basin, Inlet, Outlet, Manholes	Catch Pit (Rectangular Type) with Concrete or Steel Grating Cover Minimum Pitch: 5 m* Maximum Pitch: 30 m*	Connection between Open Ditches, Concrete Pipe, Box Culverts, Vertical Drains
Vertical Drain	PVC Pipe Type Inside Dia. (mm): 200 mm Minimum Pitch: 10 m	Guiding the water from the roadway gutter inlet to the roadside main drainage
	U-Ditch Type Inside Width (mm): 300 Height (mm): 300~1000	Ditto
Drainage Outlet	Flap Gate with Box Culvert Type Flap Gate Width and Height (mm): 1000x1000, 2000x1500 Box Culvert: Inside Width and Height (mm) are the same as for Flap Gate	Preventing reverse water flow from river side to upsteam of drainage system; The flap gate shall be provided at the end of each drainage outlet.

Source: JICA Study Team

*Note: * In accordance with Earthworks Manual, Japan Road Association, 2009*

3.8.6.2 Drainage Capacity and Design Methods

The capacity of drainage facilities, road side ditch, RC pipe culvert, box culvert, and gutter is computed applying the following formula:

Drainage Capacity: $Q = A * V$

A: Water flow area (m^2), V: Average velocity (m/sec)

Manning's Equation: V = 1/n * R2/3 * I1/2

n: Manning's roughness coefficient

(n=0.013 for precast concrete products, 0.015 for cast-in-place concrete)

R: Hydraulic mean depth: A/P (m)

I: Longitudinal slope

3.8.6.3 Discharge Capacity of Structures

The following tables show the discharge capacity of the drainage structures computed using the above formula. Minimum slope is applied for each location of drainage structure to verify the necessary capacity of each location. In the calculation, the velocity of water flow is preferably controlled between 0.6 and 3.0 m/sec.

Table 3.8.14 Result of Discharge Capacity for Left River Bank Side (Package 1)

Location of Drainage Structure	Estimated Runoff Qr	Applied Drain Type	I (Minimum)	R	A	0.8 x A	n	v	Qc*	Qr<Qc
	(m3/sec)		%	m	m2	m2		m/sec	m3/sec	
SD-A1-L-01	0.013	U800x1000	0.100	0.29	0.80	0.64	0.015	0.915	0.586	OK
SD-A1-L-02	0.265	U800x800	0.170	0.27	0.64	0.51	0.015	1.140	0.584	OK
SD-A1-L-03	0.330	U1000x1000	0.100	0.33	1.00	0.80	0.015	1.013	0.810	OK
	0.330	BC1000x1000	0.100	0.33	1.00	0.80	0.015	1.013	0.810	OK
SD-A1-R-01	0.387	U800x800	0.130	0.27	0.64	0.51	0.015	0.997	0.510	OK
	0.387	PC900	0.400	0.23	0.64	0.51	0.015	1.560	0.794	OK
SD-A1-R-02	0.808	U1000x1000	0.100	0.33	1.00	0.80	0.015	1.013	0.810	OK
	0.808	BC1000x1000	0.100	0.33	1.00	0.80	0.015	1.013	0.810	OK
SD-A1-NL-01	0.085	U500x500	0.100	0.17	0.25	0.20	0.015	0.639	0.128	OK
SD-A1-NL-02	0.033	U500x500	0.100	0.17	0.25	0.20	0.015	0.639	0.128	OK
SD-A1-NL-03	0.032	U500x500	0.100	0.17	0.25	0.20	0.015	0.639	0.128	OK
SD-A1-NR-01	0.185	U500x500	0.300	0.17	0.25	0.20	0.015	1.107	0.221	OK
SD-A1-NR-02	0.015	U500x500	0.100	0.17	0.25	0.20	0.015	0.639	0.128	OK
SD-A1-NR-03	0.055	U500x850	0.100	0.19	0.43	0.34	0.015	0.704	0.239	OK
SD-A1-OR-01	0.348	U800x800	0.100	0.27	0.64	0.51	0.015	0.874	0.448	OK
SD-A1-OR-02	0.009	U800x800	0.100	0.27	0.64	0.51	0.015	0.874	0.448	OK
SD-A1-OR-03	0.009	U800x800	0.100	0.27	0.64	0.51	0.015	0.874	0.448	OK
PC-A1-N-01	0.283	PC900	0.300	0.23	0.64	0.51	0.015	1.351	0.687	OK
PC-A1-N-02	0.735	PC900	0.400	0.23	0.64	0.51	0.015	1.560	0.794	OK
BC-A1-N-01	0.065	BC1000x1000	0.500	0.33	1.00	0.80	0.015	2.265	1.812	OK
BC-A1-E-01	0.265	BC800x800	0.300	0.27	0.64	0.51	0.015	1.514	0.775	OK

