7.8.7 Evaluation and Selection of Type of Intersections

Alternative intersections are evaluated and the most advantageous type was selected for each intersection. In the case of evaluated scours are almost same, the most economical type was selected. **Table 7.8.5** shows the evaluation results.

Table 7.8.5 Summary of Intersection Type Evaluation and Selection

Main Road	Crossroad	IC No.	Location (Current Area Division)	Full Control Interchange	Grade Separation with Access	At-grade Intersection with Signal Control	Roundabout without Signal Control	At-grade Intersection without Signal Control
Trans-Sulawesi Mamminasata Road	National Rd. / Mamminasa BP	TS-1	Gowa (Rural)	29.5	31.5	38.0	35.8	24.3
	National Rd. / Local Rd.	TS-2	Makassar /Gowa (Urban)	30.8	36.0	35.8	34.0	30.0
	Hertasning Rd.	TS-3	Makassar (Urban)	33.3	32.0	33.5	32.3	29.3
	ADS Rd.	TS-4	Makassar (Urban)	31.8	29.5	35.0	27.0	30.0
	Perintis Rd.	TS-5	Makassar (Urban)	33.0	33.0	33.5	32.5	29.3
	Ir. Sutami Rd.	TS-6	Makassar (Urban)	-	-	-	-	-
	Mamminasa BP	TS-7	Maros (Semi-urban)	29.3	33.0	34.3	33.0	29.5
	Mamminasa BP	TS-8	Maros (Semi-urban)	29.5	31.0	38.0	37.0	30.5
Mamminasa Bypass	Hertasning Rd.	MB-1	Gowa (Rural)	30.3	32.0	39.5	40.3	33.5
	ADS Rd.	MB-2	Gowa (Rural)	30.3	32.0	39.5	40.3	33.5
	National Rd.	MB-3	Maros (Urban)	24.5	26.0	37.3	36.3	30.3

Notes: Selected Type
Source: JICA Study Team

7.9 Bridge Plan

7.9.1 Bridge List

On the routes of the Mamminasa Bypass, Abdullah Daeng Sirua Road, Hertasning Road and Trans-Sulawesi Mamminasata Road, there are a total of 34 bridges and 34 box culverts crossing over rivers or canals. These bridges are listed in **Tables 7.9.1** to **7.9.4** and on **Figure 7.9.1.**

Table 7.9.1 Bridge and Box-culvert List on Mamminasa Bypass

Bridge No.	Survey No.	Section	Station	Crossing Objects			Existing Lane	Planed Lane
				Description	Length (m)	Span		
1-1	A	1-A	0+800	Canal	16	1	---	4
1-2	1	1-A	2+620	Canal	16	1	---	4
1-3	B	1-A	3+100	Canal	3	1	---	4
1-4	C	1-A	3+400	River	3	1	---	4
1-5	2	1-A	3+750	Maros Bridge	126	4	---	4
1-6	3	1-C	5+550	Canal	10	1	---	4
1-7	---	1-C	6+000	Canal	3	1	---	4
1-8	---	1-C	6+350	Canal	3	1	---	4
1-9	4	1-C	9+350	Canal	3	1	---	4

1-10	5	1-C	10+300	Canal	3	1	---	4
1-11	6	1-C	10+450	Canal	3	1	---	4
1-12	---	1-C	12+300	Canal	3	1	---	4
1-13	7	1-B	13+100	River	16	1	---	4
1-14	8	1-B	14+300	Canal	10	1	---	4
1-15	---	1-B	19+300	River	10	1	---	4
1-16	9	1-B	20+600	Ticcekang River	25	1	---	4
1-17	---	1-B	21+750	Canal	3	1	---	4
1-18	---	1-B	22+600	Sungai Ticcekang	16	1	---	4
1-19	10	1-B	23+450	Salo Pahundukang	60	2	---	4
1-20	---	1-B	24+400	Canal	3	1	---	4
1-21	11	1-B	25+600	River	10	1	---	4
1-22	---	1-B	26+350	Canal	3	1	---	4
1-23	12	1-B	28+700	Canal	3	1	---	4
1-24	---	1-B	29+750	Canal	3	1	---	4
1-25	---	1-B	30+250	Canal	3	1	---	4
1-26	13	1-B	30+900	Salo Kaccikang	25	1	---	4
1-27	---	1-B	31+600	Canal	3	1	---	4
1-28	14	1-D	32+850	Jenemanjalling River	16	1	---	4
1-29	---	1-D	33+400	Canal	3	1	---	4
1-30	---	1-D	34+100	Canal	3	1	---	4
1-31	15	1-D	35+600	Jeneberang No.1	154	5	---	4
1-32	16	1-D	39+100	Salo Bontoreo	16	1	---	4
1-33	---	1-D	39+600	Canal	3	1	---	4
1-34	---	1-D	41+150	River	16	1	---	4
1-35	17	1-D	42+350	River	16	1	---	4
1-36	18	1-D	43+900	River	16	1	---	4
1-37	---	1-D	44+100	Canal	3	1	---	4
1-38	---	1-D	44+200	Canal	3	1	---	4
1-39	19	1-D	44+400	Canal	3	1	---	4
1-40	---	1-D	45+400	Canal	3	1	---	4
1-41	20	1-D	45+900	Canal	3	1	---	4
Total					600			

Source: JICA Study Team

Table 7.9.2 Bridge and Box-culvert List on Trans Sulawesi Mamminasata Road

Bridge No.	Survey No.	Section	Station	Crossing Object			Existing Lane	Planed Lane
				Description	Length(m)	Span		
2-1	23	1-A	0+450	River	40	2	4	6

2-2	24	1-A	4+020	River	40	2	4	6
2-3	25	1-A	8+300	Bonetengga River	16	1	6	6
2-4	26	---	12+600	River	16	1	6	6
2-5	26a	---	13+600	River	16	1	6	6
2-6	27	1-B	19+550	Tallo Bridge	136	4	---	4*2
2-7	27a	1-B	20+650	Canal	50	2	---	3*2
2-8	27b	1-B	21+700	Canal	50	2	---	3*2
2-9	27c	1-B	23+700	Canal	50	2	---	3*2
2-11	---	1-B	26+200	Interchange	50	2	---	4
2-10	28	1-C	26+700	Jeneberang No2	393	12	---	4
2-12	29	1-C	29+500	Bayoa River	35	1	---	4
2-13	29a	1-C	30+480	Bontorea River	16	1	---	4
2-14	30	1-C	32+950	Barombong River	20	1	---	4
2-15	31	1-C	34+900	River	10	1	---	4
2-16	32	1-D	40+200	River	10	1	2	4
2-17	33	1-D	42+700	River	5	1	2	4
2-18	34	1-D	47+700	River	40	2	2	4
Total					600			

Source: JICA Study Team

Table 7.9.3 Bridge and Box-culvert List on Hertasning Road

Bridge No.	Survey No.	Section	Station	Crossing Object			Existing Lane	Planned Lane
				Description	Length(m)	Span		
3-1	---	3-End	5+50	Canal	10	1	2	4
3-2	18	3-End	6+600	Tallo River	20	1	2	4
Total					30			

Source: JICA Study Team

Table 7.9.4 Bridge and Box-culvert List on Abdullah Daeng Sirua Road

Bridge No.	Survey No.	Section	Station	Crossing Object			Existing Lane	Planed Lane
				Description	Length(m)	Span		
4-1	4-1	4-A	1+300	Canal	35	1	2	4
4-2	4-2	4-D3	5+650	Canal	16	1	2	4
4-3	4-3	4-D4	7+600	Canal	16	1	2	4
4-4	4-4	4-D4	8+500	River	10	1	2	4
4-5	4-5	4-E	9+450	Tallo River	60	2	2	4
4-6	---	4-F2	15+100	Canal	3	1	---	4
4-7	---	4-F2	15+450	Canal	10	1	---	4
Total					105			

Source: JICA Study Team

For the minor bridges with a length of more than 10 m, the standard PC I girder was applied and a preliminary cost estimate was made by span (35m, 30m, 25m, 20m and 16m). As to the remaining structures of a length of less than 10 m, the standard box culverts were used and a preliminary cost estimate was made for each pattern (span 10m, 5m and 3m).

The following four bridges having a length of more than 100 m were categorized as major bridges in the F/S and subjected to a structure scale examination and subjected to preliminary design:

i) Bridge No.1-5, Maros Bridge (length 126 m) on Mamminasa Bypass

ii) Bridge No.1-15, Jeneberang No.1 Bridge (length 154 m) on Mamminasa Bypass

iii) Bridge No.2-6, Tallo Bridge (length 136 m) on Trans-Sulawesi Mamminasata Road

iv) Bridge No.2-10, Jeneberang No.2 Bridge (length 393 m) on Trans-Sulawesi Mamminasata Road.

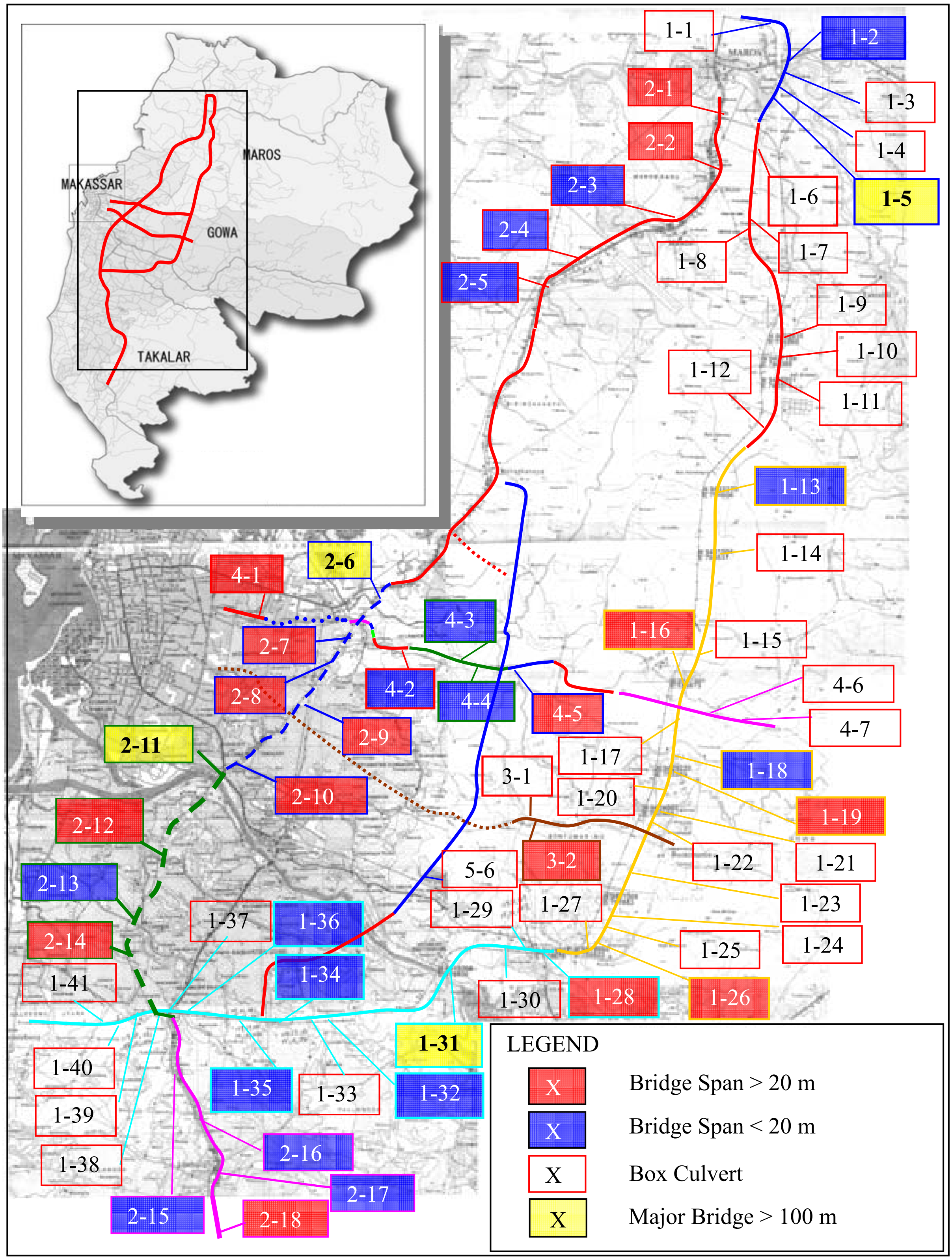


Figure 7.9.1 Location Map of Bridges and Box Culverts

7.9.2 Design Standard

The Indonesian Standard “Bridge Design Code and Manual (BMS 1993)” was applied in bridge design for the F/S. The design loads applied in the design are as follows:

(1) Dead Load

The nominal weight of various materials is shown in **Table 7.9.5**.

Table 7.9.5 Nominal Self-weight

Material	Value (kN/m^3)
Steel	77.0
Reinforced or Pre-stressed concrete (C.I.P)	25.0
Reinforced or Pre-stressed concrete (Pre-cast)	25.0
Mass concrete	24.0
Asphalt pavement	22.0
Compacted earth filling	17.2
Timber, Hardwood	11.0
Timber, Softwood	7.8

Source: Bridge Design Manual

(2) Live load

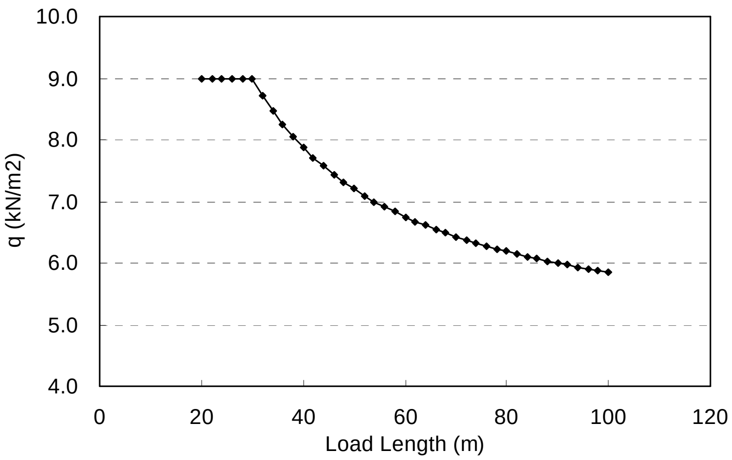
Live loads for road bridges consist of “D” lane loading and “T” truck loading.

The “D” lane loading is applied to the full width of the bridge roadway, which is equivalent to a queue of real vehicles on the bridge. Therefore, the “D” lane loading depends on the width of the bridge roadway.

The “T” truck loading is a single heavy vehicle with three axles, which is applied to any position on the Design Traffic Lane. Each axle comprises two patch loadings which simulate wheels of heavy vehicles. Only one “T” truck is applied in the Design Traffic Lane.

1) “D” Lane Load

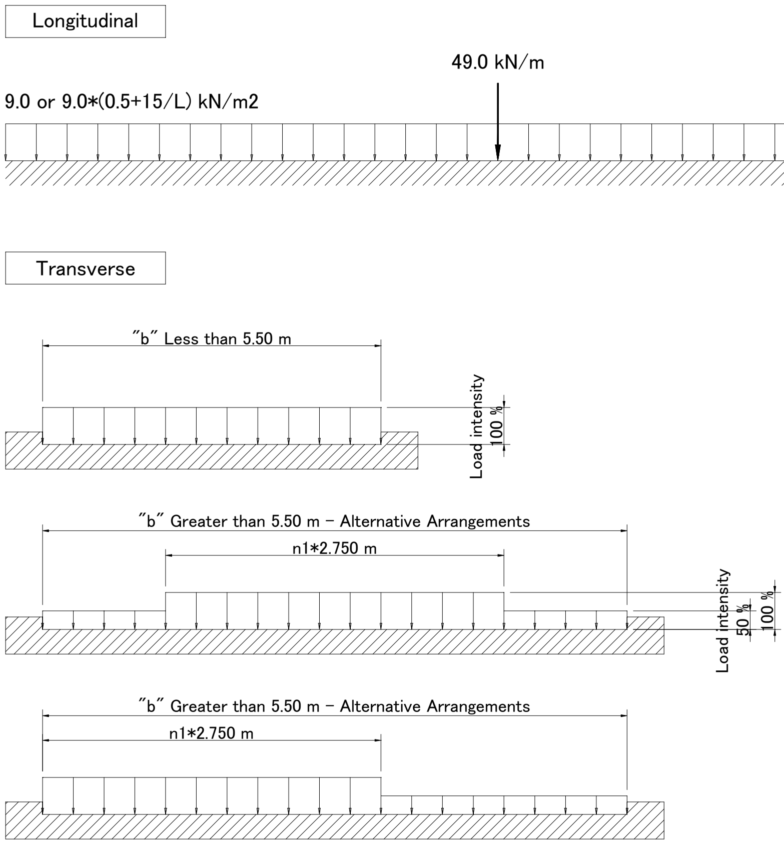
A Uniformly Distributed Load (UDL) of intensity q kN/m^2, where q depends on the total loaded length L is as follows: $L < 30$ m; $q = 9.0$ kN/m^2, $L > 30$ m; $q = 9.0*(0.5+15/L)$ kN/m^2



Source: JICA Study Team (Based on Bridge Design Manual)

A Knife Edge Load (KEL) of p (=49.0 kN/m), is applied to any position on the bridge perpendicular to road surface.

The "D" lane load is positioned perpendicular to the road surface as shown in **Figure 7.9.2**.

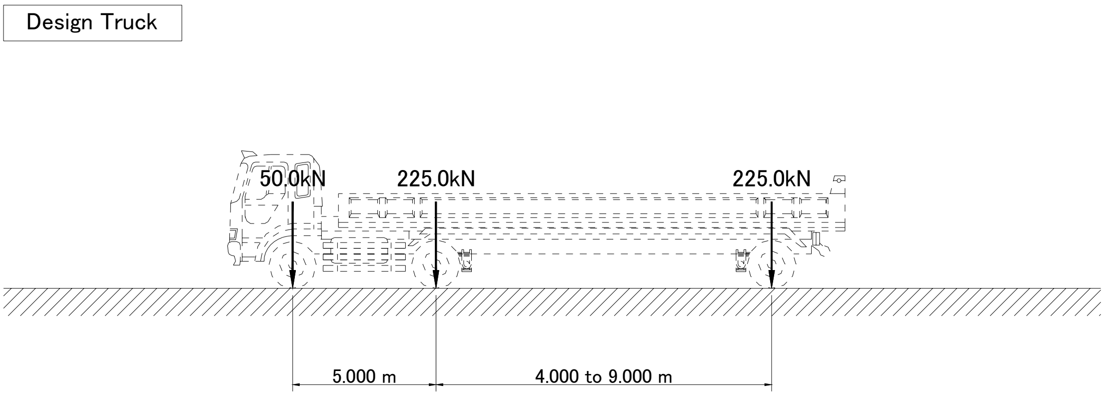


Source: JICA Study Team (Based on Bridge Design Manual)

Figure 7.9.2 "D" Lane Load

2) "T" Truck Load

The "T" truck load is shown in **Figure 7.9.3**.



Source: Bridge Design Manual

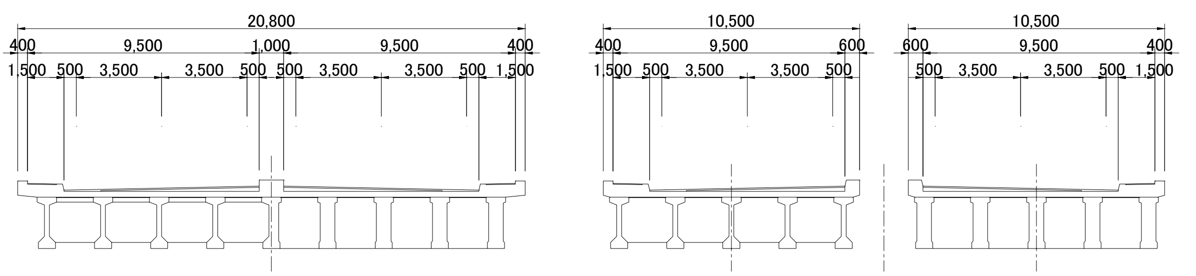
Figure 7.9.3 "T" Truck Load

(3) Seismic Forces

The effect of an earthquake on simple structures can be simulated by an equivalent static load as described in Bridge Design Manual. Large, complex or important bridges require a full dynamic analysis. However, in this F/S stage, the structure type and form were examined and selected without dynamic analysis.

7.9.3 Standard Bridge Cross Section

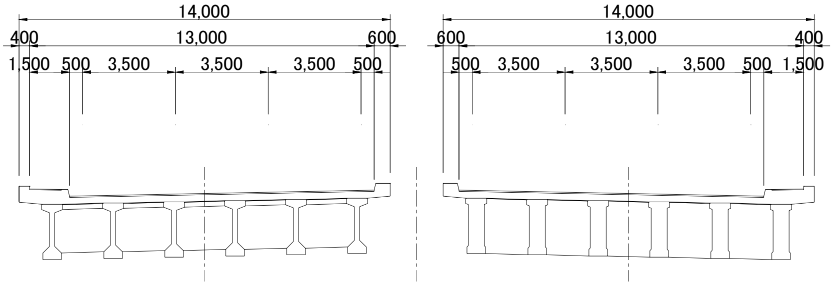
(1) 4-Lane Type



Source: JICA Study Team

Figure 7.9.4 Cross Section of 4-Lane and 2*2-Lane Type

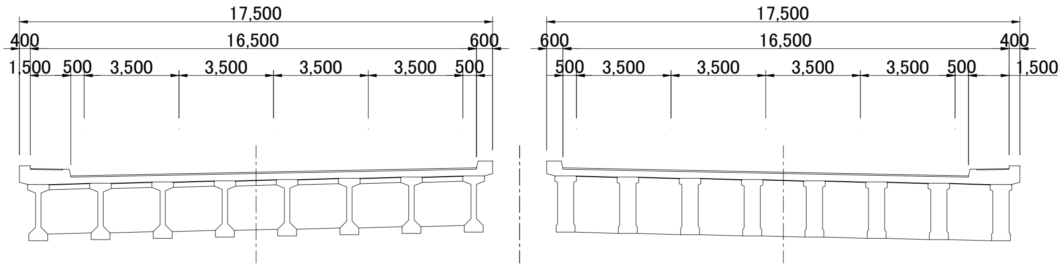
(2) 6-Lane Type



Source: JICA Study Team

Figure 7.9.5 Cross Section of 2*3-Lane Type

(3) 8-Lane Type



Source: JICA Study Team

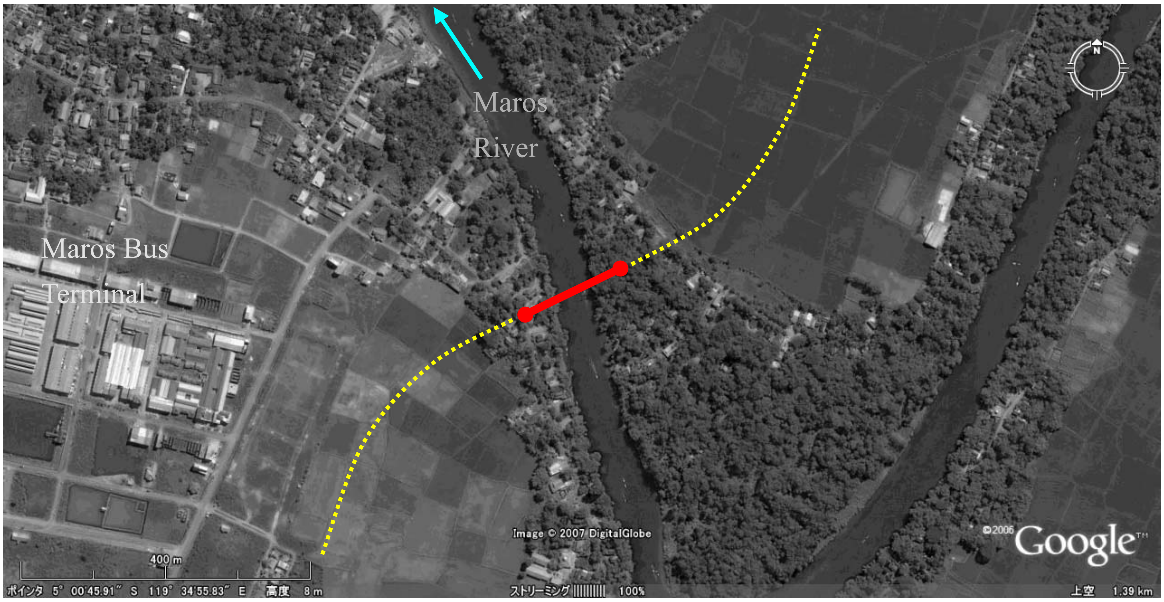
Figure 7.9.6 Cross Section of 2*4-Lane Type

7.9.4 Major Bridges

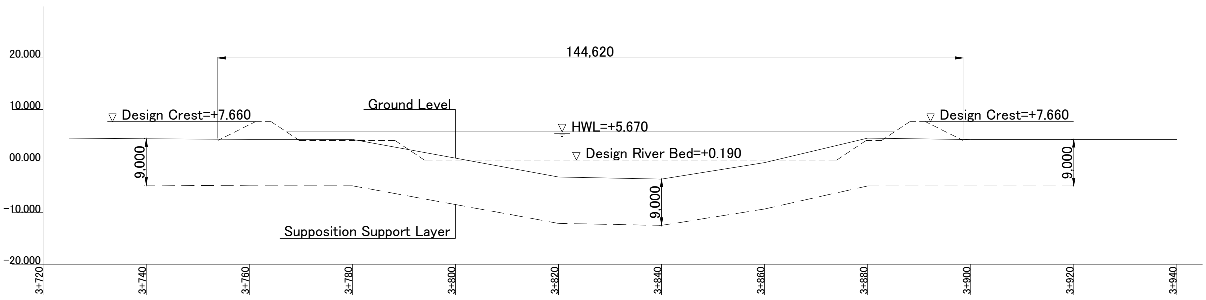
(1) Site Condition

Although the number of bridges located in this project area is more than 40, only the following four bridges which have a length of more than 100 m were examined for their structure scale by preliminary design.

