

CHAPTER 6 PRELIMINARY DESIGN

6.1 ENGINEERING SURVEYS UNDERTAKEN

6.1.1 General

This section of the report highlights the engineering surveys undertaken for the proposed.

Following two (2) engineering survey was conducted;

- (1) Topographical Suvey
- (2) Soils and Geo-technical Investigation

6.1.2 Topographical Survey

Table 6.1.2-1 shows summary of survey work conducted.

TABLE 6.1.2-1 SUMMARY OF TOPOGRAPHICAL SURVEY

No	Item	Value	Remark
1	Coordinate. grid	PRS-92	
2	Methodology	Conformed to DAO* DENR regulation	
3	Reference for Horizontal	NAMRIA NEJ-44	1 st Order
		NAMRIA NEJ-58	3 rd Order
4	Reference for Vertical	NAMRIA TA-254	1 st Order
		NAMRIA TA-262	3 rd Order
5	Quantity of levering	30.480 km	For profile
6	Quantity of topographic survey	4,876,865.44 sqm	For Main alignment
7	Quantity of topographic survey	2,191,500 sqm	For IC
8	Quantity of topographic survey	160,000 sqm	For bridge, 200m both upper stream and down stream
9	Cross Sectional Survey	608 cross section	Every 50m interval 80m both sides from center line

*DAO-Department Administrative Order. DENR-Department of Environment and Natural Resources

6.1.3 Soils and Geo-Technical Investigation

The geological survey conducted in the previous feasibility study was referred for the study. The following Soils Investigation along road alignment has been conducted especially where alignment has been changed.

Including some important description of the past feasibility study, geotechnical feature is described as below;

(1) General Geology

1) Topography

Nueva Ecija The terrain of Nueva Ecija begins with the southwest marshes near the Pampanga border. It levels off and then gradually increases in the elevation to rolling hills as it approaches the mountains of Sierra Madre in the east, and the Caraballo and Cordillera ranges in the north.

It is dominated by a broad expanse of alluvial plain covering more than one-half of the whole provinces. The only areas of high relief are the northern and eastern boundaries where the Sierra Madre, Cordillera and the Caraballo Mountains occur. The Sierra Madre constitutes one continuous topographic unit that forms an almost north-south trending block bordering the eastern boundary of the provinces of Quezon. The alluvial plain is gently undulating towards the east and rises abruptly to the Sierra Madre Cordillera.

Tarlac The Tarlac province is situated in the Central Plain of Luzon and is bounded by Pangasinan Province on the north, Nueva Ecija Province on the east, Pampanga Province on the south, and the Zambales Province on the west. Its exact position is between 120⁰10' to 120⁰47' longitudes and 15⁰10' to 15⁰55' north latitude. The location of this province in Central Luzon is nearer to the Gulf of Lingayen than to Manila Bay. Tarlac, the provincial capital, is 131.3 kilometers from Manila.

There are two distinct geographical areas in the province. The northern and eastern parts consist of an extensive level plain of recent alluvial deposits of sand, silt and small amount of clay. The western and northwestern parts consist of hills and mountains comprising the eastern sides of the Zambales mountain range. There are three prominent mountains in this range, namely, Dome Park (1,389 meters high), Iba Mountain (1,605 meters high) and Sawtooth Mountain (1,806 meters high). These mountains and the areas surrounding them consist of volcanic rocks of basalts and andesites. The andesites are mostly porphyritic.

2) General Geology

Geologically, the plain of the provinces consists of recent alluvial deposits of various materials. The depths of these deposits vary in many places according to the elevation of the area. The absence of gravel, cobble-stones, and pebble in the substratum shows that these deposits were made by slow-moving streams. The mountains in the northern part consist of Tertiary undifferentiated rocks, while those on the eastern sides consist of Tertiary and later effusive rocks of rhyolites, dacites, and basalts. The foothills on the western flank of Sierra Madre Range consist of narrow strips of volcanic tuff material, sandstone, shales and limestones.

The rock formation in the province is represented by time units ranging in the age from Pre-Cretaceous to Quarternary. Below is the Geology of Nueva Ecija presented in tabulated form. This is adopted from the Geology and Mineral Resources of Nueva Ecija by Leonardo R. Antonio.

3) Regional Tectonic and Seismic Setting

The major structural element recognized in the area of Nueva Ecija is the Dingalan-Dingalan-Gabalton Rift; a segment of Philippine Fault. The fault appears to be the major factor that influences the formation of Gabaldon Valley. It trends N 40⁰W and branches out into numerous secondary faults of minor magnitude that the northeastern part, cutting the Cretaceous-Paleogene rock series. These secondary faults appear to have sliced the rocks into a

series of parallel fault blocks. The orientation of these faults, together with the schistosity and fold axes appears to be closely related to the major northwest structure.

Gabalton lies along the boundary between the northerly trending Southern Sierra Madre Mountains and the northeasterly trending Northern Sierra Madre Mountains. The Sierra Madre Mountain Ranges represent the uplifted magnetic arc form during the westward subduction of the Philippine Sea Plate beneath the Eurasian Plate. Offshore, to the east of Sierra Madre Mountains, the surface extension of the subduction zone is represented by the East Luzon Trough, a north-northeasterly trending ocean trench that extends from northeast of Luzon to east of Gabaldon. Offshore to the west of Luzon to Mindoro. Folding of Tertiary deposits, strike-slip and thrust faulting of the Sierra Madre Mountains, and uplift and unroofing of the East Luzon Trough and the Manila Trench (Ringebach, 1992).

The Philippine Fault Zone is a major left-lateral strike-slip fault zone that has a mapped length of 1,200 km from the eastern part of Mindanao to Northern Luzon. Slip on the Philippine Fault Zone accommodates a significant portion of oblique convergence between the Philippine Sea and Eurasian Plates (Acharya, 1980; Acharya and Aggarwal, 1980). The Philippine Fault Zone trends northwest from Dingalan Bay just east of Gabaldon to the southern end of the Central Cordillera; this reach of the fault is referred to as the Philippine Fault. Northwest of Gabaldon the Philippine Fault splays into the Digdig Fault and the San Jose Fault are considered to be active, on those, are potential sources of future earthquakes.

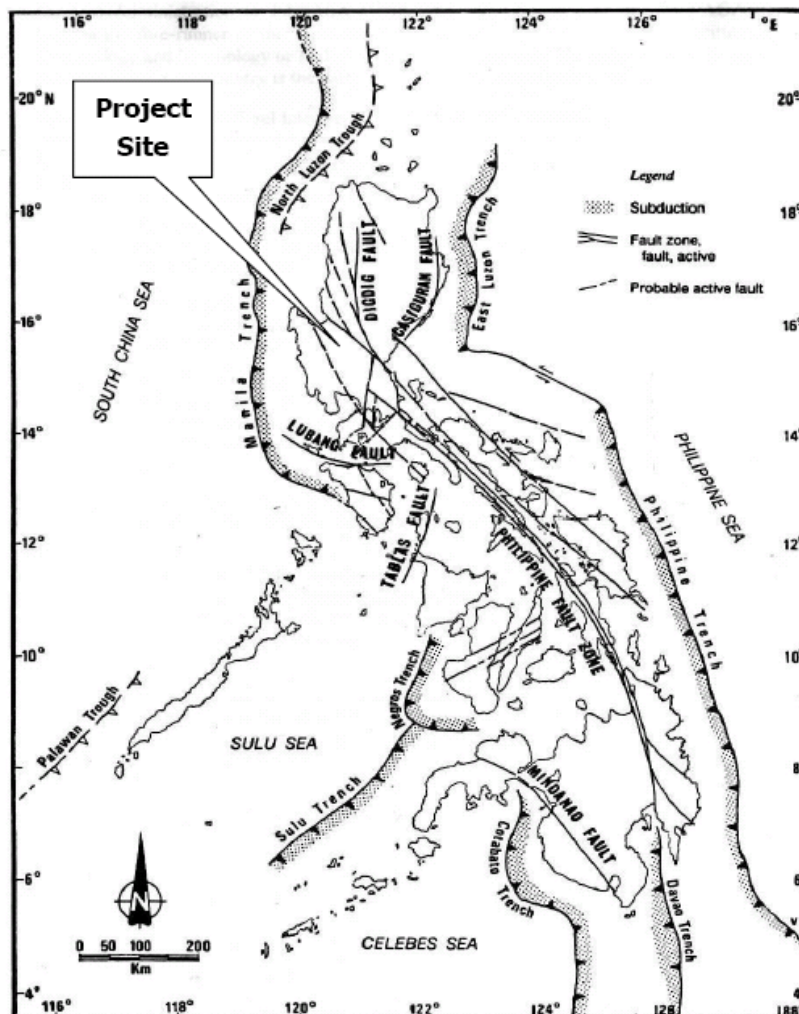


FIGURE 6.1.3-1 DISTRIBUTION OF EARTHQUAKE GENERATORS IN THE PHILIPPINES

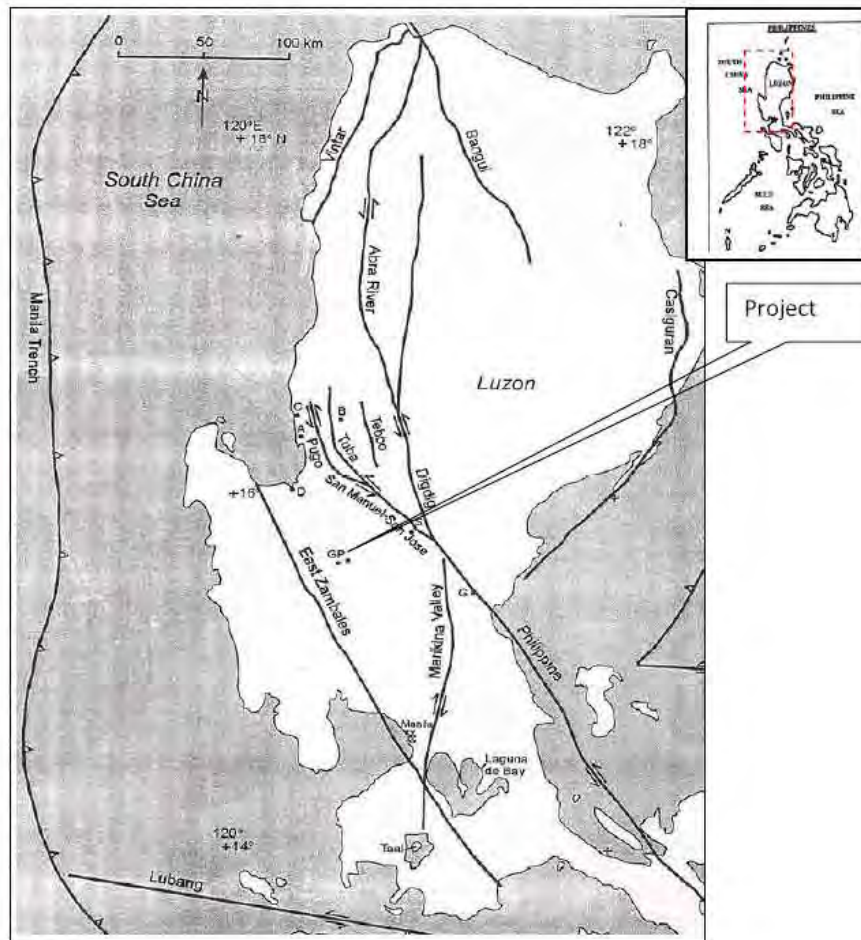


FIGURE 6.1.3-2 MAP SHOWING ACTIVE AND SUSPECTED ACTIVE FAULTS AND SEISMIC SOURCES IN CENTRAL LUZON

4) Seismicity

A compilation of historical seismicity for Luzon shows that many earthquakes occur in the vicinity of Nueva Ecija (Rapetti, 1946; SEASEE, 1985; Su, 1988; Thenhaus and others, 1995). The epicenters of huge magnitude earthquakes (Moment Magnitude $M > 6$) are reported to have occurred in the vicinity of Gabaldon. However, the area has been repeatedly affected by large events on distant faults, and the possibility of large-magnitude local earthquakes cannot be ruled out. The 1990 fault rupture passed through the study area, and the earthquake recorded by PHIVOLCS occur primarily near the epicenter at Rizal and the north (Bautista and others, 1992; Besana and others, 1991).

Recent studies of seismic sources in the Luzon have been completed by Thenhaus and others (1995), Tungol and Daligdig (1993), Maletterre (1989) Ringenbach (1992), and Dr. R. Punongbayan. Several active seismogenic faults, including the Philippine Fault, have been identified in the Gabaldon area. Other active earthquakes sources identified in these studies that could cause strong ground shaking in Gabaldon include: the Digidig Fault, the San Jose-San Manuel Fault and the East Luzon Trough/subduction zone.

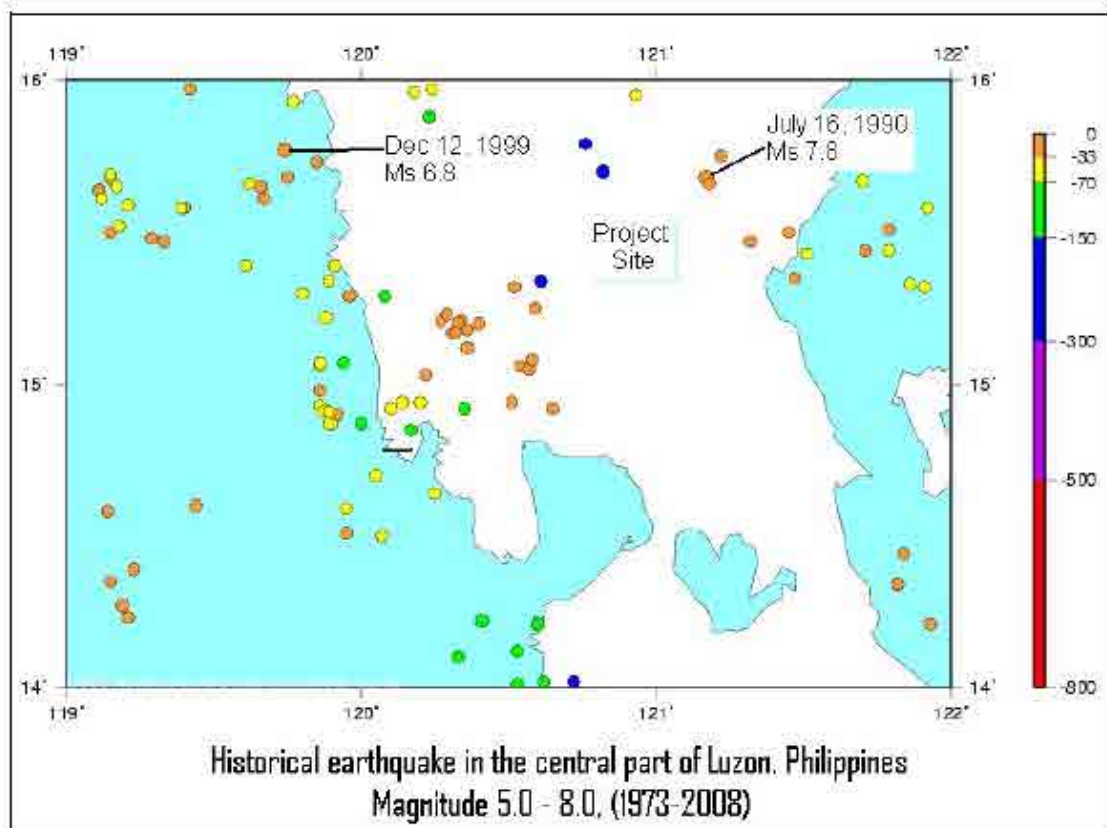


FIGURE 6.1.3-3 HISTORICAL EATHQUAKE IN THE CENTRAL LUZON, PHILIPPINES

5) Seismic Design Calculation

The nearest faults that can generate large-scale magnitude earthquake for this site are the East Zambales Fault in the western portion and the Philippines Fault-Gabalton Segment. The East Zambales Fault is situated at an approximate distance of 20km west of Tarlac while the Gabaldon Fault is situated at an approximate distance of 10km east of the farthest station near Nueva Ecija area. Hence, considerations should be made in designng the structure to resist against earthquake. As a conservative approach, the deisgn ground accerelation can be based from these faults.

The National Structural Code of the Philippines (NSCP, 1997) Code prescribes a minimum value of 0.40g for bridges located in the seismic zone 4. This site falls in the Seismic Zone 4, having A=0.4.

6) Liquefaction Potential

Alluvial deposits are susceptible to liquefaction, since most soil consists of sandy to silty in nature. Majority of the recovered soil samples (in previous study and this study) are cohesive in nature, although loose to medium dense granular materials were encountered in few intervals. It is predicted that the risk of liquefaction for this particular site is low.

(2) Geotechnical Investigation and Analysis

1) List of the geotechnical test conducted

Table 6.1.3-1 shows number of geotechnical survey conducted.

Figure 6.1.3-4 shows location of geotechnical survey.

TABLE 6.1.3-1 LIST OF GEOTECHNICAL TEST

No.	Test	Number
1	Drilling of boreholes	9
2	Test Pit	7
3	Augrer Hole	5
4	Cone Penetration Test (CPT)	58
5	Dynamic Cone Penetration Test (DCPT)	58
6	Material Sources	2

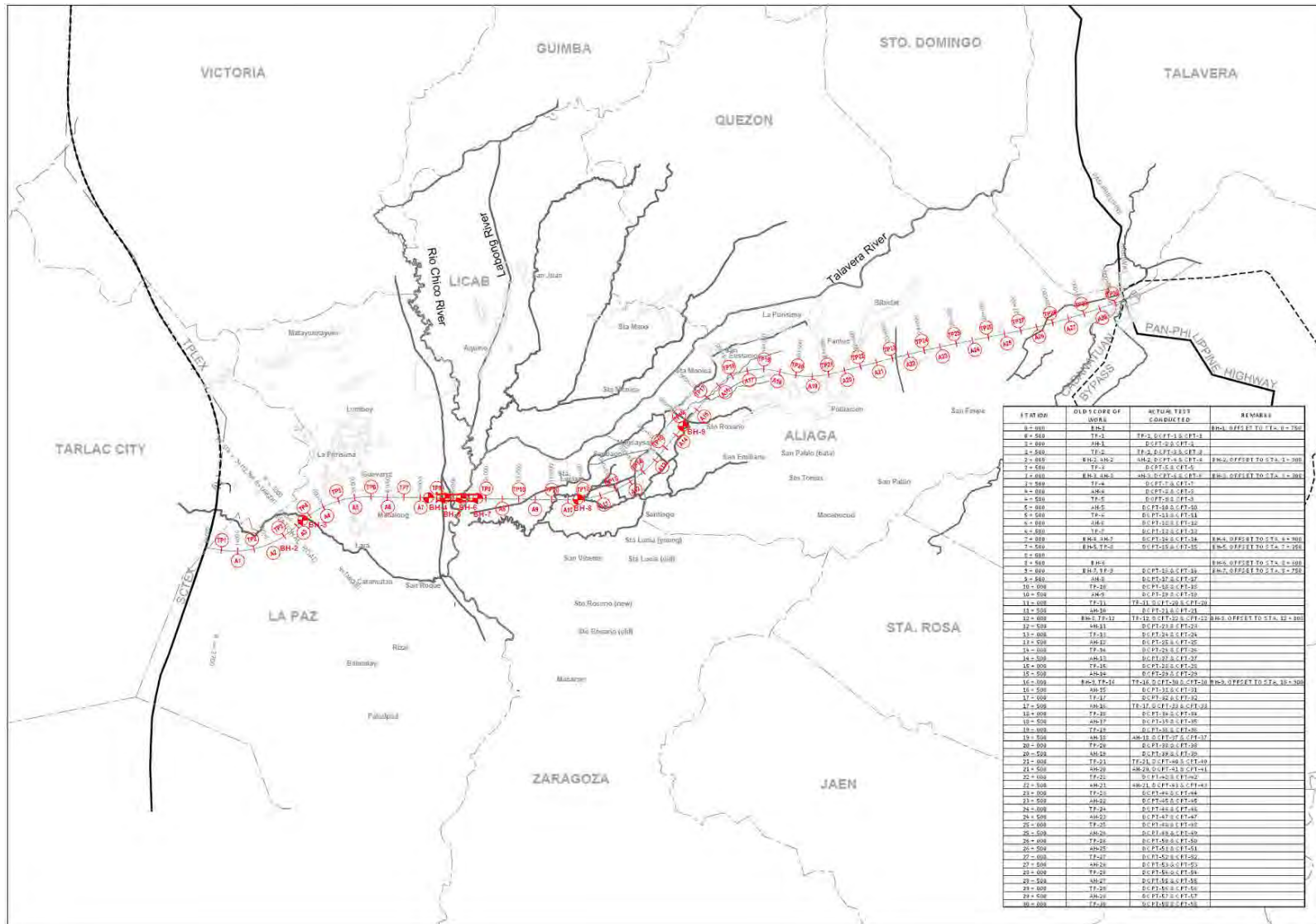


FIGURE 6.1.3-4 GEOTECHNICAL TEST LOCATION MAP

(3) Summary of Result and Findings

1) Bridge site geotechnical investigation

The profile accomplished by borehole test result is shown in **Table 6.1.3-2** and **Figure 6.1.3-5**.

TABLE 6.1.3-2 BOREHOLE TEST LOCATION

BH I.D.	Coordinates		Elevation (m)	Final Depth (m)
	Northing	Easting		
BH-1	15.45984	120.68010	21.787	18.35
BH-2	15.45937	120.69176	21.165	15.05
BH-3	15.46706	120.70262	19.656	15.40
BH-4	15.47615	120.73277	14.640	18.20
BH-5	15.47521	120.73604	14.386	18.20
BH-6	15.47313	120.74921	14.756	26.30
BH-7	15.47252	120.7499	14.638	21.35
BH-8	15.47271	120.78129	14.710	24.35
BH-9	15.50129	120.81637	18.979	25.40

The result of nine (9) boreholes revealed that the project site is underlain by alternating layers of clays and sands. In general, the soft to medium stiff Clay forms the uppermost soil cover, and then followed by the dense to very dense fine Sand where most of the boreholes were terminated.

The cohesive material is described as grayish brown, slight to high plastic Clay (CL/CH), with appreciable amount of sand. Consistency of the layer is soft to very stiff towards the bottom of the layer, with SPT blow counts ranging from $4 < N < 30$.

Underneath the cohesive layer is the medium dense to very dense fine Sand (SM), with some content of non-plastic silt. Generally, the layer found at the bottom of the borehole where blow counts hits practical refusals.

All the nine (9) boreholes were terminated after hitting five (5) meters thick of competent stratum (very dense Sand or hard Clay).

2) Test Pits and Auger Holes

Field and laboratory test result of the seven (7) test pits and five (5) auger holes, the excavated soil taken at the uppermost 0.70m to 2.00 meter is shown in **Table 6.1.3-3**.

TABLE 6.1.3-3 TEST RESULT OF TEST PITS AND AUGER HOLES

TP No.	Depth	Soil Description	AASHTO Class	Max. Dry Density (g/cc)	Optimum Moisture Content (%)	% CBR @ 95% MDD
1	0.10 – 2.0	sandy Clay	A-6 (7)	1.96	13.0	8.80
2	0.10 – 1.20	Sand and Clay mixture	A-6 (4)	1.96	14.2	8.00
11	0.10 – 2.00	Clay	A-7-6 (20)	1.62	24.0	2.4
12	0.10 – 2.00	Clay	A-7-6 (15)	1.64	20.8	1.9
16	0.20 – 1.00	Clay	A-7-5 (19)	1.66	21.2	3.4
17	0.10 – 2.00	Clay	A-7-6 (20)	1.645	21.2	2.3
21	0.20 – 1.00	sandy Clay	A-6 (9)	1.90	14.2	9.0

* Modified compaction: ASTM D1557/AASHTO T180, California Bearing Ratio: ASTM D1883/AASHTO T193

It is to note that uppermost 0.10 to 0.20 meters thick of soil cover is unsuitable materials, described as odorous, very soft organic Clay, with decayed roots and grasses.

3) Cone Penetration Test (CPT)

With respect to the Cone Penetrometer Tests (CPT), the uppermost 0.20 to 0.40 meters were generally having zero reading (indicating very little resistance), and would suggest the thickness of the unsuitable materials.

The seven (7) test pits locations with CPT would confirm very well that the unsuitable materials (zero CPT readings) correspond to the odorous, spongy, and slight to highly plastic, very soft organic Clay, with decayed roots and grasses described in the boring logs.

Thereafter, the CPT reading would progressively increase with increasing depth going thru the subsequent soil layers. Final depth of CPT ranged from 1.0m to 2.5m.

4) Dynamic Cone Penetrometer Tests (DCPT)

Generally, the uppermost 0.2-0.9 meters depth has a very low in-situ CBR values, about 1.2%, with marked increase in the calculated in-situ CBR with increasing depth.

5) Material Source Investigation

The following two (2) potential sources are identified and surveyed; Location of the material source is shown in **Figure 6.1.3-6**.

- a. MS-1, Upper Pampanga River
 Location: Brgy. Mayapyap Sur, Cabanatuan City
 Type of materials: Sand and Gravel
 Approx. Quantity: 2,000,000 cu.m
- b. BS-1, BRGY. Care Mountain Soil
 Location: Brgy. Care, Tarlac City
 Type of Materials Silty Clay
 Approx. Quantity: 1,000,000 cu.m

Laboratory test result is shown in **Table 6.1.3-4**.

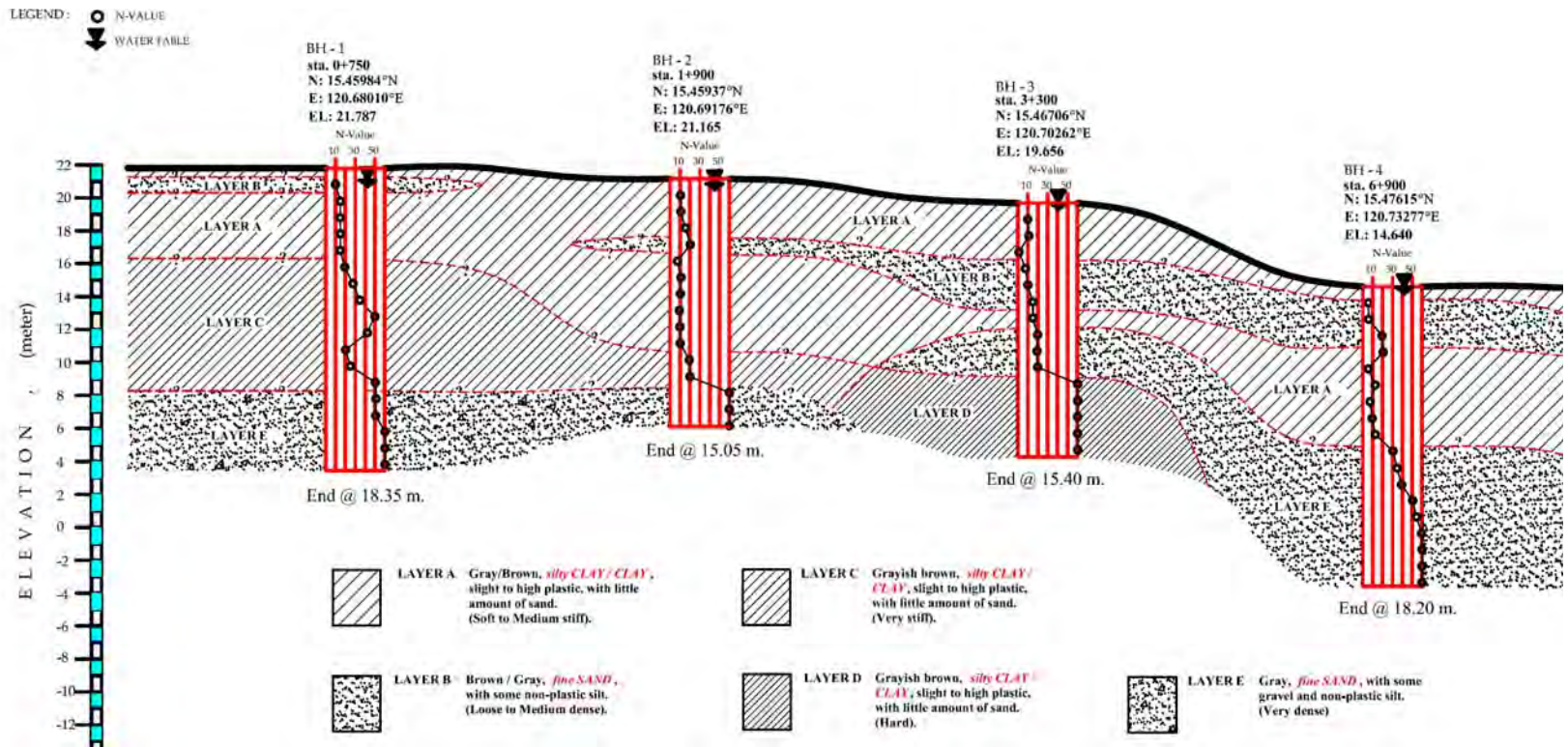


FIGURE 6.1.3-5 GEOGRAPHICAL PROFILE (1/2)