* 80% of A (m2) is applied for the calculation formula of Qc (Drainage Capacity)

Source: JICA Study Team

Note: SD=Side Ditch, PC=Pipe Culvert, BC=Box Culvert,

A1= Left River Bank Side, A2=Right River Bank Side,

L=Left Side of Main Road, R=Right Side of Main Road, OR=On-ramp Section,

NL=Left Side of Yangon and Thanlyin Access Line (P1) / of Thanlyin Chin Kat Road (P2&3),

NR=Right Side of Yangon and Thanlyin Access Line (P1) / of Thanlyin Chin Kat Road (P2&3),

N= New Culvert, E=Existing Culvert,

U=Side Ditch Type U (Inner Width (mm) x Height (mm)), PC=Concrete Pipe Culvert (Inner Dia.),

BC=Concrete Box Culvert (Inner Width (mm) x Height (mm))

Table 3.8.15 Result of Discharge Capacity for Right River Bank Side (Package 2&3) (1/2)

Location of Drainage Structure	Estimated Runoff Qr	Applied Drain Type	I (Minimum)	R	A	0.8 x A	n	v	Qc*	Qr<Qc
	(m3/sec)		%	m	m2	m2		m/sec	m3/sec	
SD-A2-L-01	2.984	U1500x2500	0.080	0.58	3.75	3.00	0.015	1.307	3.921	OK
	2.984	BC2000x1500	0.080	0.60	3.00	2.40	0.015	1.341	3.219	OK
SD-A2-L-02	2.847	U1500x2500	0.080	0.58	3.75	3.00	0.015	1.307	3.921	OK
SD-A2-L-03	2.579	U1500x2500	0.080	0.58	3.75	3.00	0.015	1.307	3.921	OK
SD-A2-L-04	1.546	U1500x1500	0.047	0.50	2.25	1.80	0.015	0.910	1.639	OK
	1.546	U1500x1700	0.047	0.52	2.55	2.04	0.015	0.935	1.907	OK
	1.546	BC1500x1000	0.330	0.43	1.50	1.20	0.015	2.178	2.614	OK
	1.546	BC1500x1500	0.047	0.50	2.25	1.80	0.015	0.910	1.639	OK
SD-A2-L-05	1.108	U1500x1500	0.105	0.50	2.25	1.80	0.015	1.361	2.450	OK
	1.108	U1500x1700	0.171	0.52	2.55	2.04	0.015	1.783	3.637	OK
	1.108	BC1500x1000	0.105	0.43	1.50	1.20	0.015	1.229	1.475	OK
SD-A2-R-01	2.244	U1500x2500	0.100	0.58	3.75	3.00	0.015	1.461	4.383	OK
	2.244	BC2000x1500	0.100	0.60	3.00	2.40	0.015	1.500	3.599	OK

* 80% of A (m2) is applied for the calculation formula of Qc (Drainage Capacity)

Source: JICA Study Team, Note: See Table 3.8.14

Table 3.8.16 Result of Discharge Capacity for Right River Bank Side (Package 2&3) (2/2)