1) Maros Bridge (Bridge No. 1-5) on Mamminasa Bypass



Source: JICA Study Team

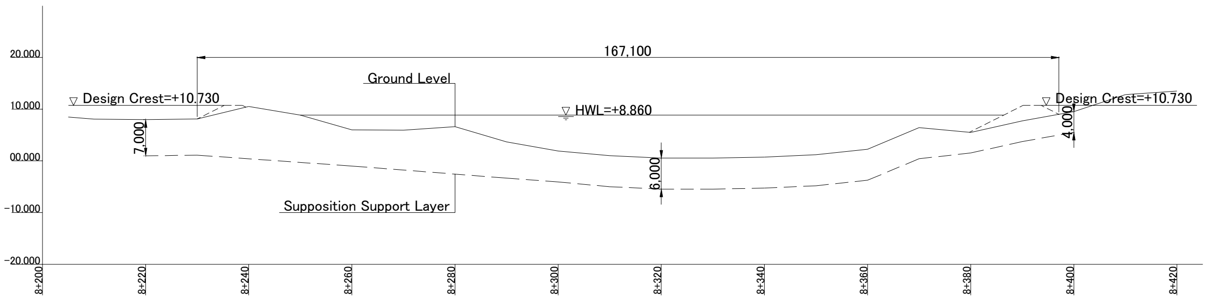


Source: JICA Study Team

Figure 7.9.7 Plane Photo and River Cross Section for Maros Bridge (Bridge No. 1-5)

2) Jeneberang No.1 Bridge (Bridge No. 1-31) on Mamminasa Bypass

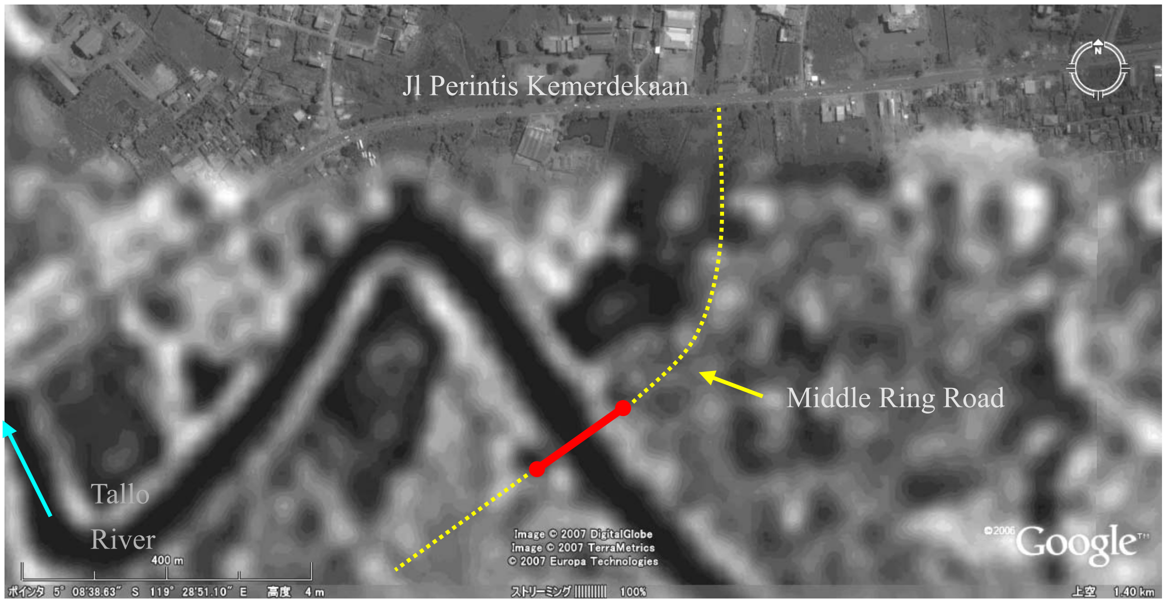
Source: JICA Study Team



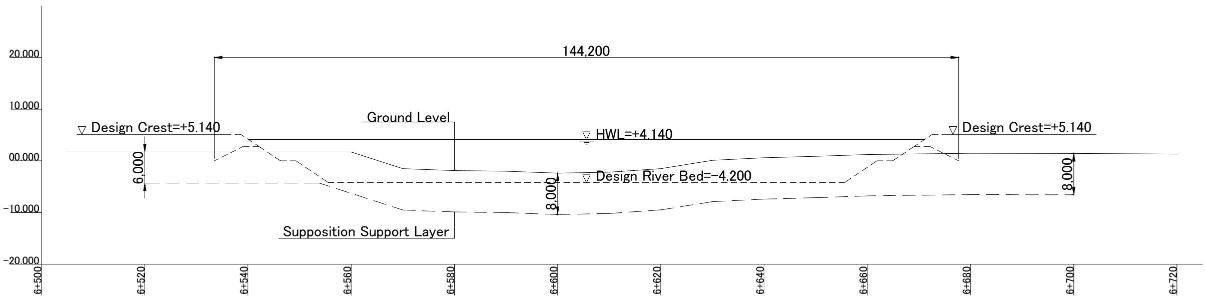
Source: JICA Study Team

Figure 7.9.8 Plane Photo and River Cross Section for Jeneberang No.1 Bridge (Bridge No.1-31)

3) Tallo Bridge (Bridge No. 2-6) on Trans-Sulawesi Mamminasata Road



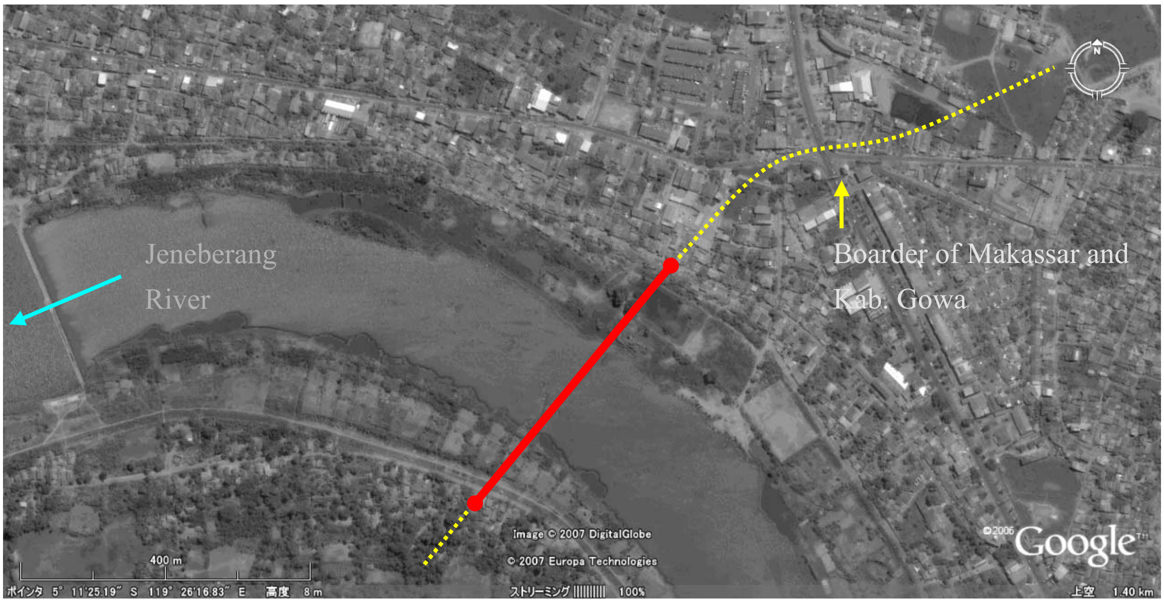
Source: JICA Study Team



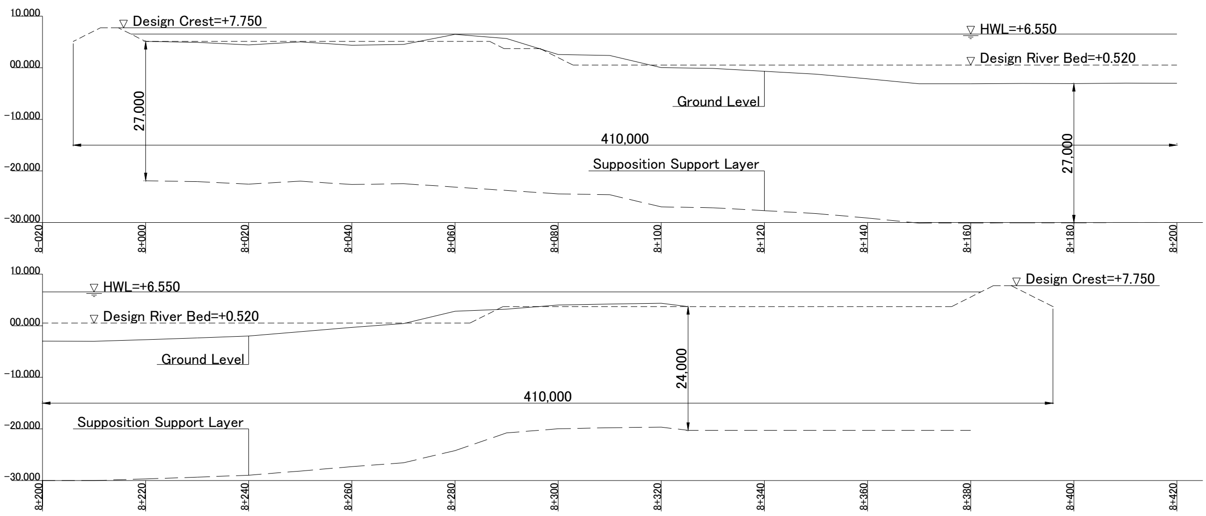
Source: JICA Study Team

Figure 7.9.9 Plane Photo and River Cross Section for Tallo Bridge (Bridge No. 2-6)

4) Jeneberang No.2 Bridge (Bridge No. 2-10) on Trans-Sulawesi Mamminasata Road



Source: JICA Study Team



Source: JICA Study Team

Figure 7.9.10 Plane Photo and River Cross Section for Jeneberang 2 Bridge (Bridge No.2-10)

(2) Selection of Structure Type

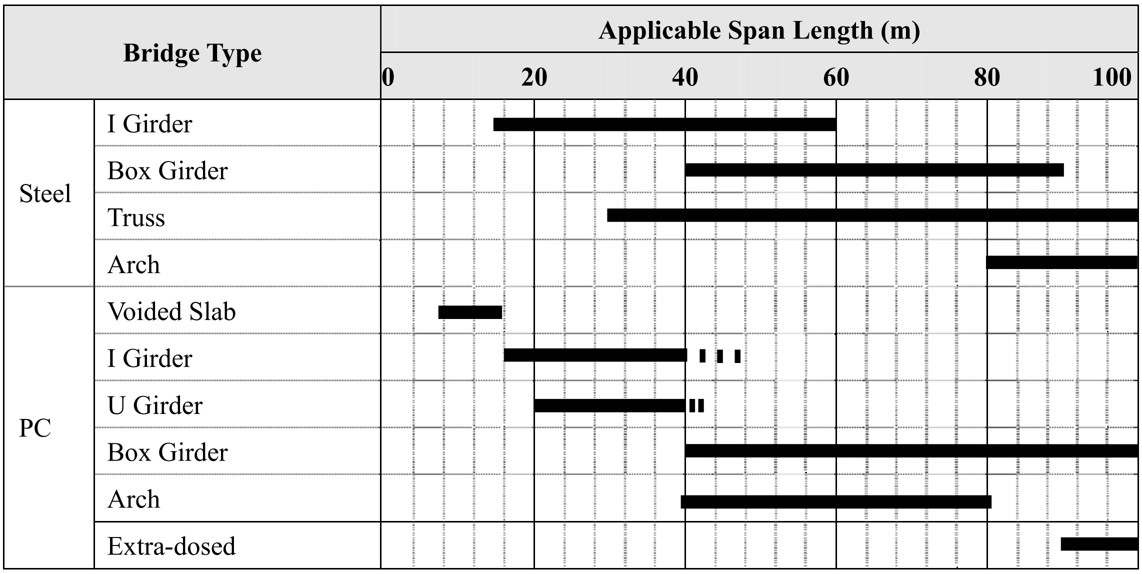
As the first step to determine the structure type, particular site conditions and design constraints are identified by site survey, and then the most appropriate structure is selected from viable alternatives. Aesthetic superstructure was also included in the study as an alternative for the bridges located in urban area.

1) Superstructure

The most economical and common structure types in Indonesia is PC I girder bridge and its applicable span length is between 10 m and 35 m as indicated in Table 7.9.6. Steel truss is common for the span length more than 30 m.

The span arrangement and alignment layout are the key elements to determine the superstructure types. The superstructure types applied are i) Steel I girder, ii) Steel box girder, iii) Steel truss, iv) Steel arch, v) PC hollow slab, vi) PC I girder, vii) PC U Girder, viii) PC box girder and (ix) PC arch. The table following table shows relationship of span lengths and superstructure types.

Table 7.9.6 Applicable Span Length by Bridge Type



Source: Bridge Design Manual, Japan Pre-stressed Concrete Contractors Association, Japan Association of Steel Bridge Construction and some modification by the JICA Study Team for application in Indonesia

A comparison study was made for bridge types including PC I girder, PC box girder, steel girder, steel truss, steel arch or PC arch. PC girder superstructure is recommended because of its economical advantage and concrete materials are available at the local market. However, it might be able to select steel or PC arch for the bridges located at urban area on aesthetic aspect though these are 200-300% more expensive compared with the standard PC I girder.

2) Substructure

Abutments transmit vertical and horizontal forces from the superstructure to the foundation. Abutments also have a function of support against earth pressure from the approach embankment to the bridge superstructure. Piers transmit vertical and horizontal forces from the superstructure to the foundation. Common abutment and pier types in relation with application height are indicated in **Tables 7.9.7** and **7.9.8**.

Table 7.9.7 Typical Height by Abutment Type

Abutment Type	Typical Height (m)			
	0	10	20	30
Gravity Abutment				
Cantilever Abutment				
Counter-forted Abutment				

Source: Bridge Design Manual

Table 7.9.8 Typical Height by Pier Type

Pier Type	Typical Height (m)			
	0	10	20	30
Pile Trestle Pier				
Single Column Pier				
Wall Pier				
I-section Wall Pier				

Source: Bridge Design Manual

The four major bridges studied are crossing rivers. Since there are no bridges planned with an abutment height of less than 5 m, a cantilever abutment (Reverse T type) was selected. The pile vent or a multi-column type should be avoided for piers of major bridges.

3) Foundation

The foundations transmit concentrated loads from the substructure into the supporting ground. Common foundation types considered are shown in **Table 7.9.9**. Since the support layer required for bridge is deep, spread footing and well foundation are not applicable. Considering the bridge scale, the caisson foundation is not required.

Table 7.9.9 Typical Foundation Type

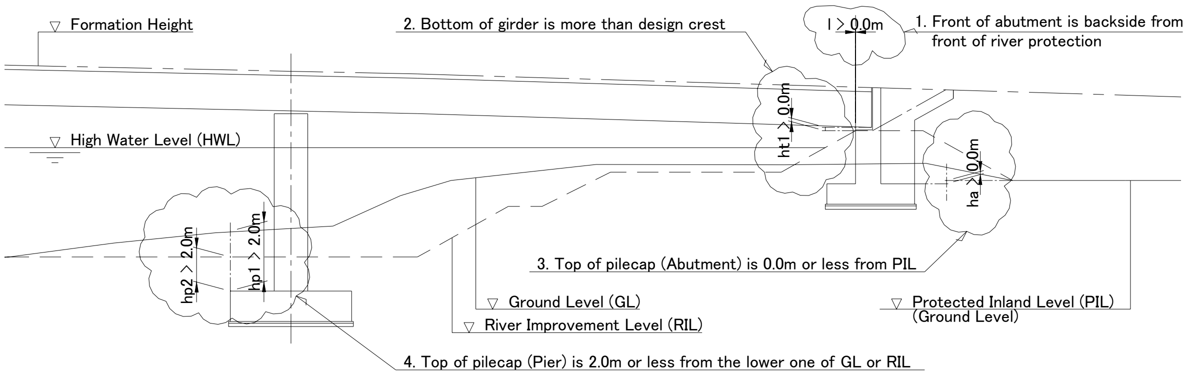
Pile	Material	Type	Nominal Diameter (mm)	
			Minimum	Maximum
Driven Pile	Steel	Steel Tube Pile	300	600
	Concrete	Reinforced Concrete Pile	300	600
		Pre-stressed Concrete Pile	400	600
Bored Pile		Bored Pile	1,000	1,500

Source: JICA Study Team (Based on Bridge Design Manual)

Pile foundation was selected because the depth of the bearing stratum is approximately from 10 to 20 m. Concrete pile or bored pile is selected as the type of foundation from an economical aspect and engineering practice in Indonesia. Bored piles are used for the foundation of major bridges, and PC piles (tube or square piles) for the foundation of minor bridges.

(3) Bridge Layout Plan

There are river improvement and training plans for the Maros River and the Tallo River. Therefore, present river cross section and after-improvement cross sections including water level and topography were considered in the bridge plan. For the Jeneberang River, which has already been improved at the time of Bili-bili dam construction, the bridge was planned based on the current condition. The basic bridge layout plan is as shown in **Figure 7.9.11**.



Source: JICA Study Team

Figure 7.9.11 Model of Bridge Layout Plan

As for bridges on these rivers, the height between MWL and the bottom of girder is kept 3m to make the navigation on the river capable.

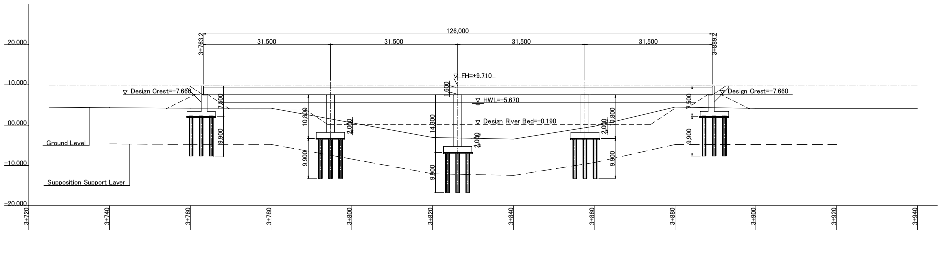
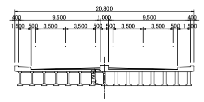
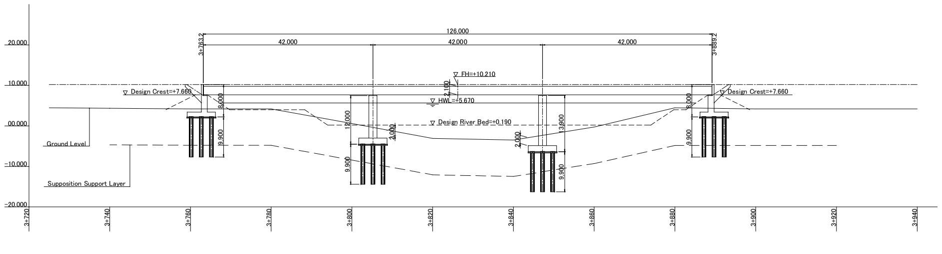
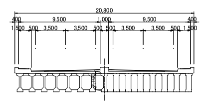
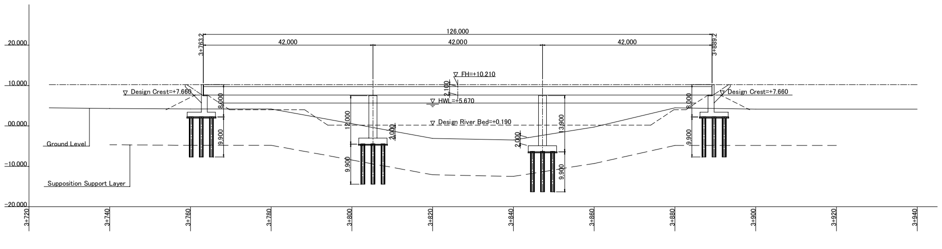
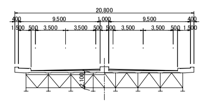
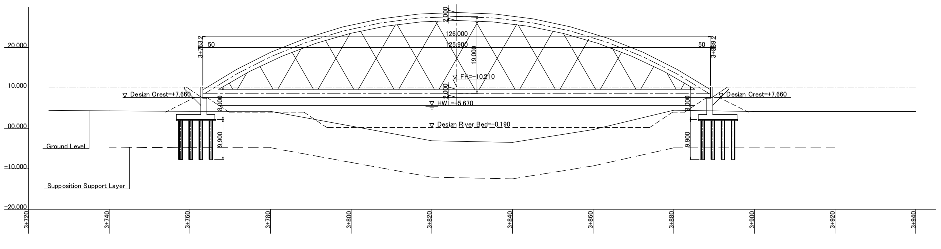
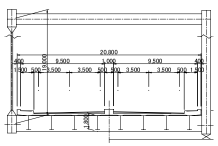
(4) Alternative Bridge Plans and Recommendations

Alternative bridge plans and concept designs were made for the following four major bridges and evaluated on stability, construction easiness, maintenance, aesthetics and construction costs.

1) Maros Bridge, Mamminasa Bypass (See **Table 7.9.10**)
2) Jeneberang No.1 Bridge, Mamminasa Bypass (See **Table 7.9.11**)
3) Tallo Bridge, Trans Sulawesi Road (See **Table 7.9.12**)
4) Jeneberang No.2 Bridge, Trans Sulawesi Road (See **Table 7.9.13**)

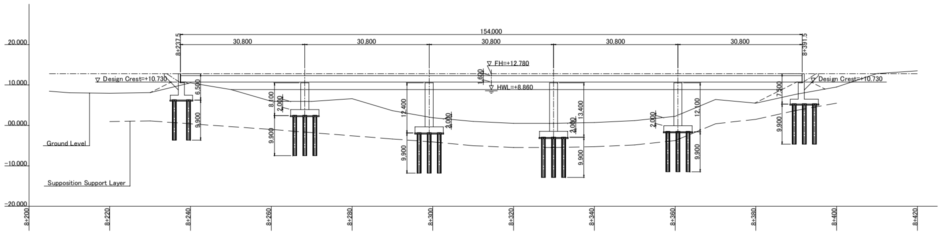
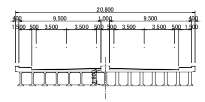
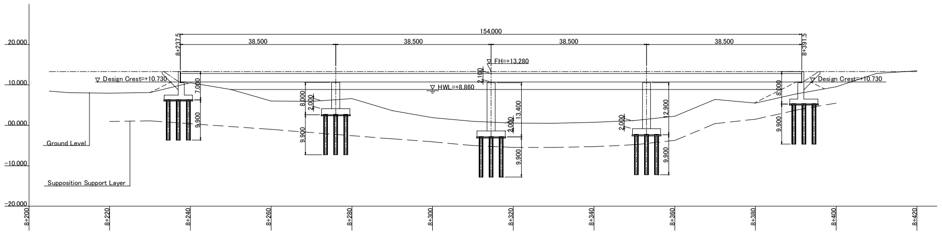
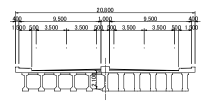
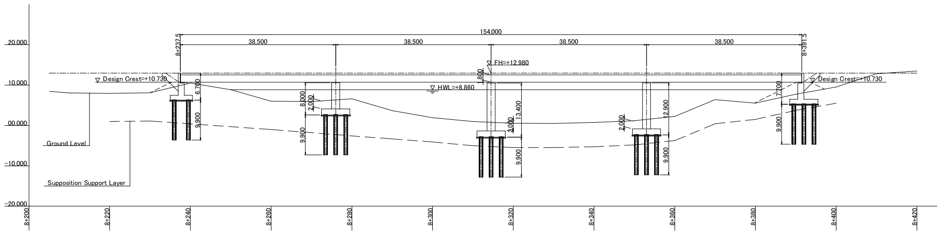
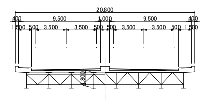
The Maros Bridge, Tallo Bridge and Jeneberang No.2 Bridge located in the Makassar urban area were subjected to aesthetic comparative study considering the landscape.

Table 7.9.10 Comparison of Bridge Types for Maros Bridge

	Layout of Maros Bridge (Bridge No.1-5)	Cross Section	Description	Evaluation
Alternative 1 **PC 4span I Girder Bridge**			Alternative 1 is PC I girder bridge. The main girder (length: 31.5m) can be controlled easily to ensure quality since it is a manufactured structure, but its transportation to the site is required. Cantilever abutment, single column pier and bored pile foundation are adopted for substructures since local contractors have much experience in the construction of this type. The total construction cost is the least. Cost Estimate (Thousand Rupiah) (1) Superstrucure 15,596,000 (2) Substructure 5,330,000 (3) Foundation 2,220,000 TOTAL 100% 23,146,000	**Best option**
Alternative 2 **PC 3span I Girder Bridge**			Alternative 2 is PC I girder bridge with a longer span. The main girder (length: 42.0m) can be controlled easily to ensure quality since it is a manufactured structure, but its transportation to the site is required. However, since the girder is long, construction is difficult. As for substructures, the same construction method as that for Alternative 1 is adopted. Cost Estimate (Thousand Rupiah) (1) Superstrucure 23,324,000 (2) Substructure 4,197,000 (3) Foundation 1,800,000 TOTAL 127% 29,321,000	Not recommended
Alternative 3 **Steel I Girder Bridge**			Alternative 3 is steel I girder bridge. The main girder (length: 42.0m) is excellent in the quality aspect since it is manufactured at factory, but its transportation to the site is required. Construction materials are to be procured overseas. The total construction cost is higher than Alternative 1. Cost Estimate (Thousand Rupiah) (1) Superstrucure 26,228,000 (2) Substructure 4,046,000 (3) Foundation 1,680,000 TOTAL 138% 31,954,000	Not recommended from cost saving view point
Alternative 4 **Nielsen-Lohse Bridge**			Alternative 4 is Niesel-Lohse bridge. The main girder (length: 125.4m) is excellent in the quality aspect since it is manufactured at factory, but its transportation to the site is required. Construction materials are to be procured overseas. Since the span length is long, construction is difficult.The total construction cost is the highest. Cost Estimate (Thousand Rupiah) (1) Superstrucure 58,178,000 (2) Substructure 1,914,000 (3) Foundation 1,280,000 TOTAL 209% 61,372,000	Recommended as an alternative on aesthetics view point as it is located in urban area

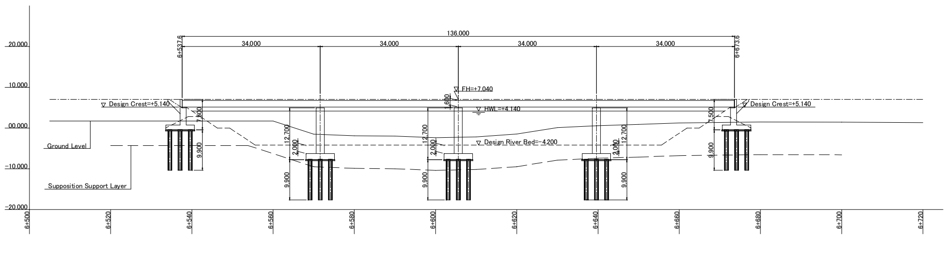
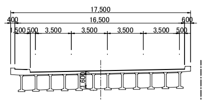
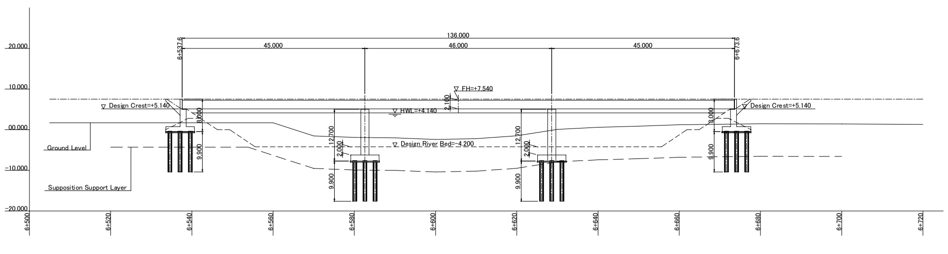
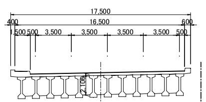
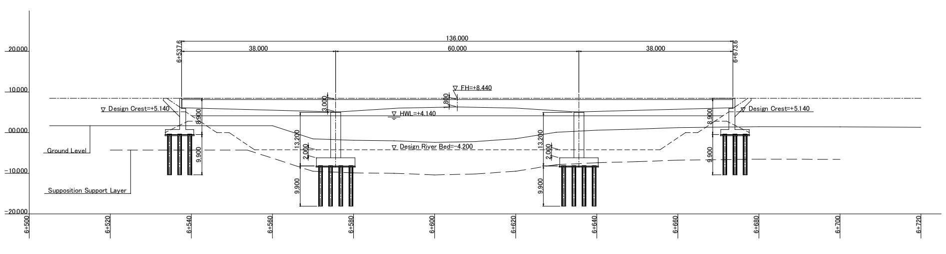
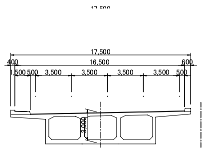
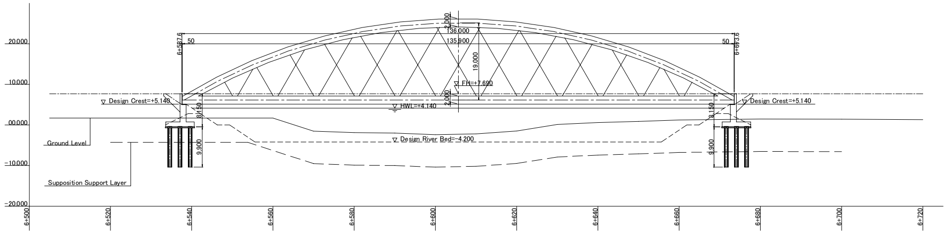
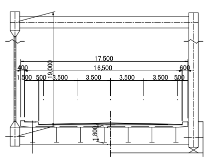
	Stability	Construction	Maintenance	Aesthetics	Cost	Total
Alternative 1	16 / 20	16 / 20	8 / 10	6 / 20	30 / 30	76 / 100
Alternative 2	16 / 20	14 / 20	8 / 10	8 / 20	24 / 30	70 / 100
Alternative 3	18 / 20	15 / 20	6 / 10	8 / 20	20 / 30	67 / 100
Alternative 4	18 / 20	10 / 20	6 / 10	20 / 20	13 / 30	67 / 100