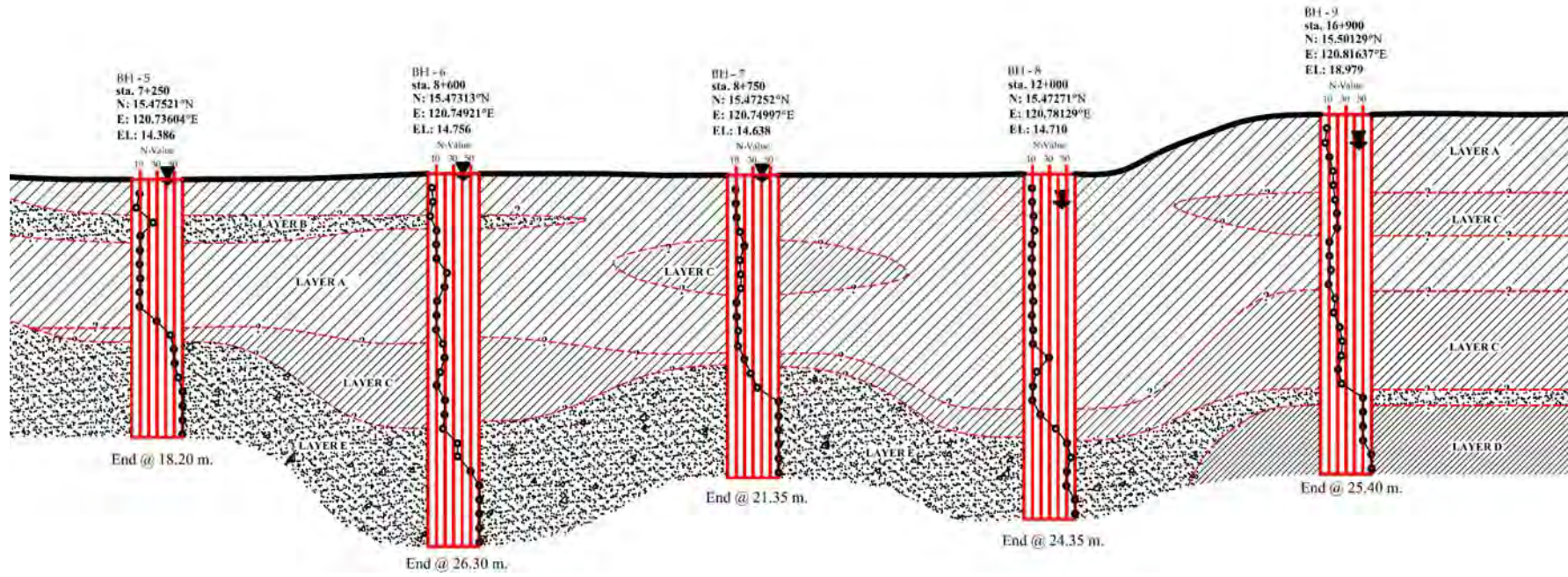
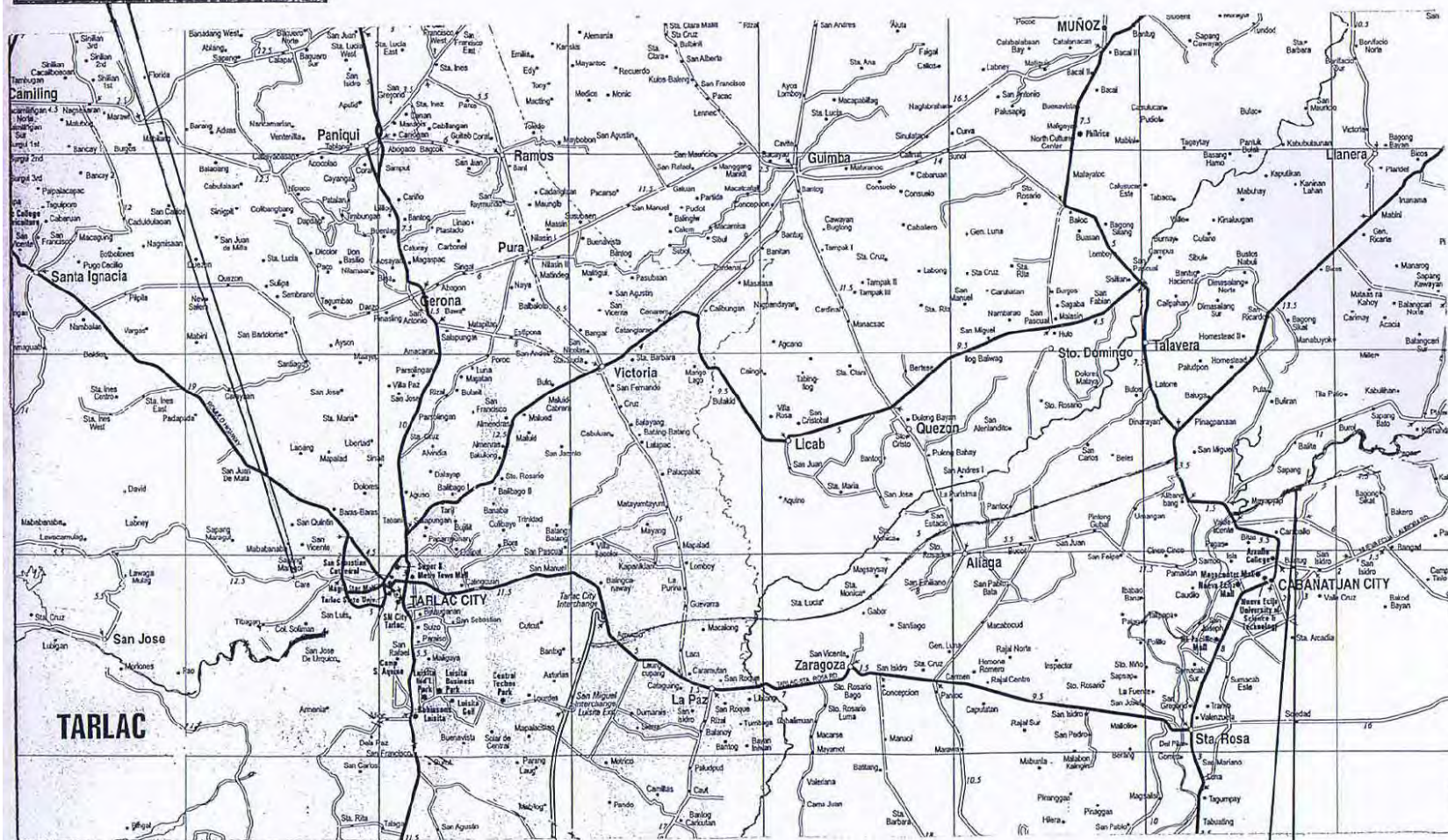


FIGURE 6.1.3-5 GEOGRAPHICAL PROFILE (2/2)

Source No	: BS-1
Source	: Brgy. Care Mountain Soil
Location	: Brgy. Care, Tarlac City
Materials	: Brown, silty CLAY
Estimated Quantity	: 1,000,000 cu. m.
Access	: Passable to any kind of vehicles
Coordinates	: Northing 15.45913°N Eastng 120.69173°E



Source No	: MS-1
Source	: Upper Pampanga River
Location	: Brgy. Mayayap Sar, Cabanatuan City
Materials	: SAND and GRAVEL
Item	: 104, 200, 201, 300
	: Fines and coarse aggregates.
Estimated Quantity	: 2,000,000 cu. m.
Access	: Passable to any kind of vehicles
Coordinates	: Northing 15.51729°N Eastng 120.96107°E

FIGURE 6.1.3-6 LOCATION MAP OF SAMPLE MATERIAL

TABLE 6.1.3-4 LABORATORY TEST RESULT OF MATERIAL SOURCE INVESTIGATION

Laboratory Tests Results		Upper Pampanga River	Brgy. Care Mountain Soil
Sieve Analysis (% Passing)	3"	-	-
	2"	91	-
	1.5"	83	-
	1"	67	-
	3/4"	55	-
	1/2"	42	-
	3/8"	35	-
	# 4	29	100
	# 8	24	99
	# 10	23	99
	# 16	21	97
	# 30	17	93
	# 40	15	91
	# 50	13	88
	# 100	10	80
# 200	9	75	
Atterberg Limit	Liquid Limit	NP	50
	Plastic Limit	NP	29
Classification		A-1-a (0)	A-7-6 (18)
Soundness (%)	Fine Aggregates	5.63	-
	Coarse Aggregates	0.16	-
Los Angeles Abrasion, %		17.82	-
Apparent Specific Gravity	Fine Aggregates	2.83	2.70
	Coarse Aggregates	2.81	-
Absorption (%)	Fine Aggregates	1.78	14.03
	Coarse Aggregates	1.2	-
Moisture Density Relation	MDD (g/cc)	2.21	1.68
	OMC (%)	8.5	21.8
California Bearing Ratio	@ 95% MDD	26.0	3.8
	@ 100% MDD	39.0	5.6
Flakiness		14.25	-
Organic Matter (%)		1.91	7.28

6.2 DESIGN STANDARD

6.2.1 Design Concept

The design concept is to provide a high speed toll road that allows safe and efficient movement of traffic as an expressway with fully controlled access, especially to improve the access from Tarlac (connection to Subic Clark Trilac Expressway) to Cabanatuan (Pan Philippines Highway) in the total length of **30.73km**.

The scope of work of the study is to review the past study and to consider stage construction in accordance with traffic demand forecast.

6.2.2 Design Standard

The following standard is mainly used as reference in Central Luzon Link Expressway (Phase I) design.

- A Policy on Geometric Design of Highways and Streets, AASHTO 2004
- Highway Safety Design Standards Part 1 Road Safety Design Manual, May 2004, DPWH
- Japan Road Association, Road Structure Ordinance, 2004
- Highway design manual, Metropolitan Expressway Co., Ltd., Japan
- Highway design manual, NEXCO, Japan

6.2.3 Design Speed

(1) Main Alignment

Recommended design speed by the previous feasibility study was 100kmh. In accordance with Road Safety Design Manual (DPWH, 2004) as well as considering the moderate topographic condition and safety of the traffic of staging construction, the design speed is recommended **100kph** for the express highway.

(2) Interchange Ramps

The interchange ramp design speed was employed as **40kph** which is 40% of the highway design speed and described minimum design speed in AASHTO 2004.

6.2.4 Design Vehicle

A **WB-15** is considered as design vehicle of the main alignment and ramp.

6.2.5 Summary of Express Highway Geometry

Geometry applied to the design of main alignment and ramp is summarized in **Table 6.2.5-1** and **Table 6.2.5-2**.

TABLE 6.2.5-1 GEOMETRY OF CLEX (MAIN ALIGNMENT) (100KM/HR)

Geometric Design Standards				
Project: CLEX				
Item	Unit	Standard	Absolute	Remark
Design Speed	kmh	100		
Design Vehicle	-	WB-15		
Stopping Sight Distance	m	185		page 56, Table 16.3, DPWH Rad Safety Design Manual
Passing Sight Distance	"	670		Page 69, Table 16.4 DPWH Road Safety Design Manual
1. Cross Section Elements				
Item	Unit	Standard	Substandard	Remark
Pavement Type				Asphalt Concrete
Lane Width	m	3.50		12ft(AASHTO2004)for high type highway, p211
Median Width(Center Separator)	"	3.00		Guard rail, drainage, tree planting included, refer to NEYCO
Inner Shoulder Wdth	"	1.00		Considering to mergin for staging construction
Outer Shoulder width	"	2.50		WB-15 trailer (2.44m)
Number of Lanes	nos	4		2 for 1st stage construction
Normal Crossfall	%	2.00		
Maximum super elevation	%	6.00		page 53, table 16.1 DPWH Road Safety Design Manual
Super elevation	%	exhibit 3-26		page 168, exhibit 3-26, ASSHTO 2004
Maximum relative gradients	%	0.43		page 62, super elevation DPWH, Road Safety Design Manual
2.Horizontal Alignment				
Item	Unit	Standard	Absolute	Remark
Minimum Radius	m	437		Page 147, exhibit 3-15, ASSHTO 2004
Min. Transition Curve Length	"	56		Page 61, Figure 16.3 DPWH Road Safety Design Manual
Min. Radius not requiring Transition Curve	"	2560		page 168, exhibit 3-26, ASSHTO 2004 (2.0%)
Superelevation run off		0.43%		p62 for 100kmh DPWH, Road Safety Design Manual
3. Vertical Alignment				
Item	Unit	Standard	Absolute	Remark
Max Vertical Gradient	%	3	4	Page 53, Table 16.1 DPWH Road Safety Deisgn Manual
Min.K value	Crest	"	85.0	1500(1000) JPN Standard
	Sag	"	52.0	2000(1400)JPN Standard
Min. Vertical Curve Length	"	60		Page 636, DPWH Design Guidelines, Criteria and Standards Vol II
Max.Composition Grade	%			
4.Vertical Clearance				
Object	Vertical Clearance (m)		Remark	
Road	5.200		DPHW Requirement, 4.9m(16feets) Clearance +0.3m (Fugure AC Overlay)	

TABLE 6.2.5-2 GEOMETRY OF CLEX (RAMP) (40KM/HR)

Geometric Design Standards				
Project: CLEX Ramp				
Item	Unit	Standard	Absolute	Remark
Design Speed	"	40		
Design Vehicle	-	WB-15		Exhibit 2-4, p22 AASHTO 2004
Stopping Sight Distance	"	50		page 56, Table 16.3, DPWH Rad Safety Design Manual
Passing Sight Distance	"	270		Page 69, Table 16.4 DPWH Road Safety Design Manual
1. Cross Section Elements				
Item	Unit	Standard	Substandard	Remark
Pavement Type				Asphalt Concrete
Lane Width	m	3.50		NEXCO A Type
Median Width	"	1.00		NEXCO A Type
Inner Shoulder Strip	"	1.00		NEXCO A Type, 1 direction 1lane ramp
Inner Shoulder Strip	"	0.75		NEXCO A Type, 2 direction 3lane ramp
Outer Shoulder Strip	"	2.50		NEXCO A Type
Number of Lanes	nos	1		
Normal Crossfall	%	2.00		
Maximum super elevation	%	6.00		page 53, table 16.1 DPWH Road Safety Design Manual
Super elevation	%	exhibit 3-26		page 168, exhibit 3-26, ASSHTO 2004
Maximum relative gradients	%	0.66		page 62, super elevation DPWH, Road Safety Design Manual
2.Horizontal Alignment				
Item	Unit	Standard	Absolute	Remark
Minimum Radius	m	50	43	Page 825,Page 147, exhibit 3-15, ASSHTO 2004
Min. Transition Curve Length	"	22		Page 61, Figure 16.3 DPWH Road Safety Design Manual
Min.Radius not requiring Transition Curve	"	525		page 168, exhibit 3-26, ASSHTO 2004 (2.0%)
Superelevation run off		0.66%		p62 for 40kmh DPWH, Road Safety Design Manual
3. Vertical Alignment				
Item	Unit	Standard	Absolute	Remark
Max Vertical Gradient	%	6	7	Page 53,Table 16.1 DPWH Road Safety Deisgn Manual
Min.K value	Crest	"	6.0	() is recommended value
	Sag	"	9.0	() is recommended value
Min. Vertical Curve Length	"	60		Page 636, DPWH Design Guidelines, Criteria and Standards Vol II
Max.Composition Grade	%	11.5		
4.Vertical Clearance				
Object	Vertical Clearance (m)		Remark	
Road	5.200		DPHW Requirement, 4.9m(16feets) Clearance +0.3m (Fugure AC Overlay)	

6.2.6 Vertical Clearance

The vertical clearance of the highway and crossing road shall be 4.0m to 5.2m (4.9m (16 feet) + 0.3m (overlay)).

6.2.7 Number of Lanes

Number of lane is set as below in accordance with traffic demand forecast;

- 1) Ultimate Stage: 4 lanes
- 2) Interim Stage: 2 lanes

6.2.8 Carriageway, Shoulder and Median Width

The cross sectional configuration is reviewed and recommended as below;

(1) Main alignment

The carriage way of the main alignment is **3.5m** in accordance with Road Safety Manual (DPWH 2004). Likewise the inner shoulder is designed as **1.0m**. This allows the construction of the 2nd stage cross without conflict from the section for the 1st stage construction. The outer shoulder is designed as **2.5m**. This permit semi trailer class (w=2.44m) emergent stops. The width of median is designed as **3.0m** with guard rail post and plantation of low height trees.

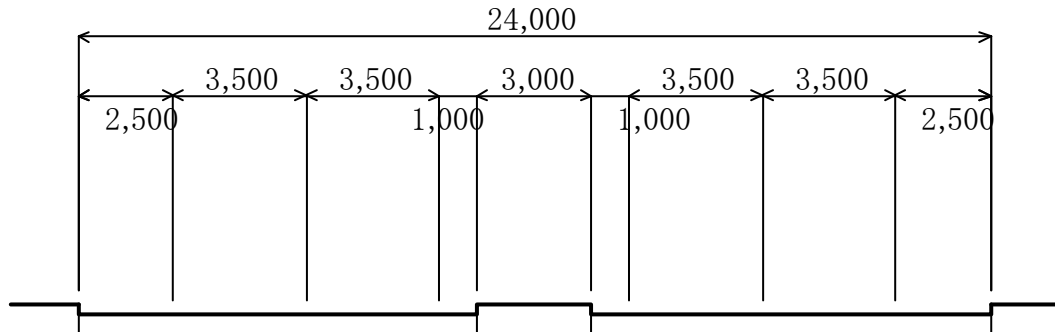


FIGURE 6.2.8-1 CROSS SECTIONAL CONFIGURATION (4 LANES)

(2) Ramp

The carriage way of the ramp is recommended same width as main alignment, namely **3.5m**. Widening of **1.0m** is added to this carriage way. The inner shoulder is designed as **1.0m** and outer shoulder **2.5m** with provision for passing a stalled vehicle of predominantly P vehicles but consideration for WB-15 trailers.

Ramp 1 lane

S=1: 200

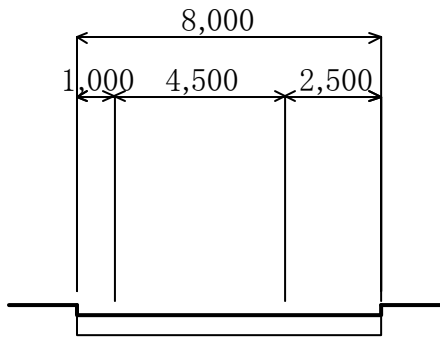
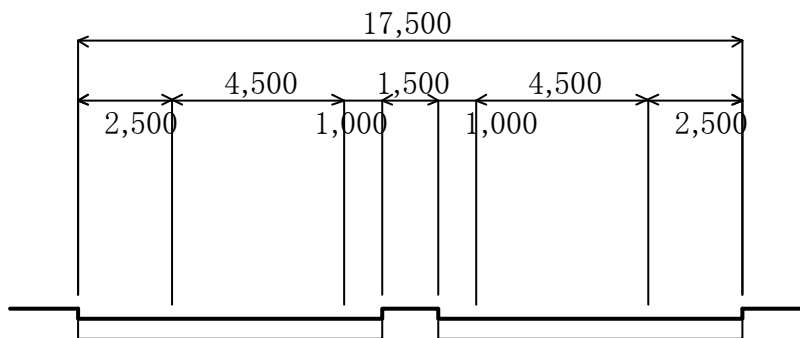


FIGURE 6.2.8-2 CROSS SECTIONAL CONFIGURATION (1 LANE RAMP)

2 Direction 2 Lanes

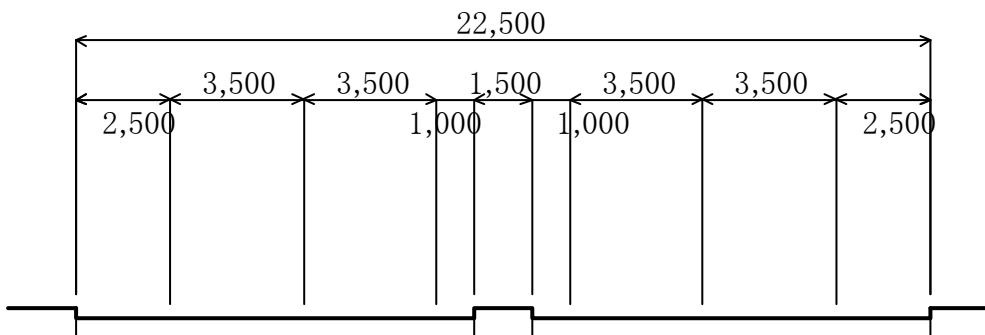
S=1: 200



**FIGURE 6.2.8-3 CROSS SECTIONAL CONFIGURATION
(2 DIRECTION 2 LANE RAMP)**

2 direction 4 lane

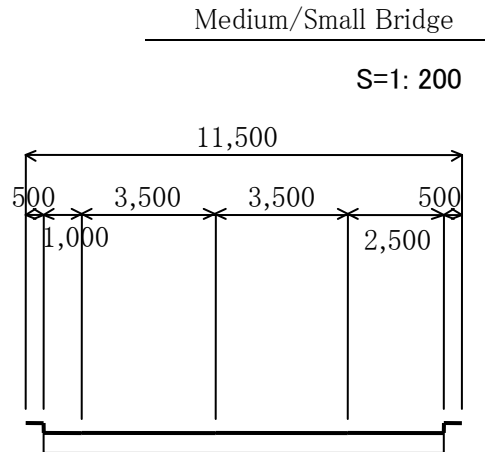
S=1: 200



**FIGURE 6.2.8-4 CROSS SECTIONAL CONFIGURATION
(2 DIRECTION 4 LANE)**

(3) **Medium/ Small size bridge ($L < 100\text{m}$)**

For small and medium size bridge ($L < 100\text{m}$), cross sectional configuration shall be the same as embankment roadway section.

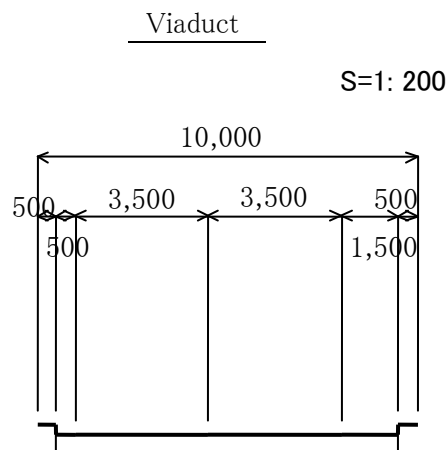


**FIGURE 6.2.8-5 CROSS SECTIONAL CONFIGURATION
(MEDIUM/ SMALL SIZE BRIDGE ($L < 100\text{M}$))**

(4) **Viaduct Bridge ($L > 100\text{m}$)**

For viaduct bridge, inner shoulder shall be reduced to **0.5m** and outer shoulder shall be reduced to **1.5m** for economical reason. (**Figure 6.2.8-6**)

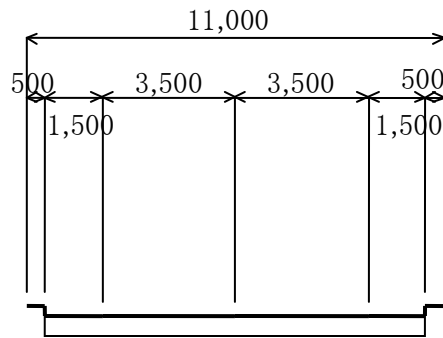
However, the bridge which will be constructed for initial open stage (2 lanes, 2 directions) shall be accommodated with outer shoulder of **1.5m**. (**Figure 6.2.8-7**)



**FIGURE 6.2.8-6 CROSS SECTIONAL CONFIGURATION FOR VIADUCT
(STANDARD)**

Viaduct

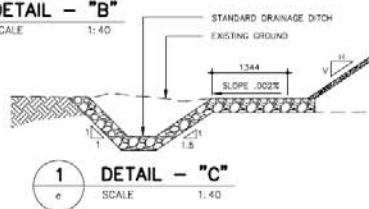
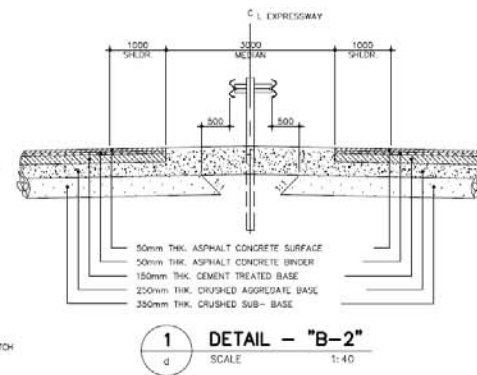
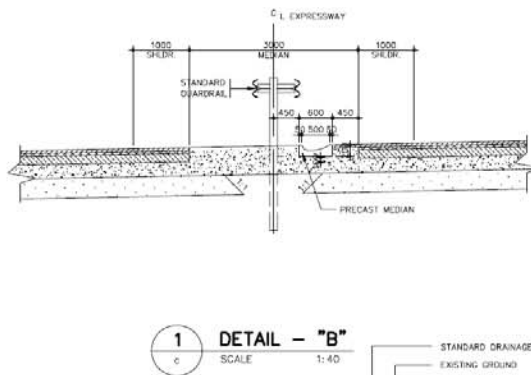
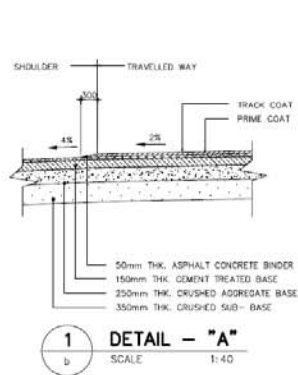
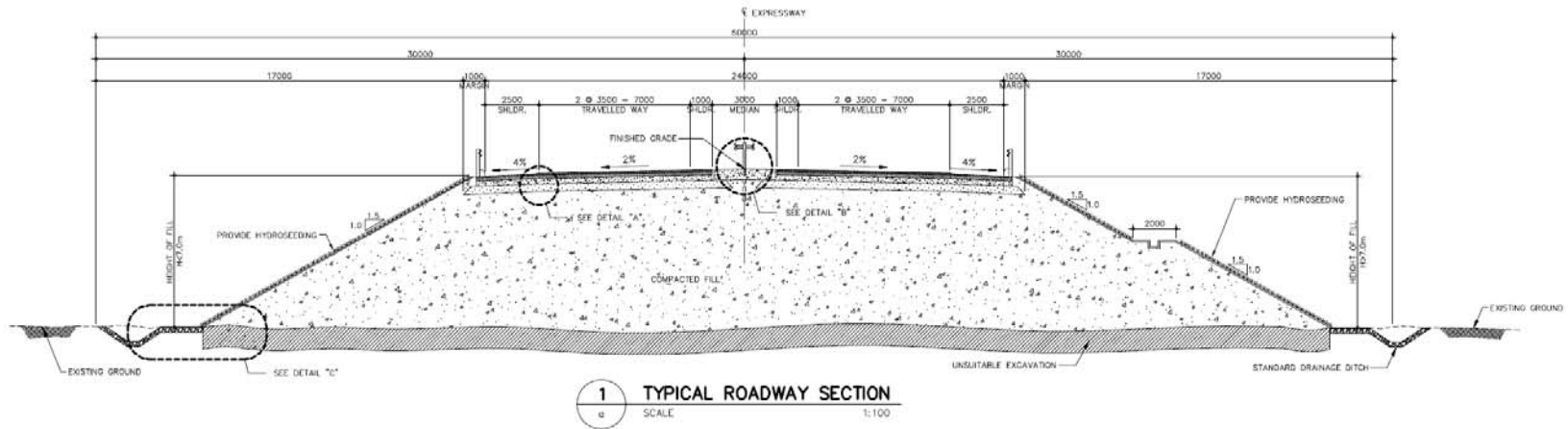
S=1: 200

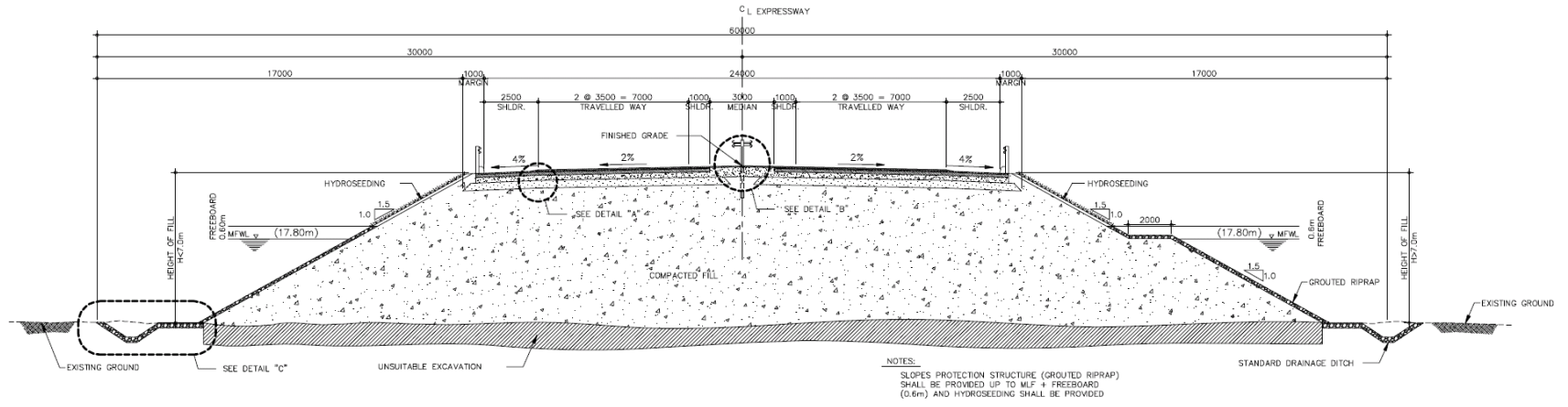


**FIGURE 6.2.8-7 CROSS SECTIONAL CONFIGURATION FOR VIADUCT
(INITIAL OPEN SIDE)**

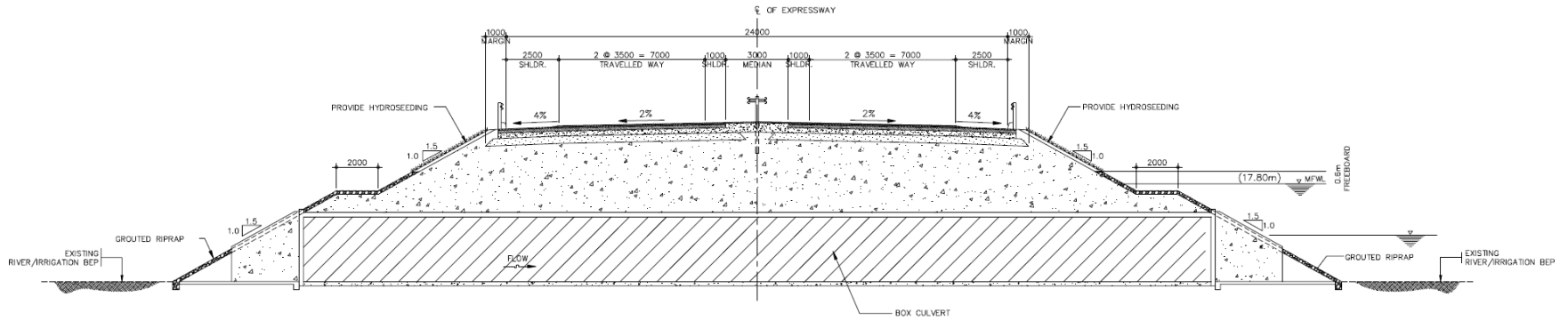
(5) Typical Cross Section

Typical Cross Sections are shown in the following pages.