Location of Drainage Structure	Estimated Runoff Qr	Applied Drain Type	I (Minimum)	R	A	0.8 x A	n	v	Qc*	Qr<Qc
	(m3/sec)		%	m	m2	m2		m/sec	m3/sec	
SD-A2-R-02	2.023	U1500x2500	0.100	0.58	3.75	3.00	0.015	1.461	4.383	OK
SD-A2-R-03	1.544	U1500x2500	0.050	0.58	3.75	3.00	0.015	1.033	3.100	OK
SD-A2-R-04	1.109	U1500x1500	0.026	0.50	2.25	1.80	0.015	0.677	1.219	OK
	1.109	BC1500x1000	0.082	0.43	1.50	1.20	0.015	1.086	1.303	OK
SD-A2-R-05	0.718	U1500x1500	0.026	0.50	2.25	1.80	0.015	0.677	1.219	OK
	0.718	BC1500x1000	0.029	0.43	1.50	1.20	0.015	0.646	0.775	OK
SD-A2-R-06	0.366	U1500x1500	0.048	0.50	2.25	1.80	0.015	0.920	1.656	OK
	0.366	BC1500x1000	0.048	0.43	1.50	1.20	0.015	0.831	0.997	OK
SD-A2-R-07	0.129	U1000x1500	0.330	0.38	1.50	1.20	0.015	1.992	2.390	OK
	0.129	U1500x1500	0.064	0.50	2.25	1.80	0.015	1.062	1.912	OK
	0.129	BC1000x1000	0.190	0.33	1.00	0.80	0.015	1.396	1.117	OK
SD-A2-NL-01	0.056	U500x500	0.300	0.17	0.25	0.20	0.015	1.107	0.221	OK
SD-A2-NL-02	0.028	U500x500	0.300	0.17	0.25	0.20	0.015	1.107	0.221	OK
SD-A2-NR-01	0.056	U500x500	0.300	0.17	0.25	0.20	0.015	1.107	0.221	OK
SD-A2-NR-02	0.028	U500x500	0.300	0.17	0.25	0.20	0.015	1.107	0.221	OK
SD-A2-SL-01	0.149	U800x800	0.300	0.27	0.64	0.51	0.015	1.514	0.775	OK
SD-A2-SL-02	0.063	U800x800	0.300	0.27	0.64	0.51	0.015	1.514	0.775	OK
SD-A2-SR-01	0.112	U500x850	0.300	0.19	0.43	0.34	0.015	1.219	0.415	OK
SD-A2-SR-02	0.026	U500x850	0.300	0.19	0.43	0.34	0.015	1.219	0.415	OK
PC-A2-N-01	0.056	PC600	0.300	0.15	0.28	0.23	0.015	1.031	0.233	OK
BC-A2-N-01	2.182	BC1500x1500	0.108	0.50	2.25	1.80	0.015	1.380	2.484	OK
BC-A2-N-02	1.221	BC1500x1000	0.082	0.43	1.50	1.20	0.015	1.086	1.303	OK
BC-A2-N-03	1.165	BC1500x1000	0.082	0.43	1.50	1.20	0.015	1.086	1.303	OK
PC-A2-E-01	0.123	PC1200	0.600	0.30	1.13	0.90	0.015	2.314	2.094	OK
BC-A2-E-01	0.111	BC1500x1000	3.000	0.43	1.50	1.20	0.015	6.568	7.882	OK
BC-A2-E-02	0.085	BC1000x1000	3.000	0.33	1.00	0.80	0.015	5.548	4.438	OK

* 80% of A (m2) is applied for the calculation formula of Qc (Drainage Capacity)

Source: JICA Study Team, Note: See Table 3.8.14

3.8.6.4 Schedule of Drainage

Based on the above study, the drainage type, dimension, slope rate, and bottom elevation of each drainage structure are shown in following tables.

Table 3.8.17 Schedule of Drainage (Left Side)