Table 7.9.11 Comparison of Bridge Types for Jeneberang No.1 Bridge

	Layout of Jeneberang No.1 Bridge (Bridge No.1-31)	Cross Section	Description	Evaluation
Alternative 1 **PC 5span I Girder Bridge**			Alternative 1 is PC I girder bridge. The main girder (length: 30.8m) can be controlled easily to ensure quality since it is a manufactured structure, but its transportation to the site is required. Cantilever abutment, single column pier and bored pile foundation are adopted for substructures since local contractors have much experience in the construction of this type. The total construction cost is the least. Cost Estimate (Thousand Rupiah) (1) Superstrucure 18,648,000 (2) Substructure 6,319,000 (3) Foundation 2,480,000 TOTAL 100% 27,447,000 Stability 12 / 20; Construction 16 / 20; Maintenance 8 / 10; Aesthetics 4 / 10; Cost 40 / 40; Total 80 / 100	**Best option**
Alternative 2 **PC 4span I Girder Bridge**			Alternative 2 is PC I girder bridge with a longer span. The main girder (length: 38.5m) can be controlled easily to ensure quality since it is a manufactured structure, but its transportation to the site is required. However, since the girder is long, construction is difficult. As for substructures, the same construction method as that for Alternative 1 is adopted. Cost Estimate (Thousand Rupiah) (1) Superstrucure 20,869,000 (2) Substructure 5,187,000 (3) Foundation 2,220,000 TOTAL 103% 28,276,000 Stability 12 / 20; Construction 14 / 20; Maintenance 8 / 10; Aesthetics 5 / 10; Cost 39 / 40; Total 78 / 100	Not recommended
Alternative 3 **Steel I Girder Bridge**			Alternative 3 is steel I girder bridge. The main girder (length: 38.5m) is excellent in the quality aspect since it is manufactured at factory, but its transportation to the site is required. Construction materials are to be procured overseas. The total construction cost is the highest. Cost Estimate (Thousand Rupiah) (1) Superstrucure 29,884,000 (2) Substructure 4,826,000 (3) Foundation 1,880,000 TOTAL 133% 36,590,000 Stability 14 / 20; Construction 14 / 20; Maintenance 6 / 10; Aesthetics 5 / 10; Cost 29 / 40; Total 68 / 100	Not recommended from cost saving view point

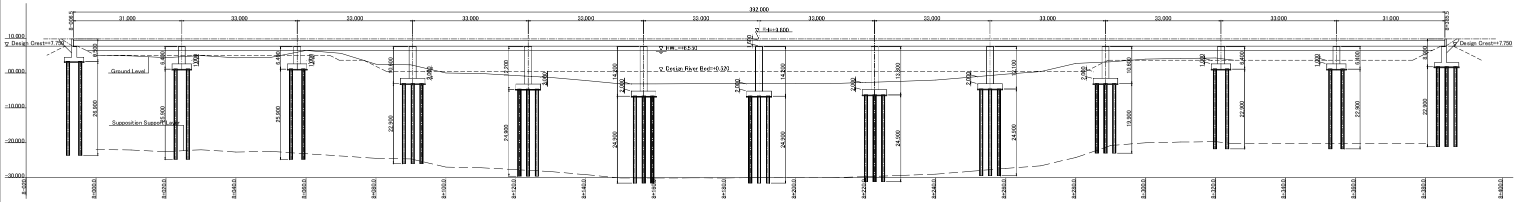
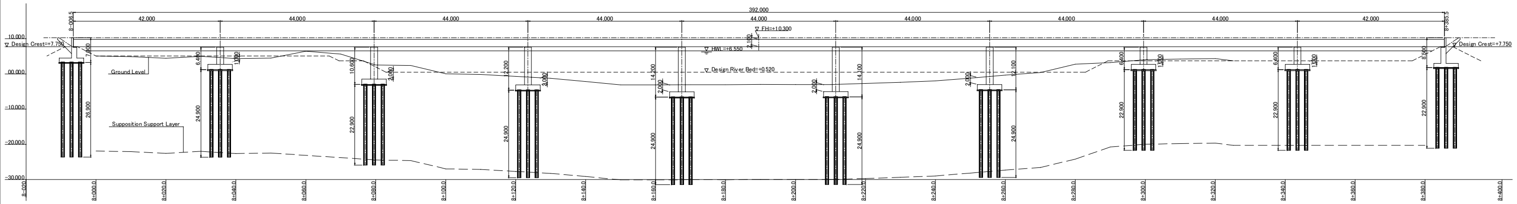
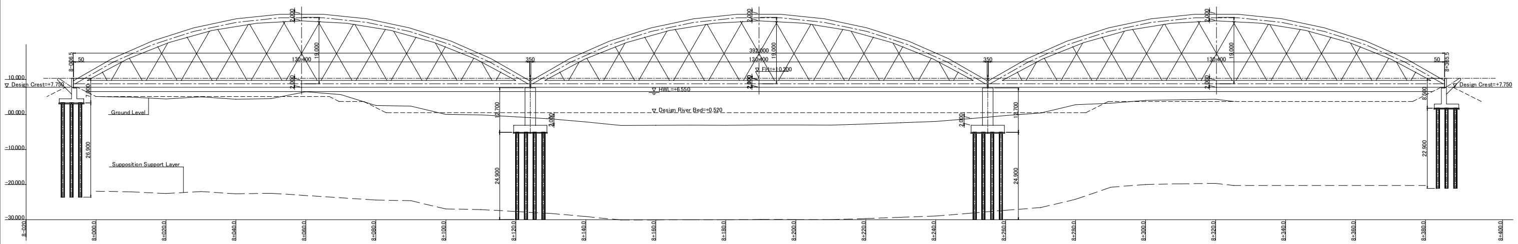
Source: JICA Study Team

Table 7.9.12 Comparison of Bridge Types for Tallo Bridge

	Layout of Tallo Bridge (Bridge No. 2-6)	Cross Section (one side bridge)	Description	Evaluation
Alternative 1 **PC 4span I Girder Bridge**			Alternative 1 is PC I girder bridge. The main girder (length: 34.0m) can be controlled easily to ensure quality since it is a manufactured structure, but its transportation to the site is required. Cantilever abutment, single column pier and bored pile foundation are adopted for substructures since local contractors have much experience in the construction of this type. The total construction cost is the least. Cost Estimate (Thousand Rupia) (1) Superstrucure 14,701,000 (2) Substructure 5,093,000 (3) Foundation 1,920,000 TOTAL 100% 21,714,000 Stability 16 / 20; Construction 16 / 20; Maintenance 8 / 10; Aesthetics 6 / 20; Cost 30 / 30; Total 76 / 100	**Best option**
Alternative 2 **PC 3span I Girder Bridge**			Alternative 2 is PC I girder bridge with a longer span. The main girder (length: 46.0m) can be controlled easily to ensure quality since it is a manufactured structure, but its transportation to the site is required. However, since the girder is long, construction is difficult. As for substructures, the same construction method as that for Alternative 1 is adopted. Cost Estimate (Thousand Rupia) (1) Superstrucure 21,825,000 (2) Substructure 3,864,000 (3) Foundation 1,560,000 TOTAL 125% 27,249,000 Stability 16 / 20; Construction 14 / 20; Maintenance 8 / 10; Aesthetics 8 / 20; Cost 24 / 30; Total 70 / 100	Not recommended
Alternative 3 **PC Box Girder Bridge**			Alternative 4 is PC box girder bridge. The main girder (center span length: 60.0m) is elected as the cantilever construction method in the site. Since the span length is long, construction is difficult.The total construction cost is the highest. Cost Estimate (Thousand Rupia) (1) Superstrucure 25,729,000 (2) Substructure 5,586,000 (3) Foundation 1,960,000 TOTAL 153% 33,275,000 Stability 16 / 20; Construction 12 / 20; Maintenance 8 / 10; Aesthetics 12 / 20; Cost 20 / 30; Total 68 / 100	Not recommended from cost saving view point
Alternative 4 **Nielsen-Lohse Bridge**			Alternative 5 is Niesel-Lohse bridge. The main girder (length: 135.9m) is excellent in the quality aspect since it is manufactured at factory, but its transportation to the site is required. Construction materials are to be procured overseas. Since the span length is long, construction is difficult.The total construction cost is the highest. Cost Estimate (Thousand Rupia) (1) Superstrucure 47,473,000 (2) Substructure 1,404,000 (3) Foundation 840,000 TOTAL 229% 49,717,000 Stability 18 / 20; Construction 10 / 20; Maintenance 6 / 10; Aesthetics 20 / 20; Cost 13 / 30; Total 67 / 100	Recommended as an alternative on aesthetics view point as it is located in urban area

Source: JICA Study Team

Table 7.9.13 Comparison of Bridge Types for Jeneberang No.2 Bridge

	Layout of Jeneberang No2 Bridge (Bridge No 2-10)	Evaluation
Alternative 1 PC 12span I Girder Bridge		**Best option**
Alternative 2 PC 9span I Girder Bridge		Not recommended
Alternative 3 Nielsen-Lohse Bridge		Recommended as an alternative on aesthetics view point as it is located in urban area

Alternative 1

Alternative 1 is PC I girder bridge. The main girder (length: 33.0m) can be controlled easily to ensure quality since it is a manufactured structure, but its transportation to the site is required. Cantilever abutment, single column pier and bored pile foundation are adopted for substructures since local contractors have much experience in the construction of this type. The total construction cost is the least.

Cost Estimate		(Thousand Rupia)
(1) Superstrucure		52,266,000
(2) Substructure		13,515,000
(3) Foundation		9,346,000
TOTAL	100%	75,127,000

Stability	Construction	Maintenance	Aesthetics	Cost	Total
16 / 20	16 / 20	8 / 10	6 / 20	30 / 30	76 / 100

Alternative 2

Alternative 2 is PC I girder bridge with a longer span. The main girder (length: 44.0m) can be controlled easily to ensure quality since it is a manufactured structure, but its transportation to the site is required. However, since the girder is long, construction is difficult. As for substructures, the same construction method as that for Alternative 1 is adopted.

Cost Estimate		(Thousand Rupia)
(1) Superstrucure		74,103,000
(2) Substructure		10,689,000
(3) Foundation		10,548,000
TOTAL	127%	95,340,000

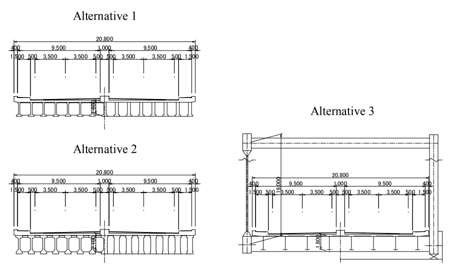
Stability	Construction	Maintenance	Aesthetics	Cost	Total
16 / 20	14 / 20	8 / 10	8 / 20	24 / 30	70 / 100

Alternative 3

Alternative 4 is Niesel-Lohse bridge. The main girder (length: 130.4m) is excellent in the quality aspect since it is manufactured at factory, but its transportation to the site is required. Construction materials are to be procured overseas. Since the span length is long, construction is difficult.The total construction cost is the highest.

Cost Estimate		(Thousand Rupia)
(1) Superstrucure		162,831,000
(2) Substructure		6,720,000
(3) Foundation		5,200,000
TOTAL	233%	174,751,000

Stability	Construction	Maintenance	Aesthetics	Cost	Total
18 / 20	10 / 20	6 / 10	20 / 20	13 / 30	67 / 100



Source: JICA Study Team

Summary of evaluation of alternative bridge types are indicated in Tables 7.9.14 – 7.9.17.

Table 7.9.14 Alternative Bridge Type Evaluation for Maros Bridge

Bridge Length: 126m

Area / Alternative	Structure Types	Span	Stability	Construction	Maintenance	Aesthetics	Cost	Total
Urban			20%	20%	10%	20%	30%	100%
Alternative 1	PC I Girder	31.5m x 4	16%	16%	8%	6%	30%	76%
Alternative 2	PC I Girder	42m x 3	16%	14%	8%	8%	24%	70%
Alternative 3	Steel I Girder	42m x 3	18%	15%	6%	8%	20%	67%
Alternative 4	Nielsen Lose (Arch)	126m	18%	10%	6%	20%	13%	67%

Table 7.9.15 Alternative Bridge Type Evaluation for Jeneberang No. 1 Bridge

Bridge Length: 154m

Area / Alternative	Structure Types	Span	Stability	Construction	Maintenance	Aesthetics	Cost	Total
Rural			20%	20%	10%	10%	40%	100%
Alternative 1	PC I Girder	30.8m x 5	12%	16%	8%	4%	40%	80%
Alternative 2	PC I Girder	38.5m x 4	12%	14%	8%	5%	39%	78%
Alternative 3	Steel I Girder	38.5m x 4	14%	14%	6%	5%	29%	68%

Source: JICA Study Team

Table 7.9.16 Alternative Bridge Type Evaluation for Tallo Bridge

Bridge Length: 136m

Area / Alternative	Structure Types	Span	Stability	Construction	Maintenance	Aesthetics	Cost	Total
Urban			20%	20%	10%	20%	30%	100%
Alternative 1	PC I Girder	34m x 4	16%	16%	8%	6%	30%	76%
Alternative 2	PC I Girder	45m+46m+45m	16%	14%	8%	8%	24%	70%
Alternative 3	PC Box Girder	38m+60m+38m	16%	12%	8%	12%	20%	68%
Alternative 4	Nielsen Lose (Arch)	136m	18%	10%	6%	20%	13%	67%

Source: JICA Study Team

Table 7.9.17 Alternative Bridge Type Evaluation for Jeneberang No. 2 Bridge

Bridge Length: 393m

Area / Alternative	Structure Types	Span	Stability	Construction	Maintenance	Aesthetics	Cost	Total
Urban			20%	20%	10%	20%	30%	100%
Alternative 1	PC I Girder	31mx2+33mx10	16%	16%	8%	6%	30%	76%
Alternative 2	PC I Girder	42mx2+44mx7	16%	14%	8%	8%	24%	70%
Alternative 3	Nielsen Lose (Arch)	130mx3	18%	10%	6%	20%	13%	67%

Source: JICA Study Team

Based on the results of comparison study, the PC-I girder was selected as the most appropriate type on its economic advantage and construction efficiency. However, it would be possible to select arch bridge by giving priority on aesthetic aspects. Though construction cost of PC arch and steel arch is approximately 200% and 230% higher than PC I girder, their advantage might be justified as a monument in the case of urban roads. The economic indicators (EIRR, NPV, B/C) would not be influenced much by bridge type as the project is evaluated as road development project.

7.9.5 Minor Bridges

(1) Selection of Structure Type

The most economical and common structure types in Indonesia are box-culverts for less than 10m span, PC hollow slab bridge for span length of 10-16m and PC I girder bridge for 16 - 35 m span. A span length is predefined by the superstructure type. **Table 7.9.18** shows the general applicable span length for various superstructure types. PC I girders and box-culverts are used according to this table.

Table 7.9.18 Applicable Span Length and Bridge Type for Minor Bridges

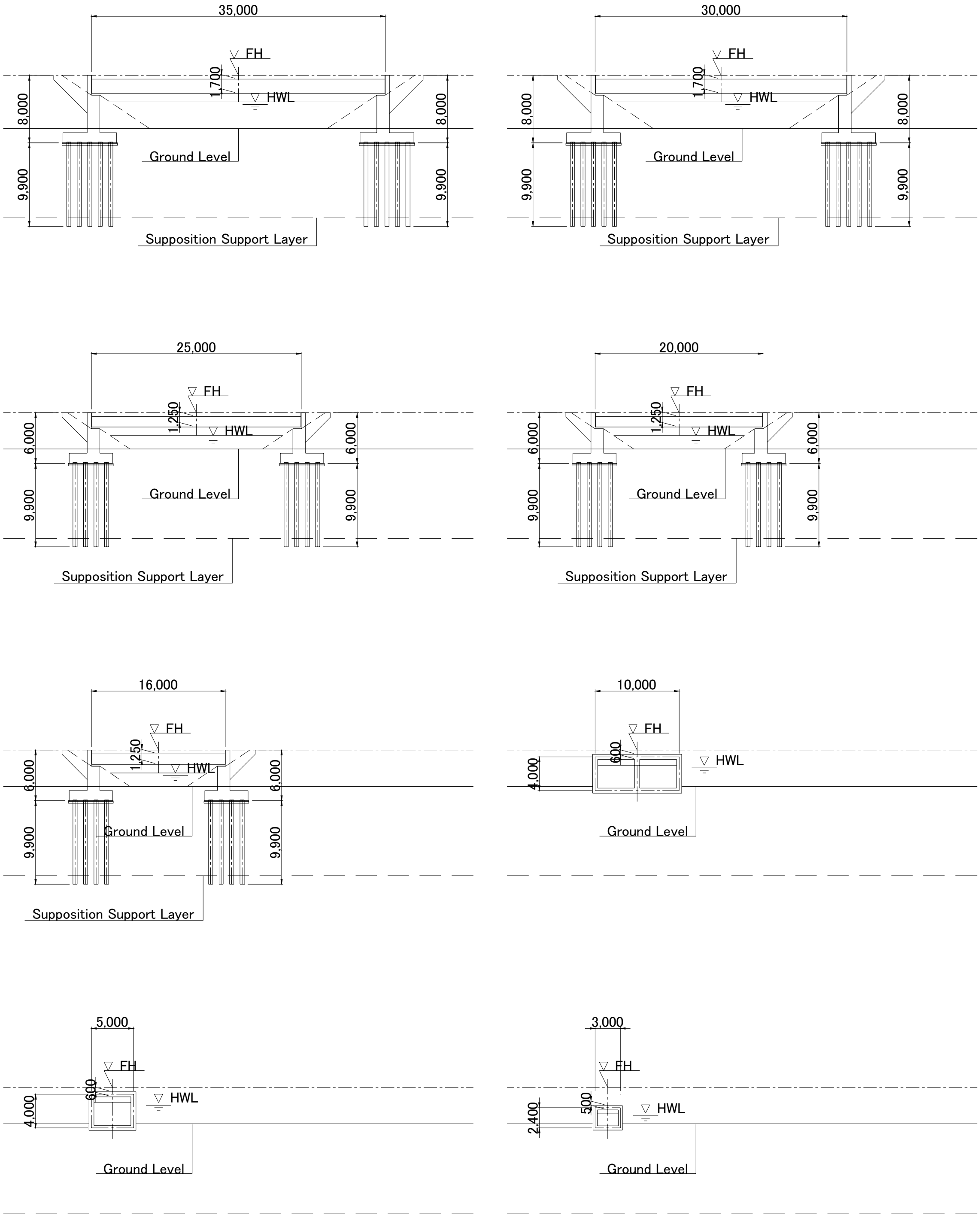
Bridge Type		Applicable Span Length (m)					
		0	20	40	60	80	100
RC	Box Culvert						
PC	Hollow Slab						
PC	I Girder						
Steel	I Girder						
Steel	Truss						

Source: JICA Study Team

Abutments of reversed T type were applied for the substructure of minor bridges. Pile foundation was selected because the depth of the bearing stratum is approximately from 10 to 30 m. PC pile was selected as the type of foundation from both economical aspect and engineering practice in the project area.

(2) Bridge Layout Plan

Five bridge span lengths of 35m, 30m, 25m, 20m and 16m were planned for minor bridges and three span lengths of 10m, 5m and 3m were planned for box culverts (refer to Figure 7.9.12).



Source: JICA Study Team

Figure 7.9.12 Standard Layout of Minor Bridges and Box Culverts

7.10 Preliminary Design of F/S Roads

7.10.1 General

The Study Team has designed roadways, intersections, bridges, pavement, drainage and other structures for the F/S roads in accordance with the design standards, road development concept, and route alignments established in Sections 7.4 – 7.9. The engineering design was based on the results of natural condition survey (topography, hydrology and geotechnical conditions) and their analysis. Overall accuracy of preliminary designs is within 10 - 15% allowable for the F/S stage.

The design results are reflected to the Drawings in Volume 2-2 (Preliminary Design Drawings). The road sections which are currently under execution or going to be implemented by 2010 by DGH and/or regional governments were not included in the preliminary design.

7.10.2 Roadways

The preliminary design of roadways was made for the Trans-Sulawesi Mamminasata Road, Mamminasa Bypass, Hertasning Road and Abdullah Daeng Sirua Road on the topographic survey maps. Topographic survey data, including the photo-mosaic of the road from aerial survey, were calibrated when drawing the horizontal alignments on the topographic maps. Digital Terrain Model was then prepared from the cross section survey point data and contours from ortho-photo after creating 3-dimensional features like existing road, existing ditches, canal, etc. and other road features. Typical cross section templates for the FS road were created and used for calculating the earthworks and other works quantities.

(1) Preliminary Design of Horizontal Alignment

1) Trans-Sulawesi Mamminasata Road

The project road alignment starts at Maros about 900 m south of the existing Maros Bridge on national road. Horizontal alignment design of Section-A of the Trans-Sulawesi Road follows the existing road, since the Right-of-Way has already been fixed at 21m on each side of the existing center-line (42m in total). As the existing road alignment fairly complies with the minimum design speed of 60 km/hr, modification of the existing alignment is not required. The total length of the road from the beginning point to the intersection with Ir Sutami Toll Road is about 8.7km. The road length from Ir Sutami Toll Road intersection to the beginning of Section-B on Perintis Kemerdekaan Road is about 10.3km, which will be widened from 4 lanes to 6 lanes with central median under ongoing projects of DGH. From Ir Sutami Toll Road intersection to Daya intersection (Sta.14+100) of Perintis Kemerdekaan Road (a part of Trans-Sulawesi Section-A) will however be winded from then 6 lanes to 8 lanes in the future.

Land acquisition has been in progress for Section-B of the Trans-Sulawesi Road (Middle Ring Road). The limits of ROW were obtained from the topographic survey and information of the ROW drawings from Dinas PU Makassar. The horizontal alignment was designed based on these data. Some adjustments will be required during the detailed design stage, especially at sharp curves. The total length of Section-B is about 7.3km from Sta.18+960 to Sta.26+300.

The road alignment in Section-C basically followed the route alignment established on Google maps during the route selection stage, except some minor modifications made as results of topographic survey and minimizing resettlement along the route. The total length of this section is about 8.6km from Sta.26+300 to Sta.34+900.

Section-D is basically widening of the existing national road from 2 lanes to 4 lanes. It passes through semi-urban to rural areas except a few locations, where it passes through urbanized areas. The most important control point in this section is the existing irrigation canal on the left side of the road. The distance of the canal from the road edge varies. In order to minimize land acquisition, avoid relocation of the canal and utilize the existing road width maximum, utmost care was given in the alignment design. Where the canal is close to the edge of the existing road, the new centerline is designed such that the edge of the existing road and that of the new road left travelway coincide on the left. Similarly, where the canal is relatively far from the existing road, the land between the existing road and the canal is utilized to reduce resettlement of houses on the opposite side. On the other hand, where the road passes through urban areas, the design centerline basically follows the existing centerline. The total length of this section is about 22.35km from Sta.30+000 to Sta.57+350 in the Takalar Town center.

2) Mamminasa Bypass

<u>North Section</u>

The project road alignment starts from national road in Maros about 1,800 m north of the existing Maros Bridge. Horizontal alignment design of the north section of the Mamminasa Bypass complied with the design speed of 60 - 80 km/hr since these are new road alignment and not restricted by the existing road. Major control points are a flood retarding basin at Maros, a crossing point of the Maros River, and connection points to the national road. The horizontal alignment is designed to avoid the planned flood retarding basin. It passes behind of the Bupati's office (Office of Regency Governor) after crossing the Maros River. This route also crosses the national road going to the east coast (Watampone / Bjoe Port). Through traffic to and from the north and the east will use this road as a bypass (Maros Town Bypass). The total length of the road from the beginning point to the intersection with the national road is about 5.6km. The north section will be developed to 4 lanes with 10.5m median which is reserved for future 6 lanes widening.

<u>Middle Section</u>

Horizontal alignment design of Middle Section of the Mamminasa Bypass is complied with the design speed of 60 – 80 km/hr, since this is new road alignment. Major control points are Kariango Hill (elevation 115 m), Kostrad Kariango (army quarters), a new runway for Hasanuddin Airport and Mt. Moncongloe (elevation 314 m). The horizontal alignment of the Middle Section was designed to avoid these control points and the alignment was designed passing through a rolling land (elevation 20-40m) of approximately 4,000 ha at the Makassar side of Mt. Moncongloe on where a new satellite town development is planned as suggested in the Mamminasata Plan (refer to Section 4.5 of this Report). The total length of the Middle Section is 27.0 km up to Jl Malino and it will be developed to 4 lanes with 10.5m median reserved for future widening.

South Section

Horizontal alignment design of South Section of the Mamminasa Bypass is complied with the design speed of 60 - 80 km/hr, since all alignments are new. The South Section is about 16.7 km in length and it starts at Jl Malino, crossing the Jeneberang River, crossing national road at Boka approximately 5.3 km south of the Sungguminasa Bridge and ends at Tj Bunga-Takalar road. There are no major control points except Jeneberang River crossing point. The horizontal alignment is designed to minimize resettlement. The South Section will be developed to 4 lanes with 10.5m median reserved for future widening.

3) Hertasning Road

Hertasning Road is divided into four (4) sections. Preliminary design was carried out only for Section D because Sections A, B and C have been implemented by Provincial Government. Horizontal alignment design of the Section D follows the existing road. As the existing road alignment mostly complies with the design speed of 60 km/hr. The total length of Section D is about 4.9 km and the existing road will be widened from 2 lanes to 4 lanes with 4 m median.

4) Abdullah Daeng Sirua Road

Makassar City Section (Sections A, C and D)

Abdullah Daeng Sirua Road is divided into six (6) sections. Sections A-D are in the Makkassar City and Sections E and F are in the Maros and Gowa Regencies. Horizontal alignment of Section A follows existing road. As the existing road alignment mostly complies with the design speed of 60 km/hr, modification of the alignment is not required. However, Section A is difficult to widen the existing 2 lanes to 4 lanes without a land adjustment method and, therefore, the existing 2-lane will be used with one-way traffic control in the short to middle term.

The existing road in Section B is located on the south side of the PDAM canal. A new 2-lane road is under construction by Makassar City and, therefore, this section was excluded from the F/S.

Horizontal alignment of Section C follows existing road. As the existing road alignment mostly complies with the design speed of 60 km/hr, modification of the existing alignment is not required.

Section D is 2-lane road along the ROW of PDAM and the existing road. Two methods are adopted. One is to construct a new road opposite the PDAM canal and the other is to construct a new road over the PDAM canal replacing it with concrete lined steel pipes (Dia.1200mm x 2 pieces). The section from Sta. 3+850 to Sta. 4+400 is designed as a new road opposite the PDAM canal to conserve water frontage environment. The section from Sta. 4+400 to Sta. 6+100 is designed with concrete lined steel pipes to minimize resettlement. After these subsections, horizontal alignment of Section D follows existing road and some resettlements are required. As the existing road alignment mostly complies with the design speed of 60 km/hr, modification of the existing alignment is not required.