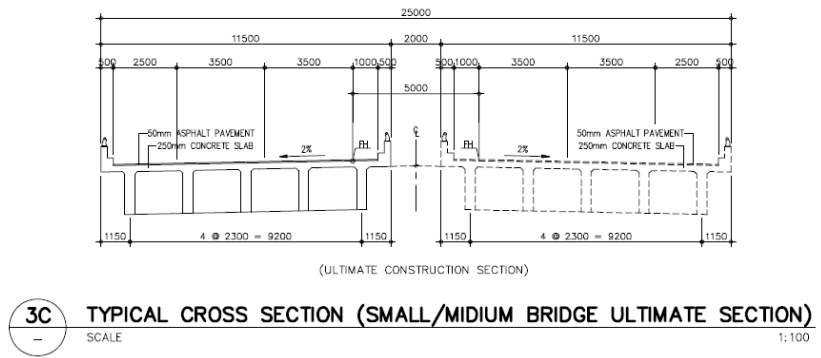
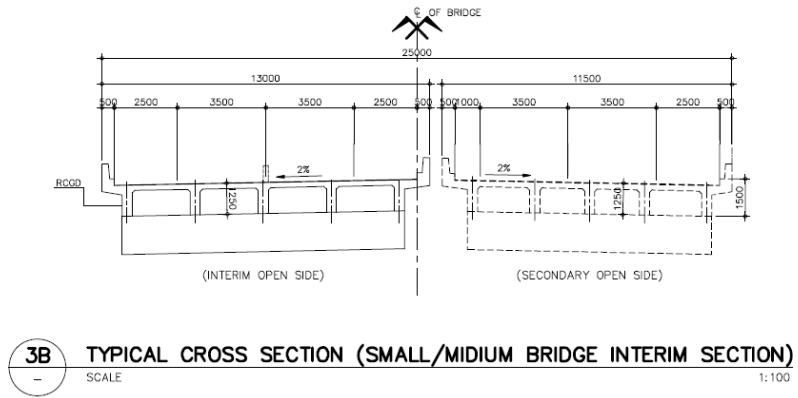
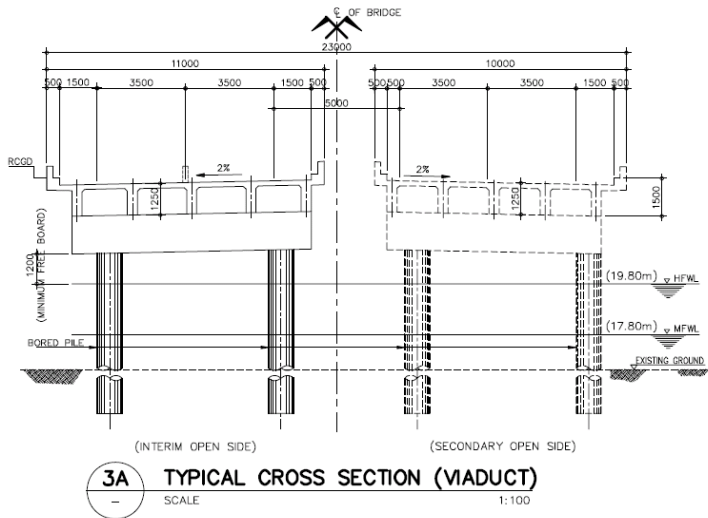


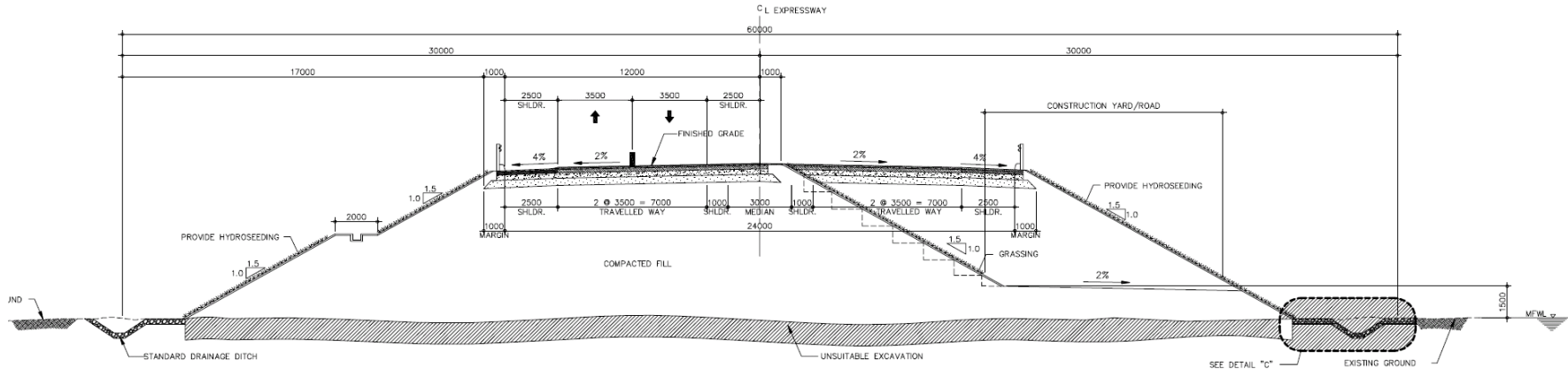


2A TYPICAL ROADWAY SECTION (EQUALIZING ZONE)
SCALE 1:100

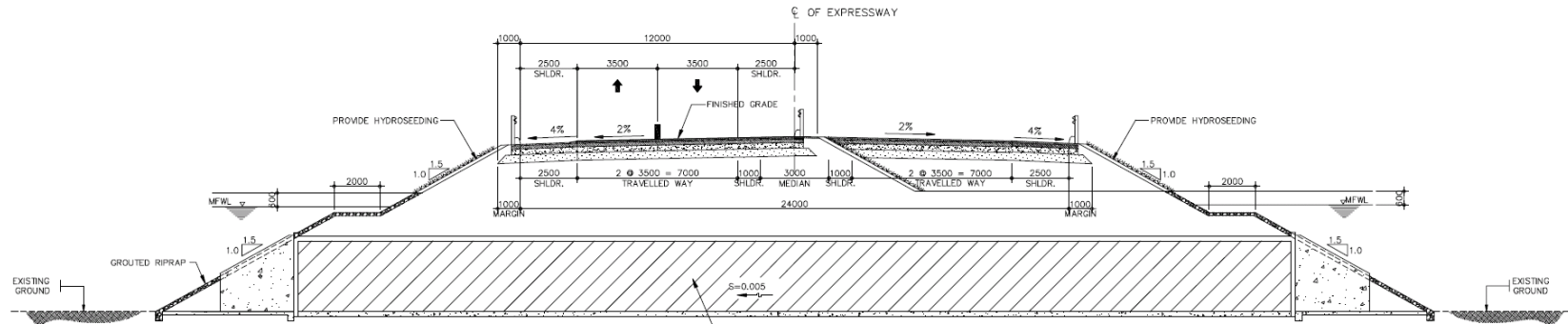


2B TYPICAL ROADWAY SECTION (EQUALIZING ZONE (BOX CULVERT))
SCALE 1:100



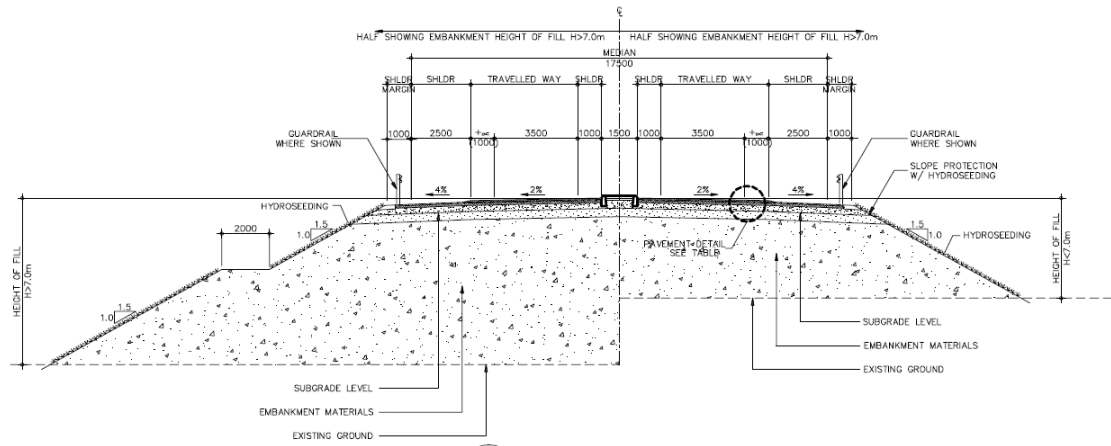


4A TYPICAL ROADWAY SECTION
SCALE 1:100

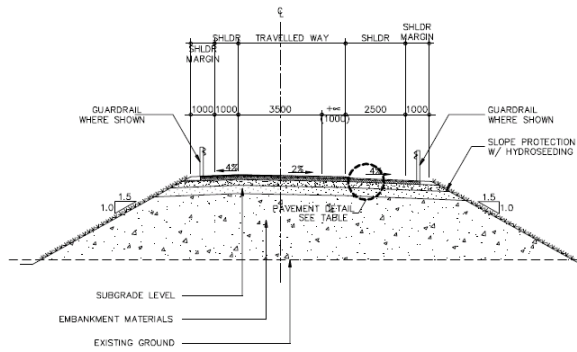


NOTES:
SLOPES PROTECTION STRUCTURE (GROUTED RIPRAP) SHALL BE PROVIDED UP TO MFL + FREEBOARD (0.60m) AND HYDROSEEDING SHALL BE PROVIDED
BOX CULVERT 3m x 3m @ 50m

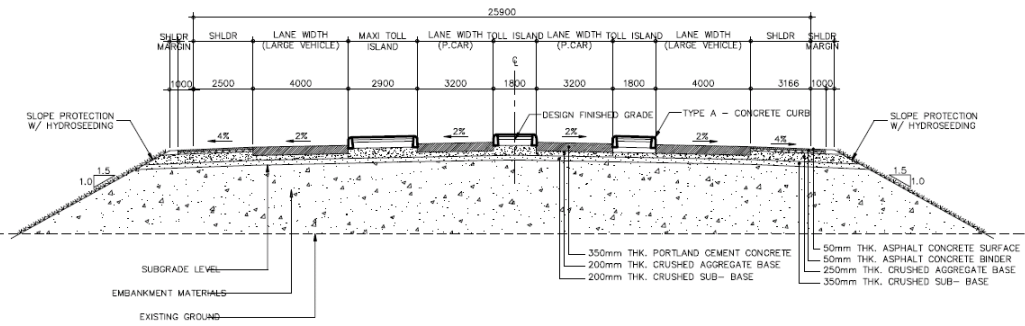
4B TYPICAL ROADWAY SECTION (EQUALIZING ZONE (BOX CULVERT))
SCALE 1:100



5A SECTION @ LOOP RAMP
SCALE 1:100



5B SECTION @ LOOP RAMP
SCALE 1:100



5C SECTION @ TOLL PLAZA
SCALE 1:100

PAVEMENT THICKNESS TABLE

LAYER	TRAVELLED WAY	SHOULDER
SURFACE COURSE	50mm THK. ASPHALT CONCRETE SURFACE COURSE	
BINDER COURSE	50mm THK. ASPHALT CONCRETE BINDER COURSE	50mm THK. ASPHALT CONCRETE BINDER COURSE
BASE COURSE	100mm THK. CEMENT TREATED BASE COURSE	100mm THK. CEMENT TREATED BASE COURSE
	250mm THK. CRUSH AGGREGATE BASE COURSE	250mm THK. CRUSH AGGREGATE BASE COURSE
SUBBASE COURSE	350mm THK. AGGREGATE SUBBASE COURSE	350mm THK. AGGREGATE SUBBASE COURSE

6.2.9 Stopping Distance

According to Road Safety Design Manual (2004, DPWH);
 Stopping distance for design speed of 100kph is 185m.
 Stopping distance for design speed of 40kph is 50m.

6.2.10 Cross fall Development

Superelevation of the carriageway shall be considered to accommodate recommendation of AASHTO 2004 as shown in **Table 6.2.10-1**. The maximum value of superelevation is 6.0% as guided in Road Safety Manual(2004) in page 53.

In principal, the superelevation is attained within spiral curve. The runoff rate of super elevation is considered 0.43% for 100kph and 0.65% for 50kph in accordance to the Road Safety Design Manual.

TABLE 6.2.10-1 MINIMUM RADII FOR DESIGN SUPERELEVATION RATES, $e_{max} = 6.0\%$

e (%)	METRIC												
	$V_d = 20$ km/h R (m)	$V_d = 30$ km/h R (m)	$V_d = 40$ km/h R (m)	$V_d = 50$ km/h R (m)	$V_d = 60$ km/h R (m)	$V_d = 70$ km/h R (m)	$V_d = 80$ km/h R (m)	$V_d = 90$ km/h R (m)	$V_d = 100$ km/h R (m)	$V_d = 110$ km/h R (m)	$V_d = 120$ km/h R (m)	$V_d = 130$ km/h R (m)	
1.5	194	421	736	1050	1440	1910	2360	2880	3510	4060	4770	5240	
2.0	138	290	525	750	1030	1380	1710	2090	2560	2970	3510	3880	
2.2	122	265	465	696	919	1230	1530	1880	2300	2670	3190	3500	
2.4	109	236	415	596	825	1110	1380	1700	2090	2420	2870	3150	
2.6	97	212	372	540	746	1000	1260	1540	1890	2210	2630	2930	
2.8	87	190	334	488	676	910	1160	1410	1730	2020	2420	2700	
3.0	78	170	300	443	615	831	1050	1290	1590	1870	2240	2510	
3.2	70	152	269	402	561	781	959	1190	1470	1730	2080	2330	
3.4	61	133	239	364	511	697	882	1100	1360	1600	1940	2190	
3.6	51	113	200	329	465	640	813	1020	1260	1490	1810	2050	
3.8	42	95	177	294	422	596	749	939	1170	1390	1700	1930	
4.0	35	82	155	261	380	535	690	870	1090	1300	1590	1820	
4.2	31	72	138	234	343	488	635	806	1010	1220	1500	1720	
4.4	27	63	121	210	311	446	584	746	938	1140	1410	1630	
4.6	24	56	108	190	283	408	538	692	873	1070	1330	1540	
4.8	21	50	97	172	258	374	496	641	812	997	1250	1470	
5.0	19	45	89	156	235	343	457	594	755	933	1190	1400	
5.2	17	40	79	142	214	315	421	549	701	871	1120	1330	
5.4	15	36	71	129	196	287	388	506	648	810	1060	1260	
5.6	13	32	63	115	176	259	351	463	584	747	960	1160	
5.8	11	28	58	102	156	232	315	416	537	679	900	1110	
6.0	8	21	43	79	123	184	252	336	437	560	766	951	

Exhibit 3-26. Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max} = 6\%$

6.2.11 Minimum Radius Without Superelevation

When the curve radius is larger than R2560min, superelevation can be omitted in accordance with AASHTO 2004.

6.2.12 Minimum Curve Length

(1) Minimum Curve length

The length of the spiral curve is recommended to take for 2 seconds of the design speed by AASHTO 2004.

$$50\text{km/h: } L_d = 13.9(\text{m/s}) \times 2(\text{sec}) = 27.8\text{m}(28\text{m})$$

$$100\text{km/h: } L_d = 27.7(\text{m/s}) \times 2(\text{sec}) = 55.5(56\text{m})$$

(2) Minimum Spiral Curve Length

The spiral lengths listed in **Table 6.2.12-1** are recommended as desirable values for highway design by AASHTO 2004. Spiral curve length shall be as long as to adequate

the desired superelevation runoff. Minimum spiral curve length for superelevation runoff is shown in **Table 6.2.12-2**.

TABLE 6.2.12-1 DESIRABLE LENGTH OF SPIRAL CURVE TRANSITION

Design Speed (km/h)	Spiral Length(m)
20	11
30	17
40	22
50	28
60	33
70	39
80	44
90	50
100	56
110	61
120	67
130	72
AASHTO 2004, p189	

TABLE 6.2.12-2 MINIMUM SPIRAL CURVE LENGTH FOR SUPERELEVATION RUNOFF (Ld)

4 lane

Main alignment

Super elevation(%)	Radius	We(m)	e(m)	S(%)	Ld	Remark
6.00	437	9.5	0.570	0.430	133	100km/h
5.00	755	9.5	0.475	0.430	110	100km/h
4.00	1000	9.5	0.380	0.430	88	100km/h
3.00	1690	9.5	0.285	0.430	66	100km/h
2.00	2560	9.5	0.190	0.430	44	100km/h

2 direction 2lane

Ramp

Super elevation(%)	Radius	We(m)	e(m)	S(%)	Ld	Remark
6.00	437	6.25	0.375	0.660	87	40km/h
5.00	755	6.25	0.313	0.660	73	40km/h
4.00	1000	6.25	0.250	0.660	58	40km/h
3.00	1690	6.25	0.188	0.660	44	40km/h
2.00	2560	6.25	0.125	0.660	29	40km/h

1 direction 1 lane

Ramp

Super elevation(%)	Radius	We(m)	e(m)	S(%)	Ld	Remark
6.00	437	2.75	0.165	0.660	38	40km/h
5.00	755	2.75	0.138	0.660	32	40km/h
4.00	1000	2.75	0.110	0.660	26	40km/h
3.00	1690	2.75	0.083	0.660	19	40km/h
2.00	2560	2.75	0.055	0.660	13	40km/h

6.2.13 Speed Change Lanes

The deceleration and acceleration length requirements are calculated based of AASHTO (2004).

(1) Deceleration Lane Length and Acceleration Lane Length

TABLE 6.2.13-1 DECELERATION LENGTH

Highway Design Speed, V (KPH)	Speed Reached, Va (KPH)	Stop Condition	20	30	40	50	60	70	80		
			For Average Running Speed on Exit Curve, V'a (KPH)								
			0	20	28	35	42	51	63	70	
50	47	75	70	60	45	-					
60	55	95	90	80	65	55	-				
70	63	110	105	95	85	70	55	-			
80	70	130	125	115	100	90	80	55	-		
90	77	145	140	135	120	110	100	75	60		
100	85	170	165	155	145	135	120	100	85		
110	91	180	180	170	160	150	140	120	105		
120	98	200	195	185	175	170	155	140	120		

Where:

- V = Design Speed of Toll-way (KPH)
- Va = Average Running Speed on Toll-way (KPH)
- V' = Design Speed of Exit (KPH)
- V'a = Average Running Speed on Exit Curve (KPH)

TABLE 6.2.13-2 ACCELERATION LENGTH

L (meters) for Entrance Curve Design Speed, V' (KPH)											
Highway Design Speed, V (KPH)	Speed Reached, Va (KPH)	Stop Condition	20	30	40	50	60	70	80		
			And Initial Speed, V'a (KPH)								
			0	20	28	35	42	51	63	70	
50	37	60	50	30	-	-					
60	45	95	80	65	45	-	-				
70	53	150	130	110	90	65	-	-			
80	60	200	180	165	145	115	65	-	-		
90	67	260	245	225	205	175	125	35	-		
100	74	345	325	305	285	255	205	110	40		
110	81	430	410	390	370	340	290	200	125		
120	88	545	530	515	490	460	410	25	245		

Where:

- V = Design Speed of Toll-way (KPH)
- Va = Average Running Speed on Toll-way (KPH)
- V' = Design Speed of Entrance Curve (KPH)
- V'a = Initial Speed on Entrance Curve (KPH)

TABLE 6.2.13-3 SPEED CHANGE LANE ADJUSTMENT FACTORS AS A FUNCTION OF GRADE

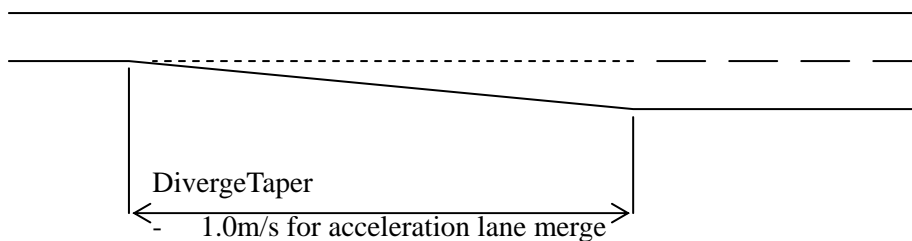
Highway Design Speed, V (KPH)	Ratio of Length on Grade to Length on Level for Design Speed of Turning Curve (Km/h)	
	3 to 4% Upgrade	3 to 4% Downgrade
All Speeds	0.90	1.2
All Speeds	0.80	1.35

TABLE 6.2.13-4 SPEED CHANGE LANE ADJUSTMENT FACTORS AS A FUNCTION OF GRADE

Highway Design Speed, V (KPH)	Ratio of Length on Grade to Length on Level for Design Speed of Turning Curve (Km/h)					
	40	50	60	70	80	All Speeds
3 to 4 % Upgrade						3 to 4 % Downgrade
60	1.3	1.4	1.4			0.70
70	1.3	1.4	1.4	1.5		0.65
80	1.4	1.5	1.5	1.5	1.6	0.65
90	1.4	1.5	1.5	1.5	1.6	0.6
100	1.5	1.6	1.7	1.7	1.8	0.6
110	1.5	1.6	1.7	1.7	1.8	0.6
120	1.5	1.6	1.7	1.7	1.8	0.6
5 to 6 % Upgrade						5 to 6 % Downgrade
60	1.5	1.5				0.6
70	1.5	1.6	1.7			0.6
80	1.5	1.7	1.9	1.8		0.55
90	1.6	1.8	2.0	2.1	2.2	0.55
100	1.7	1.9	2.2	2.4	2.5	0.5
110	2.0	2.2	2.6	2.8	3.0	0.5
120	2.3	2.5	3.0	3.2	3.5	0.5

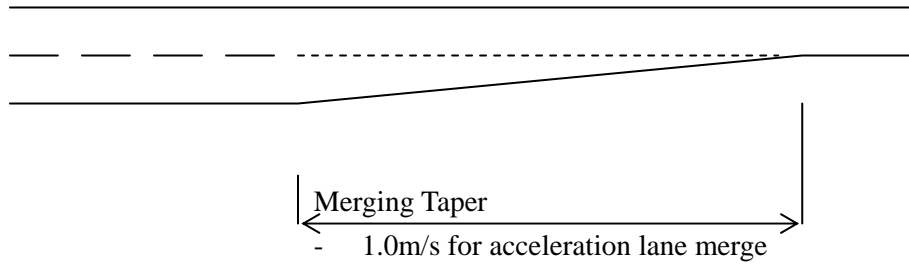
(2) Diverging Taper

*Vertical Gradient less than 3.0%



Design Speed	Lane width
	3.5m
100km/h (27.78m/s)	97m

(3) Merging Taper



Design Speed	Lane width
	3.5m
100km/h (27.78m/s)	97m

6.2.14 Maximum Gradient

For the main alignment with design speed of 100kph, the maximum vertical gradient could be applied is **4%** by referring to Road Safety Manual (2004 DPWH) while desirable max gradient is **3%**.

For interchange On and Off Ramp with design speed of 50kph, the maximum gradient recommended to apply is **6.0%** while absolute grade is **7.0%**.

6.3 EXPRESSWAY DESIGN

6.3.1 General

This section of the report highlights the engineering studies undertaken for the proposed project following the AASHTO and DPWH technical guidelines and procedures.

This section contains following technical studies;

- (1) Hydrological analysis
- (2) Crossing Road and River Design
- (3) Vertical Control
- (4) Rio Chico River Flood Prone Area Design
- (5) Interchange Design
- (6) Interim 2 Lanes Design

6.3.2 Hydrological Analysis

(1) Technical Approach

This study was carried out in the following steps;

- 1) Data collection
- 2) Hydrologic study
- 3) Hydraulic analysis
- 4) Drainage Design

(2) Data collection

Topographic maps from the National Mapping and Resource Information Authority (NAMRIA) were acquired. For the rainfall data, the same data from the existing Feasibility Study was obtained from the Philippine Atmospheric, Geophysical Astronomical Services Administration (PAGASA) was used.

1) Topographic Maps

NAMIRA is the government agency responsible for the preparation of topographic maps of the Philippines. For the project location, 1:50,000 maps were available.

2) Rainfall Data

For the purpose of this study, the same rainfall data used in the existing Feasibility Study is utilized. The available data are from the Cabanatuan City (based on 33 years of record), Munoz, Nueva Ecija (based on 21 years of record) and Pantabangan (based on 19 years of record.)

RAINFALL INTENSITY-DURATION FREQUENCY DATA

For

CABANATUAN CITY

Based on 33 years of record

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION

Return Period	5	10	15	20	30	45	60	80	100	120	150	3	6	12	24
Yrs.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	hrs.	hrs.	hrs.	hrs.
2	12.10	18.80	24.10	28.60	36.60	45.00	50.70	57.00	62.30	66.10	70.80	75.10	92.60	108.90	127.90
5	17.5	26.90	34.30	40.50	52.40	65.00	74.60	83.30	90.50	95.60	101.60	108.70	137.80	162.60	194.50
10	21.10	32.20	41.10	48.40	62.80	73.80	90.50	100.70	109.10	115.10	121.90	131.00	167.70	198.10	238.60
15	23.10	35.30	44.90	52.90	68.70	85.80	99.40	110.50	119.60	126.10	133.40	143.50	184.50	218.10	263.40
20	24.50	37.40	47.60	56.00	72.80	91.00	105.70	117.40	127.00	133.80	141.50	152.30	196.30	232.20	280.80
25	25.60	39.00	49.70	58.50	76.00	95.10	110.50	122.70	132.70	139.70	147.70	159.10	205.40	243.00	294.30
50	28.90	44.00	56.00	65.90	85.70	107.50	125.40	139.00	150.10	158.00	166.80	180.00	233.40	276.30	335.60
100	32.20	49.00	62.30	73.30	95.40	119.80	140.10	155.20	167.50	176.10	185.70	200.70	261.20	309.30	376.60

EQUIVALENT AVERAGE INTENSITY (in mm/hr.) OF COMPUTED EXTREME VALUES

Return Period	5	10	15	20	30	45	60	80	100	120	150	180	360	720	1440
Yrs.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.
2	145.20	112.80	96.40	85.80	73.20	60.00	50.70	42.80	37.40	33.00	28.30	25.00	15.40	9.10	5.30
5	210.00	161.40	137.20	121.50	104.80	86.70	74.60	62.50	54.30	47.80	40.60	36.20	23.00	13.60	8.10
10	253.20	193.20	164.40	145.20	125.60	104.40	90.50	75.50	65.50	57.50	48.80	43.70	28.00	16.50	9.90
15	277.20	211.80	179.60	158.70	137.40	114.40	99.40	82.90	71.80	63.00	53.40	47.80	30.80	18.20	11.00
20	294.00	224.40	190.40	168.00	145.60	121.30	105.70	88.00	76.20	66.90	56.60	50.80	32.70	19.30	11.70
25	307.20	234.00	198.80	175.50	152.00	126.80	110.50	92.00	79.60	69.80	59.10	53.00	34.20	20.30	12.30
50	346.80	264.00	224.00	197.70	171.40	143.30	125.40	104.30	90.10	79.00	66.70	60.00	38.90	23.00	14.00
100	386.40	294.00	249.20	219.90	190.80	159.70	140.10	116.40	100.50	88.10	74.30	66.90	43.50	25.80	15.70

Prepared by:

The HYDROMETEOROLOGICAL INVESTIGATIONS and SPECIAL STUDIES SECTION

Flood Forecasting Branch, PAGASA

RAINFALL INTENSITY-DURATION FREQUENCY DATA

for

MUNOZ, NUEVA ECIJA

Based on 21 years of record

COMPUTED EXTREME VALUES (in mm) of PRECIPITATION

Return Period	60	3	6	12	24
Yrs.	min.	hrs.	hrs.	hrs.	hrs.
2	58.80	66.30	78.70	89.00	105.40
5	67.10	82.60	98.80	125.60	144.70
10	75.30	93.30	112.10	149.90	170.70
20	83.10	103.70	124.80	173.20	195.70
25	85.60	107.00	128.80	180.50	203.60
50	93.20	117.10	141.30	203.30	228.00
100	100.80	127.10	153.60	225.90	252.30

EQUIVALENT AVERAGE INTENSITY (in mm/hr.) OF COMPUTED EXTREME VALUES

Return Period	60	180	360	720	1440
Yrs.	min.	min.	min.	min.	min.
2	54.80	22.10	13.10	7.40	4.40
5	67.10	27.50	16.50	10.50	6.00
10	75.30	31.10	18.70	12.50	7.10
20	83.10	34.60	20.80	14.40	8.20
25	85.60	35.70	21.50	15.00	8.50
50	93.20	39.00	23.50	16.90	9.50
100	100.80	42.40	25.60	18.80	10.50

Prepared by:

The HYDROMETEOROLOGICAL INVESTIGATIONS and SPECIAL STUDIES SECTION

Flood Forecasting Branch, PAGASA

RAINFALL INTENSITY-DURATION FREQUENCY DATA

for

PANTABANGAN

Based on 19 years of record

COMPUTED EXTREME VALUES (in mm) of PRECIPITATION

Return Period	60	3	6	12	24
Yrs.	min.	hrs.	hrs.	hrs.	hrs.
2	45.80	66.70	83.80	99.10	120.80
5	62.50	99.10	119.70	147.00	187.10
10	73.60	120.60	143.50	178.70	230.90
20	84.20	141.20	166.30	209.10	273.00
25	87.50	147.70	173.50	218.70	286.40
50	97.90	167.90	195.80	248.40	327.50
100	108.20	187.80	217.90	277.90	368.30

**EQUIVALENT AVERAGE INTENSITY (in mm/hr.) OF COMPUTED EXTREME
VALUES**

Return Period	60	180	360	720	1440
Yrs.	min.	min.	min.	min.	min.
2	45.80	22.20	14.00	8.30	5.00
5	62.50	33.00	20.00	12.20	7.80
10	73.60	40.20	23.90	14.90	9.60
20	84.20	47.10	27.70	17.40	11.40
25	87.50	49.20	28.90	18.20	11.90
50	97.90	56.00	32.60	20.70	13.60
100	108.20	62.60	36.30	23.20	15.30

Prepared by:

**The HYDROMETEOROLOGICAL INVESTIGATIONS and SPECIAL STUDIES
SECTION**

Flood Forecasting Branch, PAGASA

(3) Hydrologic Study

1) Design Criteria

The method used in computing the discharge was selected based on the size of the catchment area. The following criteria were used;

Catchment area Method

0 – 20 km²

Rational Formula

> 20 km²

JICA Study 1982 (Rio Chico River and Talavera River)

2) Rational Formula

The Rainfall Formula is the simplest method in estimation maximum discharge. This is widely applied when the catchment area is less than 20km².

The formula is;

$$Q = 0.278 CIA \quad (\text{in m}^3/\text{sec})$$

Where

Q = discharge in cubic meters per second

C = coefficient of runoff which depends on the topographical character of the drainage area

I = Rainfall intensity in mm/hr for a duration equal to the time of concentration

A = Drainage area in Km²

3) Catchment or Drainage Areas

The preferred alignment was plotted on the topographic maps. Eighteen (18) natural waterways were identified along the alignment. The catchment areas for each water way was delineated. A catchment area is defined as the limits of the topographic divide which is the line that separates water flow between basins. Other hydrologic parameters such as length of waterway and difference of elevation are identified. Figure ** shows the delineated catchment areas.