Package	Road	Side	Location (STA.)		Distance (m)	Type	Dimension (Width x Height)	Slope rate (%)	Drainage Bottom Elevation (Elv. m)		Concrete Cover	Remark
			B.P. side	E.P. side					B.P. side	E.P. side		
1	Main	Left	0+000.000	0+016.000	16.00	U	800x1000	0.125%	4.860	4.880	○	
			0+060.000	0+537.000	477.00	U	800x800	-0.170%	4.274	3.463	-	Along Main Road
			0+537.000	0+547.000	10.00	PC	900	-0.300%	2.720	2.690	-	Under On-ramp Rd
			0+547.000	0+640.000	93.00	U	1000x1000	-0.100%	2.690	2.597	-	To Drainage Outlet
2	Main	Left	2+240.000	2+680.992	440.99	U	1500x2500	0.080%	1.502	1.855	○	To Drainage Outlet
			2+680.992	2+775.000	94.01	U	1500x2500	0.120%	1.855	1.968	○	Along Main Road
3	Main	Left	2+775.000	2+840.000	65.00	BC	1500x1500	0.102%	1.968	2.034	-	Under Crossing Rd
			2+840.000	2+850.000	10.00	U	1500x1500	0.110%	2.034	2.045	-	Open
			2+850.000	2+860.000	10.00	BC	1500x1500	0.110%	2.045	2.056	-	Under Entrance
			2+860.000	3+060.000	200.00	U	1500x1500	0.047%	2.056	2.150	-	Open
			3+060.000	3+068.000	8.00	BC	1500x1500	0.047%	2.150	2.154	-	Under Entrance
			3+068.000	3+120.000	52.00	U	1500x1500	0.047%	2.154	2.178	-	Open
			3+120.000	3+278.000	158.00	BC	1500x1500	0.047%	2.178	2.252	-	Under Crossing Rd
			3+278.000	3+289.000	11.00	BC	1500x1000	0.330%	2.252	2.289	-	Under Entrance
			3+289.000	3+300.000	11.00	BC	1500x1500	0.220%	2.289	2.313	-	Under Side-Walk
			3+300.000	3+311.000	11.00	U	1500x1700	0.330%	2.313	2.349	○	Under Side-Walk
			3+311.000	3+330.000	19.00	BC	1500x1000	0.330%	2.349	2.412	-	Under Side-Walk
			3+330.000	3+378.000	48.00	U	1500x1700	0.330%	2.412	2.570	○	Under Side-Walk
			3+378.000	3+388.000	10.00	BC	1500x1000	0.330%	2.570	2.603	-	Under Entrance
			3+388.000	3+409.000	21.00	U	1500x1700	0.330%	2.603	2.673	○	Under Side-Walk
			3+409.000	3+434.000	25.00	BC	1500x1000	0.330%	2.673	2.755	-	Under Entrance
			3+434.000	3+455.000	21.00	U	1500x1700	0.169%	2.755	2.791	○	Under Side-Walk
			3+455.000	3+478.000	23.00	U	1500x1500	0.105%	2.791	2.815	-	Open
			3+478.000	3+483.000	5.00	BC	1500x1000	0.105%	2.815	2.820	-	Under Entrance
			3+483.000	3+540.000	57.00	U	1500x1500	0.105%	2.820	2.880	-	Open

Source: JICA Study Team

Note: U=Side Ditch Type U, PC=Pipe Culvert, BC=Box Culvert

Table 3.8.18 Schedule of Drainage (Right Side)