Maros and Gowa Regency Section (Sections E and F)

The section starts from the Tallo River Bridge where the Makassar – Maros boarder exist. Horizontal alignment of Section E follows existing road and straight embankment section. The existing alignment can be used.

Section F is the end section of Abdullah Daeng Sirua Road. The road will be connected to a satellite town as its direct access road. The road meets the Mamminasa Bypass at the middle of this section and it also connects to KIWA. Horizontal alignment of Section E was designed to minimize resettlement.

(2) Preliminary Design of Vertical Alignment

1) Trans-Sulawesi Mamminasata Road

Section-A of the Trans-Sulawesi Road will be constructed by widening the existing road and, therefore, following the existing road profile with additional height (thickness) for pavement overlay. Since the design centerline also follows the existing centerline, profile correction for pavement cross slope is not required. The existing profile complies with the design speed of 60 km/hr and no modification is required.
Section-B is a new construction. The profile of the initial section is controlled by the existing road level at Jl Perintis Kemerdekaan (Sta.19+100), the bridge elevation over the Tallo River (Sta.19+600), the existing road level of Abdullah Daeng Sirua Road (Sta.20+300) just after the bridge, Hertasning Road (Sta.23+900), several other crossing roads, and finally by the level of the flyover (26+200) at the end of section of Jl Sultan Alauddin. The embankment is 4.5m high in stretch of about 500m after the Tallo Bridge up to Abdullah Daeng Sirua Road on average to cross the Tallo River basin. The average embankment height in the stretch from Abdullah Daeng Sirua Road to Hertasning Road is 2m to 3m. The rest of section has an average embankment height of 0.5m to 1m.

The profile grade at the beginning of Section C is controlled by the profile of the flyover at Sultan Alauddin Road and the Jeneberang Bridge (Sta.26+700). Section-C passes through paddy field and the average embankment height is 0.5m to 1m.
Section D is a widening section of the existing national road and hence its profile mostly follows the existing road elevations.

2) Mamminasa Bypass

Mamminasa Bypass is a new construction and located in flat terrain. The profile grade of the North Section is controlled by the existing national road (Sta.0+000) and elevation of the Maros River Bridge. The average embankment height of the North Section is 1.0m to 1.5m.
The Middle Section mostly passes through paddy field and the average embankment height is 0.5m to 1m. The profile grades for some sections are controlled by rolling terrains located at Sta.17+850, Sta.18+950, Sta.19+650 and a bridge at Sta.23+400. The maximum profile grade of 5% is adopted for these sub-sections.
The South Section is controlled by profile grade at the bridge over the Jeneberang River and the existing road level at the Trans-Sulawesi Road (Sta.43+650). The average embankment height is 0.5m to 1.5m.

3) Hertasning Road

The profile grade of Section D of Hertasning Road is constructed by widening the existing road and, therefore, mostly follows the existing road profile. The existing profile complies the design speed of 60 km/hr and no modification is required.

4) Abdullah Daeng Sirua Road

Section A of Abdullah Daeng Sirua Road is use of the existing 2 lanes as it is since 4 lane widening is difficult except a short stretch of the end section.
Sections C, D and E of Abdullah Daeng Sirua Road are widening the existing road or construction of additional 2 lanes on PDAM canal, running in parallel with the existing road. Therefore, profile is basically follows the existing road. The existing profile complies with requirements for the design speed of 60 km/hr and no modification is required.
Section F passes through paddy or crop field and the average embankment height is 0m to 1.0m. The profile grade of some sections is controlled by rolling terrains at Sta.13+700, Sta.14+050 and Sta.14+950. The profile grade of 3% to 5% is used for these sections.

(3) Preliminary Design of Cross Section

1) Trans-Sulawesi Mamminasata Road

For the subsection from Maros to Jl Tol Ir Sutami IC in Section A, typical cross section has 6 lanes (3 lanes for each direction) by widening of existing road. Lane arrangements consist of a lane width of 3.5m x 6 lanes, planting zone of 1.5m, sidewalk of 3m and drainage on both sides, based on the Standard Specifications for Geometric Design of Urban Roads of Indonesia, as presented earlier in Section 7.5. The ROW is 42m, 21m on each side from the road centerline. Future widening to 8 lanes can be made by covering the drainage channel and using it as sidewalk.

The ROW for Section B, Middle Ring Road is 40m and land acquisition has been in progress. Typical cross section for this section is designed with stage construction approach. In the first stage, 6 lanes are constructed with wide median, which can be reduced to a standard width of 3m, when widening the road to 8 lanes in the future. In order to fit the cross section within the ROW, two of the outside lanes are designed with a lane width of 3.25m. Sidewalk is provided by covering the drainage.

Construction of Section C, Middle Ring Approach is also based on stage construction approach. In the first stage, 4 lanes (2 lanes in each direction) are constructed with a wide median. Widening to 6 lanes in future can be made by widening the road to inside.
Design cross sections in Section D require careful planning because of the existing canal. Three typical cross sections are designed. When the road passes through urban areas and the existing canal is located far from the road, widening to 4 lanes is made by widening on both sides. When the existing road is close to the canal, widening is made on the opposite side of existing canal. On the other hand, when the existing road is relatively far from the canal and enough space is available between the existing road and the canal, widening is made in the canal side. Relocation of existing canal is avoided in all cases.

2) Mamminasa Bypass

As the Mamminasa Bypass is new construction, a typical cross section was used with 4 lanes (2 lanes in each direction). Lane arrangements are made with a lane width of 3.5m, planting zone of 1.0m, sidewalk of 3m and drainage on both sides, based on the Standard Specifications for Geometric Design of Urban Roads of Indonesia. The ROW is 40m. A wide median of 10.5m is provided for future widening to 6 lanes by using this median.

3) Hertasning Road

Typical cross section for Section D of Hertasning Road is widening to 4 lanes (2 lanes in each direction). Lane arrangements are 3.5m x 4 lanes, planting zone of 1.5m, sidewalk of 3m and drainage on both sides within 34m ROW, based on the Standard Specifications for Geometric Design of Urban Roads.

4) Abdullah Daeng Sirua Road

Three typical cross sections are designed for Abdullah Daeng Sirua Road. A typical cross section for general application consists of 4 lanes (2 lanes in each direction). Lane arrangements are made with 3.5m x 4 lanes, sidewalk of 3m and drainage on both sides within the 25m ROW.

A typical cross section for part of the Section C from Sta. 3+850 to Sta. 4+400 consists of 2 new lanes (2 lanes in each direction together with the existing road) with a lane width of 3.5m x 4 and sidewalk of 3m x 2 and covered drainage within the 15m ROW. A typical cross section for part of the Sections C and D from Sta. 4+400 to Sta. 6+100 has 4 lanes (2 lanes in each direction). Lane arrangement is a lane width of 3.5m x 4 and sidewalk of 3m x 4, constructed on the canal replaced by concrete lined steel pipes, within the 25m ROW. These typical cross sections are based on the Standard Specifications for Geometric Design of Urban Roads of Indonesia.

7.10.3 Intersections

Preliminary design of intersections on the Trans-Sulawesi Mamminasata Road and the Mamminasa Bypass were conducted based on topographic survey, traffic forecasts and road alignment design.

(1) List of Intersections

1) Trans-Sulawesi Mamminasata Road

A total of six major intersections are located along the Trans-Sulawesi Mamminasata Road as listed in **Table 7.10.1**. Five intersections were designed as shown in the following table.

Table 7.10.1 List of Intersections on Trans-Sulawesi Mamminasata Road

S.N.	ID	Location	Current Station	No.of Legs	Remarks
1	TS-1	Existing National Road (Sungguminasa – Takalar Road)	34+840	3	At-grade with signal control
2	TS-2	Existing National Road (Sultan Alauddin Road)	26+200	6	At-grade with flyover for Trans-Sulawesi Road
3	TS-3	Hertasning Road	23+900	4	At-grade with signal control
4	TS-4	Abdullah Daeng Sirua Road	20+325	4	At-grade with signal control
5	TS-5	Perintis Kemerdekaan Road	19+100	3	At-grade with signal control
--	TS-6	Ir. Sutami Toll Road	8+700	4	Flyover and at grade under on-going BOP project

There are two flyover intersections crossing at Ir Sutami Toll Road and Sultan Alauddin Road. As the flyover of Ir Sutami Toll Road is constructed by the on-going BOT project, it was excluded in this FS preliminary design.

2) Mamminasa Bypass

A total of five major intersections were identified on the Mamminasa Bypass as listed in **Table 7.10.2**. In the preliminary design of the Mamminasa Bypass, five intersections were considered as shown in the following table.

Table 7.10.2 List of Intersections on Mamminasa Bypass

S.N	ID	Location	Current Station	No.of Legs	Remarks
1	TS-7	Mamminasa Bypass(South) at national road of Maros-Pangkep	0+000	3	At-grade with signal control
2	TS-8	Mamminasa Bypass(North) at national road of Makassar-Maros	0+000	3	At-grade with signal control
3	MB-1	Hertasning Road	27+100	4	Roundabout
4	MB-2	Abdullah Daeng Sirua Road	23+350	4	Roundabout
5	MB-3	National Road	2+630	4	At-grade with signal control

(2) Results of Traffic Forecast at Intersections

1) Trans-Sulawesi Mamminasata Road

The results of traffic forecast for the intersections on the Trans-Sulawesi Mamminasata Road are shown in **Figure 7.10.1**. The results are shown in PCU/day for combined all vehicles for the year 2023.

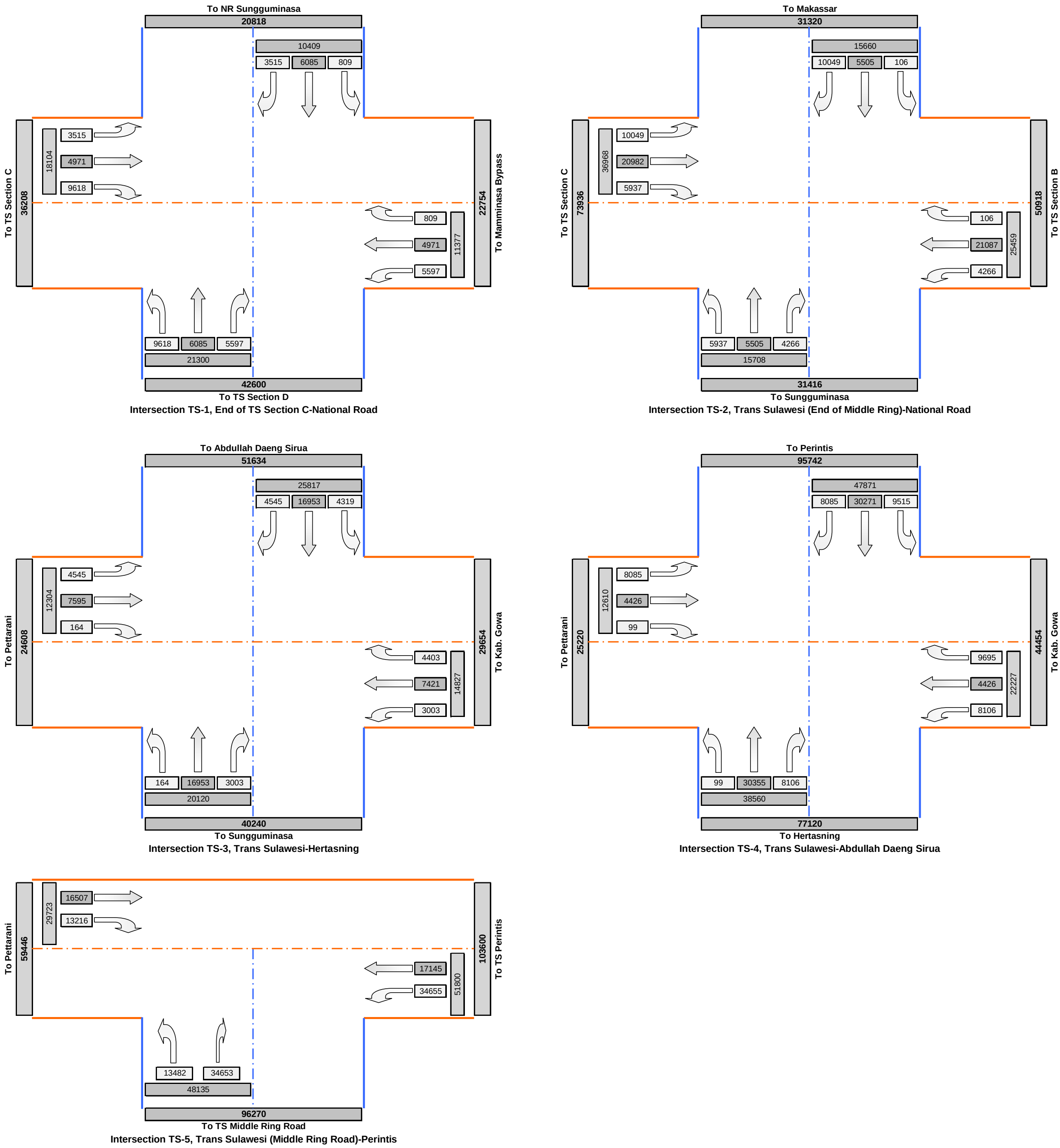


Figure 7.10.1 Traffic Volume at Intersections on Trans-Sulawesi Road (PCU/day, 2023)

Preliminary design and capacity analysis of intersections on the Trans-Sulawesi Road were conducted using the Indonesian Highway Capacity Manual. The results of analysis are shown in **Table 7.10.3**. Actual phasing pattern and cycle time should be designed during the detailed design stage. The tentative number of phases as shown on the table was used for the analysis.

Table 7.10.3 Results of Intersections Capacity Analysis for Trans-Sulawesi Mamminasata Road

Intersection TS-1, End of TS Section C/ Section D
PHF = 0.1 for City<1M 3-Phases

From Leg	Direction	To	PCU/hr	Phase	PCUrev	RT lane	Prot/Opp	We	Qrt	Qrto	So	Fcs	Fsf	Fg	Fp	Frt	S	g/c	C	No of Lanes		Round	DegSat	Remarks
TS Section D	Left	TS Section C	962	0	962	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.51		1	0.51	
	Straight	Sungguminasa	609	1	1169	y	o	10.5	250	250	4025	0.94	0.95	1	1	1	3594	0.46	1653	2.12	1.11	1	1.11	
	Right	Mamminasa BP	560	1		y	o	10.5	250	250	4025	0.94	0.95	1	1	1					1.02	1	1.02	RT lane only
TS Section C	Left	Sungguminasa	352	0	352	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.19		1	0.19	
	Straight	Mamminasa BP	497	2	497	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	0.14	263	1.89		2	0.95	
	Right	TS Section D	962	3	962	y	p	3.5	0	0	2100	0.94	0.95	1	1	1.33	2490	0.40	996	0.97		1	0.97	RT lane only
NR Sungguminasa	Left	Mamminasa BP	81	0	81	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.04		1	0.04	
	Straight	TS Section D	609	1	961	y	o	7	250	250	2500	0.94	0.95	1	1	1	2233	0.46	1027	1.87	1.19	1	1.19	
	Right	TS Section C	352	1		y	o	7	250	250	2500	0.94	0.95	1	1	1					0.69	1	0.69	RT lane only
Mamminasa BP	Left	TS Section D	560	0	560	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.30		1	0.30	
	Straight	TS Section C	497	2	497	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	0.14	263	1.89		2	0.95	
	Right	Sungguminasa	81	3	81	y	p	3.5	0	0	2100	0.94	0.95	1	1	1.33	2490	0.40	996	0.08		1	0.08	RT lane only

Intersection TS-2, End of Middle Ring Road/ National Road
PHF = 0.085 for City>1M 3-Phases

From Leg	Direction	To	PCU/hr	Phase	PCUrev	RT lane	Prot/Opp	We	Qrt	Qrto	So	Fcs	Fsf	Fg	Fp	Frt	S	g/c	C	No of Lanes		Round	DegSat	Remarks
Sungguminasa	Left	TS Section C	505	0	505	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.27		1	0.27	
	Straight	Makassar	468	1	468	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	0.25	469	1.00		1	1.00	
	Right	TS Section B	363	2	363	y	p	3.5	0	0	2100	0.94	0.95	1	1	1.33	2490	0.35	871	0.42		1	0.42	
TS Section C	Left	Makassar	854	0	854	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.46		1	0.46	
	Straight	TS Section B	1783	3	2288	y	o	10.5	250	10	5200	0.94	0.95	1	1	1	4644	0.40	1857	3.70	2.88	2	1.44	2-lane Flyover
	Right	Sungguminasa	505	3		y	o	10.5	250	10	5200	0.94	0.95	1	1	1					0.82	1	0.82	
Makassar	Left	TS Section B	9	0	9	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.00		1	0.00	
	Straight	Sungguminasa	468	1	468	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	0.25	469	1.00		1	1.00	
	Right	TS Section C	854	2	854	y	p	3.5	0	0	2100	0.94	0.95	1	1	1.33	2490	0.35	871	0.98		1	0.98	
TS Section B	Left	Sungguminasa	363	0	363	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.19		1	0.19	
	Straight	TS Section C	1792	3	1801	y	o	13	10	250	4500	0.94	0.95	1	1	1	4019	0.40	1607	4.48	4.46	3	1.49	2-lane Flyover
	Right	Makassar	9	3		y	o	13	10	250	4500	0.94	0.95	1	1	1					0.02	1	0.02	

Intersection TS-3, Middle Ring Road/ Hertasning
PHF = 0.085 for City>1M 2-Phases

From Leg	Direction	To	PCU/hr	Phase	PCUrev	RT lane	Prot/Opp	We	Qrt	Qrto	So	Fcs	Fsf	Fg	Fp	Frt	S	g/c	C	No of Lanes		Round	DegSat	Remarks
Sungguminasa	Left	Pettarani	14	0	14	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.01		1	0.01	
	Straight	Abdullah D S	1441	1	1696	y	o	10.5	250	250	4025	0.94	0.95	1	1	1	3594	0.65	2336	2.18	1.85	2	0.93	
	Right	Kab. Gowa	255	1		y	o	10.5	250	250	4025	0.94	0.95	1	1	1					0.33	1	0.33	RT lane only
Pettarani	Left	Abdullah D S	386	0	386	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.21		1	0.21	
	Straight	Kab. Gowa	646	2	660	y	o	10	0	250	3125	0.94	0.95	1	1	1	2791	0.35	977	2.03	1.98	2	0.99	
	Right	Sungguminasa	14	2		y	o	10	0	250	3125	0.94	0.95	1	1	1					0.04	1	0.04	RT lane only
Abdullah Daeng Si	Left	Kab. Gowa	367	0	367	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.20		1	0.20	
	Straight	Sungguminasa	1441	1	1827	y	o	10.5	250	250	4025	0.94	0.95	1	1	1	3594	0.65	2336	2.35	1.85	2	0.78	
	Right	Pettarani	386	1		y	o	10.5	250	250	4025	0.94	0.95	1	1	1					0.50	1	0.78	RT lane only
Kab. Gowa	Left	Sungguminasa	255	0	255	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.14		1	0.14	
	Straight	Pettarani	631	2	1005	y	o	10	250	0	4950	0.94	0.95	1	1	1	4420	0.35	1547	1.95	1.22	2	0.61	
	Right	Abdullah D S	374	2		y	o	10	250	0	4950	0.94	0.95	1	1	1					0.73	1	0.73	RT lane only

Intersection TS-4, Middle Ring Road/ Abdullah Daeng Sirua
PHF = 0.085 for City>1M 2-Phases

From Leg	Direction	To	PCU/hr	Phase	PCUrev	RT lane	Prot/Opp	We	Qrt	Qrto	So	Fcs	Fsf	Fg	Fp	Frt	S	g/c	C	Lanes		Round	DegSat	Remarks
Hertasning	Left	Pettarani	8	0	8	y	p	3.5	0	0	2100	0.94	0.95	1	1	1						0	1.05	share with ST
	Straight	Perintis	2580	1	3269	y	o	14	250	250	5125	0.94	0.95	1	1	1	4577	0.72	3295	3.98	3.14	3	1.05	extra lane needed
	Right	Kab. Gowa	689	1		y	o	14	250	250	5125	0.94	0.95	1	1	1					0.84	1	0.84	RT lane
Pettarani	Left	Perintis	687	0	687	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.37		1	0.37	
	Straight	Kab. Gowa	376	2	384	y	o	10	10	250	3150	0.94	0.95	1	1	1	2813	0.28	788	1.39	1.43	2	0.72	
	Right	Hertasning	8	2		y	o	10	10	250	3150	0.94	0.95	1	1	1					0.03	1	0.03	RT lane only
Perintis	Left	Kab. Gowa	809	0	809	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.43		1	0.43	
	Straight	Hertasning	2573	1	3260	y	o	10.5	250	250	4025	0.94	0.95	1	1	1	3594	0.72	2588	3.78	2.98	3	0.99	extra lane needed
	Right	Pettarani	687	1		y	o	10.5	250	250	4025	0.94	0.95	1	1	1					0.80	1	0.80	RT lane
Kab. Gowa	Left	Hertasning	689	0	689	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.37		1	0.37	
	Straight	Pettarani	376	2	1200	y	o	10	250	10	3150	0.94	0.95	1	1	1	2813	0.28	788	4.35	1.43	2	1.14	1share with RT
	Right	Perintis	824	2		y	o	10	250	10	3150	0.94	0.95	1	1	1					3.14	2	1.14	1 share with ST

Intersection TS-5, Middle Ring Road/ Perintis
PHF = 0.085 for City>1M 3-Phases

From Leg	Direction	To	PCU/hr	Phase	PCUrev	RT lane	Prot/Opp	We	Qrt	Qrto	So	Fcs	Fsf	Fg	Fp	Frt	S	g/c	C	No of Lanes		Round	DegSat	Remarks
TS Middle Ring	Left	Pettarani	1146	0	1146	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.61		1	0.61	
	Right	TS Perintis	2946	1	2946	y	p	3.5	0	0	2100	0.94	0.95	1	1	1.33	2490	0.40	996	2.96		3	0.99	2+1 RT lane
Pettarani	Straight	TS Perintis	1403	0	1403	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	0.75		2	0.37	
	Right	TS Middle Ring	1123	3	1123	y	p	3.5	0	0	2100	0.94	0.95	1	1	1.33	2490	0.20	498	2.26		2	1.13	2 RT lane
TS Perintis	Left	TS Middle Ring	2946	0	2946	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1875	1.57		2	0.79	
	Straight	Pettarani	1457	2	1457	y	p	3.5	0	0	2100	0.94	0.95	1	1	1	1875	0.40	750	1.94		2	0.97	

Note: For details, refer to the Indonesian Highway Capacity Manual

Where,

PCU/rev	=	Revised PCU/hr for phasing pattern, eg, add turning volumes for same phase
Prot/Opp	=	Protected or Opposed
We	=	Approach width in m
Qrt	=	Right-turn traffic volume
Qrto	=	Right-turn traffic volume in opposite direction
So	=	Base Saturation Flow

Fcs	=	Adjustment factor for city size
Fsf	=	Adjustment factor for side friction
Fg	=	Adjustment factor for gradient
Fp	=	Adjustment factor for parking
Frt	=	Adjustment factor for right-turns only for protected approach
S	=	Adjusted flow
g/c	=	Percentage green in each phase
C	=	Capacity for each group in the phase
DegSat	=	Approximate degree of saturation

The number of lanes required for each leg was determined from **Table 7.10.3**. The preliminary lane arrangements for the intersections are shown in **Figure 7.10.2**.

* In the Progress Report (1), TS-5 was recommended as a grade-separated intersection with trumpet type. However, it was modified to at-grade intersection with signal control based. According to the traffic forecast, it can be managed by signal control without the saturation and it will not exceed 1.0 until the year 2023 as shown in **Table 7.10.3**.

* TS-2 with a 2-lane flyover in each direction is recommended for the through traffic on the Trans-Sulawesi Road as analyzed in Section 7.8.

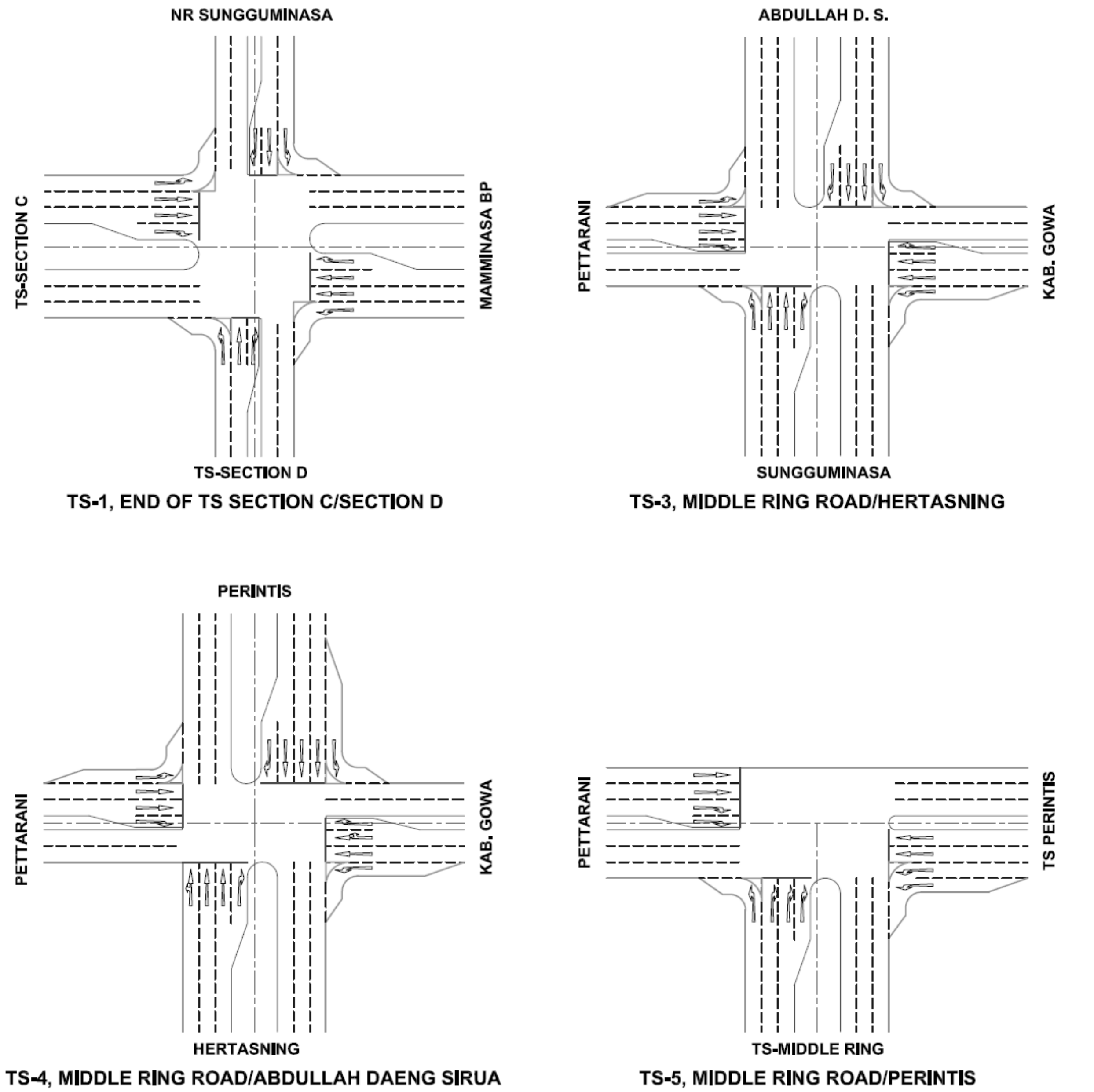


Figure 7.10.2 Lane Arrangements for Major Intersections on Trans-Sulawesi Road

2) Mamminasa Bypass

The results of traffic forecast for the intersections on the Mamminasa Bypass are shown in **Figure 7.10.3**. The forecast traffic volumes are for the year 2023, shown in PCU/day for combined all vehicles.