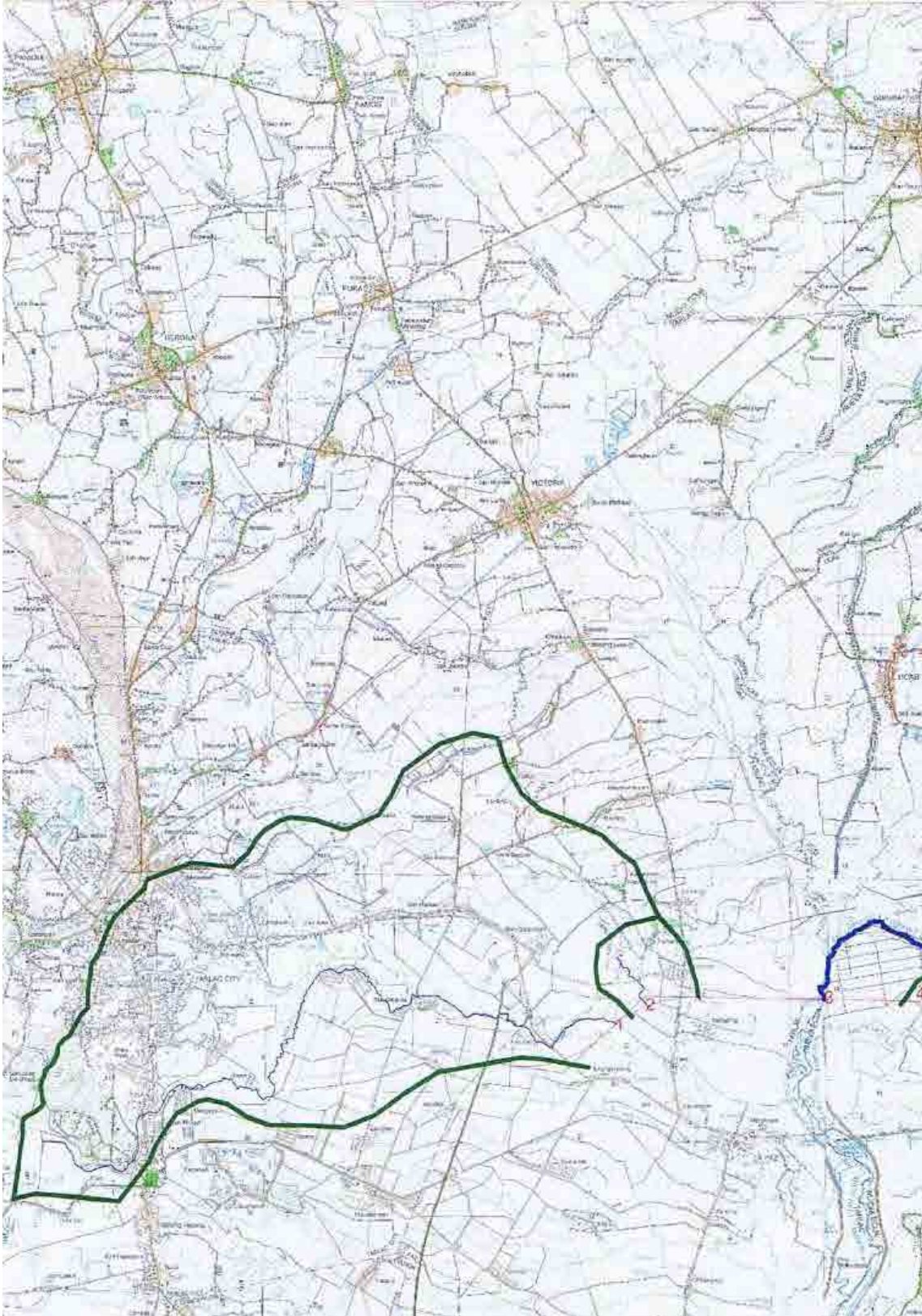


FIGURE 6.3.2-1 CATCHMENT AREA (1/2)

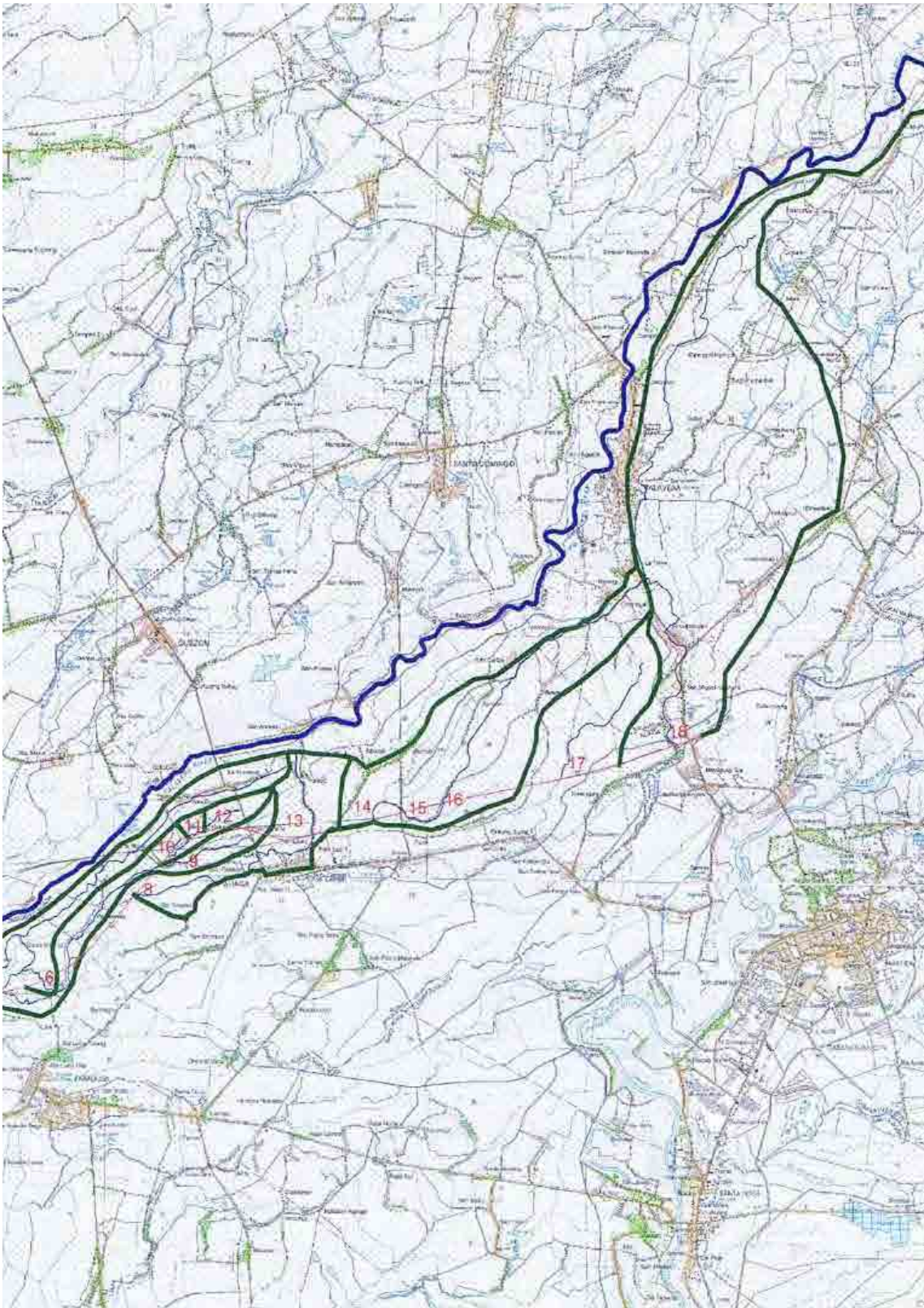


FIGURE 6.3.2-1 CATCHMENT AREA (2/2)

4) Rainfall Analysis

The rainfall data from PAGASA was converted into a simple equation in the form:

Where:

I = Rainfall Intensity, mm/hr

t = duration of rain in hours or minutes

A,B and c are constants determined from the curves

Converting the data into formula form makes it easier to compute the corresponding rainfall value for different values of the time of concentration. The result of the analysis are as follows;

Station	Return Period	A	b	c
Cabanatuan	2	977.38	0.7168	9.3
	5	1275.6	0.6951	8.4
	10	1477.9	0.6878	8.0
	15	1605.0	0.6847	8.0
	20	1868.5	0.6970	9.2
	25	1945.6	0.6957	9.2
	50	1963.7	0.6793	7.8
	100	2176.8	0.6777	7.8
Munoz, Nueva Ecija	2	1178.1	0.7691	-6.0
	5	1156.7	0.7241	-9.0
	10	1219.3	0.7082	-9.0
	20	1238.6	0.6906	-10.0
	25	1266.5	0.6887	-10.0
	50	1337.5	0.6809	-10.0
	100	1410.5	0.6745	-10.0
	Pantabangan	2	1151.9	0.7469
5		1475.7	0.7195	21
10		1880.2	0.7238	28
20		1986.6	0.7078	27
25		2091.6	0.7089	28
50		2353.9	0.7067	30
100		2628.6	0.7055	32

5) Time of concentration

The time of concentration, T_c, is the required time for the stream under consideration to reach its peak discharge and could be computed using the formula developed by Kirpich as shown below;

$$T_c = \frac{L^{1.15}}{51H^{0.38}}$$

Where:

T_c = Time of concentration in minutes

L = Length of longest water course in the watershed in meter

H = Difference in elevation between the highest point of the watershed and the point under consideration in meters

Rainfall Intensity Curve is shown in **Figure 6.3.2-2**

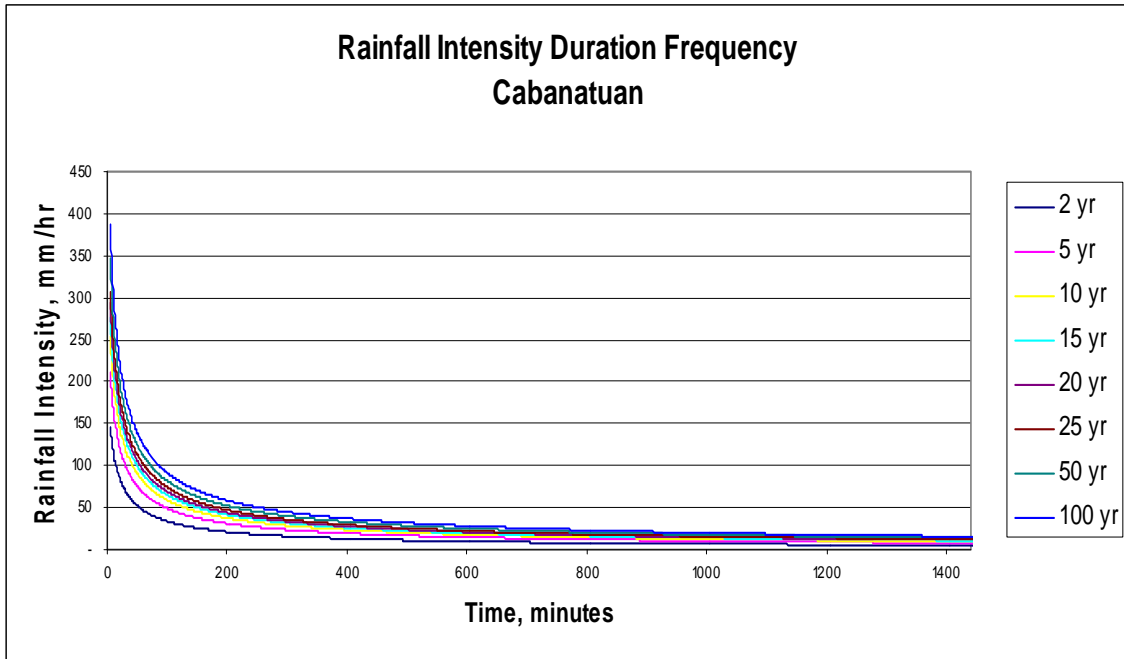


FIGURE 6.3.2-2 (1) RAINFALL INTENSITY FREQUENCY (CABANATUAN)

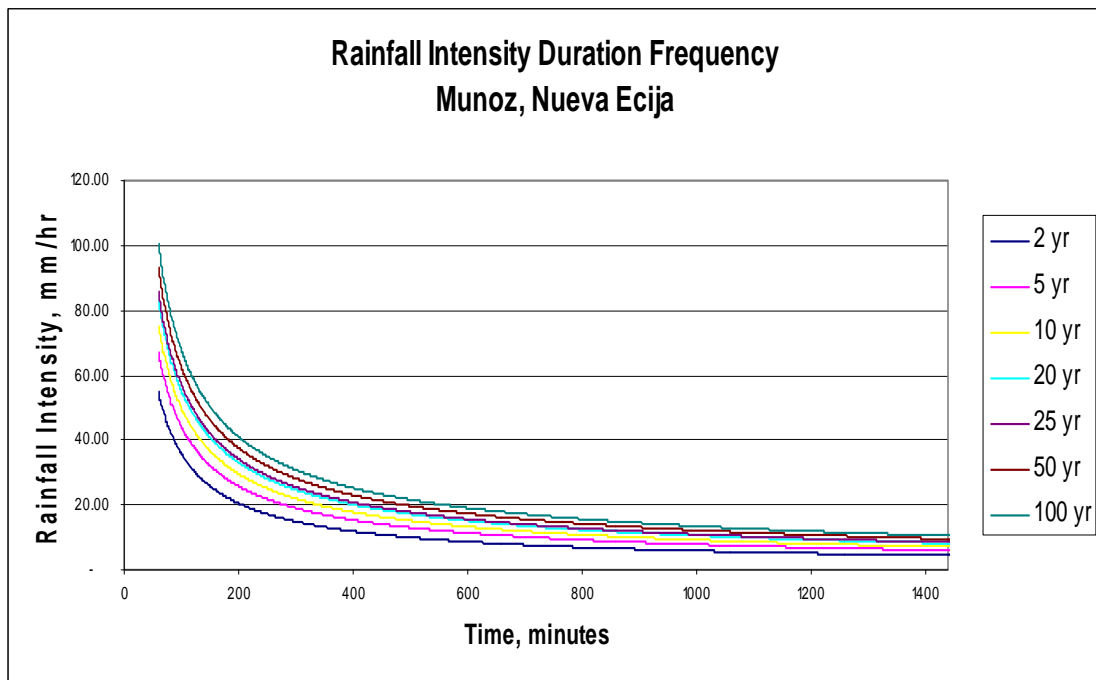


FIGURE 6.3.2-2 (2) RAINFALL INTENSITY FREQUENCY (MUNOZ, NUEVA ECIJA)

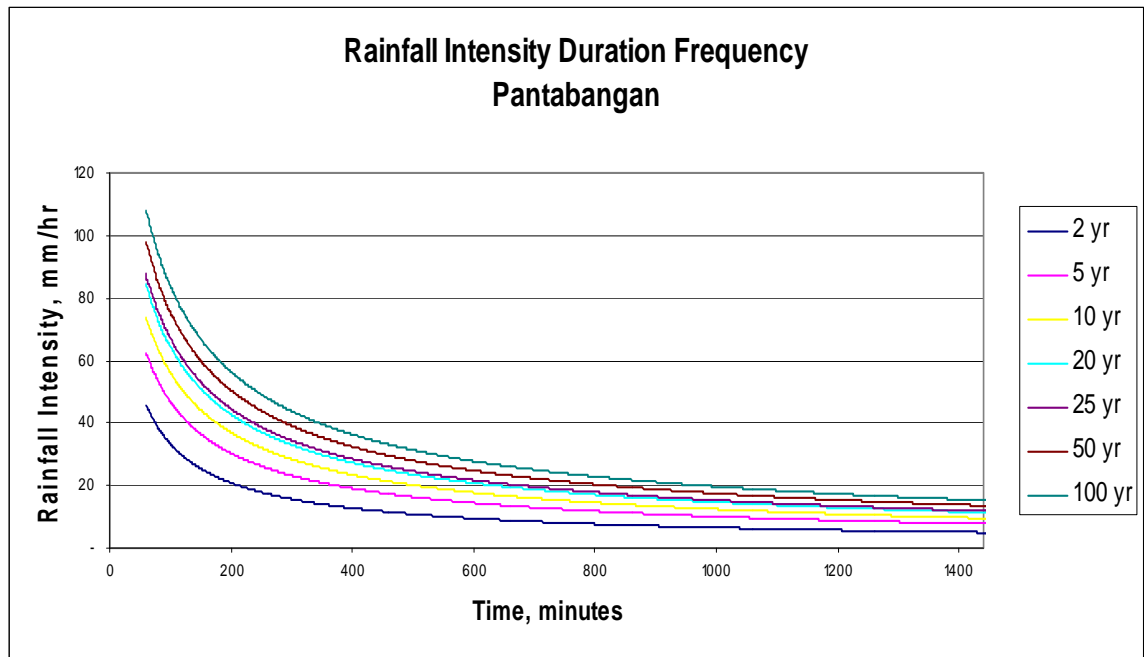


FIGURE 6.3.2-2 (3) RAINFALL INTENSITY FREQUENCY (PANTABANGAN)

6) Runoff Coefficient

The coefficient of runoff “C” is expressed as a percentage to which the peak runoff is reduced due to transitory storage. It varies according to the surface condition, slope, soil nature and rainfall duration in the drainage area. (Table 6.3.2-1)

TABLE 6.3.2-1 VALUES OF “C” FOR USE IN THE RATIONAL FORMULA

DPWH Vol. II

<u>Surface</u>	<u>Value Proposed</u>
Concrete or Asphalt Pavement *	0.9-1.0
Bituminous Macadam and Double Bituminous	
Surface Treatment (Sandy to Clay)	0.7-0.9
Gravel Surface Road and Shoulder	0.3-0.6
Residential Area - City	0.3-0.6
Residential Area – Town and Village	0.2-0.5
Rocky Surface	0.7-0.9
Bare Clay Surface (faces of slips, etc.)	0.7-0.9
Forested Land (Sandy to Clay)	0.3-0.5
Flattish Cultivated Area (not flooded)	0.3-0.5
Steep or Rolling Grassed Areas	0.5-0.7
Flooded or Wet Paddies	0.7-0.8

Adopted from BOD Guidelines, Table 4.11

7) Synthetic Unit Hydrograph

The Unit Hydrograph for each catchment area in the project was derived using the fifty (50) years rainfall intensity of Nueva Ecija as the design storm rainfall and the US Soil Conservation Service (USCS) Dimensionless Unit Hydrograph shown in Figure. A.2.

Each Unit Hydrograph was developed following the procedures below:

- (a) Determine Elements of the unit Hydrograph by Snyder's Modified Lag Equation shown below:

1. The lag time (L_g), in hours based on Snyder's Modified Lag Equations are:

$$L_g = 0.6865 (Ct) \left[\frac{L \times L_{ca}}{eS} \right]^{0.38}$$

Where:

- L_g = lag time, in hours
- Ct = lag time coefficient
- L = Length of watercourse from the drainage divide line to the point of interest, in km.
- L_{ca} = Length of watercourse perpendicular to the watershed centroid to the point of interest, in km.
- S = Average basin slope.

2. Compute the rainfall duration (D or t_r), in hours, which should be equal to one fourth (1/4) or less of lag time

$$D = t_r = L_g \text{ in hours}$$

5.5

3. Time to peak in Hours, t_p

$$t_p = L_g + \frac{1}{2} (t_r)$$

4. Unit Peak Discharge in m^3/s , q_p

$$q_p = \frac{0.278 C_p (D.A.)}{t_p}$$

t_p

5. Derivation of Unit Hydrograph for subject rivers using US SCS Dimensionless Graph
6. Tabulate ratios of T/T_p and Q/Q_p of the US SCS Dimensionless Unit Hydrograph as shown on Figure

7. With computed t_p and q_p , determine T and Q for the subject rivers
8. Construct unit hydrograph for subject basins
9. Read unit hydrograph ordinates at every time interval, t_r .

(b) Derivation of Net Rainfall

1. At every t_r (or D) interval, tabulate depth of rainfall from the 50-year rainfall of Nueva Ecija station.
2. Tabulate rainfall increment for each time t_r determined as the rainfall difference in succeeding time t_r .
3. Rearrange rainfall increment so that the peak or maximum value will be located approximately within the middle third or the two third of the base of the hydrograph reckoned from the origin and plot the hydrograph.
4. Determine rainfall losses at every time t_r .
5. Tabulate rainfall excess (net rainfall) for every time t_r .

(c) Flood Hydrograph Derivation

1. Compute the flood hydrograph ordinate.

The ordinates of the flood hydrograph are computed by Convolution Method, the equation of which is as follows:

$$Q_j = \sum_{i=1}^j P_i (U_{j-i+1})$$

where:

Q_j	=	Run-off at time I in m^3/s
P_i	=	Ordinate of Unit Hydrograph in m^3/s
U_{j-i+1}	=	Excess rainfall at time $J-i+1$
i	=	number of rainfall excess
j	=	number of unit hydrograph ordinates

The computed value for maximum discharge represents the discharge coming from rainfall during a storm event. To compute the total runoff on the river the baseflow of the river must be added. The baseflow is the flow in the river during ordinary time.

The results of the Rational Formula calculation is presented in **Table 6.3.2-2 to 3** and **Figure 6.3.2-3 to 4**.

**TABLE 6.3.2-2 RESULT OF THE RATIONAL FORMULA CALCULATION
(BASIN NO.1)**

D E S I G N S H E E T

Project :	CENTRAL LUZON EXPRESSWAY
Location:	Basin No. 1
Item :	DERIVATION OF FLOOD HYDROGRAPH
Date :	

	tr	U.H.O.	Net Rainfall	Q ₅₀
1	1.50	0.018	0.0	0.017
2	3.00	0.091	0.0	0.114
3	4.50	0.193	0.0	0.574
4	6.00	0.339	0.0	2.205
5	7.50	0.521	0.0	7.773
6	9.00	0.725	0.0	22.164
7	10.50	0.932	0.0	43.474
8	12.00	1.078	0.9	72.363
9	13.50	1.176	1.6	107.638
10	15.00	1.213	13.5	146.190
11	16.50	1.190	19.2	183.766
12	18.00	1.118	130.8	211.753
13	19.50	1.021	27.5	229.648
14	21.00	0.913	4.3	236.134
15	22.50	0.804	0.0	231.593
16	24.00	0.683	0.0	218.110
17	25.50	0.597	0.0	199.565
18	27.00	0.513	0.0	178.482
19	28.50	0.451	0.0	157.122
20	30.00	0.390	0.0	134.870
21	31.50	0.342	0.0	117.233
22	33.00	0.293	0.0	101.181
23	34.50	0.256	0.0	88.509
24	36.00	0.220	0.0	76.831
25	37.50	0.189	0.0	66.998
26	39.00	0.159	0.0	57.787
27	40.50	0.139	0.0	50.241
28	42.00	0.120	0.0	43.210
29	43.50	0.106	0.0	37.167
30	45.00	0.092	0.0	31.534

Baseflow: 23.61 m³/s
Peak Discharge: 236.134
Maximum Q: **259.747** m³/s

**TABLE 6.3.2-3 RESULT OF THE RATIONAL FORMULA CALCULATION
(BASIN NO.18)**

D E S I G N S H E E T	
Project :	CENTRAL LUZON EXPRESSWAY
Location:	Basin No. 18
Item :	DERIVATION OF FLOOD HYDROGRAPH
Date :	
PRELIMINARY CALCULATIONS	

	tr	U.H.O.	Net Rainfall	Q ₅₀
1	1.50	0.019	0.0	0.017
2	3.00	0.075	0.0	0.100
3	4.50	0.158	0.0	0.521
4	6.00	0.273	0.0	1.880
5	7.50	0.409	0.0	6.842
6	9.00	0.535	0.0	18.171
7	10.50	0.617	0.0	35.075
8	12.00	0.656	0.9	57.123
9	13.50	0.647	1.6	81.959
10	15.00	0.595	13.5	104.711
11	16.50	0.527	19.2	119.989
12	18.00	0.455	130.8	126.799
13	19.50	0.376	27.5	124.923
14	21.00	0.318	4.3	115.651
15	22.50	0.266	0.0	102.737
16	24.00	0.225	0.0	88.751
17	25.50	0.190	0.0	74.234
18	27.00	0.158	0.0	62.492
19	28.50	0.134	0.0	52.434
20	30.00	0.111	0.0	44.297
21	31.50	0.091	0.0	37.358
22	33.00	0.076	0.0	31.184
23	34.50	0.064	0.0	26.242
24	36.00	0.054	0.0	21.855
25	37.50	0.047	0.0	18.008
26	39.00	0.040	0.0	15.030
27	40.50	0.034	0.0	12.595
28	42.00	0.028	0.0	10.722
29	43.50	0.023	0.0	9.162
30	45.00	0.020	0.0	7.865

Baseflow:	12.68	m ³ /s
Peak Discharge:	126.799	
Maximum Q:	139.479	m ³ /s

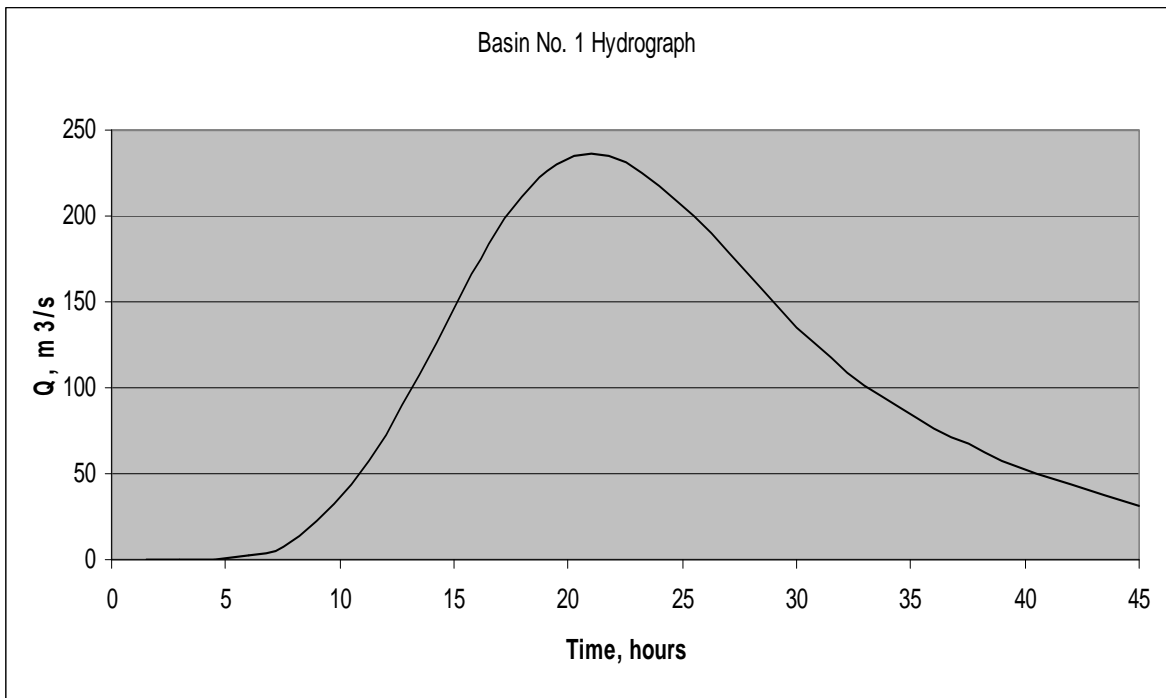


FIGURE 6.3.2-3 RESULT OF THE RATIONAL FORMULA CALCULATION (BASIN NO.1)

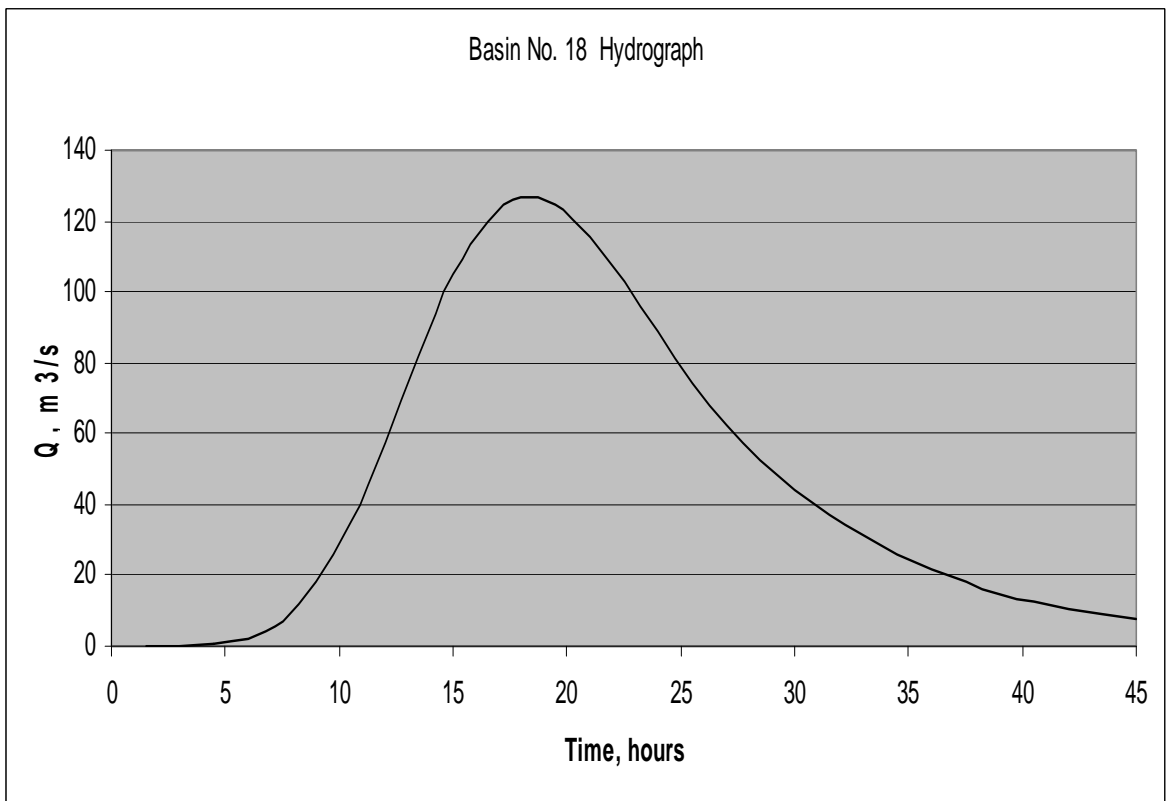


FIGURE 6.3.2-4 RESULT OF THE RATIONAL FORMULA CALCULATION (BASIN NO.18)

8) **Rio Chico**

Attached is an excerpt from the JICA Study indicating the Fifty (50) Year Maximum Discharge of Rio Chico and Talavera River calculated by storage function method. The sum of the discharges of the two rivers is the design discharge used. Below is the summary of the study:

TABLE 6.3.2-4 DISCHARGE OF RIO CHICO RIVER

Discharge Volume (m ³ /s)			
	Rio Chico	Talavera	Total
No.	45	41	
100	1,488	1,410	2,898
50	1,269	1,203	2,472
20	985	932	1,917
10	778	735	1,513

Fig. 3.5 RUNOFF CALCULATION MODEL DIAGRAM

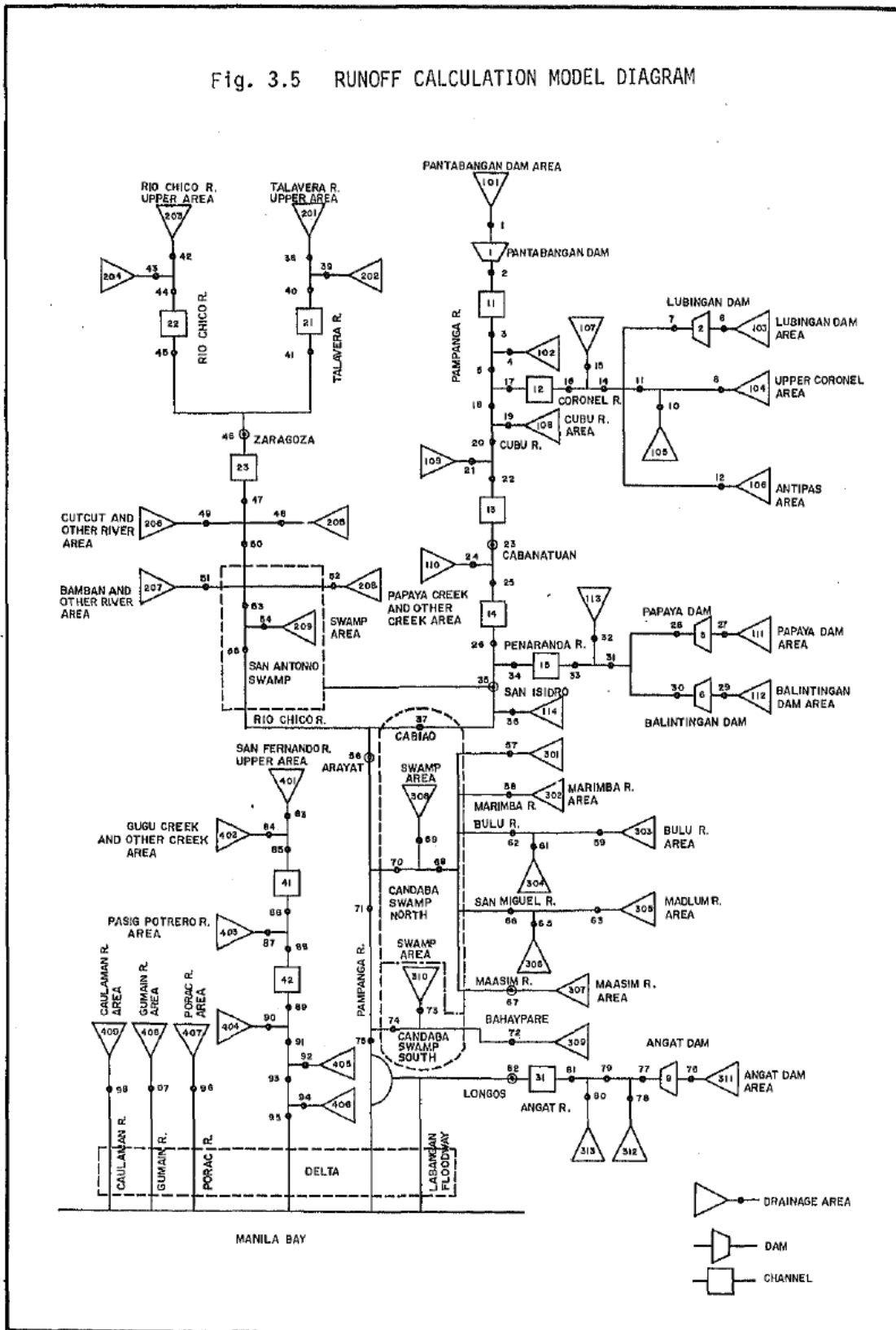


Table 3.10 (2) PEAK DISCHARGE OF PROBABLE FLOOD
(continued)

(Unit: m³/sec)

Calculation Point No.	Location	Return Period (year)				
		5	10	20	50	100
B. Rio Chico-Talavera Basin						
38		597	926	1,272	1,753	2,140
39		98	146	192	253	300
40		675	1,048	1,436	1,971	2,401
41		502	735	932	1,203	1,410
42		500	722	959	1,279	1,531
43		96	136	173	222	259
44		583	834	1,110	1,482	1,774
45		568	778	985	1,269	1,488
46	Zaragoza	1,061	1,497	1,883	2,422	2,840
47		1,022	1,469	1,863	2,398	2,812
48		86	116	147	186	217
49		241	332	418	528	612
50		1,247	1,816	2,341	3,069	3,605
51		193	285	386	521	627
52		96	133	167	211	243
53		1,485	2,180	2,812	3,667	4,307
54		56	76	97	122	140
55		1,508	2,212	2,853	3,721	4,368
C. Sierra Madre Mountain Basin						
57		26	36	44	55	65
58		88	138	184	239	280
59		24	35	50	74	95
60		24	35	50	74	95
61		87	121	159	211	250
62		106	152	209	282	336
63		41	60	88	127	163
64		41	60	88	127	163
65		154	216	294	423	530
66		190	264	380	546	681
67		59	94	130	172	201
68		466	655	869	1,233	1,520
69		89	117	142	187	228
70		551	764	970	1,393	1,728

9) **Hydrological Characteristics of Watershed along CLLEX**

The hydrological characteristics studied are shown in **Table 6.3.2-5**.