Package	Road	Side	Location (STA.)		Distance (m)	Type	Dimension (Width x Height)	Slope rate (%)	Drainage Bottom Elevation (Elv. m)		Concrete Cover	Remark
			B.P. side	E.P. side					B.P. side	E.P. side		
1	Main	Right	0+000.000	0+024.970	24.97	U	500x850	-0.577%	4.773	4.629	○	To Thanlyin Access
			0+060.000	0+165.000	105.00	U	800x800	-0.130%	4.114	3.978	○	Along Main Road
			0+165.000	0+187.000	22.00	PC	900	-0.130%	3.978	3.949	○	Along Main Road
			0+187.000	0+534.000	347.00	U	800x800	-0.130%	3.949	3.498	-	Along Main Road
			0+534.000	0+545.000	11.00	PC	900	-0.400%	2.820	2.776	-	Under On-ramp Rd
			0+545.000	0+640.000	95.00	U	1000x1000	-0.100%	2.776	2.681	-	To Drainage Outlet
	On-ramp	Right	0+000.000	0+025.900	25.90	U	300x300	-0.100%	3.500	3.474	-	Along On-ramp
			0+025.900	0+062.100	36.20	U	300x300	0.100%	3.464	3.500	-	Along On-ramp
			0+062.100	0+410.000	347.90	U	300x300	0.100%	3.292	3.640	-	Along On-ramp
2	Main	Right	2+240.000	2+620.000	380.00	U	1500x2500	0.100%	1.950	2.330	○	To Drainage Outlet
			2+620.000	2+760.000	140.00	U	1500x2500	0.050%	2.330	2.400	○	Along Main Road
			2+760.000	2+810.000	50.00	U	1500x2500	0.100%	2.400	2.450	○	Along Main Road
3	Main	Right	2+810.000	2+860.000	50.00	BC	1500x1000	0.090%	2.450	2.495	-	Under Crossing Rd
			2+860.000	2+987.000	127.00	U	1500x1500	0.028%	2.495	2.530	-	Open
			2+987.000	2+993.000	6.00	BC	1500x1000	0.029%	2.530	2.532	-	Under Entrance
			2+993.000	3+037.000	44.00	U	1500x1500	0.029%	2.532	2.545	-	Open
			3+037.000	3+043.000	6.00	BC	1500x1000	0.029%	2.545	2.546	-	Under Entrance
			3+043.000	3+080.000	37.00	U	1500x1500	0.029%	2.546	2.557	-	Open
			3+080.000	3+088.000	8.00	BC	1500x1000	0.048%	2.557	2.561	-	Under Entrance
			3+088.000	3+127.000	39.00	U	1500x1500	0.048%	2.561	2.580	-	Open
			3+127.000	3+184.000	57.00	BC	1500x1000	0.048%	2.580	2.607	-	Under Crossing Rd
			3+184.000	3+240.000	56.00	U	1500x1500	0.048%	2.607	2.634	-	Open
			3+240.000	3+247.000	7.00	BC	1500x1000	0.048%	2.634	2.637	-	Open
			3+247.000	3+301.000	54.00	U	1500x1500	0.048%	2.637	2.663	-	Open
			3+301.000	3+308.000	7.00	BC	1500x1000	0.048%	2.663	2.666	-	Open
			3+308.000	3+345.000	37.00	U	1500x1500	0.064%	2.666	2.690	-	Open
			3+345.000	3+363.000	18.00	BC	1000x1000	0.190%	2.690	2.724	-	Under Entrance
			3+363.000	3+378.000	15.00	U	1000x1500	0.330%	2.724	2.774	○	Under Side-Walk
			3+378.000	3+396.000	18.00	BC	1000x1000	0.330%	2.774	2.833	-	Under Entrance
			3+396.000	3+483.000	87.00	U	1000x1500	0.330%	2.833	3.120	○	Under Side-Walk
			3+483.000	3+499.000	16.00	BC	1000x1000	0.330%	3.120	3.173	-	Under Entrance
			3+499.000	3+517.000	18.00	U	1000x1500	0.330%	3.173	3.232	○	Under Side-Walk

Source: JICA Study Team
Note: U=Side Ditch Type U, PC=Pipe Culvert, BC=Box Culvert

3.8.7 New Drainage Outlets

3.8.7.1 Necessity of Protection Against Reverse Water Flow and Installation of New Drainage Outlets

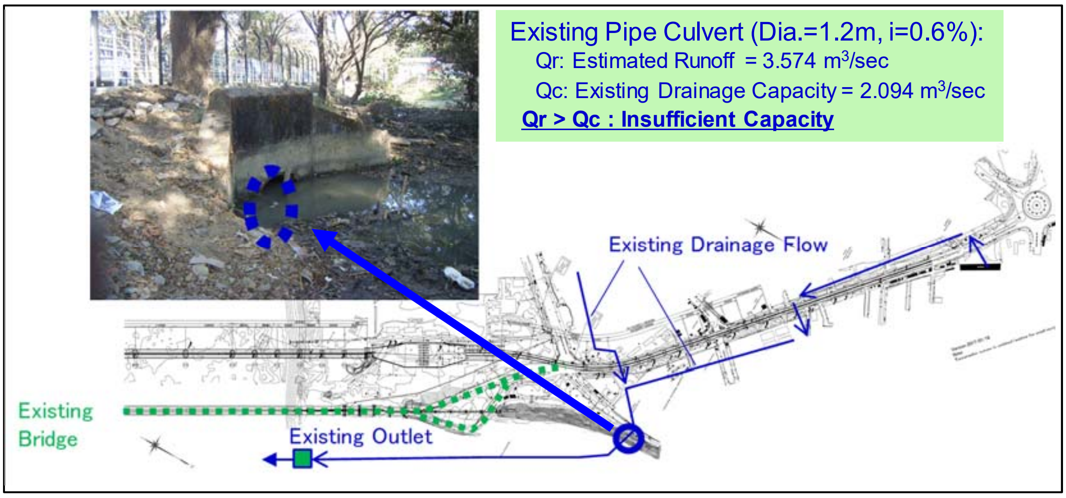
Regarding the existing drainage system, the JICA Study Team identified the following two issues based on the river and hydrological survey (see Table 3.8.3) and site investigation in addition to the discharge calculation using the same method as in Section 3.8.6.