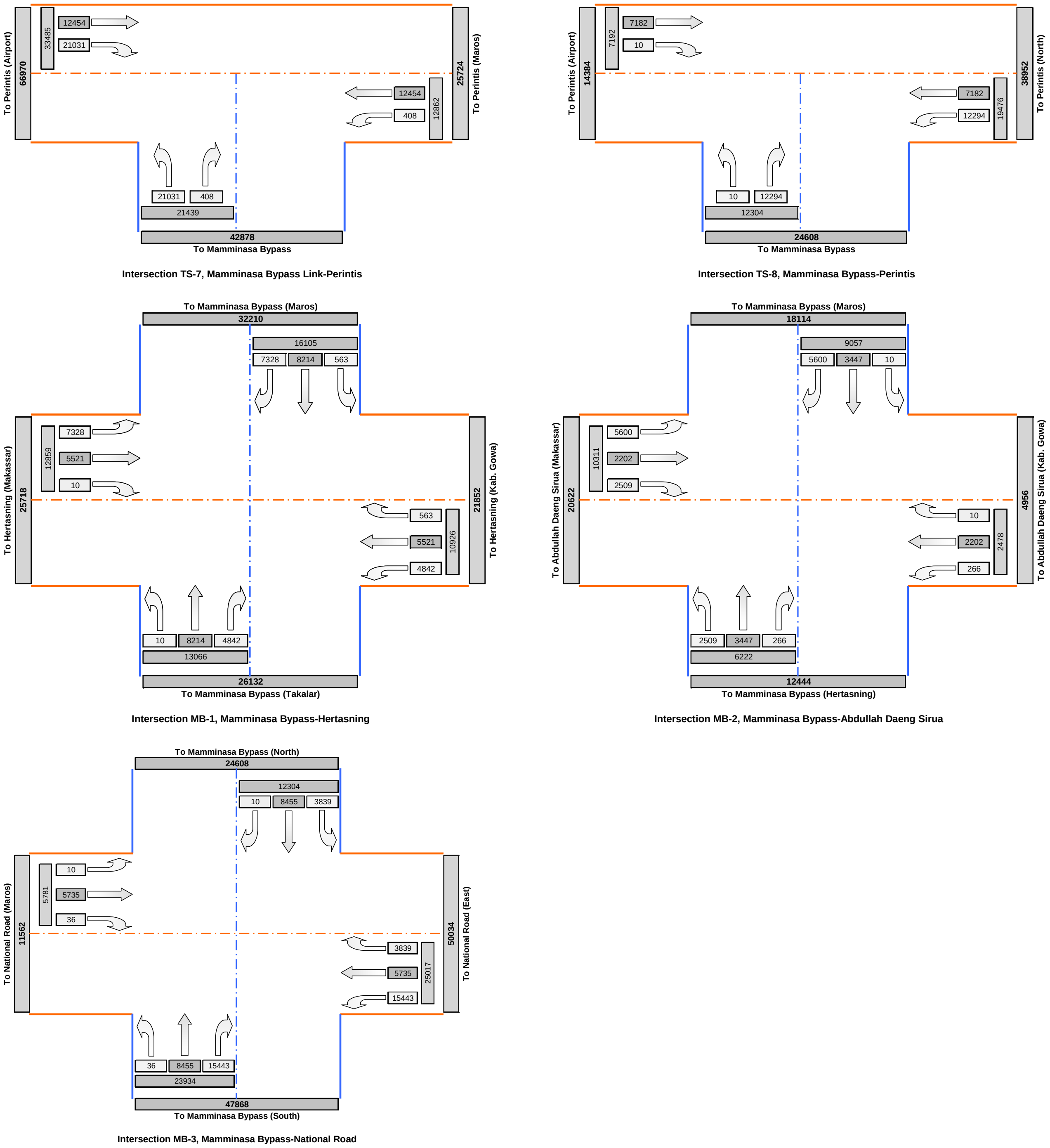


Figure 7.10.3 Traffic Volume at Intersections on Mamminasa Bypass (PCU/day, 2023)

Preliminary design and capacity analysis of intersections on Mamminasa Bypass were conducted by same method with the Trans-Sulawesi Road. However, preliminary design and capacity analysis of MB-1 and MB-2 intersections were conducted as roundabout intersection in accordance with the plan described in Section 7.8. The results of analysis are shown in **Table 7.10.4**. Actual phasing pattern and cycle time shall be designed during the detailed design stage. The tentative number of phases as shown on the table was used for the analysis.

Table 7.10.4 Results of Intersections Capacity Analysis for Mamminasa Road

Intersection TS-7, Mamminasa Bypass Link-Trans Sulawesi
PHF = 0.085 for City>1M 3-Phases

From Leg	Direction	To	PCU/hr	Phase	PCUrev	RT lane	Prot/Opp	We	Lane	Qrt	Qrto	So	Fcs	Fsf	Fg	Fp	Frt	S	Leg %	g/c	C	No of Lanes		Round	DegSat	Remarks
Mamminasa Bypass	Left	Trans Sulawesi (Airport)	1788	0	1788	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.95		1	0.95	
	Right	Trans Sulawesi (Maros)	35	1	35	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	0.01	0.01	23	1.54		2	0.77	
Trans Sulawesi (Airport)	Straight	Trans Sulawesi (Maros)	1059	0	1059	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.56		3	0.19	1 share with RT
	Right	Mamminasa Bypass	1788	2	1788	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	0.62	0.62	1163	1.54		2	0.77	
Trans Sulawesi (Maros)	Left	Mamminasa Bypass	35	0	35	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.02		1	0.02	No LT lane
	Straight	Trans Sulawesi (Airport)	1059	3	1059	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	0.37	0.37	689	1.54		3	0.51	1 share with LT

Intersection TS-8, Mamminasa Bypass-Trans Sulawesi
PHF = 0.085 for City>1M 3-Phases

From Leg	Direction	To	PCU/hr	Phase	PCUrev	RT lane	Prot/Opp	We	Lane	Qrt	Qrto	So	Fcs	Fsf	Fg	Fp	Frt	S	Leg %	g/c	C	No of Lanes		Round	DegSat	Remarks
Mamminasa Bypass	Left	Trans Sulawesi (Airport)	10	0	10	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.01		1	0.01	
	Right	Trans Sulawesi (North)	1045	1	1045	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	0.63	0.63	1177	0.89		1	0.89	
Trans Sulawesi (Airport)	Straight	Trans Sulawesi (North)	610	0	610	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.33		2	0.16	
	Right	Mamminasa Bypass	10	2	10	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.01		1	0.01	
Trans Sulawesi (North)	Left	Mamminasa Bypass	1045	0	1045	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.56		1	0.56	No LT lane
	Straight	Trans Sulawesi (Airport)	610	3	610	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	0.37	0.37	687	0.89		2	0.44	1 share with LT

Intersection MB-3, Mamminasa Bypass-National Road
PHF = 0.085 for City>1M 3-Phases

From Leg	Direction	To	PCU/hr	Phase	PCUrev	RT lane	Prot/Opp	We	Lane	Qrt	Qrto	So	Fcs	Fsf	Fg	Fp	Frt	S	Leg %	g/c	C	No of Lanes		Round	DegSat	Remarks
Mamminasa Bypass (South)	Left	National Road (Maros)	3	0	3	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.00		1	0.00	No LT lane
	Straight	Mamminasa Bypass (North)	719	1	719	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	0.39	0.39	731	0.98		2	0.49	1share with LT
	Right	National Road (East)	1313	2	1313	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1.33	2490	0.34	0.34	846	1.55		2	0.78	
National Road (Maros)	Left	Mamminasa Bypass (North)	10	0	10	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.01		1	0.01	No LT lane
	Straight	National Road (East)	487	3	490	y	o	10	3	0	250	3125	0.94	0.95	1	1	1	2791	0.27	0.27	753	1.86	1.94	2	0.97	1share with RT, 1 share with LT
	Right	Mamminasa Bypass (South)	3	3		y	o	10	3	0	250	3125	0.94	0.95	1	1	1						0.01	1	0.01	No RT lane
Mamminasa Bypass (North)	Left	National Road (East)	326	0	326	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.17		1	0.17	No LT lane
	Straight	Mamminasa Bypass (South)	719	1	719	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	0.39	0.39	731	0.98		2	0.49	1share with LT
	Right	National Road (Maros)	10	2	10	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1.33	2490	0.34	0.34	846	0.01		1	0.01	
National Road (East)	Left	Mamminasa Bypass (South)	1313	0	1313	y	p	3.5	1	0	0	2100	0.94	0.95	1	1	1	1875	1.00	1.00	1875	0.70		1	0.70	
	Straight	National Road (Maros)	487	3	813	y	o	10	3	250	0	4950	0.94	0.95	1	1	1	4420	0.27	0.27	1193	1.95	1.22	2	0.61	
	Right	Mamminasa Bypass (North)	326	3		y	o	10	3	250	0	4950	0.94	0.95	1	1	1						0.82	1	0.82	

Intersection MB-1, Mamminasa Bypass-Hertasning
PHF = 0.1

From Leg	Direction	To	PCU/hr	Leg Total	W	A	K	q	C (q×0.8)	DegSat
Mamminasa Bypass (Takalar)	Left	Hertasning (Makassar)	10	1315	26.5	147.75	60	7039	5631	0.94
	Straight	Mamminasa Bypass (Maros)	821							
	Right	Hertasning (Kab. Gowa)	484							
Hertasning (Makassar)	Left	Mamminasa Bypass (Maros)	733	1295	20.0	147.75				
	Straight	Hertasning (Kab. Gowa)	552							
	Right	Mamminasa Bypass (Takalar)	10							
Mamminasa Bypass (Maros)	Left	Hertasning (Kab. Gowa)	56	1610	26.5	147.75				
	Straight	Mamminasa Bypass (Takalar)	821							
	Right	Hertasning (Makassar)	733							
Hertasning (Kab. Gowa)	Left	Mamminasa Bypass (Takalar)	484	1092	20.0	147.75				
	Straight	Hertasning (Makassar)	552							
	Right	Mamminasa Bypass (Maros)	56							

Intersection MB-2, Mamminasa Bypass-Abdullah Daeng Sirua
PHF = 0.1

From Leg	Direction	To	PCU/hr	Leg Total	W	A	K	q	C (q×0.8)	DegSat
Mamminasa Bypass (Hertasning)	Left	Abdullah Daeng Sirua (Makassar)	251	623	26.5	147.75	60	6919	5535	0.51
	Straight	Mamminasa Bypass (Maros)	345							
	Right	Abdullah Daeng Sirua (Kab. Gowa)	27							
Abdullah Daeng Sirua (Makassar)	Left	Mamminasa Bypass (Maros)	560	1031	19.0	147.75				
	Straight	Abdullah Daeng Sirua (Kab. Gowa)	220							
	Right	Mamminasa Bypass (Hertasning)	251							
Mamminasa Bypass (Maros)	Left	Abdullah Daeng Sirua (Kab. Gowa)	10	915	26.5	147.75				
	Straight	Mamminasa Bypass (Hertasning)	345							
	Right	Abdullah Daeng Sirua (Makassar)	560							
Abdullah Daeng Sirua (Kab. Gowa)	Left	Mamminasa Bypass (Hertasning)	27	257	19.0	147.75				
	Straight	Abdullah Daeng Sirua (Makassar)	220							
	Right	Mamminasa Bypass (Maros)	10							

Design formula of the roundabout capacity was adopted research findings introduced by OECD report stated in "the planning and design of At-grade Intersection" issued by Japan Society of Traffic Engineer, as follows:

C (Design capacity; pcu/h) = q ×0.8

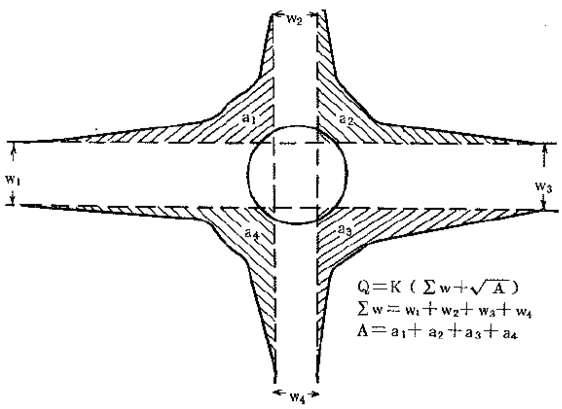
q = Total inflow volume (pcu/h)

K = Capacity factor (pcu/h・m)

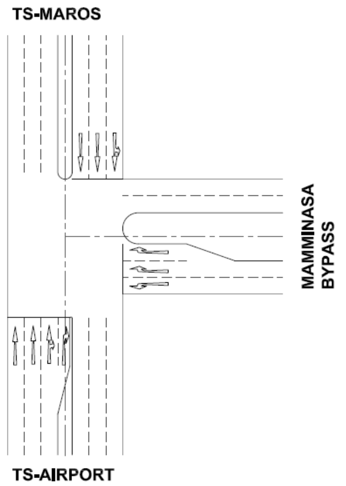
(3-leg = 80, 4-leg = 60, 5-leg = 55)

Σ W = Sum of road widths of access roads (m)

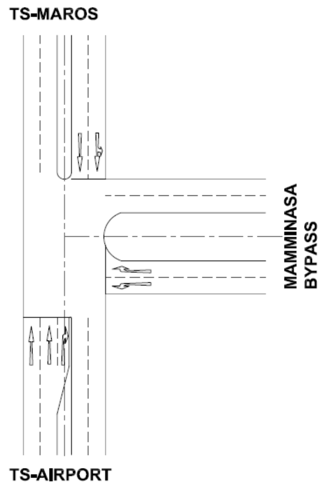
A = Sum of additional areas due to widened access road approaches (m^2)



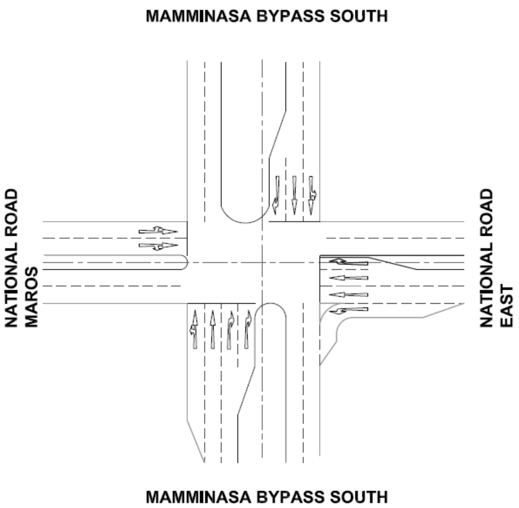
The number of lanes required for each leg was then determined from **Table 7.10.4**. The preliminary lane arrangements for the intersections are shown in **Figure 7.10.4**.



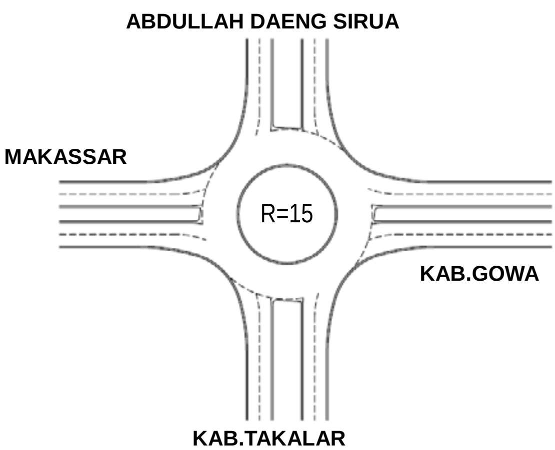
TS-7, MAMMINASA BYPASS LINK/TRANS SULAWESI



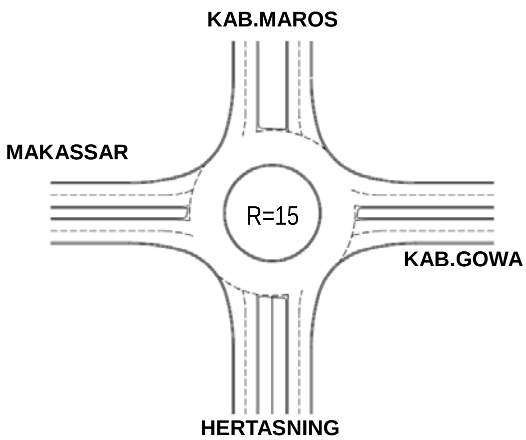
TS-8, MAMMINASA BYPASS/TRANS SULAWESI



MB-3, MAMMINASA BYPASS/NATIONAL ROAD



MB-1, MAMMINASA BYPASS/HERTASNING



MB-2, MAMMINASA BYPASS/ABDULLAH DAENG SIRUA

Figure 7.10.4 Lane Arrangements for Major Intersections on Mamminasa Bypass

7.10.4 Bridges

(1) Preliminary Design and General View Drawings

On the routes of the Mamminasa Bypass, Trans Sulawesi Road, Hertasning Road and Abdullah Daeng Sirua Road, there are 35 bridges and 33 box culverts crossing over rivers or canals.

Of these bridges, preliminary design has been conducted for four bridges having a length of more than 100 m. General view drawings of the structures proposed as optimal are provided in Volume2-2: Preliminary Design Drawings.

For the minor bridges with a length of more than 10 m, the standard PC I girder type was applied and a preliminary cost estimate was made for span of 35m, 25m, 20m and 16m. As to the structures with a length of less than 10 m, the standard box culverts were applied and a preliminary cost estimate was made for span of 10m, 5m and 3m.

(2) Specification and Major Quantities of Bridges

The work quantities required for construction of these road structures are shown in **Tables 7.10.5 – 7.10.6**.

Table 7.10.5 Specification and Quantities for Major Bridges

Item	Unit	Maros	Jeneberang No.1	Tallo	Jeneberang No.2	Tallo No.2	Jeneberang No.3
		Mamminasa Bypass		Trans Sulawesi Road		Outer Ring Road	
1) General							
Structure Length	m	126	154	136	392	120	210
Superstructure Span	m	31	30	34	33	30	30
Substructure Number	nos	5	6	5	13	5	8
Bearing Depth	m	10	10	10	20	10	10
Pile Nos	nos	22	21	30	18	22	21
2) Superstructure							
Girder	nos	60	75	80	180	44	77
Cross Beam Concrete	m3	325	406	418	975	232	406
Slab Concrete	m3	786	961	1,142	2,446	749	1,310
Reinforcement	tf	167	205	234	513	147	258
Carriageway Pavement	m2	2,016	2,464	3,128	6,272	1,920	3,360
Sidewalk Pavement	m2	378	462	408	1,176	360	630
Surface Area	m2	2,394	2,926	3,536	7,448	2,280	3,990
Support	No.	120	150	160	360	88	154
Joint	m	104	125	140	270	104	166
Railing	m	252	308	544	784	240	420
3) Substructure							
Concrete	m3	1,983	2,318	2,983	4,900	2,030	3,218
Reinforcement	tf	225	267	340	577	231	376
Leveling Concrete	m3	67	77	102	150	67	101
Earthwork	m3	3,011	3,849	7,160	7,665	2,739	4,738
4) Foundation							
PC Pile (0.5m)	m						
Bored Pile (1.0m)	m	1,100	1,240	1,500	4,673	1,110	1,660
5) Re-bar Unit Weight							
Superstructure	kg/m3	150	150	150	150	150	150
Substructure	kg/m3	113	115	114	118	114	117

Table 7.10.6 Specification and Quantity of Box Culverts and Minor Bridges

Item	Unit	Culvert			Bridge							
1) General												
Structure Length	m	3	5	10	16	20	25	30	35	40	50	60
Superstructure Span	m	3	5	10	16	20	25	30	35	20	25	30
Substructure Number	nos				2	2	2	2	2	3	3	3
Bearing Depth	m				10	10	10	20	10	20	20	10
Pile Nos	nos				28	30	32	36	40	29	47	36
2) Superstructure												
Girder	nos				9	9	15	11	11	18	30	22
Cross Beam Concrete	m3				56	56	56	62	70	112	106	116
Slab Concrete	m3				100	125	156	187	218	250	312	374
Reinforcement	tf				23	27	31	37	43	54	63	74
Carriageway Pavement	m2	48	80	160	256	320	400	480	560	640	800	960
Sidewalk Pavement	m2	9	15	30	48	60	75	90	105	120	150	180
Surface Area	m2	57	95	190	304	380	475	570	665	760	950	1,140
Support	No.				18	18	30	22	22	36	60	44
Joint	m	42	42	42	42	42	42	42	42	83	83	83
Railing	m	6	10	20	32	40	50	60	70	80	100	120
3) Substructure												
Concrete	m3	202	270	479	480	480	480	563	646	836	1,240	1,488
Reinforcement	tf	20	27	48	48	48	48	56	65	91	131	157
Leveling Concrete	m3	8	11	21	23	23	23	25	28	32	44	53
Earthwork	m3	125	166	333	559	559	559	601	644	1,136	1,052	1,262
4) Foundation												
PC Pile (0.5m)	m				560	600	640	720	800			
Bored Pile (1.0m)	m									1,720	2,800	888
5) Re-bar Unit Weight												
Superstructure	kg/m3				150	150	150	150	150	150	150	150
Substructure	kg/m3	100	100	100	100	100	100	100	100	109	106	106

7.10.5 Pavement

(1) Approach for Pavement Design

The pavement is one of the most essential parts of roadway and its cost is substantial. **Figure 7.10.5** shows a work flow for the pavement design.

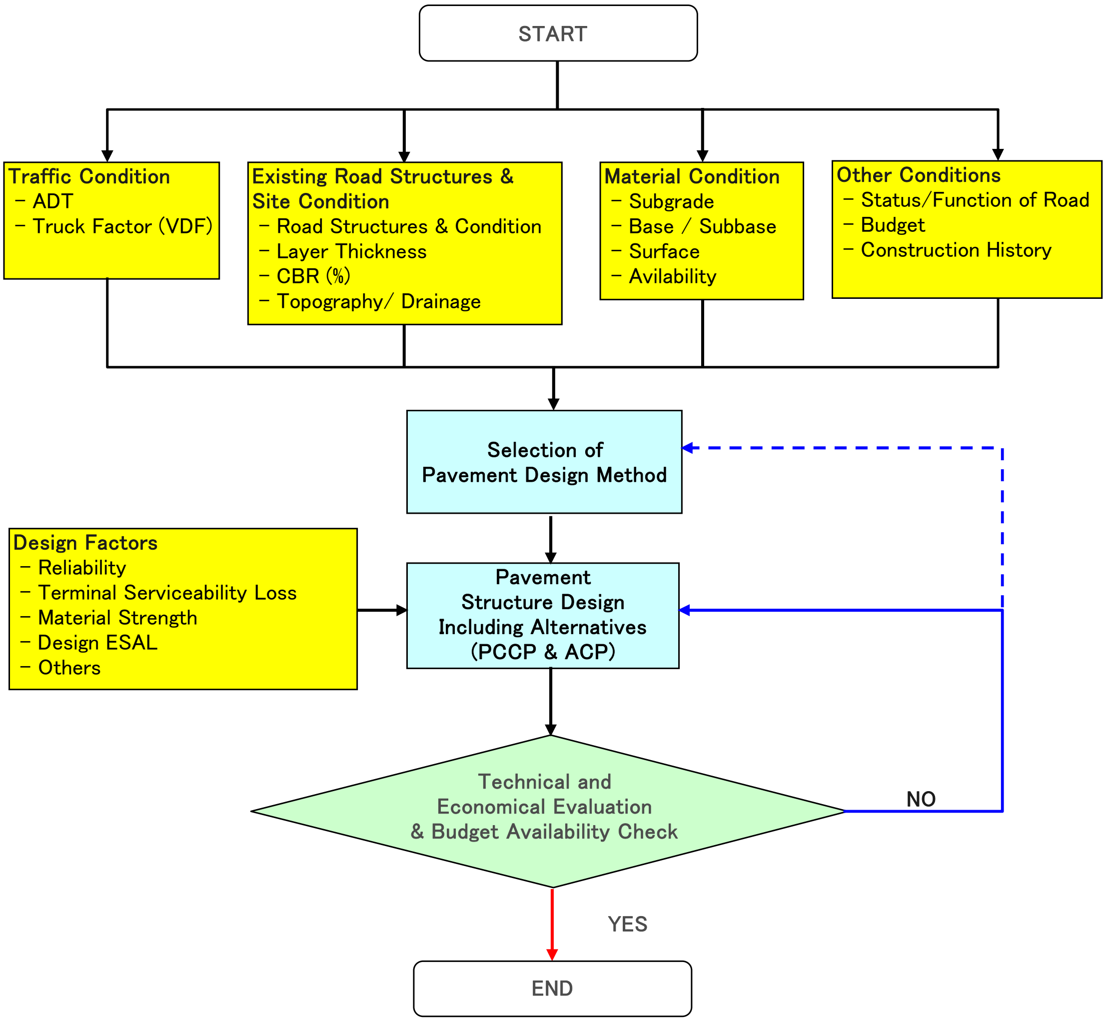


Figure 7.10.5 Work Flow for Pavement Design

Bina Marga has RDS (Road Design System) as a module of the IRMS. However, as it is under a review, the JICA Study Team designed the pavement for the F/S roads based on "AASHTO Guide for Design of Pavement Structures, 1993". The design methodology was compared with other methods (Road Notes and Japanese Standard) for evaluation. Road Note 31 is applicable up to Cumulative Equivalent Single Axle (CESA) limit of 30 x 10^6.

Both flexible (asphalt concrete) and rigid pavement (Portland cement concrete pavement) are studied and evaluated. A design period of 10 years was adopted for the flexible pavement and 20 years for the rigid pavement after opening to the public.

Comprehensive data (traffic, site condition, materials, etc.) collected and/or analyzed through field surveys and traffic surveys were used for the pavement design. The latest technical specifications of Bina Marga were referred to in material selection.

(2) Design Conditions

1) Design Traffic and CESA (Cumulative Equivalent Single Axle Load)

CESA was computed from several relevant factors including ESA, AADT, traffic growth rate, loading/empty ratio, directional distribution and lane distribution. The design traffic (AADT) and traffic growth rate used for CESA were based on the Traffic Analysis in Chapter 5. Directional distribution was assumed to be 55% and 45%. The lane distribution of 80 – 100% and 60% - 80% was used for 4-lane roads (4/2D) and 6-lane roads (6/2D), respectively.

In general, only buses and trucks are accounted for in estimating the pavement design load as the effect of light vehicles is small. However, as the F/S roads are located in the urban area, mini-buses and pickups are also included in the CESA estimation as their number is large. Loading and empty ratios were adopted referring to the loading condition survey of the Mamminasa Study. The VDF (Vehicle Damage Factor) used for CESA estimation is as shown in **Table 7.10.7**.

Table 7.10.7 Vehicle Damage Factor (VDF)

Vehicle Type	Flexible Pavement				Rigid Pavement			
	Empty		Loaded		Empty		Loaded	
		VDF/Veh		VDF/Veh		VDF/Veh		VDF/Veh
Mini Bus/Pickup	30%	0	70%	0.00066	30%	0	70%	0.00066
Large Bus	10%	0.04	90%	0.57	10%	0.04	90%	0.57
Truck (2-Axles)	30%	0.08	70%	1.41	30%	0.08	70%	1.41
Truck (3-Axles)*	30%	0.43	70%	1.71	30%	0.43	70%	2.09

Note: VDF (Truck Factor) was estimated based on Appendix D of AASHTO Pavement Guide
Source: JICA Study Team

The design ESAL was estimated for a period of 10 years for flexible pavement and for 20 years for rigid pavement. Overloaded condition was not considered much as it should be controlled by weigh bridge stations located at inlets/outlets of the F/S roads. **Table 7.10.8** shows the CESA for the F/S roads used for the pavement design (refer to **Appendix D** as to details of CESA estimation by road link and road section).