TABLE 6.3.2-5 HYDROLOGICAL CHARACTERISTICS OF WATERSHEDS

Basin No.	Station	Catchment Area (km ²)	Difference in Elevation H (m)	Length of Stream L (m)	Time of Concentration Tc (min)					Runoff Coeff.	Discharge Q (Rational Formula)				JICA Study	Synthetic Unit Hydrograph	Design Q
						2 Yrs. mm/hr	10 Yrs. mm/hr	25 Yrs. mm/hr	50 Yrs. mm/hr		2 Yrs. m ³ /s	10 Yrs. m ³ /s	25 Yrs. m ³ /s	50 Yrs. m ³ /s			
1	3+380.00	93.70	37	21599	471.26											259.75	259.75
2	4+220.00	3.88	1	1686	100.78	33.62	58.73	73.95	81.32	0.75	27.22	47.56	59.88	65.84			65.84
3						RIO CHICO									2472		2472.00
4	1+140.00	16.01	5	10020	421.04	12.65	22.86	28.63	31.99	0.75	42.25	76.31	95.59	106.81			106.81
5	11+970.00	2.71	5	8876	366.24	13.95	25.11	31.48	35.10	0.75	7.90	14.21	17.82	19.87			19.87
6	13+000.00	2.36	4	7708	339.31	14.72	26.43	33.15	36.93	0.75	7.24	13.00	16.31	18.17			18.17
7	13+660.00	3.81	4	6344	271.26	17.20	30.71	38.56	42.83	0.75	13.67	24.42	30.66	34.06			34.06
8	16+050.00	6.46	5	7658	309.08	15.71	28.14	35.31	39.29	0.75	21.16	37.90	47.56	52.92			52.92
9	16+930.00	1.73	1	2160	133.95	27.84	48.91	61.56	67.85	0.75	10.04	17.63	22.19	24.46			24.46
10	17+050.00	0.20	5	2628	90.33	36.12	62.96	79.27	87.10	0.75	1.47	2.56	3.23	3.54			3.54
11	17+860.00	1.20	5	1570	49.95	52.42	90.57	113.85	124.83	0.75	13.10	22.63	28.44	31.19			31.19
12	18+020.00	0.90	5	1059	31.76	68.17	117.36	147.01	161.37	0.75	12.81	22.05	27.62	30.32			30.32

TABLE 6.3.2-5 HYDROLOGICAL CHARACTERISTICS OF WATERSHEDS

Basin No.	Station	Catchment Area (km ²)	Difference in Elevation H (m)	Length of Stream L (m)	Time of Concentration Tc (min)					Runoff Coeff.	Discharge Q (Rational Formula)				JICA Study	Synthetic Unit Hydrograph	Design Q
						2 Yrs. mm/hr	10 Yrs. mm/hr	25 Yrs. mm/hr	50 Yrs. mm/hr		2 Yrs. m ³ /s	10 Yrs. m ³ /s	25 Yrs. m ³ /s	50 Yrs. m ³ /s			
13	20+920.00	3.31	2	2112	99.98	33.80	59.03	74.33	81.72	0.75	23.32	40.73	51.29	56.39			56.39
14	22+430.00	15.67	10	10324	333.69	14.89	26.73	33.53	37.34	0.60	38.93	69.88	87.65	97.63			97.63
15	23+210.00	14.00	9.5	9148	296.18	16.18	28.96	36.34	40.42	0.60	37.77	67.59	84.84	94.35			94.35
16	24+150.00	12.76	8	7820	264.20	17.51	31.25	39.25	43.58	0.60	37.29	66.54	83.56	92.80			92.80
17	27+040.00	6.44	3	4030	179.79	22.82	40.34	50.74	56.09	0.60	24.50	43.32	54.48	60.23			60.23
18	29+990.00	41.68	22	16280	415.91											139.48	139.48

(4) Hydraulic Analysis

1) Manning's Formula

For open channel, the calculation of Discharge, Q is based on the river properties such as cross-sectional area, perimeter and slope. Manning's Formula is of the form:

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

$$Q = AV$$

Where:

V = velocity in m/s

Q = discharge in m³/s

A = cross-sectional area of water in m²

R = hydraulic radius in m.

$$R = \frac{A}{P}$$

P = wetted perimeter in m.

S = slope

n = coefficient of roughness tabulated below

2) Values of Manning’s Roughness Coefficient “n”

Surface / Description	Range	
	Minimum	Maximum
1. Natural stream channels (top flood width less than 30 m.	0.030	0.035
i. Fairly regular section:		
a. Some grass and weeds, little or no brush	0.035	0.050
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035	0.050
c. Some weeds, light brush on banks	0.050	0.530
d. Some weeds, heavy brush on banks	0.050	0.070
e. Some weeds, dense trees	0.050	0.070
f. For trees within channel, with branches submerged at high flood increase all above values by	0.010	0.020
ii. Irregular sections, with pools, slight channel meander; increase values given above about	0.01	0.02
iii. Mountain streams, no vegetation in channel banks usually steep, trees and brush along banks submerged at high flood:		
a. Bottom of gravel, cobbles, and few boulders	0.040	0.050
b. Bottom of cobbles, with large boulders	0.050	0.070
2. Larger stream channels (top flood width greater than 30 m.)		
Reduce smaller coefficient by 0.010		
3. Flood plain (adjacent to stream beds)		
Pasture, short grass, no brush	0.030	0.035
Pasture, tall grass, no brush	0.035	0.050
Cultivated land – no crop	0.030	0.040
Cultivated land – nature field crops	0.045	0.055
Scrub and scattered bush	0.050	0.070
Wooded	0.120	0.160
4. Man-made channels and ditches		
Earth, straight and uniform	0.017	0.025
Grass covered	0.035	0.050
Dredged	0.025	0.033
Stone lined and rock cuts, smooth & uniform	0.025	0.033
Stone lined and rock cuts, rough and irregular	0.035	0.045
Lined – metal corrugated	0.021	0.024
Lined – smooth concrete	0.012	0.018
Lined – grouted riprap	0.017	0.030
5. Pipes		
Cast Iron	0.011	0.015
Wrought Iron	0.012	0.017
Corrugated Steel	0.021	0.035
Concrete	0.010	0.017

3) Results of the Hydraulic Analysis

Results of the hydraulic analysis are shown in **Table 6.3.2-6 to 8** and **Figure 6.3.2-5 to 7**.

TABLE 6.3.2-6 RIO CHICO RIVER

Elevation m	Area m ²	Perimeter m	n	Slope	Velocity m/s	Capacity m ³ /s
17.00	7869.23	3483.98	0.12	0.0003	0.24	1908.19
17.30	8913.86	3485.78	0.12	0.0003	0.26	2347.98
17.40	9262.19	3486.50	0.12	0.0003	0.27	2502.54
17.50	9610.59	3487.37	0.12	0.003	0.28	2660.95

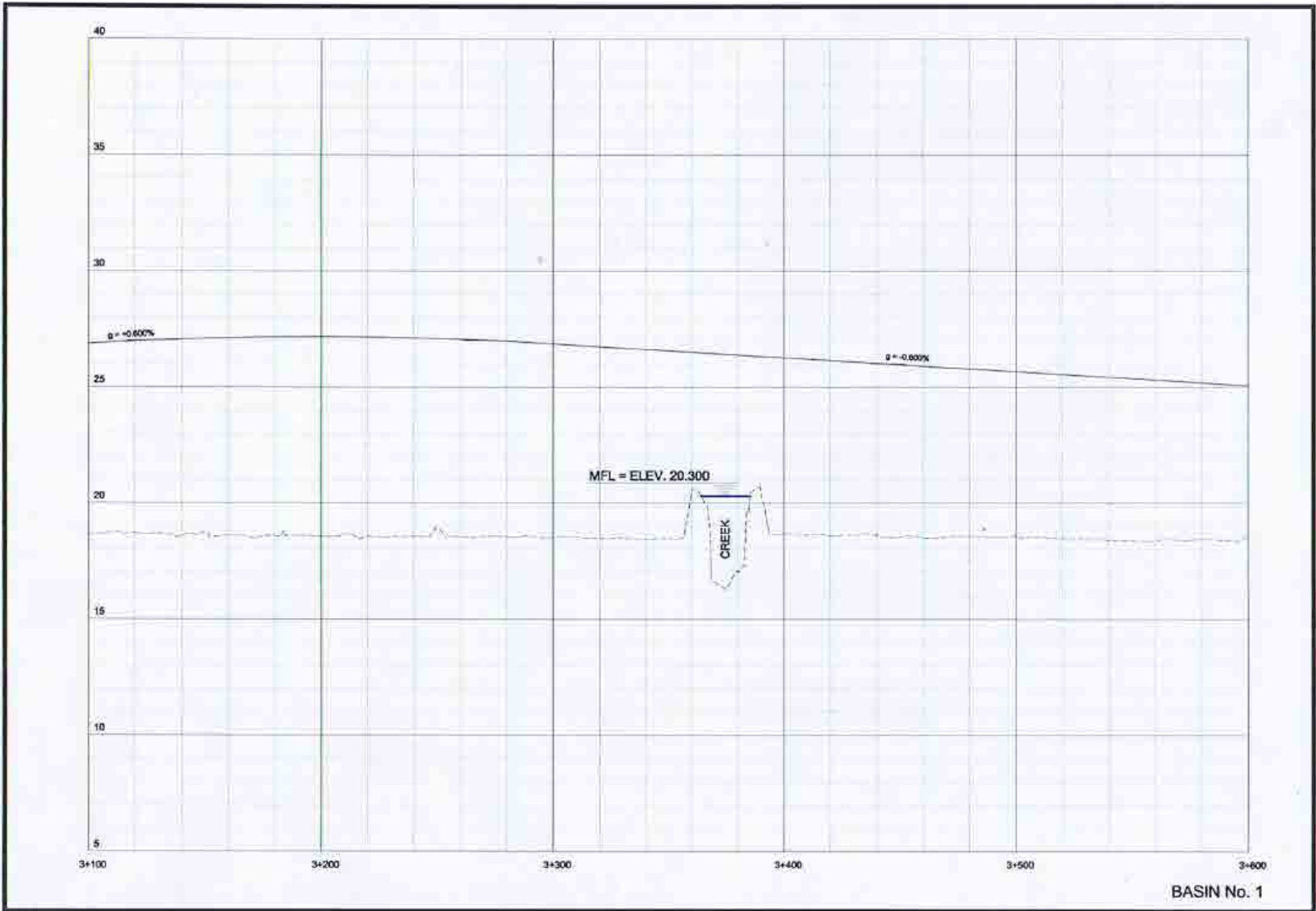
TABLE 6.3.2-7 BASIN NO. 1

Elevation m	Area m ²	Perimeter m	n	Slope	Velocity m/s	Capacity m ³ /s
19.00	104.82	257.93	0.04	0.003	0.23	24.30
20.00	489.90	426.01	0.04	0.003	0.46	227.23
20.10	532.41	426.53	0.04	0.003	0.49	260.83
20.50	702.93	429.38	0.04	0.003	0.59	412.60

TABLE 6.3.2-8 BASIN NO. 18

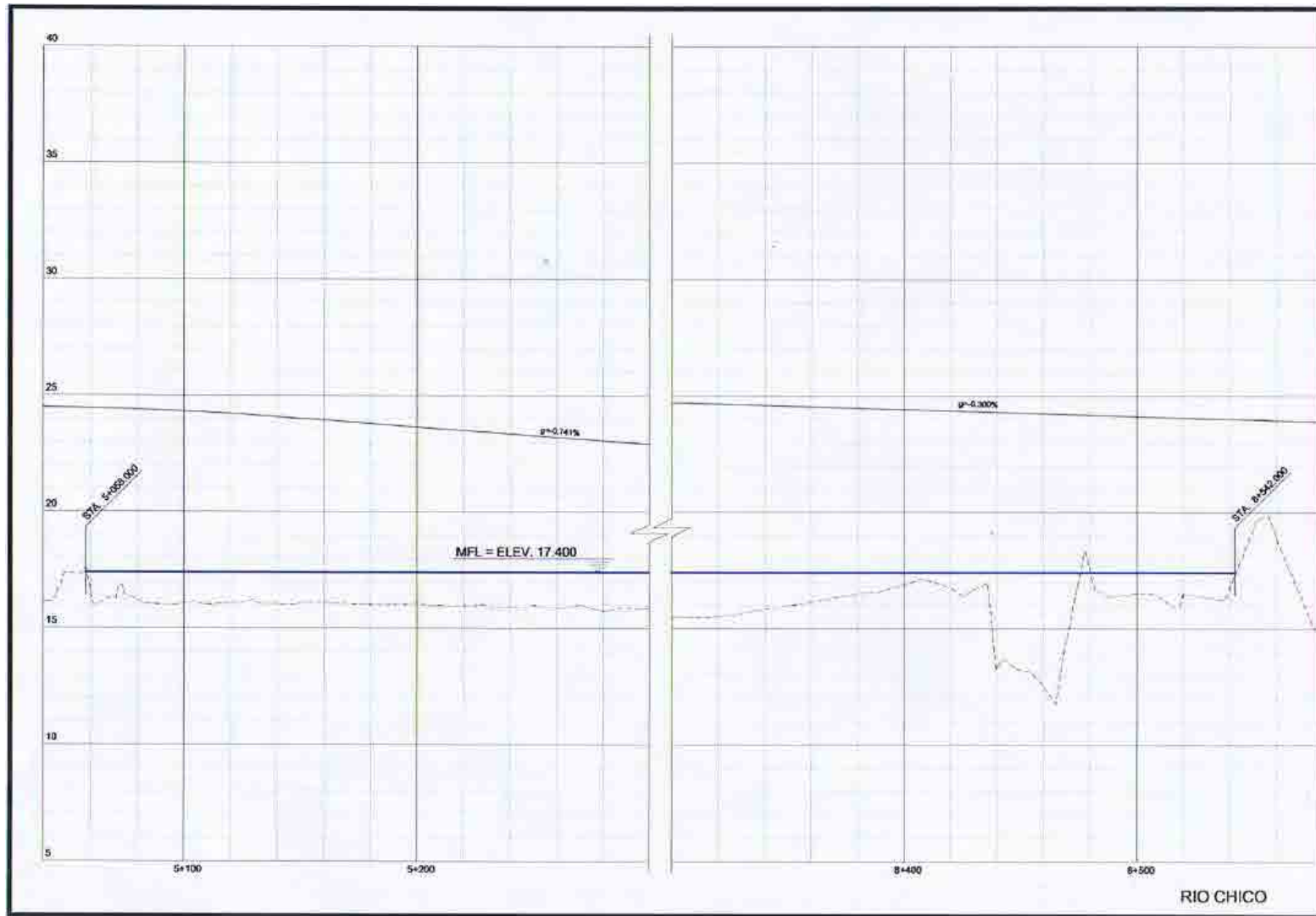
Elevation m	Area m ²	Perimeter m	n	Slope	Velocity m/s	Capacity m ³ /s
31.00	0.232	4.12	0.04	0.005	0.26	0.06
32.00	21.73	39.00	0.04	0.005	1.20	26.01
32.70	151.07	322.60	0.04	0.005	1.07	161.20
33.00	248.86	331.32	0.04	0.005	1.46	362.60

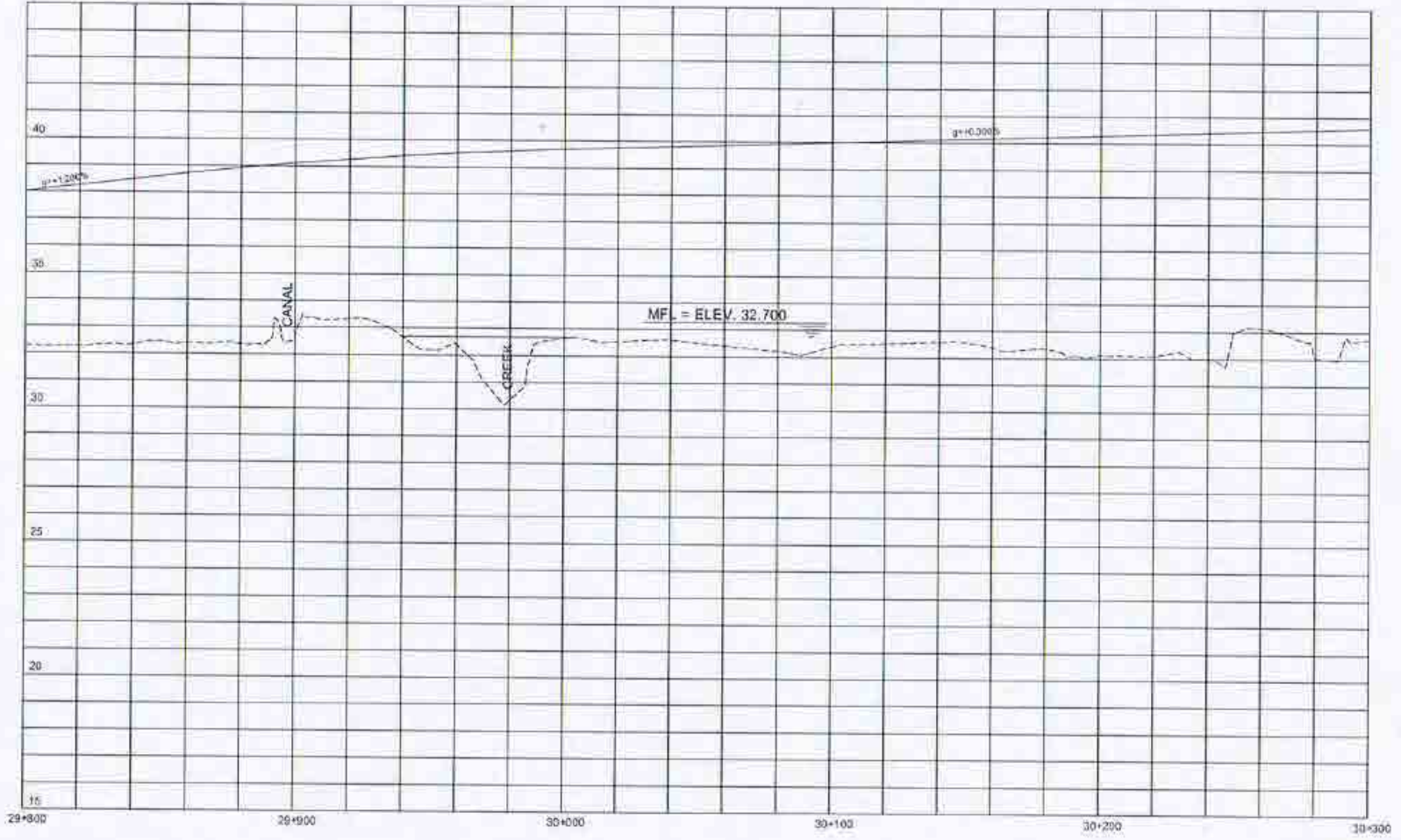
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BASIN No. 1

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BASIN No. 18

(5) Drainage Design Frequency

The design storm frequency adopted for this project is shown in **Table 6.3.2-9** by recommendation in DPWH Design Guidelines Criteria and Standards Volume II (p697).

TABLE 6.3.2-9 DESIGN FREQUENCY BY ROAD STRUCTURE

Structure	Return Period (year)
Bridge	1/50
Box Culvert	1/25
Earth Embankment	1/10
Pipe Culvert	1/10
Road Structure Drainage	1/2
Road side drainage	1/2

Source: DPWH

(6) Design Flood Level

The area between SCTEX and Aliaga is known as flood prone area (more detail is described in Section 6.3.5). Water from Rio Chico River overflows and causes flood frequently.

In the profile design of this section, two (2) design flood level was considered to determine the finished grade, namely 1) Medium Flood Water Level (MFWL) and 2) HWL (High Water Level).

6.3.3 Crossing Road and Water Way Design

(1) Technical Approach

In order to maintain the present accessibility after the construction of the highway, crossing road (under the highway or overpass the highway) and service road are designed.

Technical approach of the design is described as below;

- (1) To provide crossing road to maintain present accessibility after the construction
- (2) To provide enough road width considering future widening if any.
- (3) To provide enough vertical clearance in accordance with road category

(2) Typical Condition of Crossing Road

Cross sectional configuration of the crossing road and vertical clearance is designed According to present condition of the road, as shown in **Table 6.3.3-1**.

TABLE 6.3.3-1 CROSS SECTIONAL CONFIGURATION OF CROSSING ROAD

No	Road Category	Road width (m)	Cross Sectional Configuration	Vertical Clearance (m)	Remark
1	National Road/ Municipality Road to be widened	18.0m		5.2m Vertical clearance (4.9m) + overlay(0.3m)=5.2m	Pan Philippine Highway Sta.Roas-Tarlac RD Cabanatuan BP
2	National Road / Provincial Road not to be widened	10.0m		5.2m Vertical clearance (4.9m) + overlay(0.3m)=5.2m	La Paz- Victoria RD Gumba-Aliaga RD
3	Municipality Road	10.0m		4.0 m Vertical clearance (3.8m) +Over ray(0.2m) =4.0m	
4	Farm road / BRGY Road (1lane)	5.0m		4.0 m Vertical clearance (3.8m) +Over ray(0.2m) =4.0m	
5	Farm road / BRGY Road (2 lane)	8.0m		4.0 m Vertical clearance (3.8m) +Over ray(0.2m) =4.0m	

(3) Typical Condition of Crossing Water Way

Table 6.3.3-2 shows Typical condition of crossing water way.

TABLE 6.3.3-2 TYPICAL CONDITION OF CROSSING WATER WAY

Category of water way	Crossing Condition	Structure
River	Discharge Volume (50years) <80m ³ /s	RCBC with free board
	Discharge Volume(50 years)>80m ³ /s	Bridge with free board
	Existing Water Way Width >10m	Bridge with free board
Irrigation Canal	Keep the same or more cross section of existing canal	Varies with free board

Table 6.3.3-3 shows Freeboard allowance of water way.

TABLE 6.3.3-3 FREEBOARD ALLOWANCE

No	Design Discharge Q (m ³ /s)	Free board (m)
1	Less than 200	0.6m
2	200 to less than 500	0.8m
3	500 to less than 2,000	1.0m
4	2000 to less than 5,000	1.2m
5	5000 to less than 10,000	1.5m
6	More than 10,000	2.0m

(4) List of crossing road and water way

List of crossing road and water way is shown in Table 6.3.3-4 to Table 6.3.3-7.

TABLE 6.3.3-4 LIST OF BRIDGE

Package	No.	Station	Length (m)	No. of Span(s)	Span Arrangement	Angle (degrees)	Bridge Type		Crossing Object	Remarks
Main Carriageway Bridge										
Package 1	1	-0 + 024.4 - 0 + 035.6	60.0	2	30+30	80.00	AASHTO Girder V	Road	SCTEX Junction (Ramp Bridge)	
	2	1 + 875.0 - 1 + 899.0	24.0	1	24	115.00	RCDG	Road	(National Road) Sta. Rosa - Tarlac Road	
	3	3 + 358.0 - 3 + 393.0	35.0	1	35	115.00	AASHTO Girder V	River	Tin Tin River	
	4	7 + 528.0 - 9 + 033.0	1,505.0	43	43@35	90.00	AASHTO Girder V	River	Rio Chico River	
	5	11 + 107.0 - 11 + 179.0	72.0	3	3@24	115.00	RCDG	River	Natural creek	
Package 2	6	29 + 971.0 - 30 + 006.0	35.0	1	35	105.00	AASHTO Girder V	River	Natural creek	
	7	30 + 255.0 - 30 + 325.0	70.0	2	35+35	90.00	AASHTO Girder V	Road	(Local Road) Cabanatuan Bypass	West Bound
		30 + 245.0 - 30 + 330.0	85.0	3	30+25+30	90.00	AASHTO Girder V		(National Road) Pan-Philippines Highway	East Bound
Crossover Bridge for Main Carriageway										
Package 2	8	23 + 108.0	60.0	2	30+30	100.00	AASHTO Girder V	Road	CLLEX main expressway	
	9	25 + 840.0	60.0	2	30+30	90.00	AASHTO Girder V	Road	CLLEX main expressway (Cabanatuan Half IC Ramp Bridge)	

TABLE 6.3.3-5 LIST OF RCBC OF ROADWAY

Package	No.	Station	Crossing Object	Skew (degrees)	Dimensions			Remarks
					Barrel(s)	Inner Section (mm)		
						Width	Height	
Package 1	1	2 + 935	Farm road	138.00	1	5,000	4,600	
	2	3 + 830	Municipal road (paved)	135.00	1	8,000	4,600	
	3	4 + 554	Municipal road (paved) with irrigation canal	70.00	1	8,000	6,000	
	4	5 + 050	National Road: La Paz - Victoria Road (paved) with natural creek	78.00	1	16,000	8,000	
	5	6 + 788	Municipal road (earth)	90.00	1	5,000	4,600	
	6	9 + 100	Farm road	105.00	1	5,000	4,600	
	7	9 + 388	Farm road	100.00	1	5,000	4,600	
	8	10 + 102	Farm road	103.00	1	5,000	4,600	
	9	10 + 268	Municipal road (earth) with natural creek	40.00	1	12,000	6,000	
	10	10 + 448	Farm road with irrigation canal	92.00	1	8,000	6,000	
	11	10 + 858	Farm road with irrigation canal	65.00	1	8,000	6,000	
	12	11 + 002	Municipal road (earth)	85.00	1	8,000	4,600	
Package 2	13	11 + 888	Farm road with irrigation canal	145.00	1	8,000	6,000	
	14	12 + 248	Farm road	67.00	1	5,000	4,600	
	15	12 + 598	Farm road	82.00	1	5,000	4,600	
	16	12 + 988	Farm road with irrigation canal	80.00	1	8,000	6,000	
	17	13 + 682	Municipal road (earth) with natural creek	55.00	1	12,000	6,000	
	18	14 + 688	Farm road with irrigation canal	86.00	1	8,000	6,000	
	19	15 + 653	Farm road with irrigation canal	60.00	1	8,000	6,000	
	20	17 + 021	Farm road	87.00	1	5,000	4,600	
	21	19 + 388	Municipal road - Guimba - Aliaga Road (paved)	123.00	1	11,000	5,800	
	22	19 + 715	Aliaga Interchange	90.00	2	9,000	5,800	
	23	20 + 948	Municipal road (paved)	80.00	1	11,000	4,600	
	24	21 + 248	Municipal road (paved)	33.00	1	11,000	4,600	
	25	24 + 098	Farm road with irrigation canal	60.00	1	12,000	6,000	
	26	26 + 348	Municipal road (earth) with irrigation canal	75.00	1	12,000	6,000	
	27	26 + 528	Farm road with irrigation canal	65.00	1	8,000	6,000	
	28	27 + 748	Municipal road (paved) with irrigation canal	45.00	1	16,000	6,800	
	29	29 + 918	Municipal road (paved) with irrigation canal	100.00	1	16,000	8,000	

TABLE 6.3.3-6 LIST OF RCBC OF RIVER AND IRRIGATION

Package	No	Station	Crossing Object	Skew (degrees)	Dimensions		Remarks	
					Nos. of Barrel(s)	Inner Section (mm)		
						Width (m)		Height (m)
Package 1	1	0 + 566	Irrigation canal	90.00	1	3,000	2,400	
	2	1 + 220	Irrigation canal	85.00	1	3,000	2,400	
	3	4 + 220	Irrigation canal	95.00	1	3,000	2,400	
	4	9 + 665	Irrigation canal	100.00	2	3,000	2,400	
Package 2	5	11 + 988	River - Natural creek	145.0	1	3,000	2,400	
	6	15 + 858	Irrigation canal	120.00	1	2,400	2,100	
	7	16 + 050	River - Natural creek	75.00	3	3,000	2,750	
	8	16 + 928	River - Natural creek	120.00	2	2,400	2,400	
	9	17 + 060	River - Natural creek	135.00	1	2,400	1,800	
	10	17 + 860	River - Natural creek	75.00	2	3,000	2,100	
	11	18 + 510	Irrigation canal	120.00	1	2,400	2,100	
	12	20 + 920	River - Natural creek	75.00	3	3,000	2,400	
	13	22 + 428	Irrigation canal	90.00	2	2,400	2,100	
	14	23 + 210	Irrigation canal	120.00	2	2,400	2,100	
	15	24 + 148	Irrigation canal	90.00	1	3,000	2,400	
	16	24 + 428	Irrigation canal	35.00	1	3,000	2,400	
	17	25 + 588	Irrigation canal	110.00	1	2,400	2,100	
	18	25 + 768	Irrigation canal	47.00	1	3,000	2,400	
	19	0 + 205	Irrigation canal	85.00	1	3,000	2,400	Cabanatuan Half IC STA.
	20	0 + 380	Irrigation canal	80.00	1	3,000	2,400	Cabanatuan Half IC STA.
	21	0 + 400	Irrigation canal	75.00	1	3,000	2,400	Cabanatuan Half IC STA.
	22	27 + 038	River - Natural creek	40.00	3	3,000	2,750	
	23	28 + 148	Irrigation canal	35.00	2	2,400	2,100	

TABLE 6.3.3-7 LIST OF RCBC (EQUALIZATION ZONE)

RCBC Dimension: 1barrel - 3.0m x 3.0m

Package	No	Station	Crossing Object	Skew (degrees)	Dimensions			Remarks
					Barrel(s)	Width (m)	Height (m)	
Package 1		6 + 788	Municipal Road (earth)	90.00	1	5.00	4.60	
	1	6 + 888	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	2	6 + 988	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	3	7 + 088	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	4	7 + 188	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	5	7 + 288	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	6	7 + 388	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	7	7 + 488	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		7 + 528	Rio Chico River		Rio Chico River Bridge A1 Abutment			
		9 + 033			Rio Chico River Bridge A2 Abutment			
		9 + 100	Farm road (earth)	105.00	1	5.00	4.60	
	8	9 + 196	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	9	9 + 292	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		9 + 388	Farm road (earth)	100.00	1	5.00	4.60	
	10	9 + 480	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	11	9 + 572	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		9 + 665	Irrigation canal	100.00	2	3.00	2.40	
	12	9 + 774	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	13	9 + 884	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	14	9 + 993	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		10 + 102	Farm road (earth)	103.00	1	5.00	4.60	
	15	10 + 185	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		10 + 268	Municipal Road (earth) with Natural Creek	40.00	1	12.00	6.00	
	16	10 + 358	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		10 + 448	Farm road (earth) with irrigation canal	95.00	1	8.00	6.00	
	17	10 + 551	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	18	10 + 653	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	19	10 + 756	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		10 + 858	Farm road (earth) with irrigation canal	65.00	1	8.00	6.00	
	20	10 + 930	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	11 + 002	Municipal road (earth)	85.00	1	8.00	5.80		
	11 + 107	River Bridge		A1 Abutment				
	11 + 179			A2 Abutment				
Package 2	21	11 + 280	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	22	11 + 381	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	23	11 + 482	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	24	11 + 583	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	25	11 + 684	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	26	11 + 785	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		11 + 888	Footpath (earth) with irrigation canal	145.00	1	8.00	6.00	
		11 + 988	River - Natural creek	145.00	1	3.0	2.4	

6.3.4 Vertical Control

(1) Technical Approach

The Express highway is situated in the very flat plane land. The profile was studied in accordance with following orientations;

- 1) To Minimize Construction Cost: The embankment height shall be minimum while providing sufficient clearance at road and water way crossing points.
- 2) To Secure from Flood: The minimum finished grade shall be determined in accordance with present and past flood in order to be secured from flood.
- 3) To Secure smoothness of drive: The minimum distance between PI point of vertical profile shall be 500m in order to secure smoothness of drive.
- 4) To accommodate surface drainage: It is also important to accommodate surface drainage to secure drivers safety during rain. The minimum vertical gradient is set as 0.3% for this reason.