i) Bottom of Existing Drainage Height is Lower than the Probable High Water Level (=4.22 m)

The bottom height of the existing drainage system connecting to the designed drainage structures in both river banks (Thaketa and Thanlyin side) is equal to or less than 4.22 m (probable high water level in case of 3-year return period). Because of this, there is a concern on the occurrence of reverse water flow from the river side to the upstream of the drainage structures.

ii) Insufficient Capacity of Existing Drainage Outlet

The JICA Study Team identified the existing drainage flow system and calculated the capacity of the drainage discharge in the right river bank (Thaketa side) with same conditions as mentioned in Sections 3.8.5 and 3.8.6 above. The estimated runoff is 3.574 (m^3/sec); however, the capacity of the existing pipe culvert (Dia.=1.2 m, Slope=0.6%) located at the existing drainage outlet is just 2.094 m³/sec. Therefore, new drainage outlet shall be installed to discharge the estimated runoff water from the upstream side.

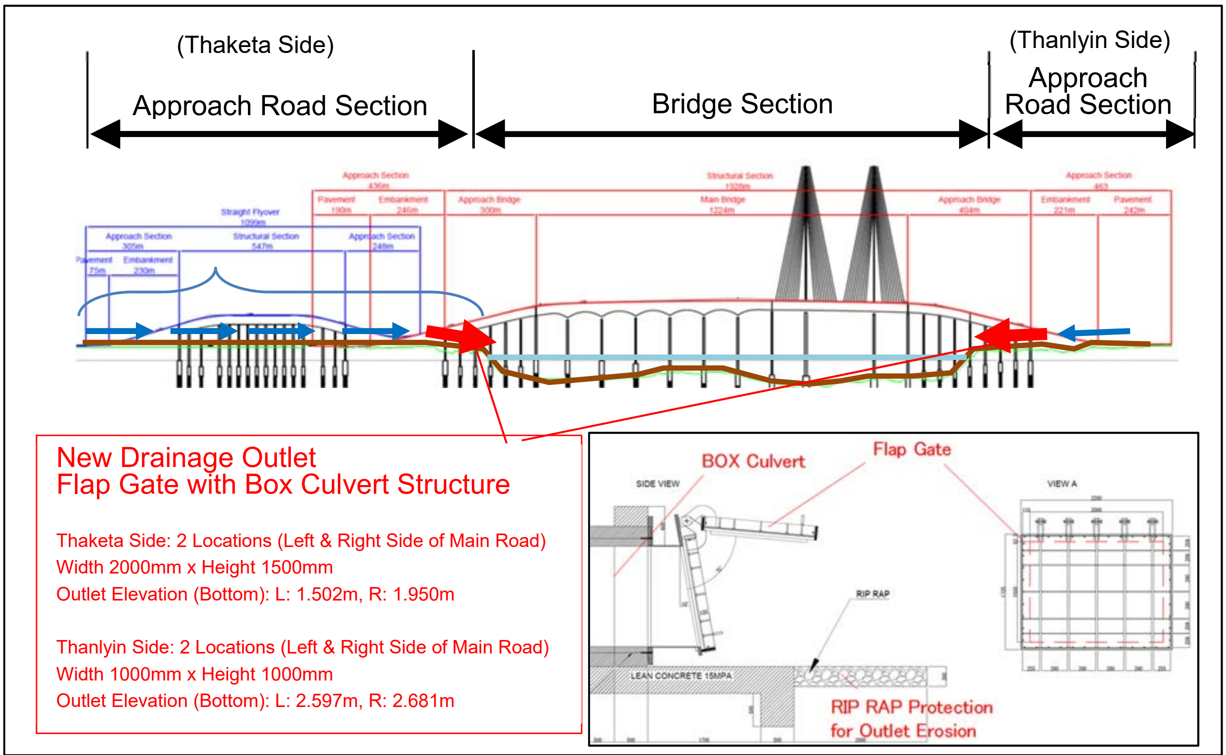


Source: JICA Study Team

Figure 3.8.6 Insufficient Capacity of Existing Drainage Outlet (Thaketa side)

3.8.7.2 New Drainage Outlets

The new drainage outlets planned to deal with the issues mentioned in Section 3.8.7.1 above are shown in Figure 3.8.7.



Source: JICA Study Team

Figure 3.8.7 New Drainage Outlets