Table 7.10.8 Cumulative Equivalent Standard Axles for F/S Roads (CESA)

Road Link	Section		Design CESA	
			Flexible Pavement	Rigid Pavement
Trans-Sulawesi Mamminasata Road	A	Maros-Jl.Ir.Sutami IC	15	34
	B	Middle Ring	9	21
	C	Middle Ring Access	9	
	D	Boka-Takalar	4	
Mamminasa Bypass	A	North Section	4	
	B	Middle Section	4	
	C	South Section	4	
Jl. Hertasning		Gowa Section	4	
Jl.Abdullah Daeng Sirua Road	A	Makkassar City	4	
	B	Maros/Gowa Section	4	

Source: JICA Study Team

2) Design CBR and Resilient Modules (MR)

The CBR values of soil along the road alignment vary from 2% to 10%. Substantial parts are embankment sections and CBR of borrow materials is more than 6%. The design CBR of subgrade (1m-depth from the formation level) used for flexible pavement is 8% throughout the F/S roads. To maintain the design CBR, it may require 20-30cm of capping layer (selected material of CBR 30%), especially at cut sections, if the CBR of subgrade soil is less than 8%. The average CBR value is calculated by the following formula:

$$CBRm = \{(h_1 \text{ x } CBR_1^{1/3} + h_2 \text{ x } CBR_2^{1/3} + \cdots + h_n \text{ x } CBR_n^{1/3}) / 100\}^3$$

where:

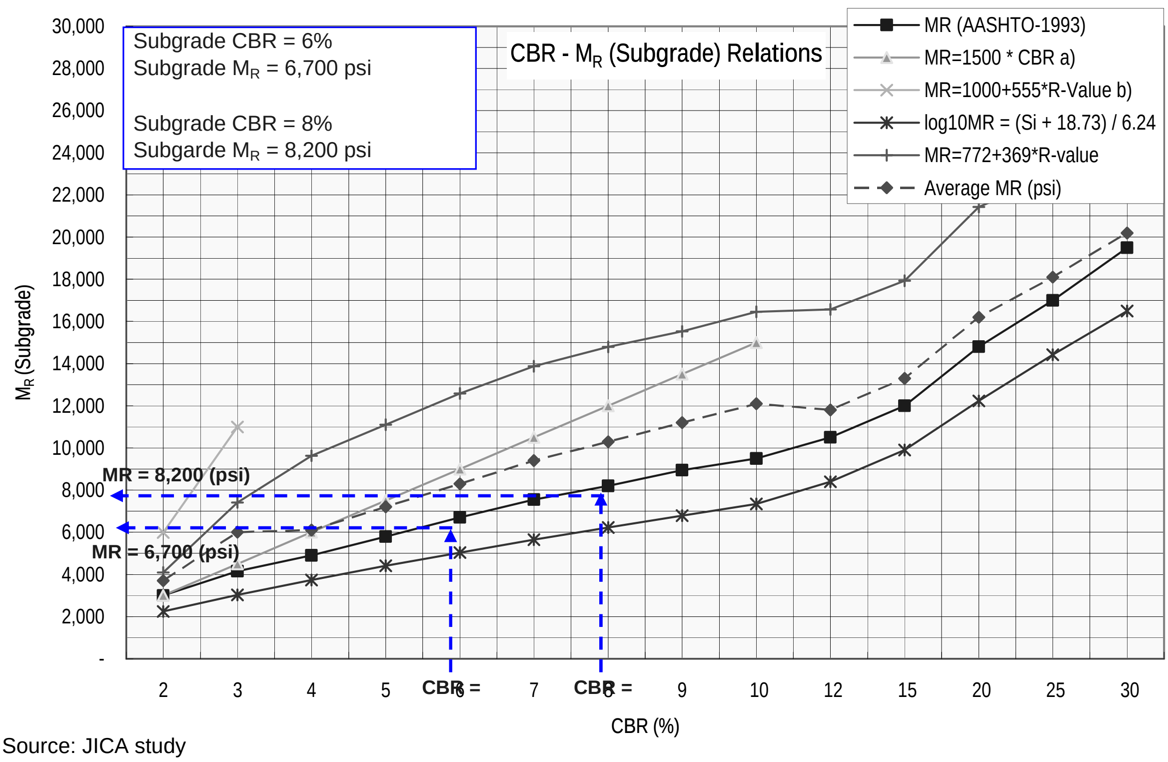
CBRm = average CBR for individual spots
CBR1, CBR2….CBRn = CBR value of soil layers
h_1, h_2…….hn = thickness of soil layers in cm
(Note: 100cm= total depth of h_1,h_2….hn)

The design CBR of subgrade (1m-depth from the formation level) used for rigid pavement is 6% throughout the F/S roads as the rigid pavement thickness is not influenced much by the subgrade strength.

There are several methods to define Subgrade Resilient Modules (MR) as shown in **Figure 7.10.6** and the Study Team applied the conservative values. The MR used for flexible pavement is 8,200 psi for 8% CBR and that for rigid pavement is 6,700 psi for 6% CBR.

CBR (%)	AASHTO				AI			
	M_R (AASHTO-	M_R=1500 * CBR [a)]	M_R=1000+555*R-Value [b)]	log10M_R = (Si + 18.73) / 6.24	M_R=772+369 *R-value	**Average M_R (psi)**	Soil Support Values	R-value
2	3,000	3,000	5,995	2,245	4,093	3,700	3.00	9.00
3	4,150	4,500	10,990	3,025	7,414	6,000	3.80	18.00
4	4,900	6,000		3,740	9,628	6,100	4.30	24.00
5	5,800	7,500		4,406	11,104	7,200	4.75	28.00
6	6,700	9,000		5,040	12,580	8,300	5.10	32.00
7	7,550	10,500		5,645	13,872	9,400	5.40	35.50
8	8,200	12,000		6,230	14,794	10,300	5.65	38.00
9	8,950	13,500		6,795	15,532	11,200	5.85	40.00
10	9,500	15,000		7,345	16,455	12,100	6.00	42.50
12	10,500			8,400	16,565	11,800	6.35	42.80
15	12,000			9,900	17,931	13,300	6.70	46.50
20	14,800			12,235	21,436	16,200	7.35	56.00
25	17,000			14,420	22,912	18,100	7.70	60.00
30	19,500			16,500	24,573	20,200	8.15	64.50

Notes: a) Applicable up to CBR 10
b) Applicable up to R-value less than 20



Source: JICA study

Figure 7.10.6 Subgrade CBR and Modules for Pavement Design

3) Design Equations and Parameters

The design equations, design parameters, layer coefficients, drainage coefficients, pavement material modules were based on "AASHTO Pavement Design Guide of 1993". The pavement materials are those specified in the DGH's Standard Technical Specifications. The following are major parameters applied for the design (also refer to **Appendix D**).

Reliability

The F/S roads are classified as **Arterial** roads in the urban area, reliability applied for the project roads is 90% in accordance with the AASHTO Guide (see **Table 7.10.9**).

Table 7.10.9 Reliability

Functional Classification	Recommended Level of Reliability	
	Urban	Rural
Interstate and Other	85 – 99.9	80 – 99.9
Freeways	80 – 95	75 – 95
Principal Arterial	80 – 95	75 – 95
Collected Local	50 - 80	50 – 80

Note: source; AASHTO Guide for Design of Pavement Structure, 1993

Serviceability Loss (ΔPSI)

The design serviceability loss applied in AASHTO Guide is shown below:

- Rigid Pavement Δ PSI = 4.5 – 2.5 = 2.0
- Flexible Pavement Δ PSI = 4.2 – 2.5 = 1.7

Drainage Coefficient (Cd)

The design serviceability loss applied is 1.10 for both flexible and rigid pavements in accordance with the AASHTO Guide as better maintenance is expected after the construction.

Overall Standard Deviation, So (%)

The overall standard deviation (So) adopted is 0.45 for flexible pavement and 0.35 for rigid pavement.

Load Transfer Coefficient, J

The load transfer coefficient "J" is a factor used in rigid pavement design to account for the ability of a concrete pavement structure to transfer (distribute) load across joints and cracks. Load transfer is important to pavement longevity. Load transfer can be made by load transfer devices and aggregate interlock. Dowel bars provide a mechanical connection between slabs without restricting horizontal joint movement. Reliance on aggregate interlock without dowels is acceptable on low-volume and secondary road systems. ACPA (American Concrete Pavement Association) advises to use dowels for a 20cm thick pavement and ESAL over 5 million. Road transfer coefficient of "3.2" (**Table 7.10.10**) was used for the project roads.

Table 7.10.10 Reliability Load Transfer Coefficients for Rigid Pavement

Shoulder	**Asphalt**		**Tide PCC**	
Load Transfer Devices	**Yes**	No	Yes	No
Pavement Type				
Plane Joint and Jointed Reinforced	3.2	3.8 – 4.4	2.5 – 3.1	3.6 – 4.2
CRCP	2.9 – 3.2	N/A	2.9 – 3.2	N/A

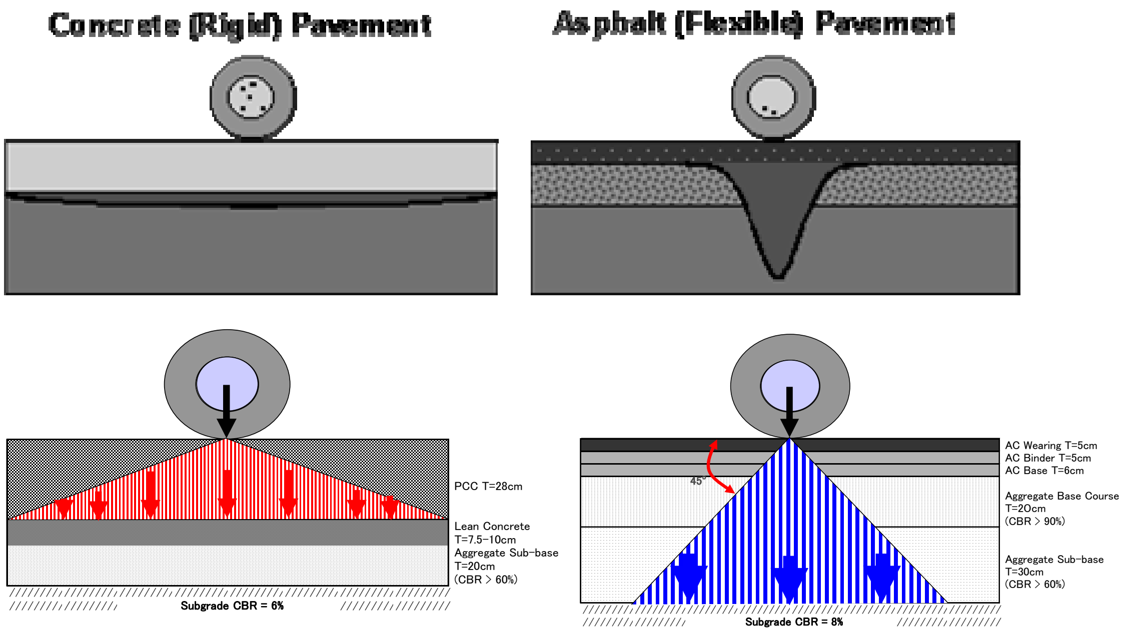
Source: AASHTO Design of Pavement Structure,1993

(3) Comparison of Flexible Pavement with Rigid Pavement

1) Load Transfer Mechanism

The substantial length of pavement in Indonesia is flexible pavement (AC, HRS, etc). Rigid pavement is used for some of the urban roads and toll roads. As the F/S roads are located in the Mamminasata Metropolitan Area, the JICA Study Team analyzed both AC and concrete pavement designs and evaluated them as requested by Bina Marga.

Figure 7.10.7 illustrates a load transfer and subgrade support system of both pavements. Concrete slab (rigid pavement) acts like a bridge slab on subgrade and less pressure works on the subgrade compared with flexible pavement.



Source: JICA Study Team

Figure 7.10.7 Load Transfer Mechanism of Rigid and Flexible Pavements

Load transfer devices (dowel bars and tie bars) is required for concrete pavement to transfer (distribute) load across joints and cracks as illustrated in **Figure 7.10.8**. Dowel bars provide a mechanical connection between slabs without restricting horizontal joint movement while tie bars ensure friction between slabs.

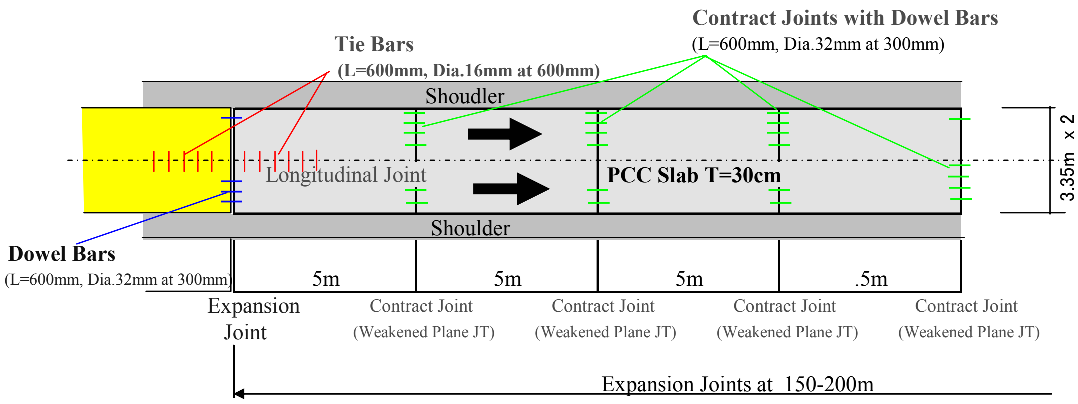


Figure 7.10.8 Dowel Bars and Tie Bars for Rigid Pavement

2) Damage Factor (Truck Factor)

Vehicle Damage Factors (VDF or ESA) are the same between the rigid and flexible pavements in the case of single axle but there is some difference in the case of tandem axles. The tandem VDF for concrete pavement is approximately twice that for the flexible pavement as indicated **in Figure 7.10.9** at a level of 8-ton axle.

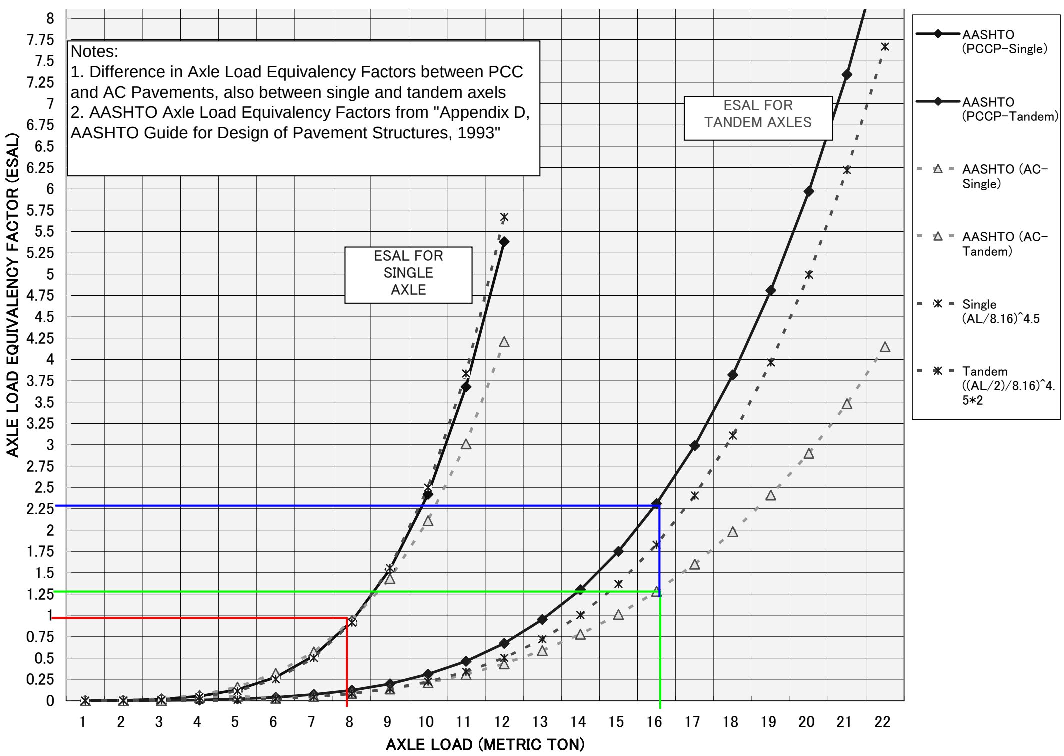


Figure 7.10.9 VDF (Truck Factor) for Rigid and Flexible Pavements

3) Sensitivity on Subgrade and CESA

The concrete slab thickness is sensitive to axle load (CESA), especially between CESA 5 million and 40 million (**Figure 7.10.10**). After that level, slab thickness will lose its sensitivity against CESA. This means that the concrete pavement has an advantage for the high design axles and the road on which heavy vehicles pass, in general.

Item	Design Pavement Thickness (cm) by ESAL								
CESA (10^6)	5	10	20	30	40	50	60	70	80
PCC Thick.(cm)	17.7	20.5	23.3	25.0	26.3	27.3	28.2	28.9	29.5

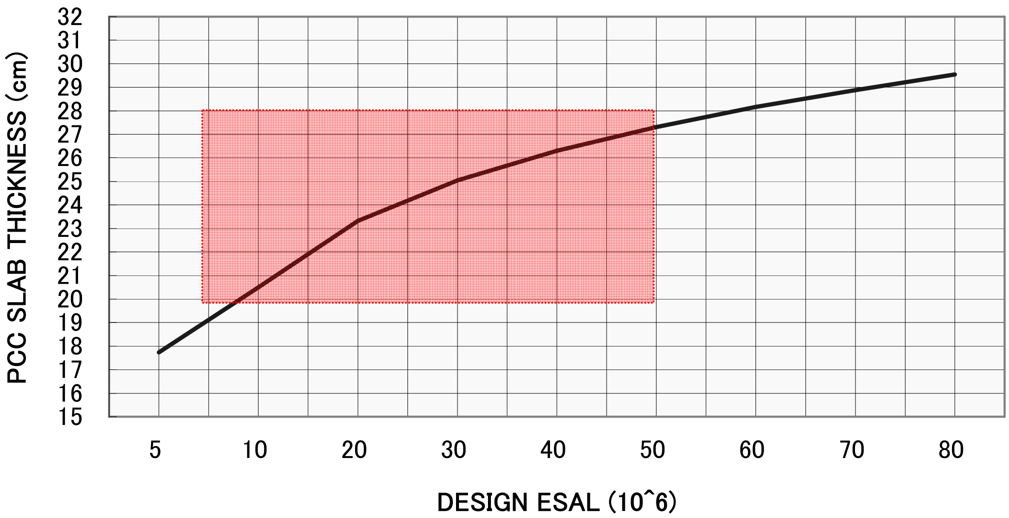


Figure 7.10.10 ESAL and PCC Thickness Sensitivity

On the other hand, the concrete slab thickness is not sensitive to subgrade strength as shown in **Figure 7.10.11**. This means that the concrete pavement has advantages for weak subgrade compared with flexible pavement.

Asphalt concrete pavement is sensitive both for axle load and subgrade strength, especially for weak subgrade. This means that weak subgrade should be improved during design and construction to reduce the pavement thickness.

	PCC Slab Thickness by Subgrade Reaction Module (k)				
k (subgrade),pci	500	580	600	620	630
k_a,pci	500	580	600	620	630
$M_{R\text{-subgrade}}$ (psi)	6,700	8,100	9,500	10,000	10,500
(CBR: %)	6.0	8.0	10.0	12.0	14.0
PCC Thickness(cm)	**26.30**	**25.98**	**25.91**	**25.83**	**25.79**

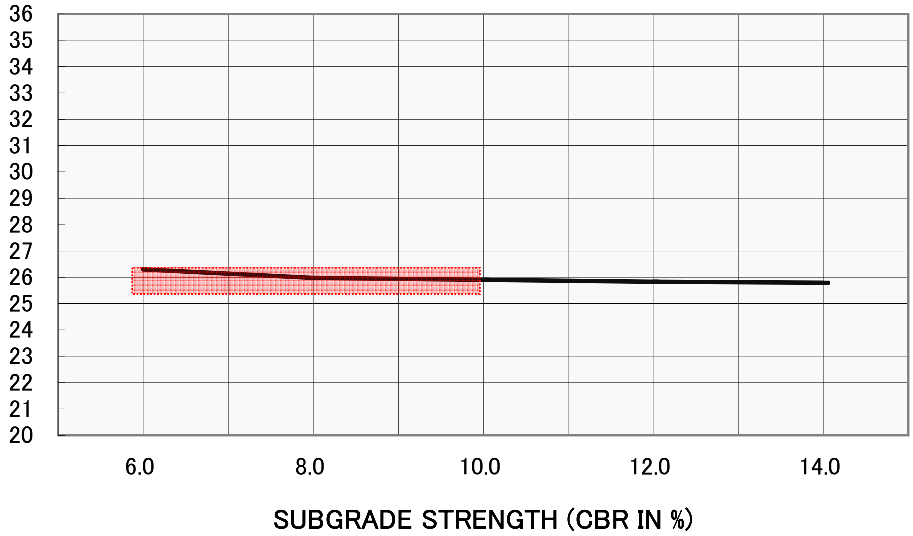


Figure 7.10.11 Subgrade Strength and PCC Thickness Sensitivity

4) Comparison of Rigid Pavement Design with Other Design Methods

Three representative rigid pavement designs were compared on the same design conditions of subgrade CBR 6% and CESA 40 million. The required concrete slab thicknesses by AASHTO, Portland Cement Association, Japan (**Figure 7.10.12**) and Overseas Rode Note 29 (**Figure 7.10.13**) were 27 cm, 28 cm and 26 cm, respectively. The results are not much different and, therefore, the AASHTO method was used for the F/S.

Classification of Traffic	* ADT	** Base Thickness (cm) on Subgrade CBR =			# Concrete Slab Thickness (cm)		Dia. Of Dowel Bars (mm)
		6%	8%	>12%			
L	< 100	20	15	15	15	& (20)	25
A	100 - 250				20	& (25)	
B	250 - 1000	25	20	15	25		
C	1000 - 3000				28		
D	> 3000				30		28

Notes: * ADT of Large Vehicles, 5 years after the opening
** Crushed Well graded base CBR > 80%
# Concrete with steel mesh (dia.6mm, 3kg/m2)
& For Concrete Module of Rupture 39kg/cm2 (550 psi)
Concrete Module of Rupture 45kg/cm2 (650 psi)
Contract Joints at 10m
Dowel Bars L=700mm at 400mm

Figure 7.10.12 Rigid Pavement Design by Portland Cement Association (Japan)

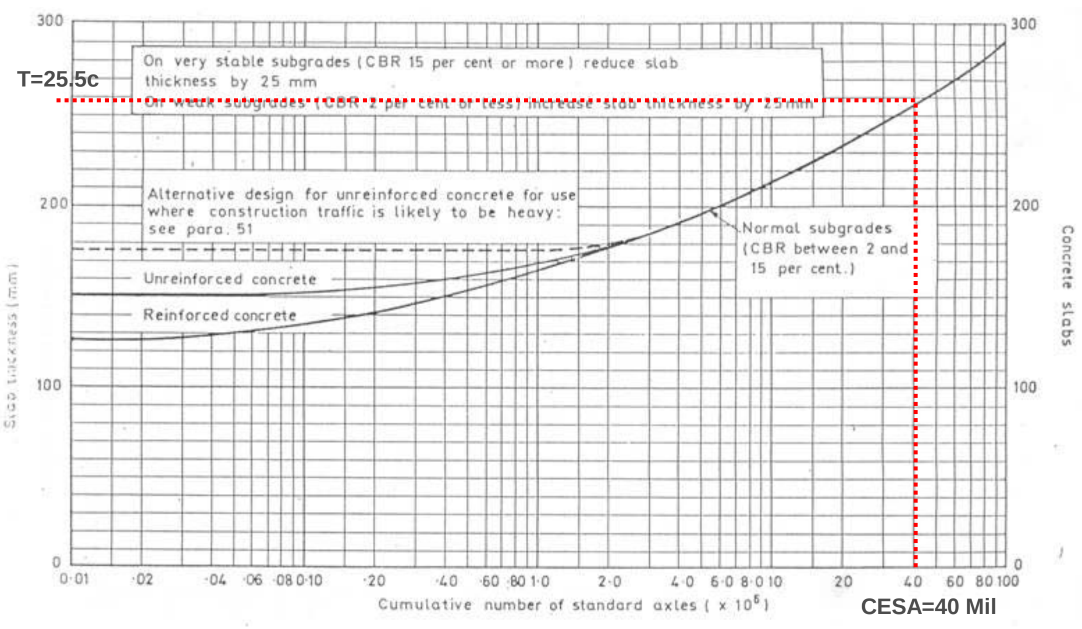
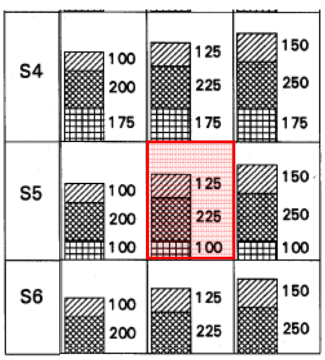


Figure 7.10.13 Rigid Pavement Design by Road Note 29 (UK)

5) Comparison of Flexible Pavement

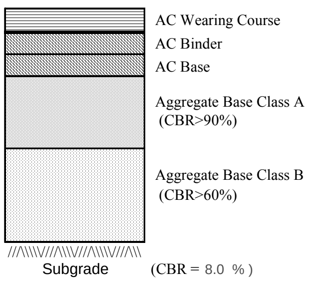
The AASHTO and Overseas Road Note 31 (TRL 1993) design methods were compared. The former is a comprehensive approach based on experiments while the latter uses chart catalogues established by TRL.

The pavement structure for the subgrade class of S4 (CBR 8-14%) and the traffic class of T6 (10-17 million ESA) in Road Note 31 is as indicated in **Figure 7.10.14**. Asphalt concrete surface thickness is 125 mm on 225 mm aggregate base and 100 mm thick subbase. AC thickness of 150 mm on 200 mm thick base and 300 mm subbase is required in the case of AASHTO 1993. The structure number specified in Road Note 31 is approximately 75% of the AASHTO design.



Overseas Road Note 31

PAVEMENT STRUCTURE



	Layer Coefficient per cm (Input)	per inch	Thickness Product mm (Input)	in inch	Drainage Coefficient
a_1=	0.165	**0.42**	40	0.66	
a_2=	0.165	**0.42**	50	0.83	
a2=	0.165	**0.42**	50	0.83	
$a_{2''}$=	0.055	**0.138**	200	1.20	1.10
a_3=	0.051	**0.128**	278 **(300)**	1.54	1.10
		Total:	618	5.05	
		Total Design SN =		**5.051**	**o.k. !!!**
		Required SN =		5.050	

AASHTO 1993 Design Guide

Figure 7.10.14 Rigid Pavement Design Comparison by Road Note 29 (UK) and AASHTO 1993

6) Cost Comparison of Rigid Pavement with Flexible Pavement

The life cycle cost of pavement consists of initial investment, periodic maintenance and routine maintenance costs. Those are estimated and converted to the discounted current cost. A turning point of the rigid pavement advantage seems to exist at 20 million CESA or at 7 million CESA for AC (**Figure 7.10.15**). This point is equivalent to 23 cm slab thickness of concrete pavement. After the turning point, not much difference is seen between both pavements.