(2) Minimum Embankment Height

The most parts of the present surface of the land is paddy filed. The minimum embankment height is set as **1.5m**. This is to secure stability of embankment from water and to provide sufficient clearance for small size pipe culverts for drainage.

(3) Vertical Control and Clearance List

Vertical Control List is shown in **Table 6.3.4-1**.

TABLE 6.3.4-1 VERTICAL CONTROL POINT LIST (1/2)

Profile Control Point List (CLLEX 1)

No	Station	Control name	Crossing Type	No	Type of Crossing structure	Control Elevation (A)										Others	Total
						Existing GL	Vertical CL	Girder	Top Slab	Pave	Super elevation						
											%	width	Height				
1	0 + 5.000	SGTEX	Under pass	1	W=25.00 Br L=35.00	25.600	5.200	2.0		0.080	2.0 %	9.500	0.190		33.070		
2	1 + 887.000	Sta Rosa-Tarlac RD	Under pass	1	W=25.00 Br L=35.00	22.200	5.200	2.0		0.080	2.0 %	9.500	0.190		29.670		
3	2 + 940.000	Farm Road	Under pass	2	W=4.00 RCBC H=4.60		4.000		0.500		2.0 %	9.500	0.190		4.690		
4	3 + 375.000	Tin Tin River	Under pass	1	W=25.00 Br L=35.00	18.800	4.000	2.0		0.080	2.0 %	9.500	0.190		25.070		
5	3 + 830.000	Municipal Road	Under pass	2	W=8.00 RCBC H=5.80	18.200	4.000		0.500	0.500	2.0 %	9.500	0.190		23.390		
6	4 + 363.600	Natural Creek	Under pass	1	W=25.00 Br L=35.00	18.100	4.000	2.0		0.080	2.0 %	9.500	0.190		24.370		
7	4 + 550.000	Municipal Road	Under pass	2	W=8.00 RCBC H=6.00	17.100	4.000		0.500	0.500	2.0 %	9.500	0.190		22.290		
8	5 + 50.000	La Paz-Victoria Rd	Under pass	2	W=16.00 RCBC H=8.00	17.400	5.200		1.200	0.500	2.0 %	9.500	0.190		24.490		
9	7 + 528.100	Rio Chico(W)	Under pass	1	W=25.00 Br L=35.00	HWL 19.200	3.200			0.080	2.0 %	9.500	0.190		22.670		
10	9 + 33.000	Rio Chico(E)	Under pass	1	W=25.00 Br L=35.00	HWL 19.200	3.200			0.080	2.0 %	9.500	0.190		22.670		
11	9 + 388.000	Farm Road	Under pass	2	W=5.00 RCBC L=4.60	14.400	4.000		0.400	0.500	2.0 %	9.500	0.190		19.490		
12	10 + 108.000	Farm Road	Under pass	2	W=5.00 RCBC L=4.60	14.500	4.000		0.400	0.500	2.0 %	9.500	0.190		19.590		
13	10 + 268.000	Municipal Road	Under pass	2	W=12.00 RCBC L=6.00	15.100	4.000		0.600	0.500	2.0 %	9.500	0.190		20.390		
14	10 + 448.000	Farm Road	Under pass	2	W=8.00 RCBC L=6.00	14.600	4.000		0.500	0.500	2.0 %	9.500	0.190		19.790		
15	10 + 858.000	Farm Road	Under pass	2	W=8.00 RCBC L=6.00	15.400	4.000		0.500	0.500	2.0 %	9.500	0.190		20.590		
16	11 + 8.000	Municipal Road	Under pass	2	W=8.00 RCBC L=5.80	15.500	4.000		0.500	0.500	2.0 %	9.500	0.190		20.690		
17	11 + 103.100	Natural Creek	Under pass	1	W=25.00 Br L=25.00	14.600	4.700	2.0		0.080	2.0 %	9.500	0.190		21.570		
18	11 + 888.000	Farm Road	Under pass	2	W=8.00 RCBC H=6.00	14.800	4.000		0.500	0.500	2.0 %	9.500	0.190		19.990		
19	12 + 248.000	Farm Road	Under pass	2	W=5.00 RCBC H=4.60	14.800	4.000		0.400	0.500	2.0 %	9.500	0.190		19.890		
20	12 + 598.000	Farm Road	Under pass	2	W=5.00 RCBC H=4.60	15.500	4.000		0.400	0.500	2.0 %	9.500	0.190		20.590		
21	12 + 988.000	Farm Road	Under pass	2	W=8.00 RCBC H=6.00	15.300	4.000		0.500	0.500	2.0 %	9.500	0.190		20.490		
22	13 + 668.000	Municipal Road	Under pass	2	W=12.00 RCBC H=6.00	15.800	4.000		0.600	0.500	2.0 %	9.500	0.190		21.090		
23	14 + 688.000	Farm Road	Under pass	2	W=12.00 RCBC L=6.00	15.800	4.000		0.500	0.500	2.0 %	9.500	0.190		20.990		

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TABLE 6.3.4-1 VERTICAL CONTROL POINT LIST (2/2)

Profile Control Point List (CLEX

2)

No	Station	Control name	Crossing Type	No	Type of Crossing structure	Control Elevation (A)									
						GL	Vertical CL	Girder	Top Slab	Pave	Super elevation			Others	Total
											%	width	Height		
24	15 + 653.000	Farm Road	Under pass	2	W=8.00 RCBC L=6.00	17.000	4.000		0.500	0.500	2.0 %	9.500	0.190		22.190
25	16 + 28.000	Farm Road	Under pass	2	W=5.00 RCBC H=4.60	17.500	4.000		0.400	0.500	2.0 %	9.500	0.190		22.590
26	17 + 28.000	Farm Road	Under pass	2	W=5.00 RCBC H=4.60	17.700	4.000		0.400	0.500	2.0 %	9.500	0.190		22.790
27	19 + 388.000	Provincial RD Guimba-Aliaga	Under pass	2	W=11.00 RCBC L=5.80	21.100	5.200		0.600	0.500	2.0 %	9.500	0.190		27.590
28	19 + 715.000	Aliaga IC	Under pass	2	W=9.00 RCBC H=5.80	20.800	5.200		0.500	0.500	2.0 %	9.500	0.190	1.500	28.690
29	20 + 948.000	Municipality RD	Under pass	2	W=11.00 RCBC L=5.80	22.600	4.000		0.600	0.500	2.0 %	9.500	0.190		27.890
30	21 + 248.000	Municipality RD	Under pass	2	W=11.00 RCBC H=5.80	22.100	4.000		0.600	0.500	2.0 %	9.500	0.190		27.390
31	23 + 108.000	Municipality RD	Over pass	2	W=8.00 RCBC H=5.80	24.100	5.200		0.500	0.500	2.0 %	9.500	0.190		17.710
32	24 + 98.000	Farm Road	Under pass	2	W=12.00 RCBC L=6.00	25.300	4.000		0.600	0.500	2.0 %	9.500	0.190		30.590
33	25 + 838.000	Cabanatuan H IC	Under pass	2	W=9.00 RCBC H=5.80	25.200	5.200		0.500	0.500	2.0 %	9.500	0.190	1.500	33.090
34	26 + 348.000	Municipality RD	Under pass	2	W=12.00 RCBC H=6.00	28.200	4.000		0.600	0.500	2.0 %	9.500	0.190		33.490
35	26 + 528.000	Farm Road	Under pass	2	W=8.00 RCBC H=6.00	26.800	4.000		0.500	0.500	2.0 %	9.500	0.190		31.990
36	27 + 748.000	NH Cabanatuan- Carmen	Under pass	2	W=18.00 RCBC H=8.00	30.500	4.000		1.800	0.500	2.0 %	9.500	0.190		36.990
37	29 + 918.000	Municipality RD	Under pass	2	W=16.00 RCBC H=8.00	33.000	4.000		1.200	0.500	2.0 %	9.500	0.190		38.890
38	29 + 988.600	Natural Creek	Under pass	1	W=25.00 Br L=35.00	32.500	4.000	2.0		0.080	2.0 %	9.500	0.190		38.770
39	30 + 290.000	Cabanatuan BP	Under pass	1	W=25.00 Br L=35.00	32.800	5.200	2.0		0.080	2.0 %	9.500	0.190		40.270
40	17 + 88.000	Irrigation	Under pass	2	RCBC										

99-9

6.3.5 Rio Chico River Flood Prone Area Design

(1) Technical Approach

The express highway across flood prone area of Rio Chico River. This Section summarize following points regarding to road structure design in such area.

- 1) Hydrological characteristics of Rio Chico River
- 2) Flood condition and mechanism
- 3) Structural design for the flood prone area

(2) Hydrological characteristics of Rio Chico River

Tarlac province is bound by two (2) principal rivers; Tarlac River and Rio Chico River which are both heavily silted. Tarlac River aggradation problem is attributed to the heavy transport of lahar due to Mt. Pinatubo eruption while Rio Chico has narrow/limited river cross section with meandering flow and serves as the catch basin of waterways from Talavera-Aliaga, Zaragoza, Cabanatuan, Guimba, Licab and Sto. Domingo and the eastern towns of Tarlac, outfall to Sacobia-Bamban-Paura River and Quitangil River.

Rio Chico River is one of the tributaries of Pampanga River which is located upper part of Pampanga River Basin. The Rio Chico River and Talavera River confluence in La Paz and flow to San Antonio Swamp before meet to Pampanga River.

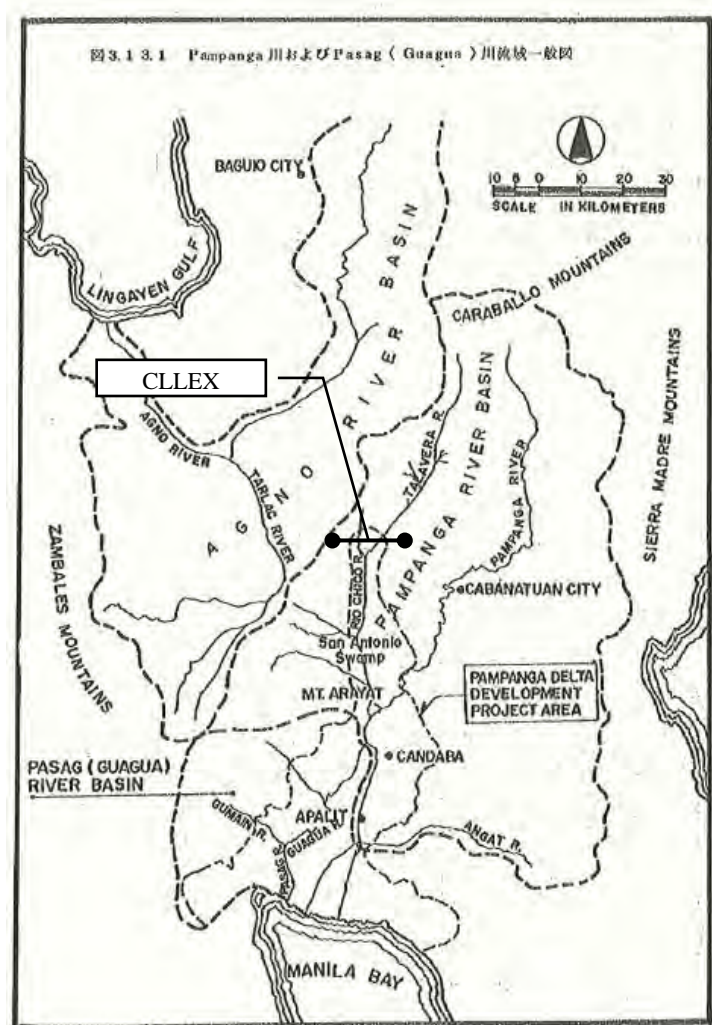


FIGURE 6.3.5-1 PAMPANGA RIVER BASIN

Major characteristics of Rio Chico River is shown in **Table 6.3.5-1**.

TABLE 6.3.5-1 CHARACTERISTICS OF RIO CHICO AND PAMPANGA RIVER

	Rio Chico River	Pampanga River
Catchment Area	1700km ²	7700km ²
River Slope	1/3,500	1/10,000 – 1/8,000
Discharge (50years)	2,400 (at Zaragoza) 3,700(at San Antonio)	4,350 (at Cabiao)
Discharge (100 years)	2,800(at Zaragoza) 4,400(at San Antonio)	4,900 (at Cabiao)

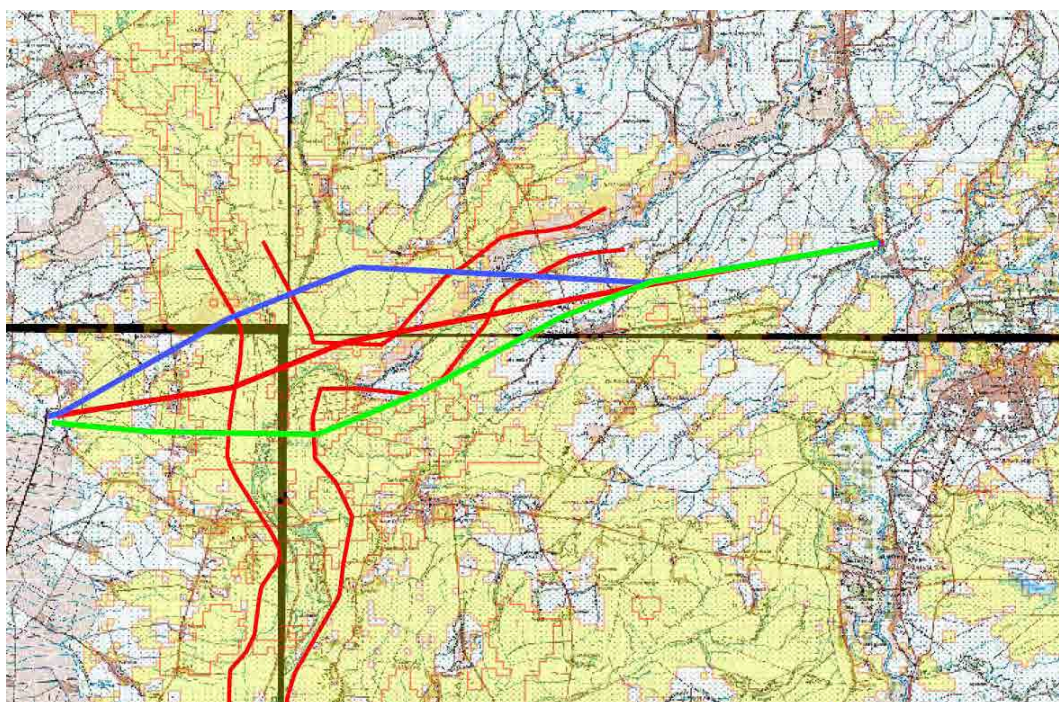
Source: JICA 1982

(3) Flood Condition

1) Flood Prone Area

The maximum inundated area by 2004 is shown in **Figure 6.3.5-2**. The inundated area by Typhoon Pepeng in 2009, which caused the most flood disaster in this region, is assumed almost the same according to interview survey by the study team. This figure illustrates that major parts of the road stretch is within inundated area.

Table 6.3.5-2 shows average inundated depth and days of related municipalities. La Paz has the most serious flood condition among all.



Source: JICA 2010

**FIGURE 6.3.5-2 INUNDATED AREA ALONG STUDY ROUTE
(MAXIMUM FLOOD BY 2004)**

TABLE 6.3.5-2 FLOOD CONDITION BY MUNICIPALITY ALONG RIO CHICO RIVER

Municipality	Inundated depth (ave)	Inundated days (ave)
Victoria	0.8m	3-5 days
Licab	0.5m	1-3 days
Quezon	0.5m	1-3 days
La Paz	1.8m	8-12 days
Zaragoza	0.5m	2-3 days

Frequent flood area and historical flood area were identified by interview survey to the Local Government Office.

2) Close of Tarlac- Sta. Rosa National Highway

Table 6.3.5-3 shows closure days of national highway due to flood.

TABLE 6.3.5-3 RECORD OF ROAD CLOSURE TARLAC-STA ROSA ROAD

Year	Month/ Date	Cause
2006	July 24	Not specified
2007	Record not found	n/a
2008	August 10	Typhoon "Julian"
2009	October 09-11	Typhoon "Pepeng"
2010	October 21-22	Typhoon "Juan"
2011	June 26-27, 2011	Typhoon "Falcon")
Source: DPWH Tarlac 2nd District Eng'g. Office		

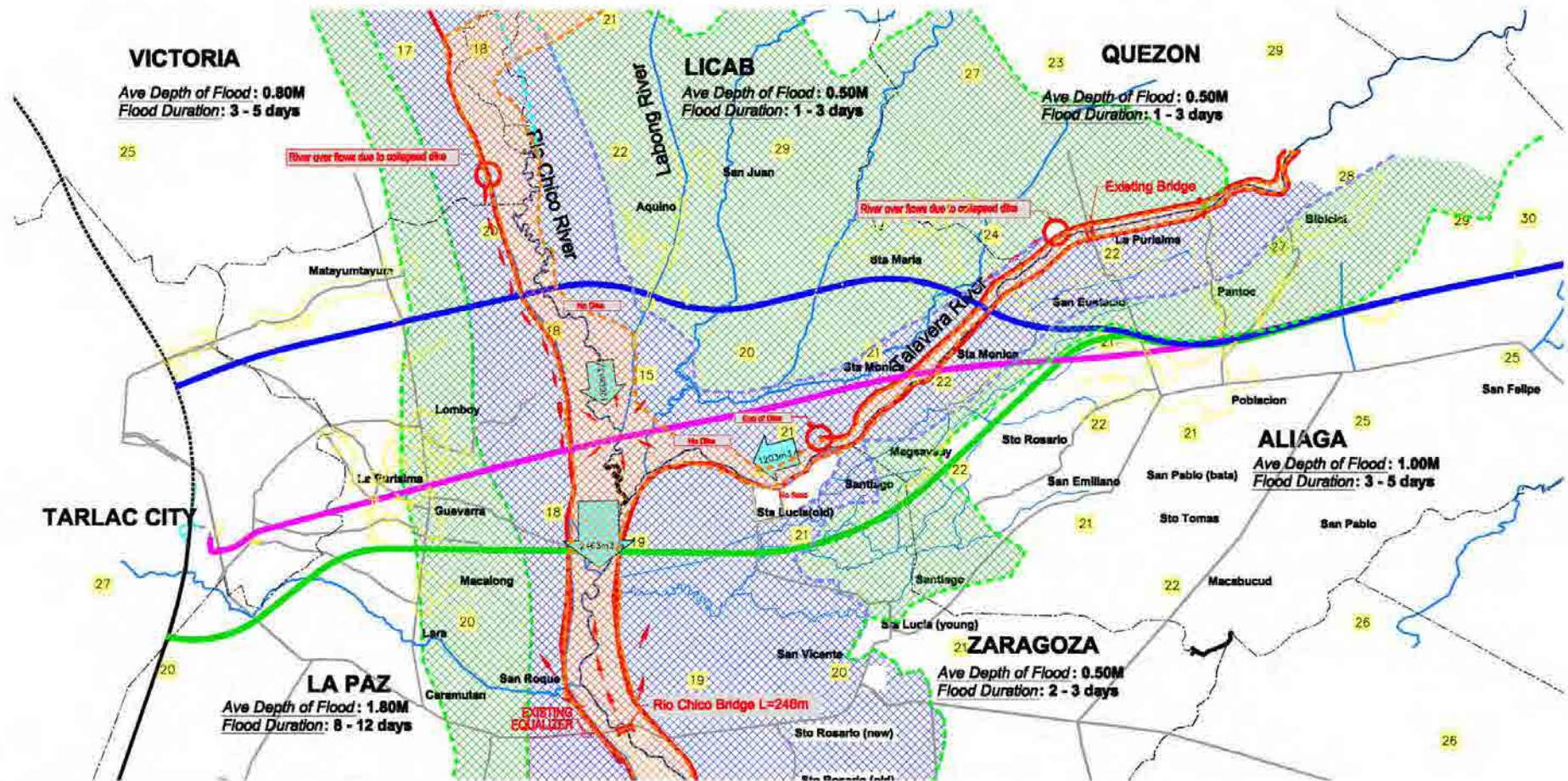
Year	Month/ Date	Cause
Average for the last 5 years	Three (3) incidents of road closures each year. Each road closure incident is about 2 to 3 days long. Thus, about 6-10 days (with 10 as maximum).	Heavy Rains / Typhoons (June to November)

(4) Flood Mechanism

Flood mechanism in this area is summarized as **Table 6.3.5-4** and **Figure 6.3.5-3**.

TABLE 6.3.5-4 SUMMARY OF FLOOD MECHANISM AT RIO CHICO RIVER

No	Location	Reason	Flood
1	Confluence of Rio Chico River and Labong River	Low land	Ground elevation is 16 to 18m while other is approx.20m River water gathers at low land.
2	Confluence of Rio Chico Rive and Talavera River	Confluence of two major river	Both rive has approx 1,200m ³ /s (50years). There is only low earth dike at the confluence point which is easily flow over.
3	National Road Crossing Point at Rio Chico River	Narrow river channel	There is equalizer constructed in 2009 and a bridge of 250m passes over Rio Chico River. Flood frequently occurs at this point due to insufficient capacity of present river corridor. This causes back flow to the upper stream.
4	Rio Chico River and Talavera River	Collaption of existing dike	Existing dike is mostly earth bank which is already collapsed due to lack of maintenance. River water easily over flow from such portion.



Note 1: The flood area was identified by interview to the municipality by the Study Team.
 Note 2: The Discharge of 50-year return period is from Feasibility Report on the Pampanga Delta Development Project Feb 1982

LEGEND:	
EXPRESSWAY	(Blue line)
Existing Dike	(Red line)
HOUSE and BLDG.	(Yellow area)
RiverFlowArea	(Blue hatched area)
Primary Flood Area	(Blue grid pattern) (Average 1 time/1-2 years)
Secondary Flood Area	(Green grid pattern) Past Maximum Flood Area (Ondoy in 2009)
Ground Elevation	(Yellow circle with number) 21

FIGURE 6.3.5-3 FLOOD CONDITION AT RIO-CHICO RIVER

(5) Rehabilitation Plan Of Rio Chico River

The JICA study conducted in 2007, THE STUDY ON THE NATIONWIDE FLOOD RISK ASSESSMENT AND THE FLOOD MITIGATION PLAN FOR THE SELECTED AREAS IN THE REPUBLIC OF THE PHILIPPINES, is proposing the rehabilitation of Rio Chico River as **20th priority** among all river in the Philippines.

(6) Design High Water Level of Rio Chico River Flood Prone Area

Historical flood level is shown in **Table 6.3.5-5** and comparison from analyzed value is shown in **Table 6.3.5-6**.

Design flood level is determined as shown in **Table 6.3.5-7** by following reasons;

- a. The actual high water level at crossing point is calculated as 19.2m from past record which can be assumed corresponding to 50 years return period.
- b. Analyzed water level is 17.4m for 50 years discharge. It is -1.8m of record level.
- c. The existing equalizer elevation at Tarlac-Sta Rosa NH is approximately 17.8m verified by topographic survey.
- d. It is observed that flood water is blocked at equalizer and causing backflow to the upper stream. This explains recorded water level is higher than calculated level.
- e. For such reason the Design Water Level is set as **19.2m** for Bridge Design (50years) and **17.8m** for Embankment Design.

TABLE 6.3.5-5 HISTORICAL FLOOD LEVEL

Location	Water level	Remark	Source
1. Along C route (FS2010)	19.75m	Ondoy 2009, 5.1km from recommended alignment	FS2010 DPWH
2. Tarlac-Sta. Rosa NH	18.4m	Ondoy 2009, 3.2km from recommended alignment	FS2010 DPWH
3. Tarlac-Sta Rosa NH	17.8m	Average flood area	DPWH Tarlac
Tarlac –Sta Rosa NH	+1.0m from road surface at Equalizer	According to interview to LGU, Ondoy 2009	
Tarlac – Sta. Rosa NH		Surface elevation 17.5m – 18.0m	Topo survey conducted July 2011
Assumed water level at CLLEX crossing	19.2m	Calculated from 1 and 2	

TABLE 6.3.5-6 COMPARISON OF RECORD AND ANALYZED VALUE

	Water level	Remark
(1) Recorded water level (historical)	19.2m	Table 6.3.5-5
(2) Calculated water level (50years)	17.4m	Table 6.3.2-6

TABLE 6.3.5-7 DESIGN FLOOD LEVEL

Design Water Level	Corresponding Return Period (assumed)	Water Level	Design Control		Structure
MFWL (Medium Flood Water Level)	10 years	17.8m*	19.2m	Minimum elevation = MFWL +0.6m(Freeboard) +0.8 (Pavement) =17.8+0.6+0.8=19.2m	Embankment
HWL (High Water Level)	50 years	19.2m**	22.4m	Minimum elevation = HWL+1.2m(Freeboard)+2.0 m(Bridge girder and slab) = 19.2+1.2+2.0=22.4m	Rio Chico Bridge

* Assumed from flood at Tarlac – Sta.Rosa National Road

** Assumed from past maximum flood level

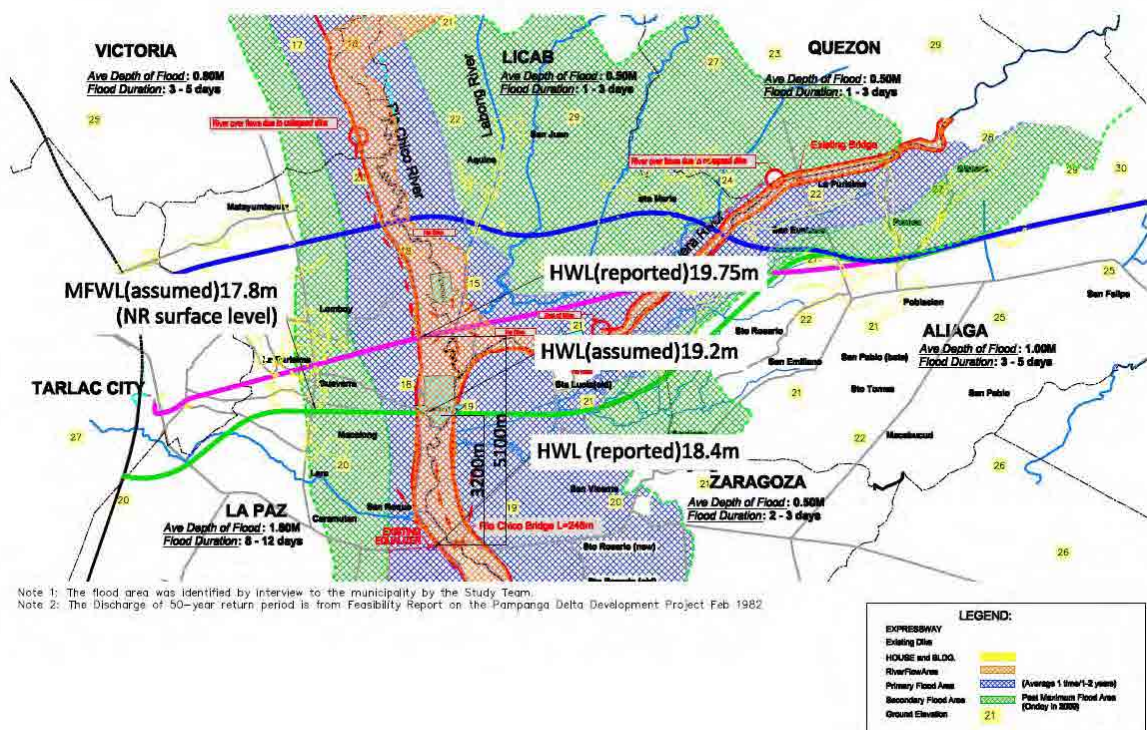


FIGURE 6.3.5-4 ASSUMPTION OF MFWL AND HWL

(7) Vertical Control at Rio Chico River Bridge

Considering the flood condition, vertical control of Rio Chico River bridge is set as below; (Figure 6.3.5-5)

Minimum Vertical Clearance is 19.2m(HWL) + Freeboard 1.2m (corresponding to 2,500m³/s for 50 years return period.)

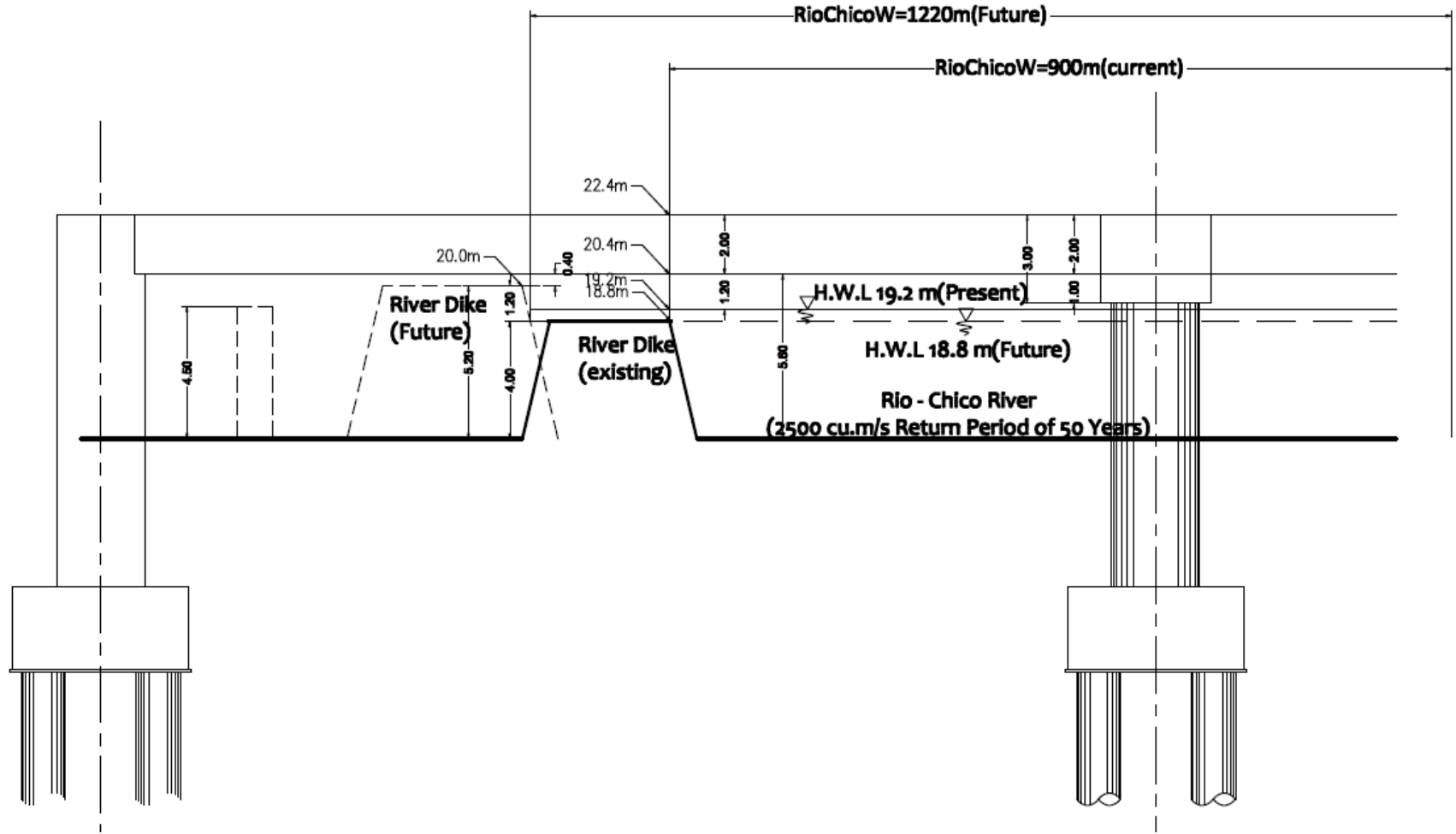


FIGURE 6.3.5-5 SCHEMATIC IMAGE OF VERTICAL CONTROL POINT OF RIO CHICO RIVER

(8) Structural design in the flood prone area

1) Bridge and Equalizer

Technical approach of the structural design in flood prone area is shown as follows;

- 1) Existing Rio Chico River corridor and future river corridor (for 50 years return period) shall be crossed by bridge structure.
- 2) Equalizer shall be provided whole stretch of “frequent flood area”
- 3) Equalizer shall be series of box culvert (3.0mx3.0m) @100m
- 4) Slope protection by stone rip rap shall be provided under MFWL within frequent flood area

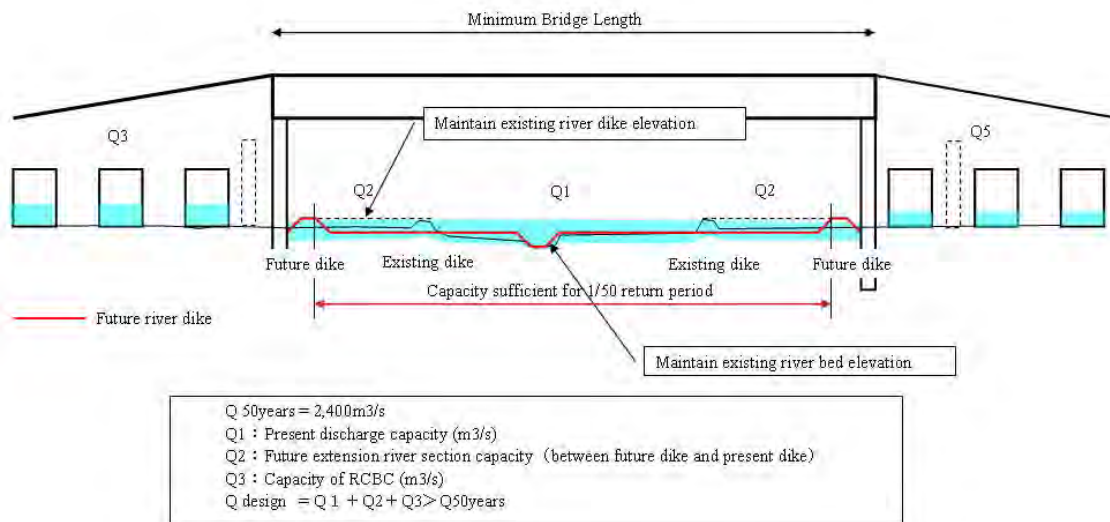


FIGURE 6.3.5-6 MINIMUM BRIDGE LENGTH AND DISCHARGE CAPACITY

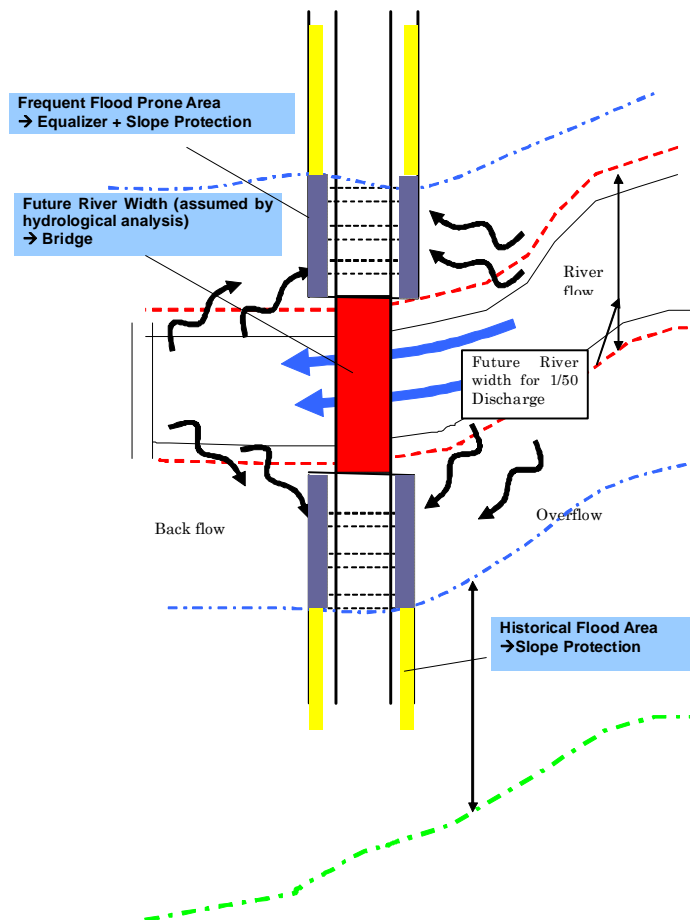


FIGURE 6.3.5-7 STRUCTURAL DESIGN AT FLOOD PRONE AREA

2) Minimum required bridge length of Rio Chico Bridge

Table 6.3.5-8 shows summary of hydrological calculation of Rio Chico River.

TABLE 6.3.5-8 REQUIRED BRIDGE LENGTH OF RIO CHICO RIVER

Case	Check	Width m	Discharge m ³ /s	Calculation Condition			Remark
				Roughness coefficient	Capacity (m ³ /s)	Evaluation for 50 years	
Rio Chico River	Necessary Section	1222m	2472	0.1	2479	OK	

3) Slope Protection

The water flow speed can be 1.5m/s to 2.0m/s during flood time. Riprap Stone shall be provided for slope protection. **Figure 6.3.5-8** illustrate existing equalizer along national highway and flooded situation (June 27, 2011, Typhoon Falcon).



**FIGURE 6.3.5-8 FLOOD ON 27 JUNE, 2011 BY TYPHOON FALCON
(RIO CHICO RIVER EQUALIZING ZONE)**



FIGURE 6.3.5-9 EQUALIZER AT SAME PLACE ABOVE

6.3.6 Interchange Design

(1) Technical Approach

Followings are basic technical approach to design interchange of CLLEX.

- 1) To provide number of toll booth lane in accordance with traffic demand forecast.
- 2) To provide weigh station and U turn space for overloaded vehicle
- 3) To provide necessary widening of the existing road at future intersection

(2) Interchange location and booth lane number

Figure 6.3.6-1 illustrates IC location and booth lane number.

(3) Typical Toll booth layout

Basic layout and dimension of toll booth is referred to TPLEX which is under construction, as shown in Figure 6.3.6-2.

(4) Selection of Interchange Type

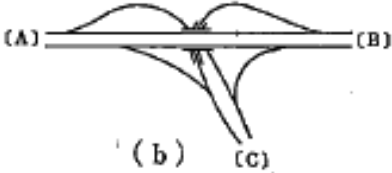
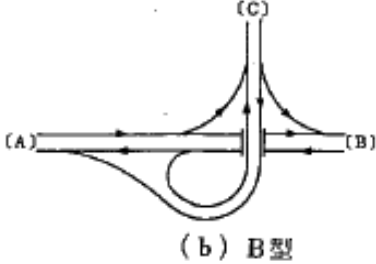
1) Junction from SCTEX

“Junction” is commonly applied to the road crossing structure between “expressway” and “expressway”. It is widely applied “Y Type” because of good geometrical alignment of ramps for the Junction. (Table 6.3.6-1)

For CLLEX, Trumpet type is recommended by following reasons;

- a. There is the main toll barrier at 1.9km from the Junction. All the traffic will be forced to stop at this point. Trumpet Type naturally guide drivers to slow down which encourage traffic safety and smoothness.
- b. Trumpet type requires less land acquisition and less construction cost.

TABLE 6.3.6-1 TYPICAL JUNCTION TYPE

Plan		
Type	Y Type	Trumpet Type
Structure	3F	2F
Ramp Alignment	Good	Fair
Cost	High	Low
CLLEX		Recommended

2) Interchange

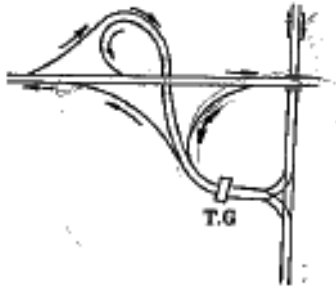
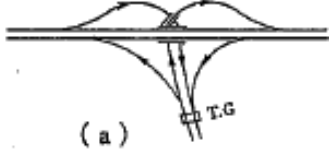
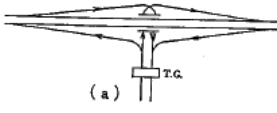
Table 6.3.6-2 shows typical interchange type.

Trumpet type is most popular structure for interchange. Y type is often used where Trumpet type is difficult such as in terms of land acquisition. Flat Y type is the smallest structure and most economical in cost with least land acquisition. This type is adequate when In and Out traffic volume is small because two ramps are crossing by flat intersection.

For CLLEX, Trumpet type is recommended by following reasons;

- Land acquisition is not critical and land price is not critical
- It is recommendable to select commonly used type in Philippines.

TABLE 6.3.6-2 TYPICAL INTERCHANGE TYPE

Plan			
Type	Trumpet Type	Y Type	Flat Y Type
Structure	2F	3F	2F
Traffic	large	large	small
Cost	middle	high	Low
CLLEX	Recommended		

(5) Design Traffic Volume and required lane number

In accordance with traffic forecast (Chapter 4), the required lane number is studied as below. The recommendation is shown in **Table 6.3.6-3**.

- The number of lane shall be sufficiently provided for 30th peak hour traffic for Average Daily Traffic (ADT)
- Capacity of traffic per lane for the design speed of 40km/h is 1200 /day.

The lane number is studied in year of **2030 (4 lane)**.

$$DHV = ADT \times K \times D$$

Where;

ADT (Average Daily Traffic): Traffic projection

K: 30th traffic (0.14 – 0.16) : **0.15**

D: Directional ratio (0.6 – 0.7):**0.65**

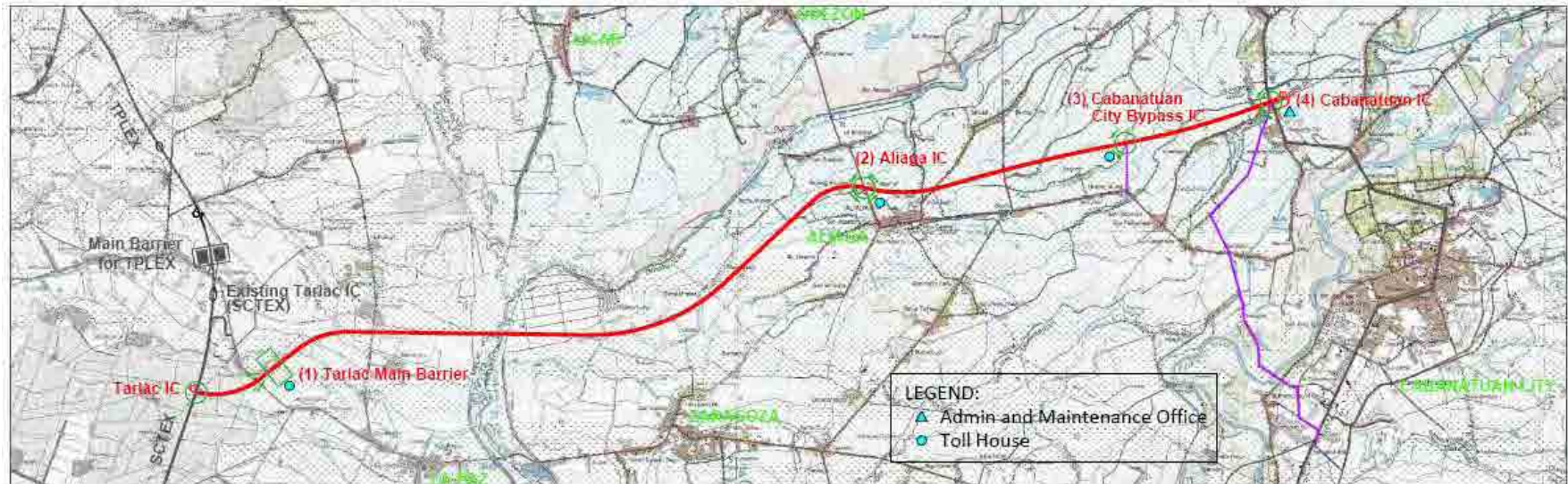
TABLE 6.3.6-3 REQUIRED LANE NUMBER OF INTERCHANGE RAMP

Interchange	Ramp		Estimated traffic(ADT) 2030	K	D	Design Traffic	Capacity of 1 lane (car/h)	Required lane number
Tarlac IC	A	CLLEX to SCTEX	6,154	0.15	0.65	600	1,200	1
	B	TPLEX to CLLEX	2,010	0.15	0.65	196	1,200	1
	C	CLLEX to TPLEX	1,933	0.15	0.65	188	1,200	1
	D	SCTEX to CLLEX	6,400	0.15	0.65	624	1,200	1
Tarlac IC	E	CLLEX to NH	2,473	0.15	0.65	241	1,200	1
	F	NH to CLLEX	2,529	0.15	0.65	247	1,200	1
Aliaga IC	A	Aliaga to SCTEX	241	0.15	0.65	23	1,200	1
	B	Cabanatuan to Aliaga	17	0.15	0.65	2	1,200	1
	C	Aliaga to Cabanatuan	15	0.15	0.65	1	1,200	1
	D	SCTEX to Aliaga	287	0.15	0.65	28	1,200	1
Cabanatuan Bypass IC	A	Bypass to SCTEX	3,152	0.15	0.65	307	1,200	1
	B	SCTEX to Bypass	2,706	0.15	0.65	264	1,200	1
Cabantuan IC	A	Cabantuan to SCTEX	7,183	0.15	0.65	700	1,200	1
	B	San Jose to Cabanatuan	6,566	0.15	0.65	640	1,200	1
	C	Cabantuan to San Jose	6,599	0.15	0.65	643	1,200	1
	D	SCTEX to Cabantuan	7,961	0.15	0.65	776	1,200	1

(6) Interchange Ramp Layout

Interchange Ramp layout are shown in **Figure 6.3.6-3** to **Figure 6.3.6-8** .

LOCATION FOR TRAFFIC AND MAINTENANCE OFFICE



INTERCHANGE	DESCRIPTION	NO. OF TOLL BOOTH *	WEIGHT IN MOTION	ADMIN/MAINT. OFFICE	TOLL HOUSE
(1) Tarlac Main Barrier	From SCTEX : Pay SCTEX Toll And Get Ticket For CLLEX	3	-	-	1
	From Tarlac IC : Get Ticket For CLLEX	2	1	-	-
	To SCTEX : Pay CLLEX Toll And Get Ticket For SCTEX	3	-	-	-
	To Tarlac IC : Pay CLLEX Toll	2	-	-	-
(2) Aliaga IC	Entrance : Get Ticket	2	1	-	1
	Exit : Pay CLLEX Toll	2	-	-	-
(3) Cabanatuan City Bypass IC	Entrance : Get Ticket	2	1	-	1
	Exit : Pay CLLEX Toll	2	-	-	-
(4) Cabanatuan IC	Entrance : Get Ticket	2	1	1	-
	Exit : Pay CLLEX Toll	3	-	-	-
TOTAL		23	4	1	3

Note: * Number of Toll Booth is estimated by future traffic volume and service time (entrance - 6 sec/veh., exit 14 sec/veh.)

FIGURE 6.3.6-1 LOCATION OF IC AND NUMBER OF FACILITIES

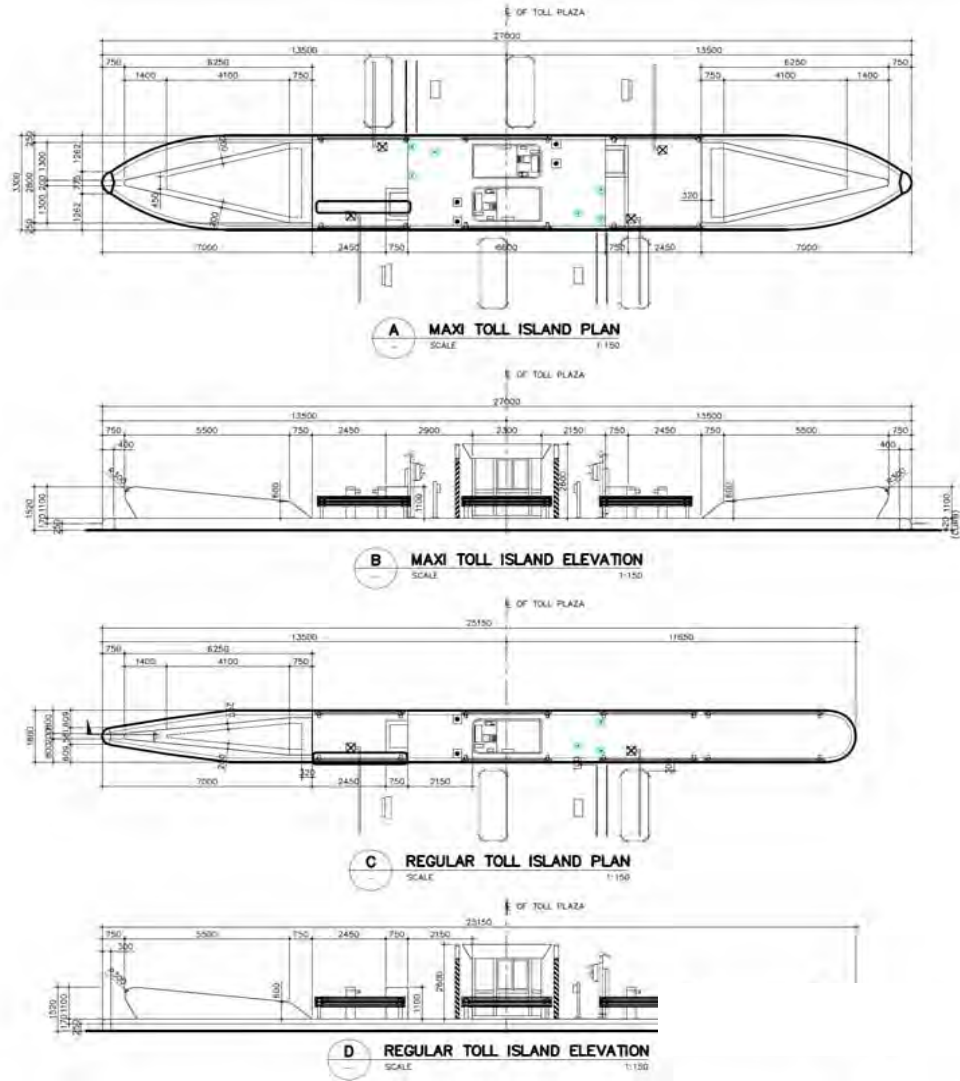


FIGURE 6.3.6-2(1) TYPICAL DRAWING OF TOLL BOOTH

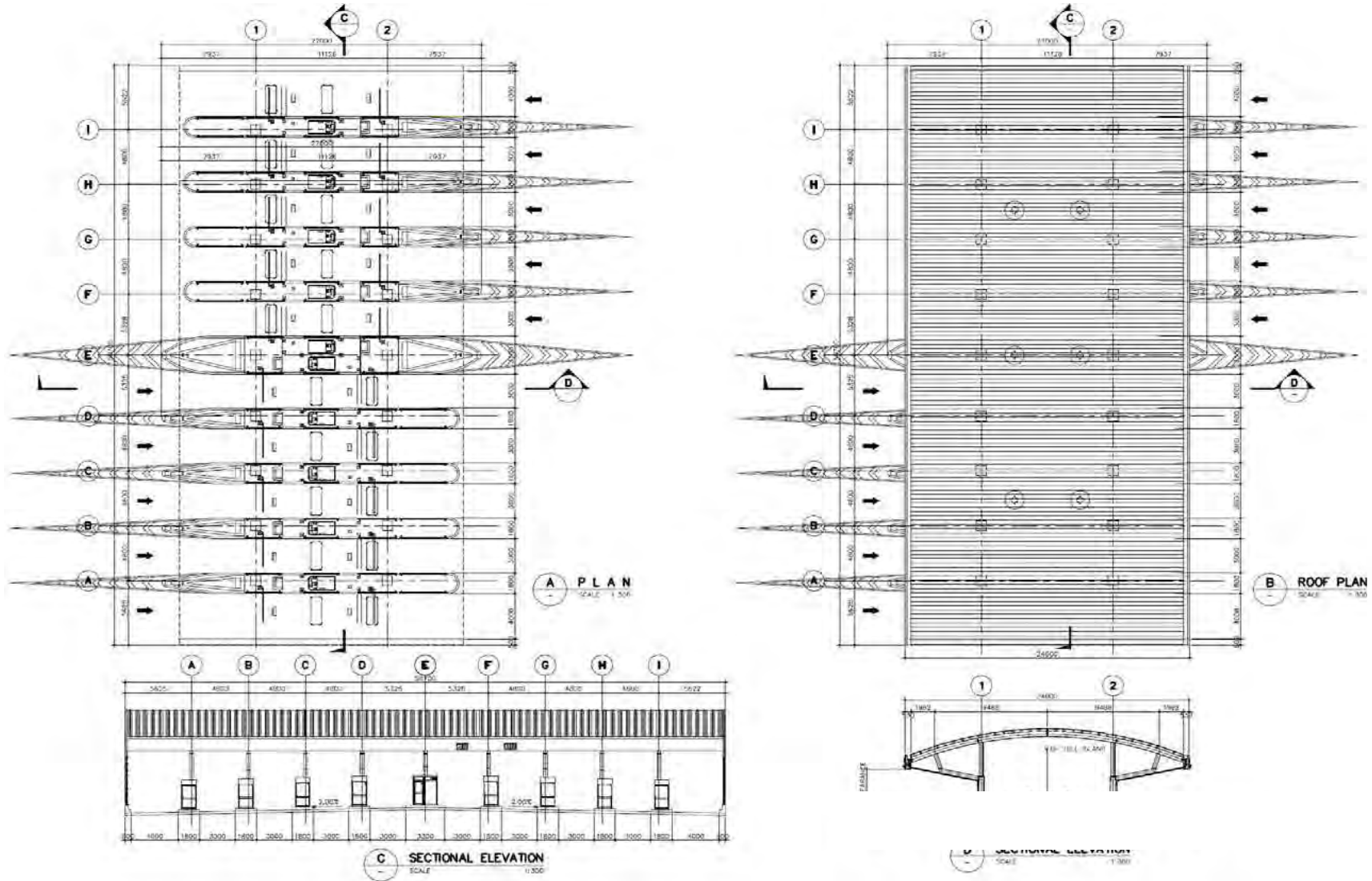


FIGURE 6.3.6-2(2) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (9BOOTHS)

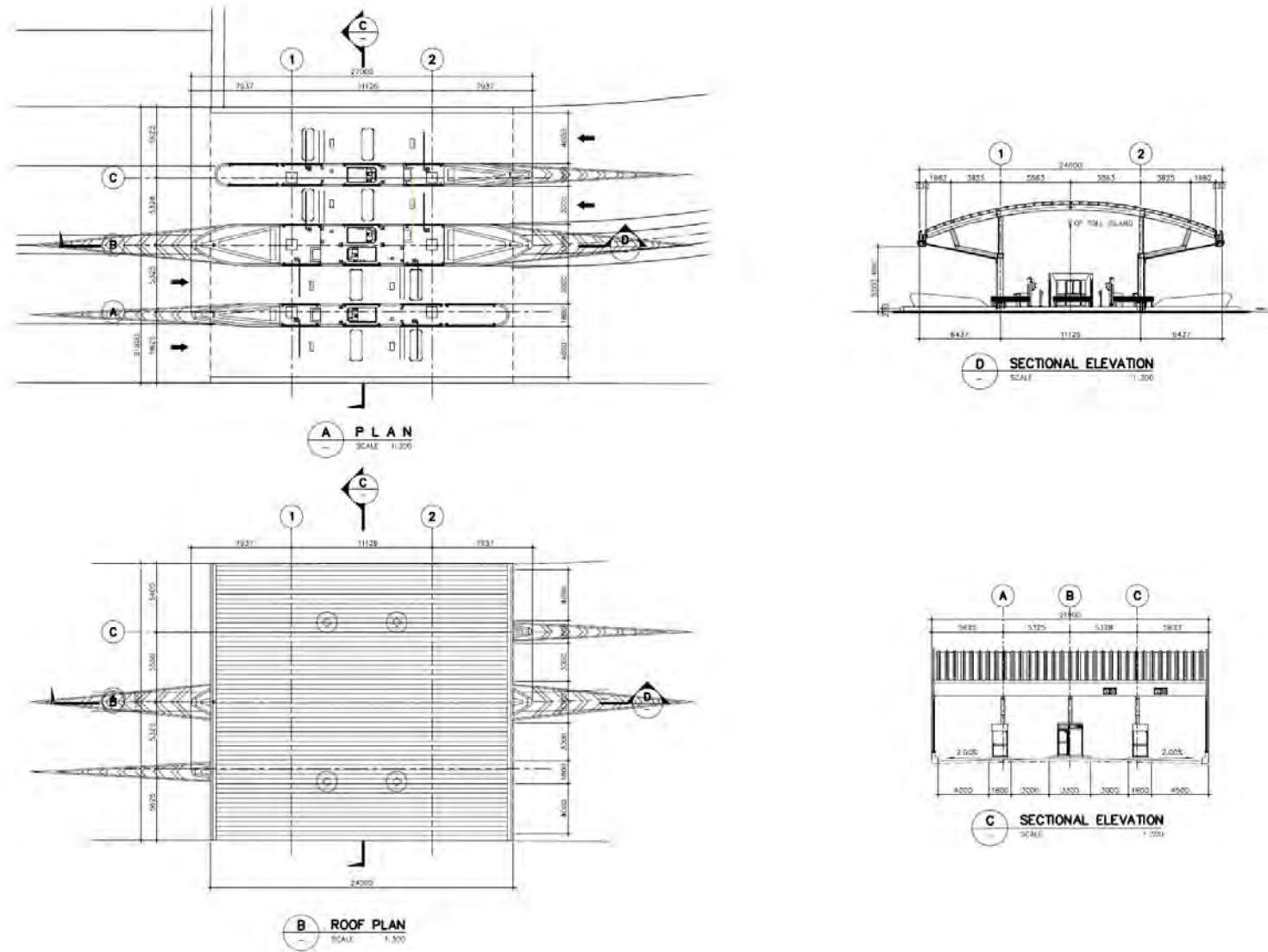


FIGURE 6.3.6-2(3) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (3BOOTHS)

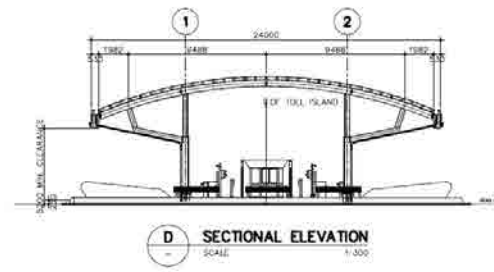
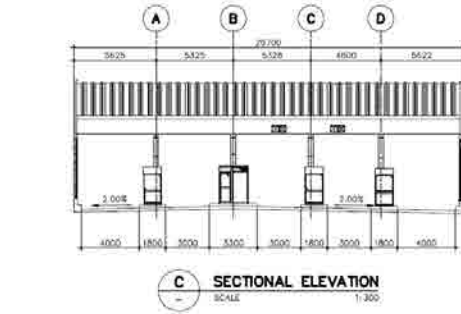
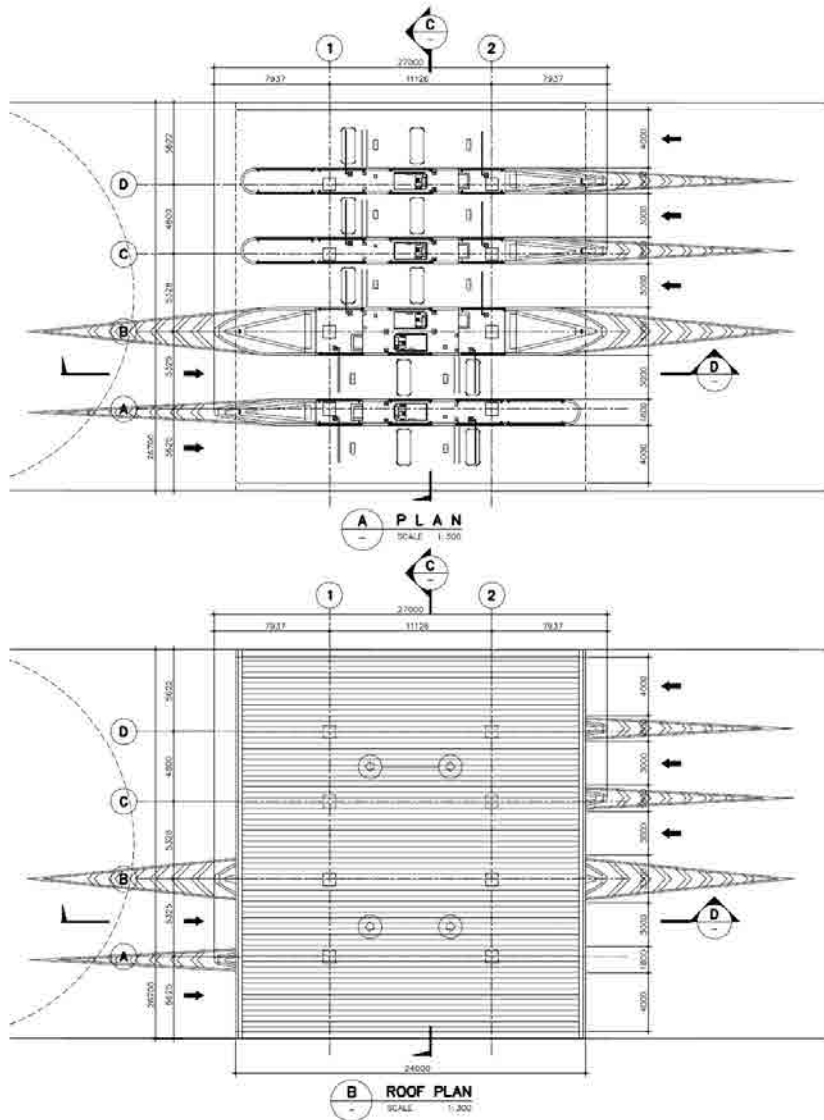