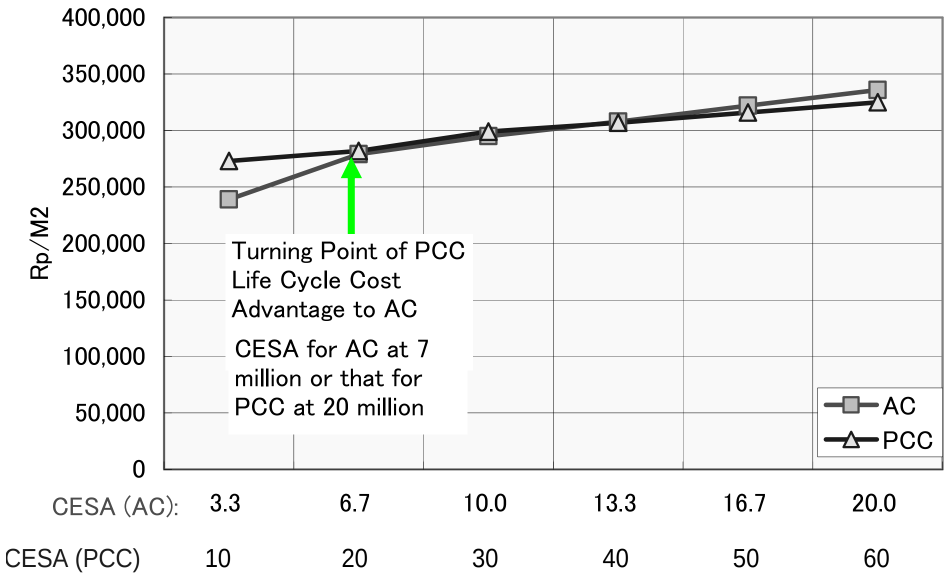


Figure 7.10.15 Advantage Point of Rigid (PCC) and Flexible (AC) Pavements

7) Construction and Productivity

There would not be much difference in equipment requirements. Asphalt concrete pavement construction requires mixing plant, paver, trucks and compaction equipment while concrete pavement requires concrete mixing plant, trucks and paver. Major materials for the asphalt concrete are asphalt and aggregate. Those for the concrete pavement are cement, aggregate and steel bars. Daily construction productivity would not differ much if a slip form paver is used for the concrete pavement construction as it can produce 700-800 m^2 per day.

The following photographs show PCC pavement construction for Ir.Sutami Toll Roads Project with a slip form paver.

The biggest difference is that asphalt concrete pavement can open to traffic just 1-2 hours after construction while the concrete pavement requires 14 days.

8) Overall Evaluation and Application for FS Roads

The Study Team made an overall evaluation on the pavement types taking technical and economic points analyzed in the above into consideration (**Table 7.10.11**).

Table 7.10.11 Overall Evaluation of Pavement Types

Items / Description	Location	Flexible (AC)		Rigid (PCC)		Remarks (refer to)
		Technical Aspect	Cost	Technical Aspect	Cost	
Location	Urban	△		O		
	Semi-urban	△		△		
	Rural	O	O	X	X	
Subgrade Strength (CBR)	Good	O		△		Figure 7.10.4
	Fair	△		△		
	Bad	△	△	O	O	
Design CESA ($10^{\wedge 6}$) for 20-year Period	Less $20^{\wedge 6}$	O	O	X	X	
	$20^{\wedge 6}$ - $40^{\wedge 6}$	△		△		
	Over $40^{\wedge 6}$	△	X	O	O	
Local Economical Material Availability	Cement	△		O		
	Asphalt	O		△		
	Aggregate	O	O	△		
	Soil (CBR.8%) for borrow	O	O	△		
Equipment	Asphalt Plant	O		–		
	Concrete Plant	–		O		
	Asphalt Paver	O		–		
	Concrete Paver	–		O		
Productivity	With conventional method	O	O	X	△	
	with Slip Form Paver)	-	-	O	O	
Traffic Management during construction	Existing Road Widening	O		X		
	New Road	O		O		
Maintenance	Routine	△	△	O	O	
	Periodic (Overlay)	X		-		

Note: O; Good (advantage), △; Fair or not clear advantage, X; Bad (disadvantage)
Source: JICA Study Team

If the design ESAL is over 40 million, the rigid pavement has advantages in both technical and economic aspects. The rigid pavement is also has advantages if the CBR of available subgrade materials (borrowed materials) is less than 8%. Notwithstanding those, the rigid pavement has advantages in the urban area if there are many accessed and traffic signals. Flexible pavement is damaged by rutting, shoving and/or spilled oil by stop-start action of vehicles. **Table 7.10.15** summarizes the pavement type selection criteria for the F/S roads.

The Study Team recommended the application of the flexible and rigid pavements for the F/S roads as shown in **Table 7.10.12**. Rigid pavement is recommended for the Maros-Jl.Ir.Sutami section and the Middle Ring Road section of the Trans-Sulawesi Mamminasata Road.

Table 7.10.12 Recommended Application for F/S Roads

Road Link	Section		Location	Cut or Fill	Subgrade Strength (CBR)	Design CESA (10^{6})		Type of Pavement	
						10 years period	20 years period	Flexible Pavement	Rigid Pavement
Trans-Sulawesi Mamminasata Road	A	Maros-Jl.Ir.Sutami IC	Urban	Cut*/ Fill	8%		34.0		O
	B	Middle Ring	Urban	Fill	6%		21.0		O
	C	Middle Ring Access	Urban	Fill	8%	9.0		O	
	D	Boka-Takalar	Semi-urban	Fill	8%	4.0		O	
Mamminasa Bypass	A	North Section	Semi-urban	Fill	8%	4.0		O	
	B	Middle Section	Urban	Cut*/ Fill	8%	4.0		O	
	C	South Section	Semi-urban	Fill	8%	4.0		O	
Jl. Hertasning		Gowa Section	Semi-urban	Fill	8%	4.0		O	
Jl.Abdullah Daeng Sirua Road	A	Makkassar City	Urban	Cut*/ Fill	8%	4.0		O	
	B	Maros/Gowa Section	Semi-urban	Fill	8%	4.0		O	

Note: * improvement of subgrade to CBR 8% with replacing the top of subgrade for cur section with selected materials.
Source: JICA Study Team

(4) Pavement Thickness Design

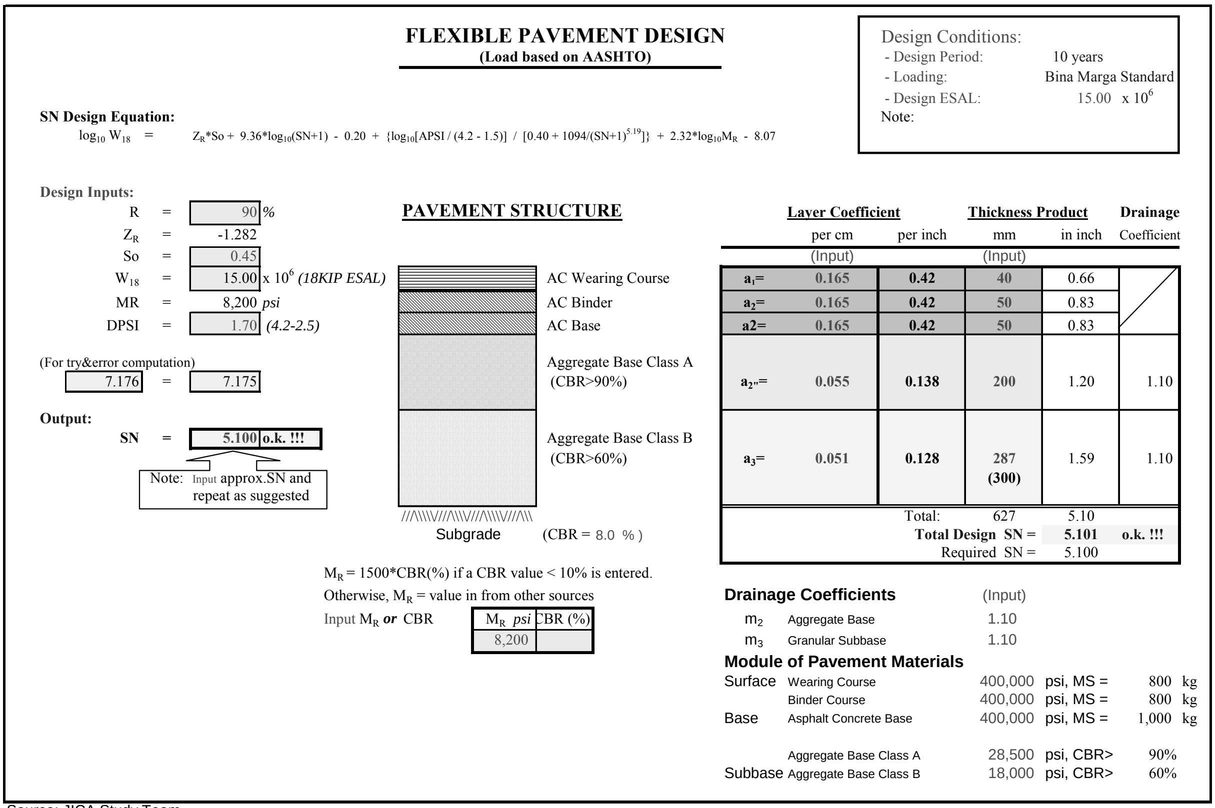
Table 7.10.13 summarizes the pavement structures for the F/S roads (refer to Appendix D as to the details of pavement design).

Table 7.10.13 Summary of Pavement Design for F/S roads

Road Link	Section		Surafce				Base and Subbase			Sub-grade CBR
			AC (W)	AC (B)	AC (base)	PCC	Class A	Class B	SCB	
Trans-Sulawesi Mamminasata Road	A	Maros-Jl.Ir.Sutami IC				26		20	10	8%
	B	Middle Ring				24		20	10	6%
	C	Middle Ring Access	4	4	5		20	30		8%
	D	Boka-Takalar	4	6			20	30		8%
Mamminasa Bypass	A	North Section	4	6			20	30		8%
	B	Middle Section	4	6			20	30		8%
	C	South Section	4	6			20	30		8%
Jl. Hertasning		Gowa Section	4	6			20	30		8%
Jl.Abdullah Daeng Sirua Road	A	Makkassar City	4	6			20	30		8%
	B	Maros/Gowa Section	4	6			20	30		8%

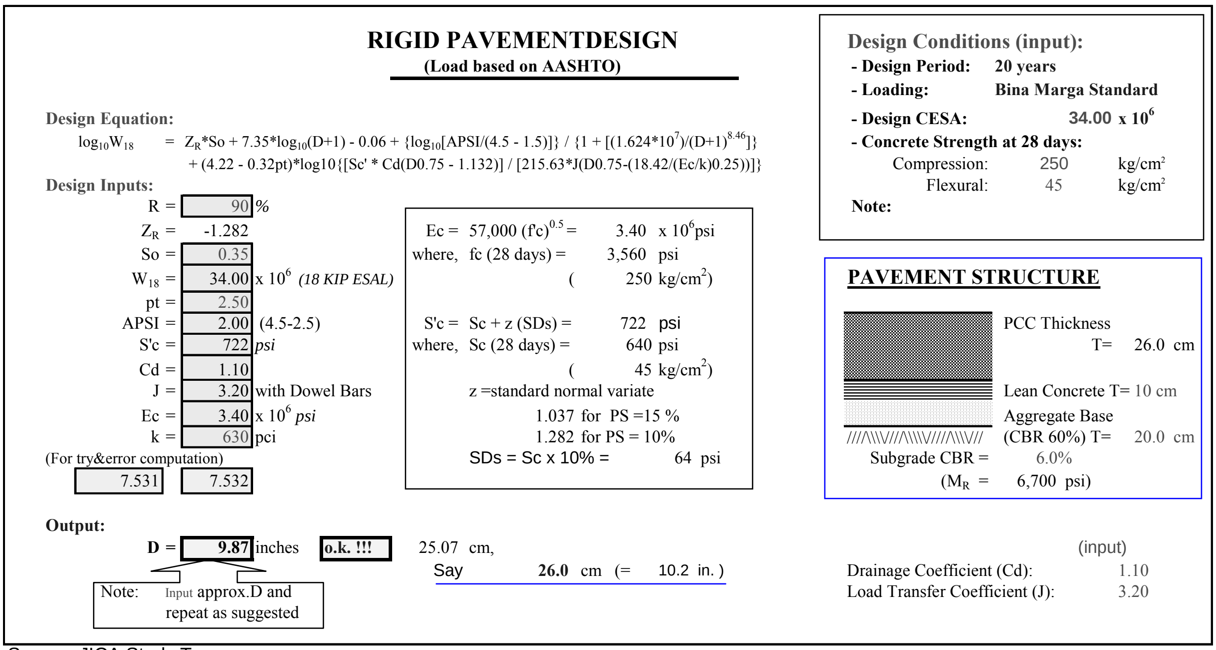
Source: JICA Study Team

The pavement design was carried out using Excel-basis design programs developed by the Study Team as shown in **Figure 7.10.16** for flexible pavement design and in **Figure 7.10.17** for rigid pavement design (refer to **Appendix D** as to details)..



Source: JICA Study Team

Figure 7.10.16 Design Program for Flexible (AC) Pavement



Source: JICA Study Team

Figure 7.10.17 Design Program for Rigid (PCC) Pavement

(5) Asphalt Concrete Overlay Design

The Trans-Sulawesi Mamminasata Road has two development concepts by subsection. One is the widening of the existing national roads from Maros to Jl.Ir.Sutami IC and from Bajeng (Panciro) to

Takalar. The other is a new road construction for the Middle Ring Road and the Middle Ring Road Access (Jl.Sultan Alauddin IC – Boka IC). Asphalt concrete overlay will be made on the existing road for strengthening the pavement and/or adjustment of superelevation.

RDS of Bina Marga has a standard overlay design system based on deflection measurements either by FWD or Benkelman beam. The "AASHTO 1993 Pavement Design Guide" and "Asphalt Overlays for Highways and Street Rehabilitation", Asphalt Institute suggest different overlay design methods. The former applies structure deficiency approach and the latter applies Representative Rebound Deflection (RRD) approach.

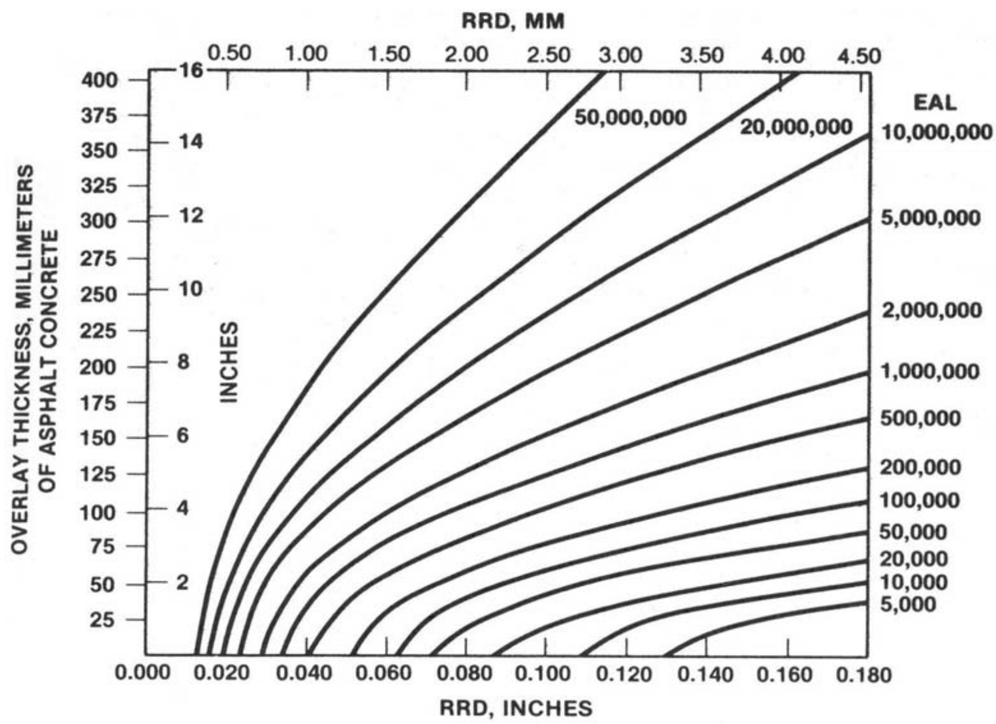


Figure IV-6—Asphalt concrete overlay thickness required to reduce pavement deflections from a measured to a design deflection value (rebound test)

Figure 7.10.18 Design Diagram for AC Overlay

As the current road condition is good and no deflection data is available, two layers of AC overlay, 4 cm AC Wearing and 5 cm AC Binder (including leveling layer thickness) were planned for structural strengthening. Field survey shall be conducted in the detailed design stage.

7.10.6 Drainage and Other Structures

(1) Drainage Design

Drainage design along the F/S roads was carried out based on the design run off from the adjacent areas.

1) Design Period

According to the drainage design standard of Indonesia, the design period for culverts along the arterial road is 10 years. 5years design period is applied for roadside ditch drainage.

Table 7.10.14 Required Design Period for Culvert

Road Classification	Required Design Period for Culvert
Toll Road	25 years
Arterial Road	10 years
Local Road	5 years

Source: Metode, Spesifikasi dan tata cara Edisi Pertama, Dec.2002 Bagian:13 Kayu, Bahan lain, lain-lain Departemen Permukiman dan Prasarana Wilayah Badan Penelitian dan Pengembangan P.659 3.4 7)

2) Method of Run off Calculation

The design run off from the adjacent area was calculated by the following rational formula.

$$Q = \frac{1}{3.6 \times 10^6} \cdot C \cdot I \cdot a$$

where, Q : Peak runoff (design peak discharge: m^3/sec)
C : Runoff coefficient
I : Design rainfall intensity for a duration equal to the time of concentration (mm/h)
a : Catchment area (m^2)

Based on the site conditions, runoff coefficient (C) was determined as follows:

Table 7.10.15 Applied Runoff Coefficients (C)

Land Use	Applied “C”
Paved Road Surface	0.8
Residential area	0.7
Agro Field	0.5

Source: Guidelines for earthworks - drainage system, Japan Road Association

The time of concentration (“t” in minute) is the time required for the surface runoff from the remotest part of the catchment to reach the point being considered. The time of concentration (t) consists of the time (t_1) required for overland flow and the time (t_2) required for stream flow. The time of concentration for overland flow (t_1) down to the point being considered was estimated by the following formula proposed by Kerby:

$$t_1 = \left[\frac{2}{3} \times 3.28 \cdot L \cdot \frac{n_d}{\sqrt{s}} \right]^{0.467}$$

where, t1 : Time of concentration for overland flow (min)
L : Length of flow (m)
Nd: Retardance coefficient
S : Slope of the surface

Retardance coefficient (nd) was recommended for use as shown in Table 7.10.16.

Table 7.10.16 Retardance Coefficient (nd) for Kerby's Formula

Ground Cover	Value of Nd
Asphalt, Concrete surface	0.013
Smooth bare packed soil, free of stones	0.10
Average grass	0.40
Deciduous timberland	0.60
Conifer timberland, dense grass	0.80

The time of concentration for stream flow (t_2) was estimated by the following formula:

$$t_2 = \frac{L}{60 \cdot V}$$

where, t2: Time of concentration for stream flow (min)
V: Average flow velocity (m/sec)
V was estimated by the following equation:

Catchment areas were estimated based on the topographic map of 1:5,000 scale, prepared by the topographic survey.

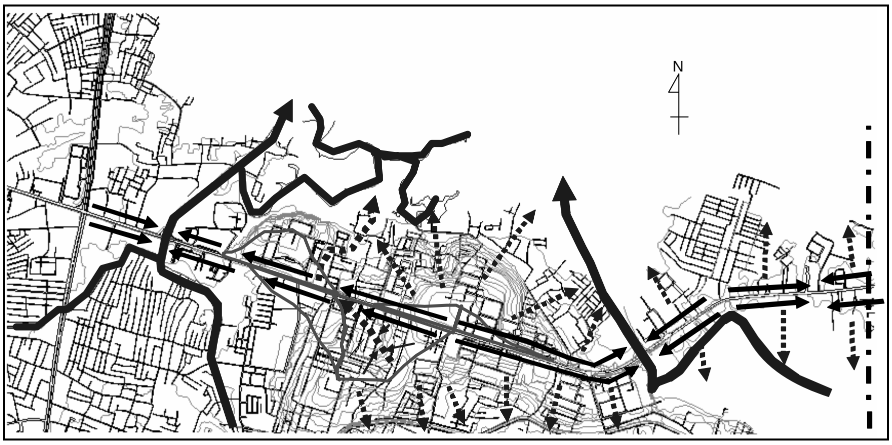


Figure 7.10.19 Existing Drainage Network of Section A (1/4)

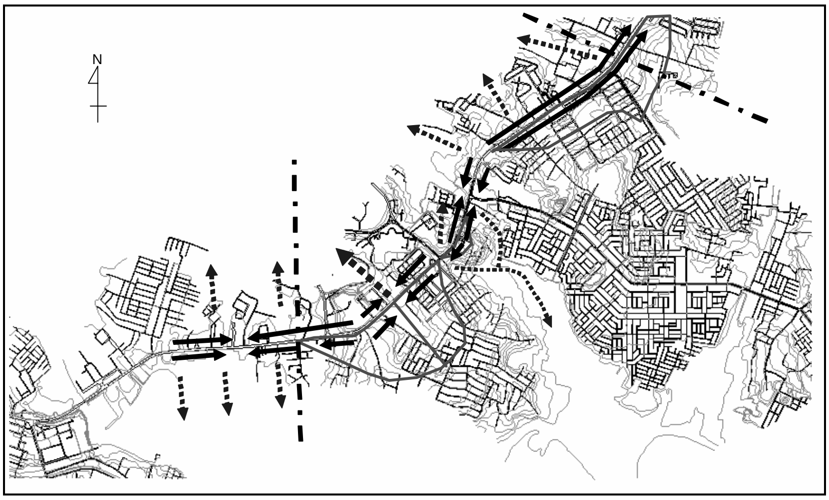


Figure 7.10.20 Existing Drainage Network of Section A (2/4)

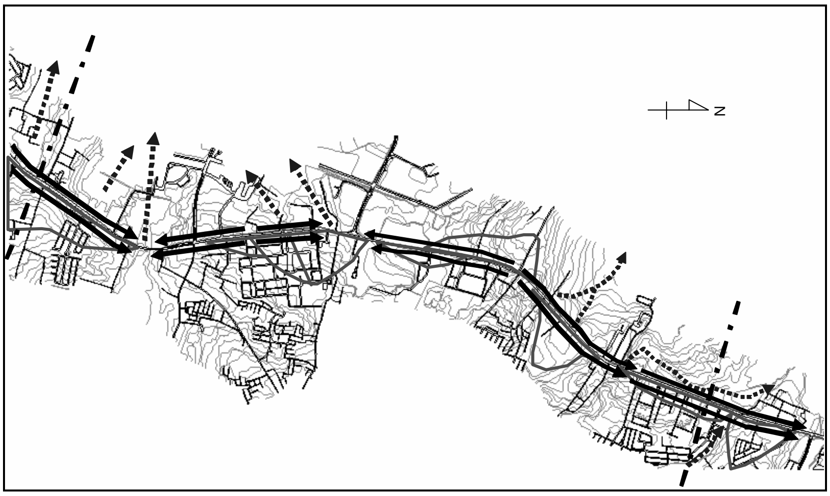


Figure 7.10.21 Existing Drainage Network of Section A (3/4)

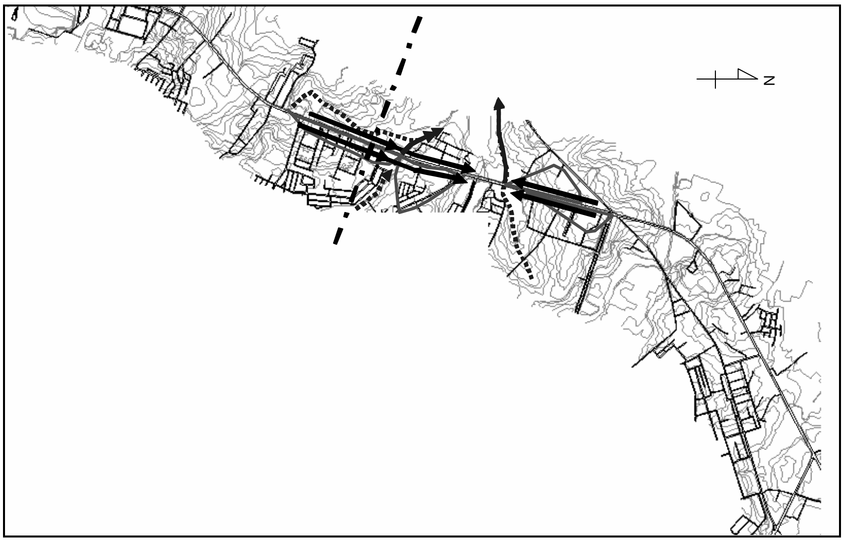
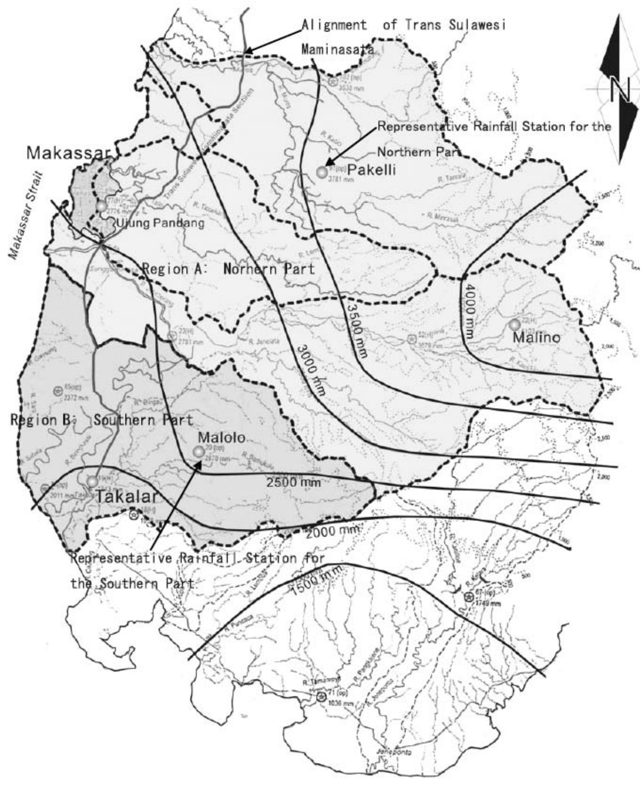


Figure 7.10.22 Existing Drainage Network of Section A (4/4)

The rainfall intensity data recorded at Pakelli (Maros River Basin) and Malolo (Pappa River Basin, Takalar) rainfall stations shall be adopted to show the regional rainfall intensity pattern of the northern part and southern part of the study area. The regional area for calculation of rainfall intensity is shown in **Figure 7.10.23**.

Probable rainfall intensity-duration-frequency curves of Pakelli and Malolo rainfall stations were made as representative of regional rainfall intensity of the study area as shown in **Figure 7.10.24**. Design run off was calculated at 0.21m^3/sec following the typical conditions of the study road (Catchment area 10,000 m^2, Run coefficient 0.7, Time of concentration 20 min, Design rainfall intensity 109.1mm/h, Region A).



Source: Isohyetal Map, Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001

Figure 7.10.23 Regional Area for Calculation of Rainfall Intensity

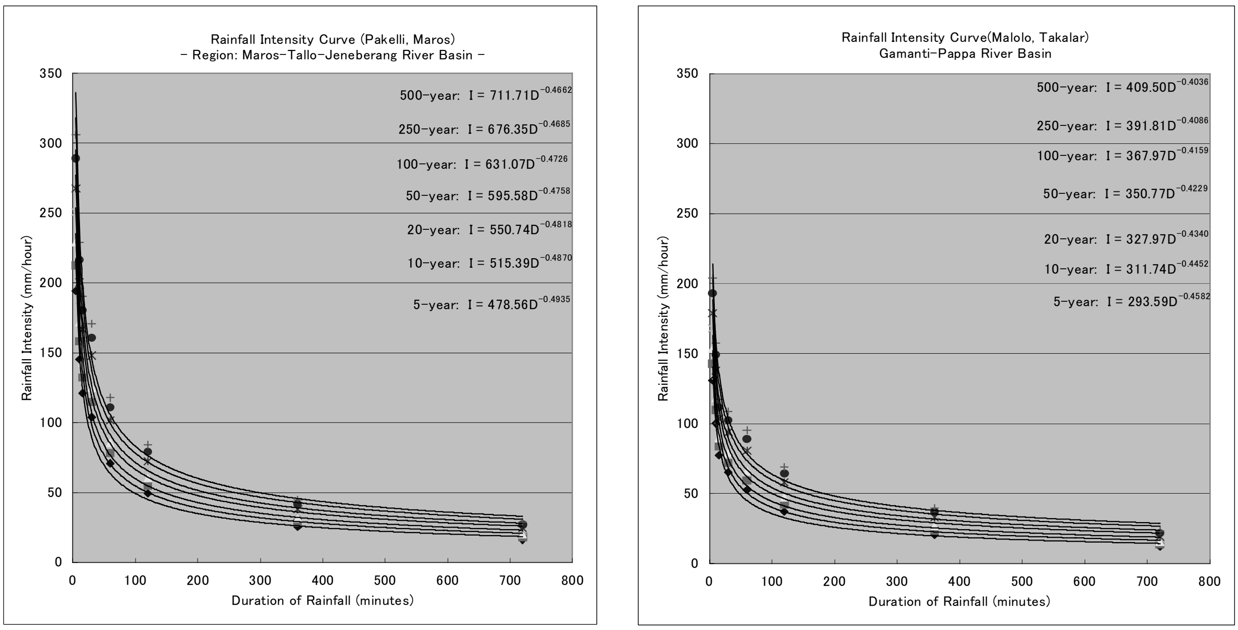


Figure 7.10.24 Rainfall Intensity-Duration-Frequency Curves of Pakelli and Malolo

Flow volume of drain water was calculated by the following method:

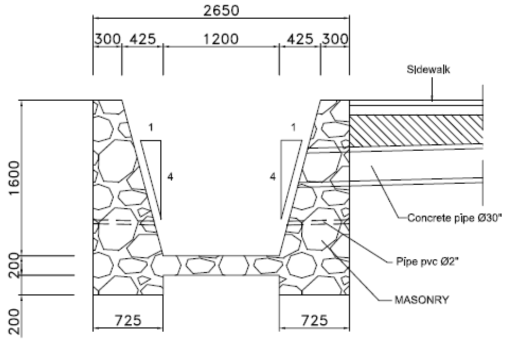
Q=A・V

where, A: Area (m3/sec)
V: Average Velocity of Flow (m/sec)

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}}$$

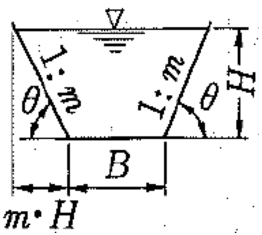
where, n: Mannings roughness coefficient (wet masonry:0.025)
R: Hydraulic Radius (m)
= Area/Wetted
Perimeter I: Stream Slope

Figure 7.10.25 shows design side ditch section, and its area and hydraulic radius were calculated as shown in **Figure 7.10.26**.



(A;2.56m2, R;0.58m)

Figure 7.10.25 Designed Side Ditch Section



A=H(B+m・ H), R=(H(B+m・ H))/(B+2H√(1+m2))

Figure 7.10.26 Calculation of Area and Hydraulic Radius

Average stream flow velocity of 80% water depth in designed side ditch (allowable flow capacity) was estimated as illustrated in **Figure 7.10.27**. The relationship between flow volume and stream slope of the designed side ditch / pipe culverts are shown in **Figure 7.10.28** and **Figure 7.10.29**.

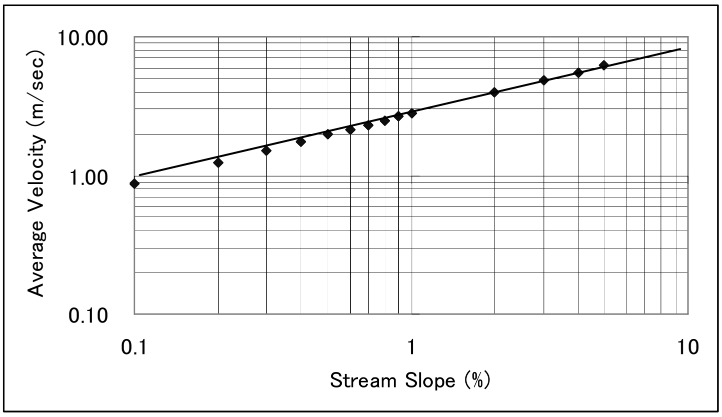


Figure 7.10.27 Relationship between Average Velocity and Stream Slope

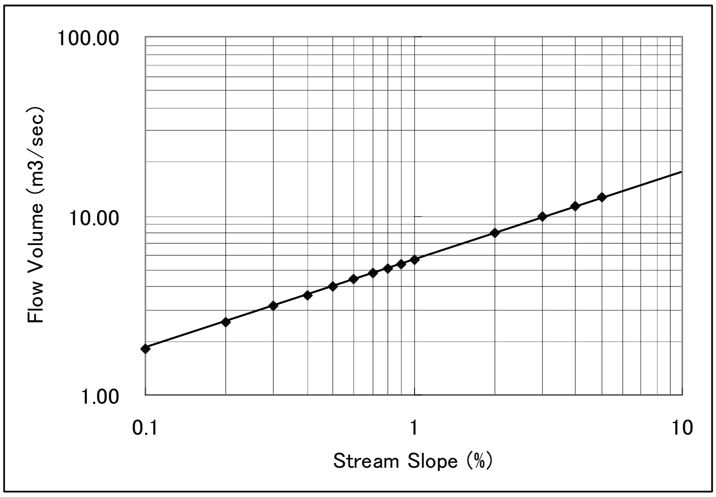


Figure 7.10.28 Relationship between Flow Volume and Stream Slope of Designed Side Ditch

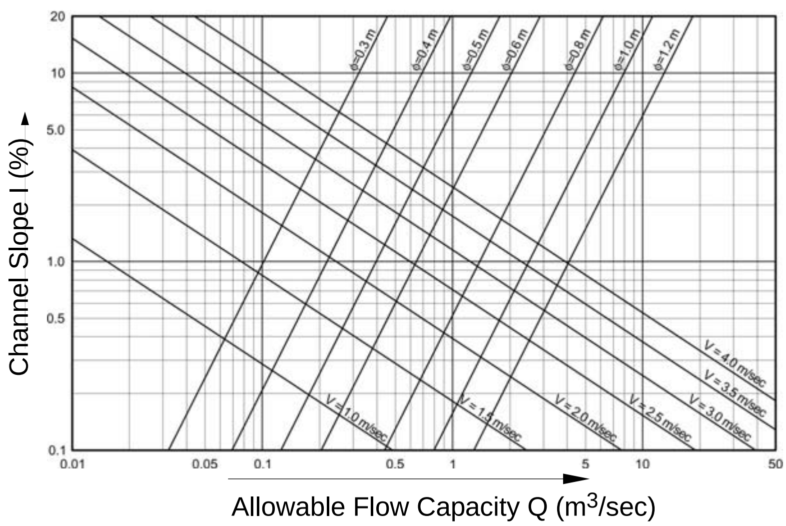


Figure 7.10.29 Relationship between Flow Volume and Stream Slope of Pipe Culvert

(1) Drainage Facilities

Based on the calculated run off volume of the area adjacent to the study road, volume of waste water flow from the roadside residences and flow volume of the designed side ditch and pipe culvert, the following drainage facilities were designed:

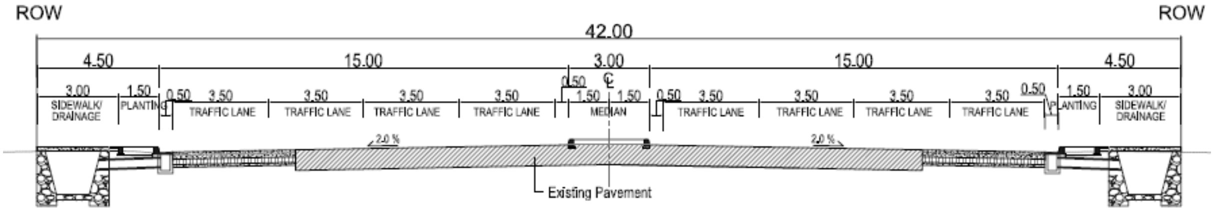


Figure 7.1030 Section of Side Ditch

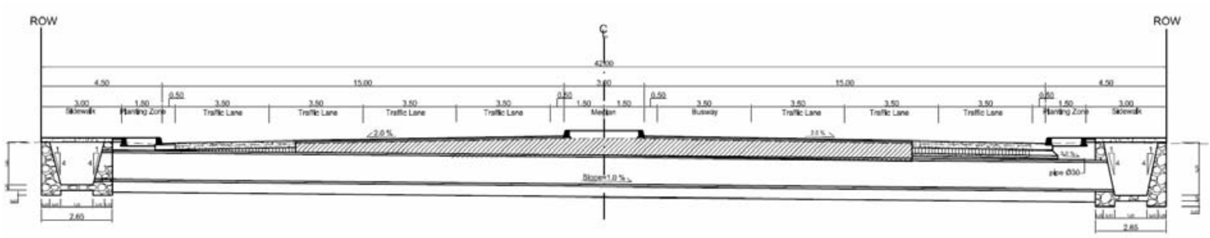


Figure 7.10.31 Section of Cross Drain Pipe and Catch Pit

(2) Culvert

There are several existing culverts along the study road. The culverts serve as drain outlets for the roadside drainage, and the drain joins into the river water flowing under the road. Because the existing culverts work properly and are in a stable condition, extension of the existing culverts was planned as shown in **Figure 7.10.32**.

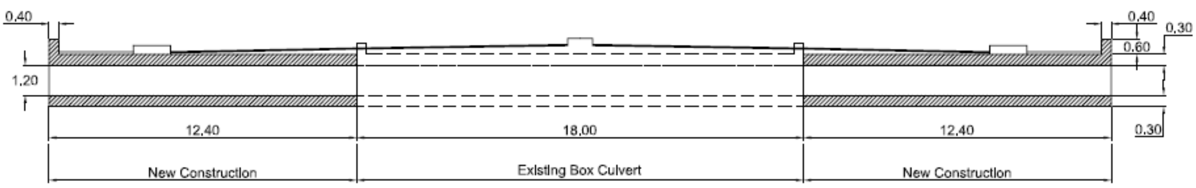


Figure 7.10.32 Culvert Extension Plan

(3) Soft Ground Countermeasure Structures

A 470m-long soft ground section is located in the Tallo swamp area as shown in **Figure 7.10.33**, and its geological characteristics were examined by the geological survey conducted in this study. RC slab on PC-piles is recommended as countermeasure for the soft ground as shown in **Figure 7.10.34**. Pile length was designed at 10m in reference with the Tallo Bridge, considering the similar geological condition of the neighboring area.

Figure 7.10.33 Planned Section for Structure on Soft Ground

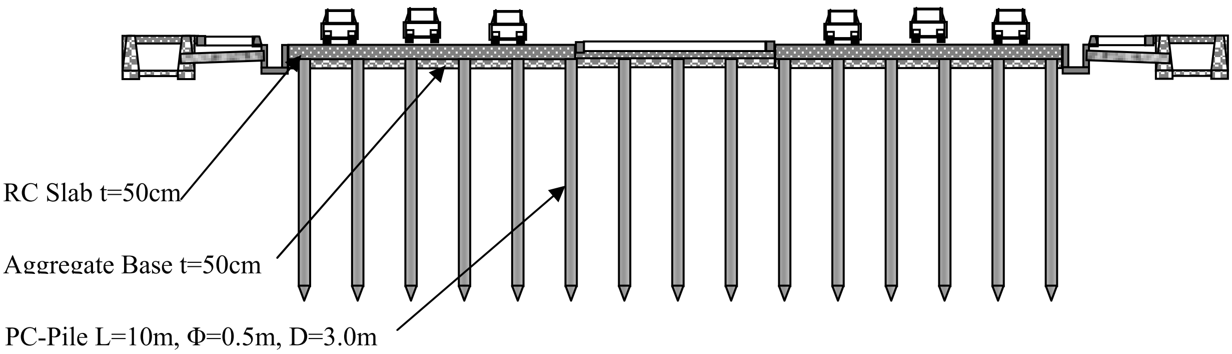


Figure 7.10.34 Countermeasure Structure for Soft Ground at Tallo River Swamp

(4) Retaining Wall

The section between the Middle Ring Road/Jl. Alaudin intersection and Jeneberang River Bridge was planned to have retaining walls because it otherwise becomes difficult to properly arrange the vertical alignment. Reinforced earth wall is planned due to the needs to maintain frontage road space on both sides of the study road, as shown in **Figures 7.10.35 and 7.10.36**.

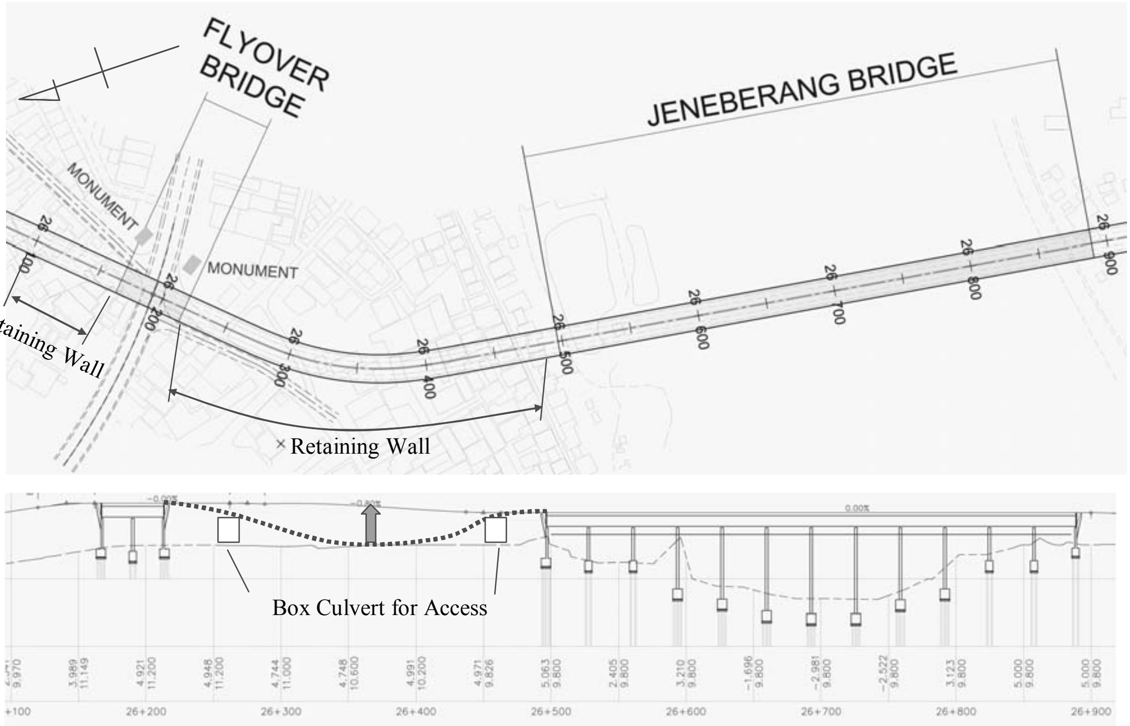


Figure 7.10.35 Plan and Profile of Retaining Wall Section

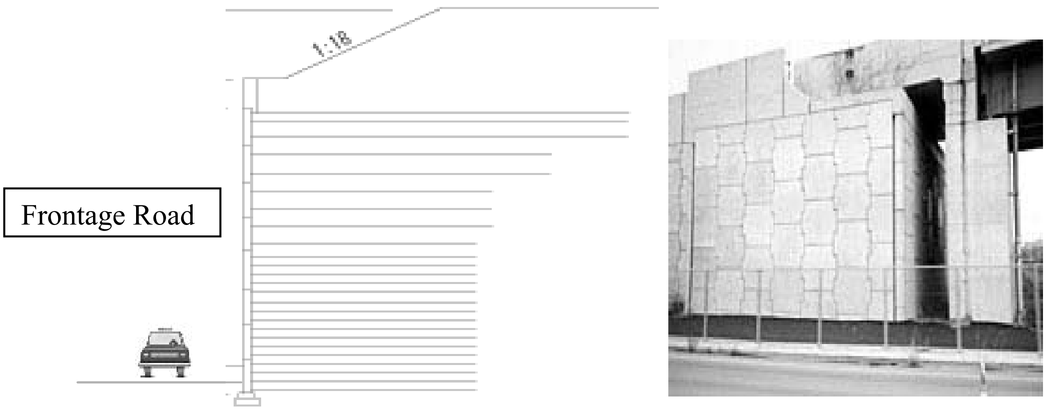


Figure 7.10.36 Example of Reinforced Earth Wall

7.10.7 Miscellaneous

(1) Grade Separated Pedestrian Crossing Facilities

Pedestrian bridges and box culverts are planned for pedestrian safety. These are located at heavily traffic intersections near public facilities such as hospital, school and mosque, as shown in **Figure 7.10.37**. The box culverts are planned on embankment sections as alternative of the pedestrian bridge.

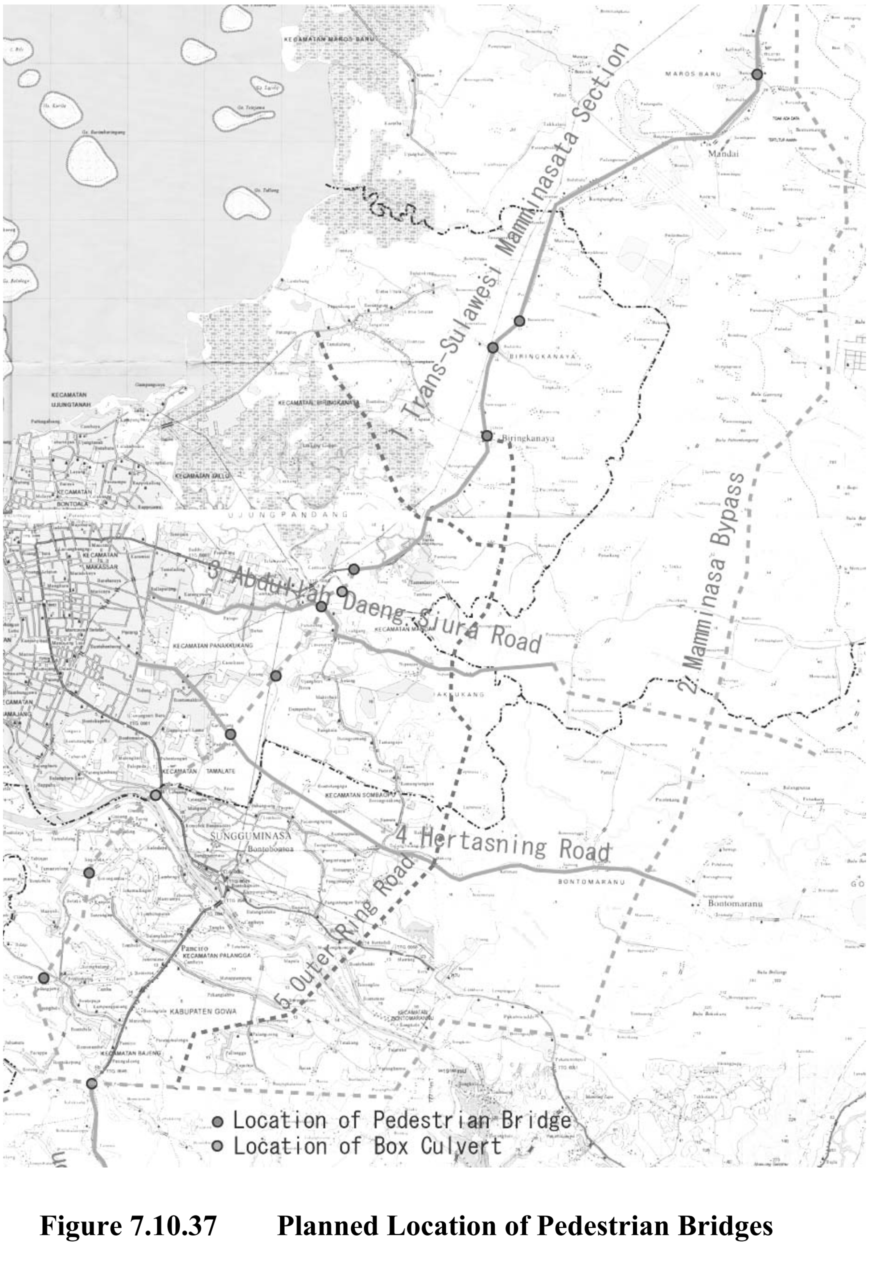


Figure 7.10.37 Planned Location of Pedestrian Bridges

A typical pedestrian bridge is shown in **Figure 7.10.38**. The bridge is designed to mitigate the usage difficulty of the disabled and the cyclists with a gentle slope. Four-leg pedestrian bridge is also planned for some intersections to promote its utilization.

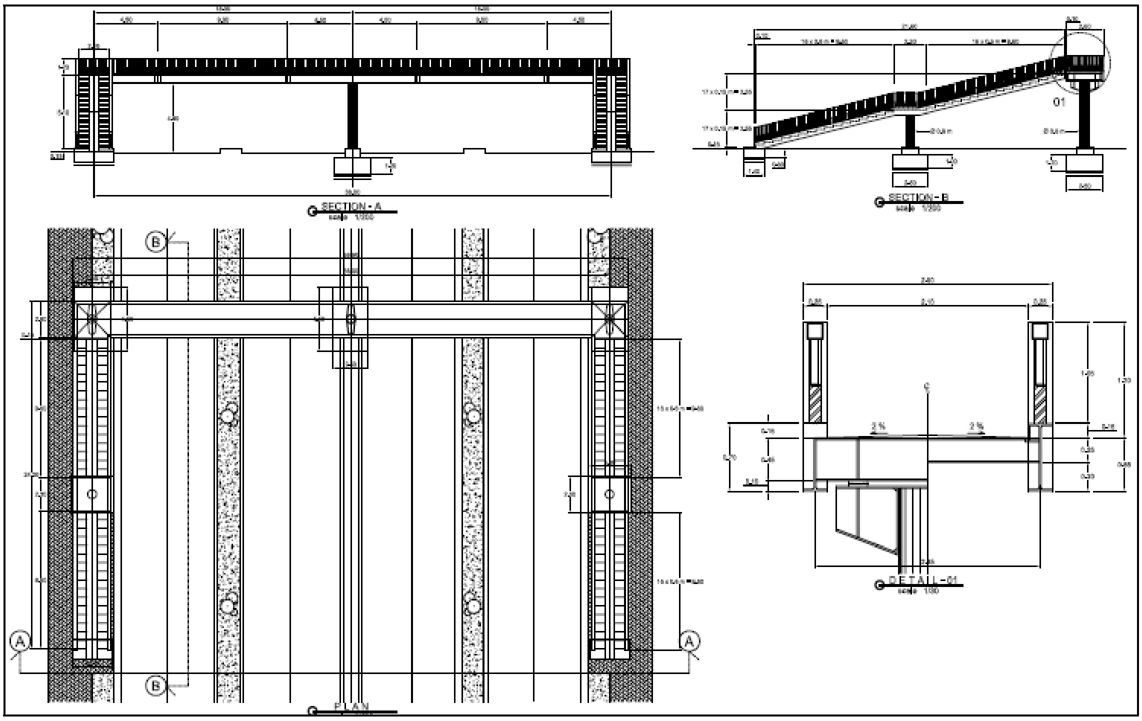


Figure 7.10.38 Pedestrian Bridge Plan

(2) Traffic Safety Facilities

1) Street Light

Street light should be installed at intersections and along urban sections of the study road. Location of the street light installation will be on the median, and the twin bulb type is recommended as shown in **Figure 7.10.39**. Interval of the street lights would be at 30 - 50m.

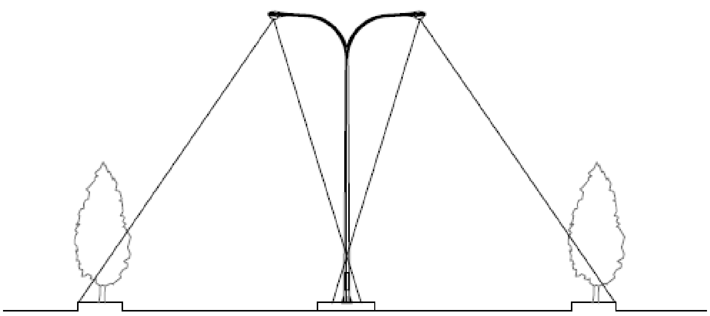


Figure 7.10.39 Street Light Plan

2) Road Marking and Traffic Sign

Road markings and traffic signs are planned in compliance with the Indonesian standard.

(3) Public Utility Relocation Plan

Public utilities such as power lines, telecommunication lines and water mains exist along the study road. **Figure 7.10.38** shows a typical public utilities relocation plan for existing road sections.

The precise location of all public facilities should be confirmed during the detailed design stage.

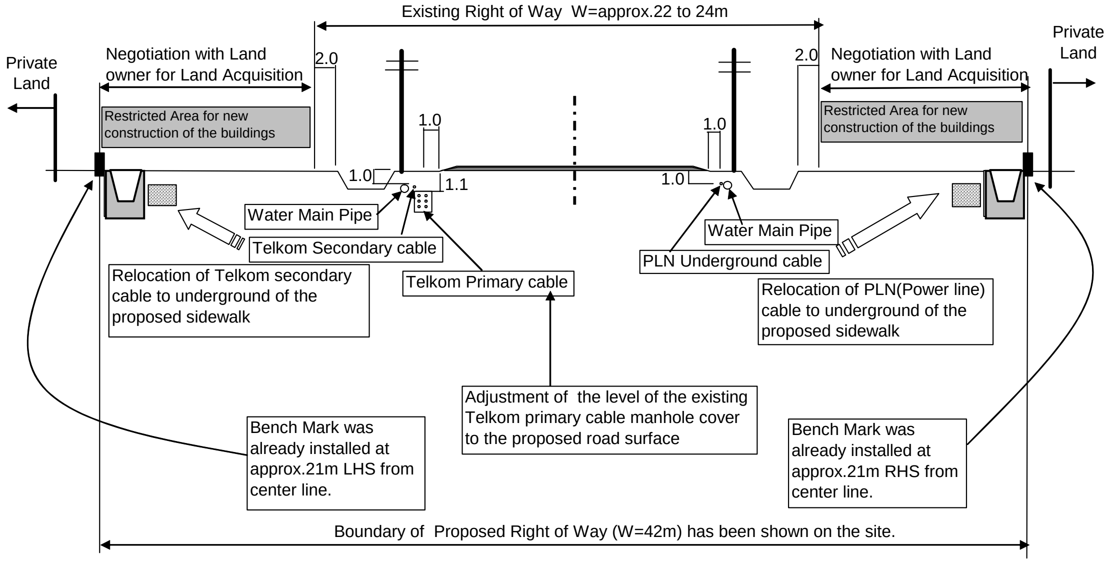


Figure 7.10.40 Typical Public Utilities Relocation Plan