FIGURE 6.3.6-2(4) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (4BOOTHS)

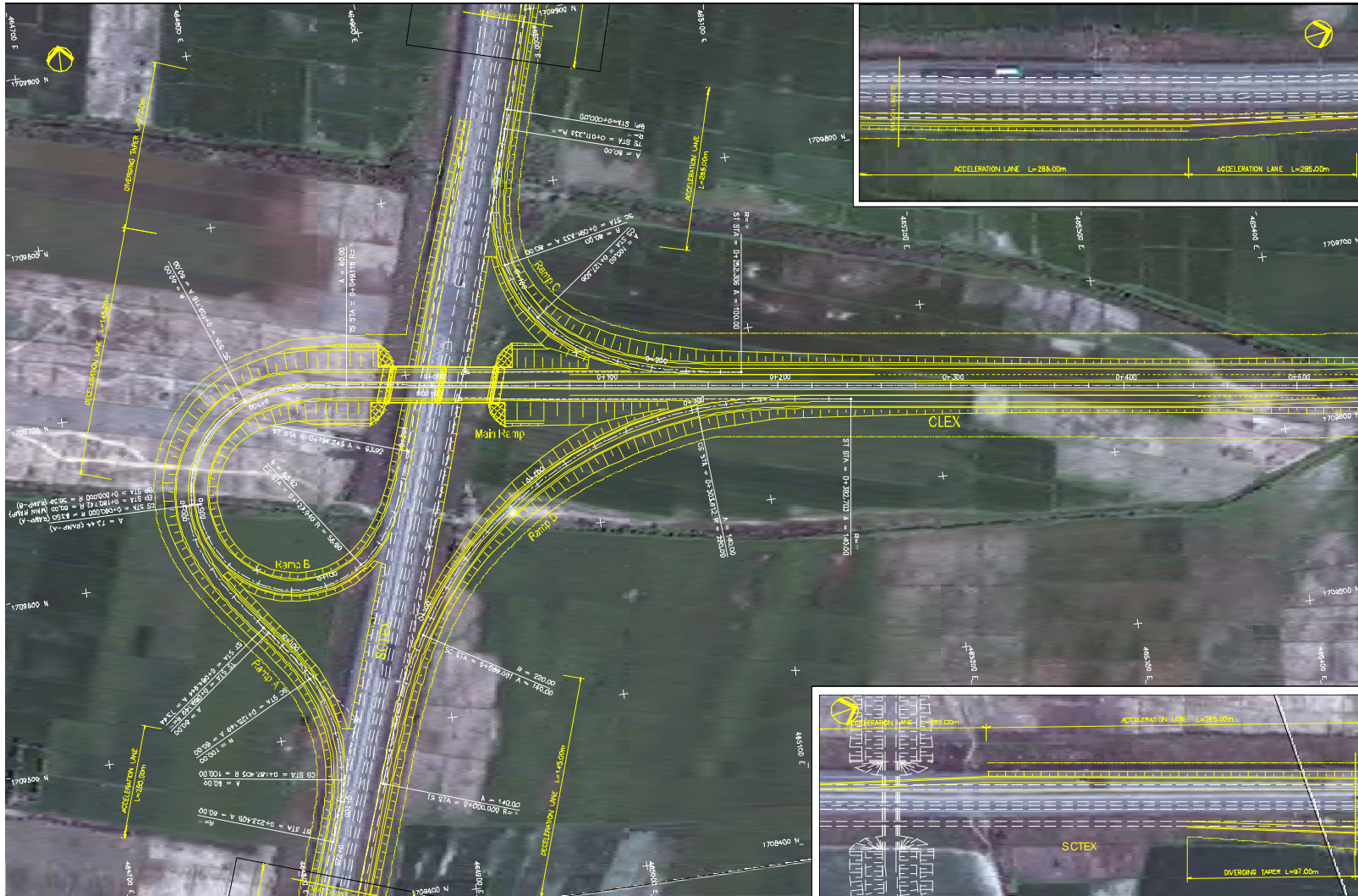


FIGURE 6.3.6-3 TARLAC JUNCTION



FIGURE 6.3.6-4 TARLAC INTERCHANGE AND TOLL BARRIER



FIGURE 6.3.6-5 ALIAGA INTERCHANGE



FIGURE 6.3.6-6 CABANATUAN BYPASS INTERCHANGE (1/2)



FIGURE 6.3.6-8 CABANATUAN INTERCHANGE

6.3.7 Interim 2 Lanes Design

(1) Design speed

100km/h (same as 4 lane design)

(2) Cross sectional configuration

Figure 6.3.7-1 illustrates the comparison of cross sectional configuration between 1st and 2nd stage.

Bridge width for the 1st stage shall be 12m while 10.5m for the 2nd stage in order to take outer shoulder width of 2.5m.

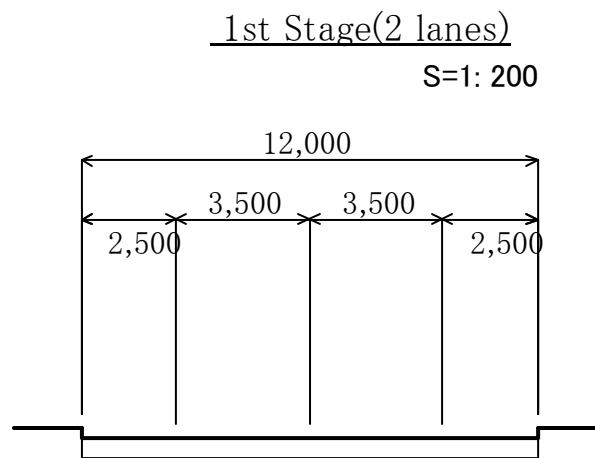


FIGURE 6.3.7-1 CROSS SECTIONAL CONFIGURATION (1ST STAGE: 2 LANES)

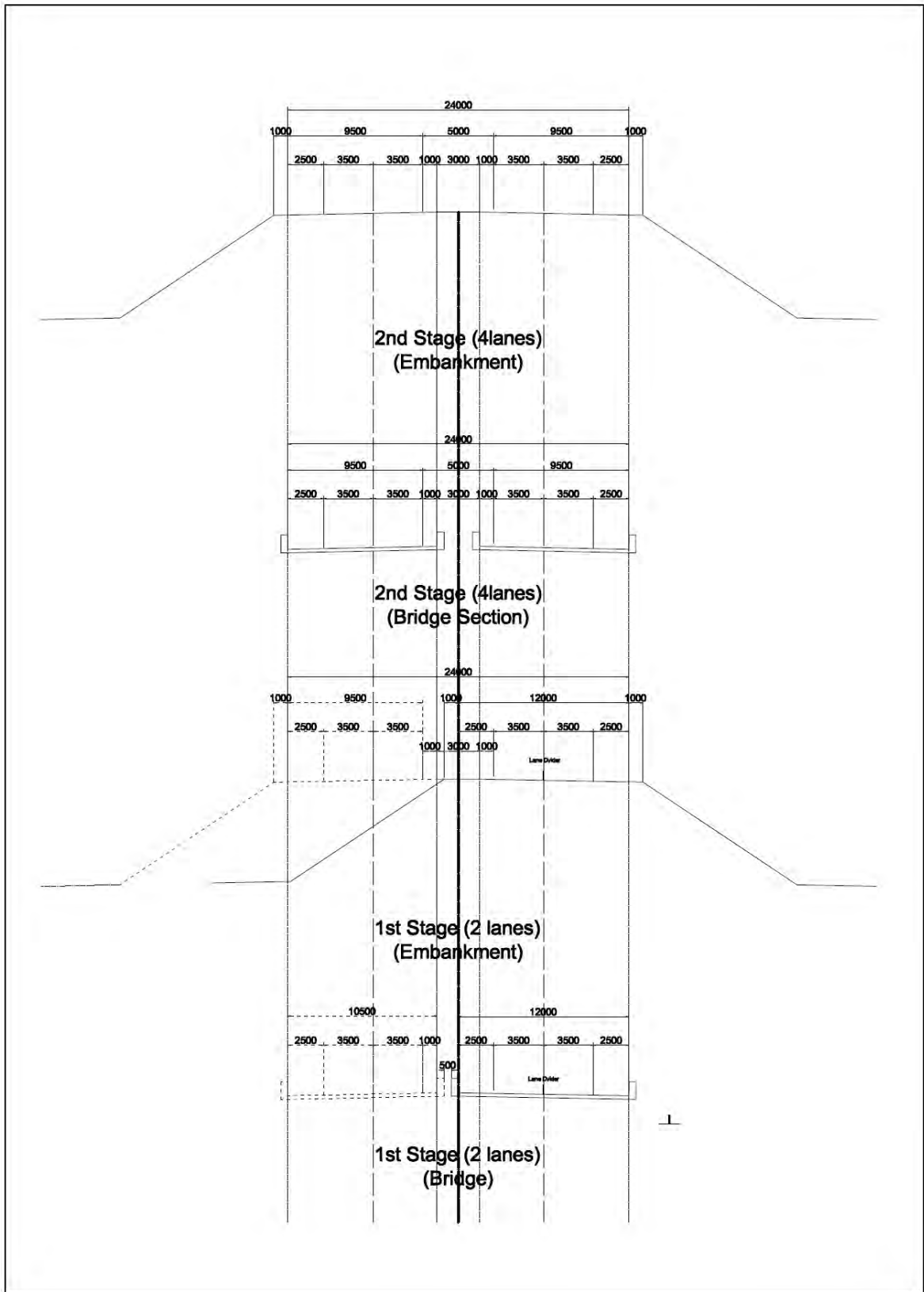


FIGURE 6.3.7-2 CROSS SECTIONAL CONFIGURATION OF STAGE CONSTRUCTION

(3) Lane divider for Initial Opening Section

In order to maintain safe and smooth traffic, it is recommended to install equipment to clarify the center line to the driver as shown in **Figure 6.3.7-3**.



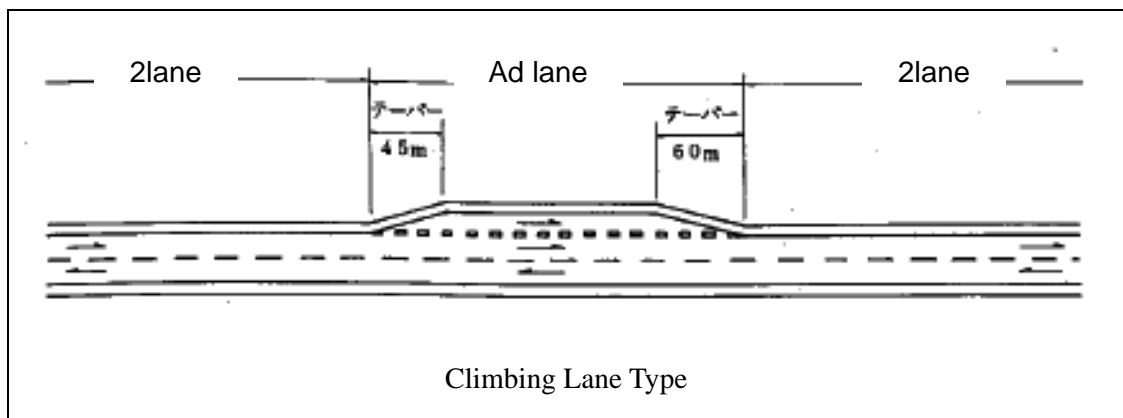
FIGURE 6.3.7-3 SAMPLE OF LANE DIVIDER

(4) Additional Lane design criteria

1) Type of Additional Lane Provision

In order to facilitate the traffic and maintain traffic safety in the interim 2 lane highway, it is essential to provide additional lane to accommodate with fast and slow vehicles.

There would be two different types of way to provide additional lane, namely, climbing lane type or taking over lane type as shown in **Figure 6.3.7-4**. Taking over lane type is applied to the desing.



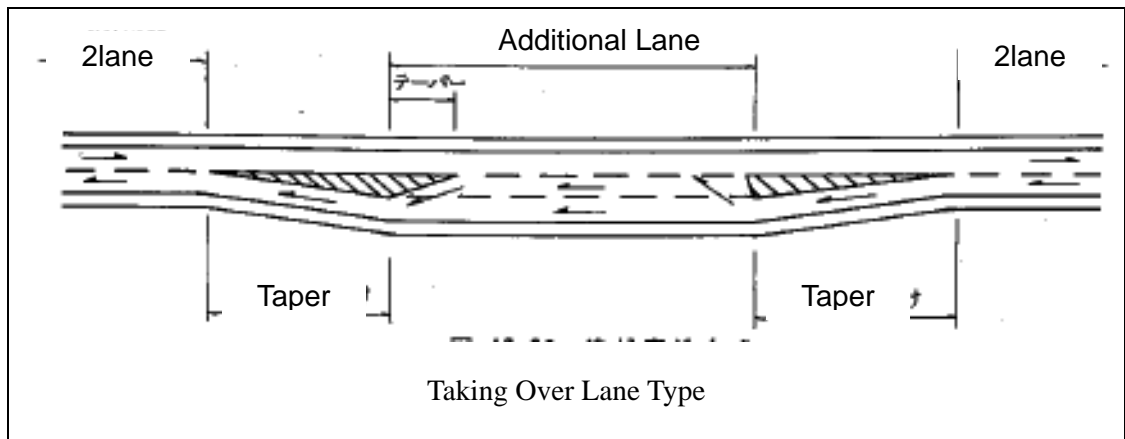


FIGURE 6.3.7-4 TYPE OF ADDITIONAL LANE PROVISION

2) Length of Additional Lane

The effect of additional lane to facilitate the traffic is not seen if the length is less than 1 km according to experiment by NEXCO. The length in **Table 6.3.7-1** is recommended in accordance with traffic volume.

Considering the traffic volume forecasted for CELEX, **1,000m** of additional lane shall be adequate.

TABLE 6.3.7-1 ADEQUATE LENGTH OF ADDITIONAL LANE

Vertical gradient Traffic Volume(V/day)	Less than 2.5%	2.5% to 3.5%	More than 3.5%
7,500	800	1,000	1,000
7500 to 12,500	1,000	1,000	1,200
12,500 to 17,500	1,000	1,000	1,200
17,500 to 22,500	1,000	1,200	1,500

3) Interval Distance of Additional Lane

It is recommended to provide additional lane of 15% to 30% (average 20%) of total stretch according to NEXCO design guide line. Considering also easiness for the drivers to recognize the traffic condition, **Figure 6.3.7-5** is recommended for the additional lane provision. The design shall consider location of road facilities such as viaduct, interchange, bridges, and design additional lane layout.

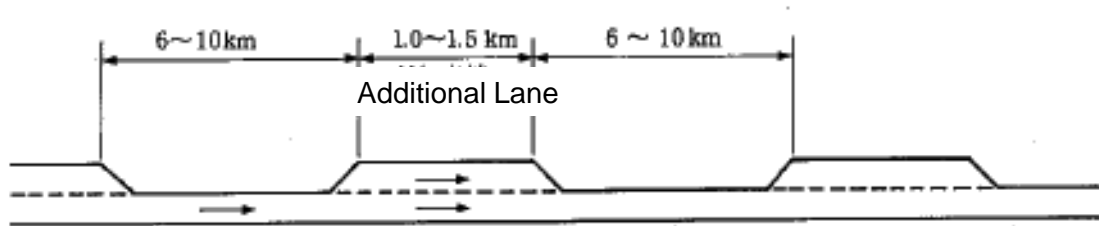


FIGURE 6.3.7-5 RECOMMENDED ADDITIONAL LANE LAYOUT

4) Taper Layout of Additional Lane

- Taper length

Taper length@0.6m/s lateral shift

Design speed 100km/h =27.78m/s

Shift width 3.5m

$$T=3.5/0.6=5.8s$$

$$L=27.78 \times 5.8=161m \rightarrow \mathbf{180m}$$

- Shifting Length of Main Lane

Taper length@0.6m/s lateral shift

Design speed 100km/h =27.78m/s

Shift width 12m

$$T=12/0.6=20s$$

$$L=27.78 \times 20=555.6m \rightarrow \mathbf{560m}$$

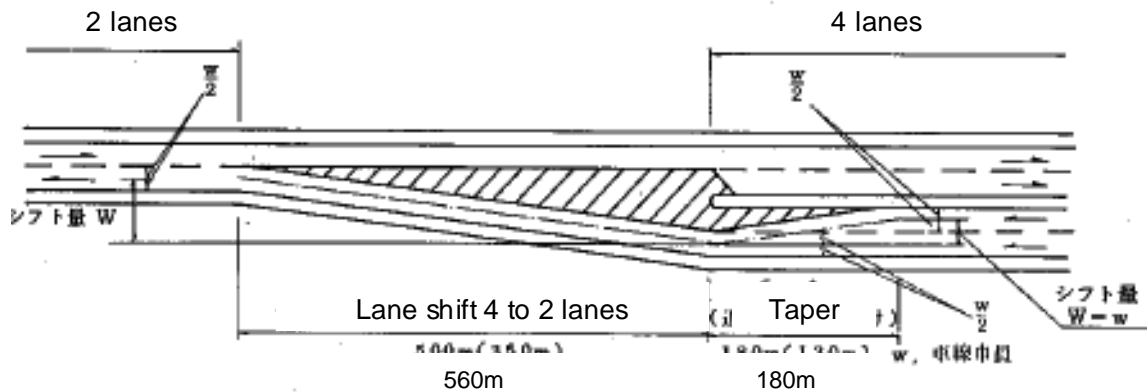


FIGURE 6.3.7-6 TAPER LAYOUT OF ADDITIONAL LANE

(5) Additional Lane Layout

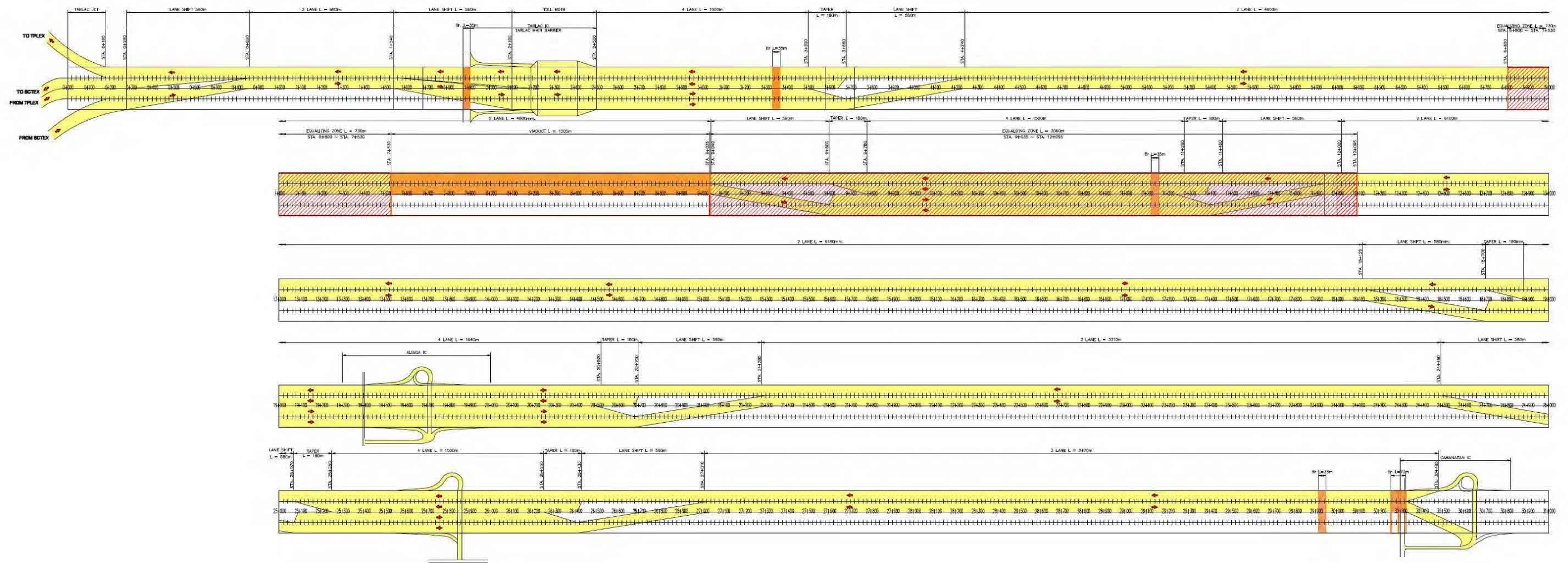
Interim 2 lane layout is shown in Figure 6.3.7-7. Table 6.3.7-2 to 3 shows breakdown of sectional configuration.

TABLE 6.3.7-2 SUMMARY OF INTERIM 2 LANE DESIGN SECTIONAL CONFIGURATION

Section Type	Embankment		Total Length	Remark
	2 lane	4 lane		
2 lane interim section	19.1km	5.5km	24.5km (80%)	Include lane shift section
4 lane ultimate section		6.2km	6.2km (20%)	20%
Total	19.1km	11.7km	30.7km	

TABLE 6.3.7-3 INTERIM 2 LANE DESIGN SECTIONAL CONFIGURATION

Station	Section Type		Remarks
	Length	No. of lanes Embankment	
0+000			
0+180	180.000	4 Ultimate	IC
0+180			
0+280	100.000	4 Ultimate	
0+860	580.000	2 Ultimate	Lane Shift
1+540	680.000	2 Interim	
2+100	560.000	2 Ultimate	Lane Shift
2+190	90.000	4 Ultimate	
2+293	103.000	4 Ultimate	Toll Plaza
2+343	50.000	4 Ultimate	Toll Plaza
2+500	157.000	4 Ultimate	Toll Plaza
3+500	1,000.000	4 Ultimate	
3+680	180.000	4 Ultimate	Taper
3+680			
4+240	560.000	2 Ultimate	Lane Shift
7+530	3,290.000	2 Interim	
9+040	1,510.000	2 Interim	Viaduct
9+600	560.000	2 Interim	Lane Shift
9+600			
9+780	180.000	2 Ultimate	Taper
11+280	1,500.000	4 Ultimate	
11+460	180.000	4 Ultimate	Taper
12+020	560.000	2 Ultimate	Lane Shift
12+095	75.000	2 Interim	
18+120	6,025.000	2 Interim	
18+700	580.000	2 Ultimate	Lane Shift
18+700			
18+880	160.000	2 Ultimate	Taper
19+700	820.000	4 Ultimate	Aliaga Interchange
20+520	820.000	4 Ultimate	
20+700	180.000	2 Ultimate	Taper
21+280	580.000	2 Ultimate	Lane Shift
21+280			
24+490	3,210.000	2 Interim	
25+070	580.000	2 Ultimate	Lane Shift
25+070			
25+250	180.000	2 Ultimate	Taper
26+250	1,000.000	4 Ultimate	Cabanatuan Half IC
26+430	180.000	2 Ultimate	
26+430			
27+010	580.000	2 Ultimate	
30+330	3,320.000	2 Interim	End of Main(Interim)
30+725	395.000	2 Interim	Cabantuan IC Main Ramp



SCHEMATIC DIAGRAM FOR INTERIM 2 LANE DESIGN

FIGURE 6.3.7-7 SCHEMATIC DIAGRAM FOR INTERIM 2 LANE DESIGN

6.4 STRUCTURE DESIGN

6.4.1 Structure Design Standard

(1) General

The Structure Design Standard shall be in accordance with the following codes and guidelines:

- AASHTO Standard Specifications for Highway Bridges 17th edition 2002,
- DESIGN Guidelines Criteria and Standard for Department of Public Works And Highways,
- Basic Specifications – DPWH Standard Specifications 2004, Highways, Bridges and Airports
- Alternatively, Japanese Standards also will be adopted as the structure design standards.

(2) Loading Specifications

Structure shall be designed to carry the following loads and forces:

1) Dead Load

2) Live Load

Live Load shall be MS18 (HS-20-44)

3) Impact Load

$I = 15.24/(L+38)$

4) Sidewalk Live Load

4.07 KPa of sidewalk area

5) Earthquake Load

A = 0.4g, SPC D

6) Earth Pressure

Coulomb's Formula

7) Wind Load

For the Superstructure design, 2,394Pa of wind load shall be applied horizontally at right angle to the longitudinal axis of girders and beams.

8) Thermal Forces

The range of temperature shall be as follows:

17.8 °C to 48.9 °C

16.7 °C temperature rise

22.2 °C temperature fall

(3) Seismic Design

Seismic Design shall be in accordance with AASHTO Standard Specifications Division I-A. Acceleration coefficient of **0.4g** shall be adopted to consider importance classification and past/recent experience in the Philippines.

(4) Superstructure

1) Bridge Type

The following bridge types shall be adopted depending on the span length, economy, and sight conditions:

- a) Simple span pre-stressed concrete AASHTO I-Girders with continuous concrete deck slab every three or four spans.
- b) Simple/multi span reinforced concrete deck girder.
Deck discontinuity such as expansion joints shall be kept to minimum in accordance to the DPWH Design Advisory.

2) Expansion Joint

The following types of expansion joints shall be adopted depending on the bridge type and movement.

- a) Hot poured joint sealer with angles type,
- b) Closed cell elastomeric sealer made of Neoprene type.

3) Bridge Drainage

Catch basins shall be made of cast iron and PVC drainpipes shall be used for bridge surface drainage system.

4) Bearings Shoe

Elastomeric bearing pad shall be used for pre-stressed concrete girder supports.

5) Bridge Pavement

Asphalt concrete pavement with 5 cm thickness shall be laid on concrete deck slab.

6) Construction Force and Effect

Forces and Effects developed during construction shall be considered in design.

(5) Substructure and Foundation

1) The following type of pier shall be adopted in accordance to the site conditions and restrictions.

- a) Reinforced concrete column with pier-head type pier,
- b) Reinforced concrete hammerhead type pier.
Pile bent-type shall be allowed for ramps and multi column type pier.

2) Depth of Footing

Footings shall be embedded into the ground at least 1.0 meter from ground surface to the top of footing, and at least 2.0 meters from the river bed in the river. The effect of buoyancy on the structure shall be verified.

3) Foundation Type

In accordance to the result of the sub-surface soil investigation, constraints factors during construction and others if any, the following types of foundation shall be selected;

- a) Spread footing type,
- b) Cast in place concrete pile (1.2m to 2.0m diameter of piles will be adopted).

(6) Materials

All materials to be used in the project shall be conformed to DPWH Standard Specifications (2004), and AASHTO Code.

1) Concrete

DESCRIPTION	<u>fc' (Min.)</u> MPa	MAXIMUM SIZE OF CONCRETE AGGREGATES (mm)	MINIMUM CONCRETE COVER (mm)
a. Superstructure			
- Deck slabs, Diaphragms	28	20	Deck slab with BWS Top: 50 Bottom: 50 Others: 35
- Sidewalk, railings, parapets, medians	21	20	
- PSC I-Girders	38	20	PSC I-Girders: 35
b. Substructure			
- PC Pier copings, columns, footings	28	20	Pier Copings, RC & PSC: 50
- PSC Pier copings, rotating pier head	38	20	PSC Hammerheads: 40 RC columns: 50
- RC Abutment walls, footings	28	20	Footing and Bored Piles: 75
- Bored piles	28	20	Abutment Walls: 50
c. Earth covered RC Box structures	28	20	Earth covered Box structures: 50
d. Other concrete (normal use)	21	20	
e. Lean concrete (for leveling)	17	25	
f. Non shrink grout	41	40	

2) Reinforcement Steel

All prestressing steel shall be high strength stress relieved wires or strands with an ultimate stress, $f_s' = 1860$ MPa.

Prestressing steel shall be free from kinks, notches and other imperfections that will tend to weaken its strength or its bonding properties with concrete.

3) Prestressing

All prestressing steel shall be high strength stress relieved wires or strands with an ultimate stress, $f_s' = 1860$ MPa.

Prestressing steel shall be free from kinks, notches and other imperfections that will tend to weaken its strength or its bonding properties with concrete.

4) Structural Steel

All structural steel shall conform to the requirements of AASHTO or ASTM Designations as follows:

- a) Structural Steel Shapes - AASHTO M 270 (ASTM A 36) Gr 36 and (ASTM A572) Gr 50.
- b) Steel Sheet Pile - AASHTO M 202 (ASTM A 328)
- c) Bridge Bearing - AASHTO M 270 (ASTM A 36) AASHTO M 106 (ASTM B 100)
AASHTO M 103 (ASTM A 27) (Copper Alloy Bearing Expansion Plates Grade 70 – 36 of Steel and Sheets)
- d) Deck Drain - AASHTO M 105 (ASTM A 46) Class No. 30 (Gray Iron Casting)
- e) Bridge Railing - Sch. 40 Galvanized Steel Pipe

5) Elastomeric Bearing Pads

Elastomeric bearing pads shall be 100% virgin chloroprene (neoprene) pads with durometer hardness 60. Unless otherwise specified in the plans, bearing pads shall be laminated type bearing pads consisting of layer of elastomer, restrained at their interfaces by bonded laminations are required on the plans, laminated plate shall be non-corrosive mild steel sheet.

6) Joint Filler

Joint filler, hot poured elastic type, used for expansion joint shall conform to AASHTO M 213.

7) Bituminous Wearing Course

Bituminous wearing course to be used as surface overlay shall conform to the requirements of DPWH Standard Item 307 with minimum dry compressive strength of 1.4 MPa (200 pal). The wearing course may be used to adjust elevations on the vertical grade by varying the thickness from 50mm (min.) to 75mm (max).

6.4.2 Structure Type Study

Structure Location Map in CLLEX is shown in **FIGURE 6.4.2-1**. Nine (9) bridges and seventy eight (78) reinforced concrete box culverts (RCBC) were proposed along or crossing to the main expressway.

In bridge structure, seven (7) expressway bridges including a long bridge – Rio Chico River crossing bridge with 1,505m length and two (2) bridges crossover to the main expressway are studied.

RCBC structure was planned as the crossing under the main expressway, based on the following three (3) purposes;

- a. Road crossing – for IC ramp, national road, provincial road, municipality road, farm road,
- b. River and Irrigation crossing – for small discharged natural creek and irrigation canal, and,
- c. Equalizing – for Rio Chico River flooding control.

(1) General

The general features of bridges are described as follows;

1) AASHTO Girder

AASHTO Girder, prestressed concrete I-section girder, is selected because it is the most economical and widely used in the Philippines. Erection of the girder during construction will not affect to the at-grade traffic.

The bridge span ranged **between 25 and 35 m** in length are applied in the design.

2) DPWH Standard Bridge – RCDG

DPWH standardized Reinforced Concrete Deck Girder, RCDG is adopted the bridge span ranged up to **24m** in length.

3) Single/Multi Column type Pier

Single or multi column with pier-head type pier is applied. The column section is adopted cylindrical or circular shape, especially in the river area to minimize the streaming inhibition. This shape can also provide well environmentally harminalzing perspective view of the bridge.

4) Reversed T-shape Abutment

The abutment height ranges between 10 to 12m. “the reversed T shape type” is applied which is most common type in the height range. This type for the height could be stable and minimizes the construciton cost.

5) Bored Pile Foundation

Bored pile foundation was designed because the hard stratum (assumed bearing strata) exists deeper than 8m (deepest is more than 24m) in the Project area based on the soil survey results. The pile diameter was adopted ranges between 1.2m and 2.0m.

6) RCBC

DPWH Standard RCBC was adopted for the most of the crossing structure. Japanese Standard was also reffered for the size which is not corresponding to DPWH standard.

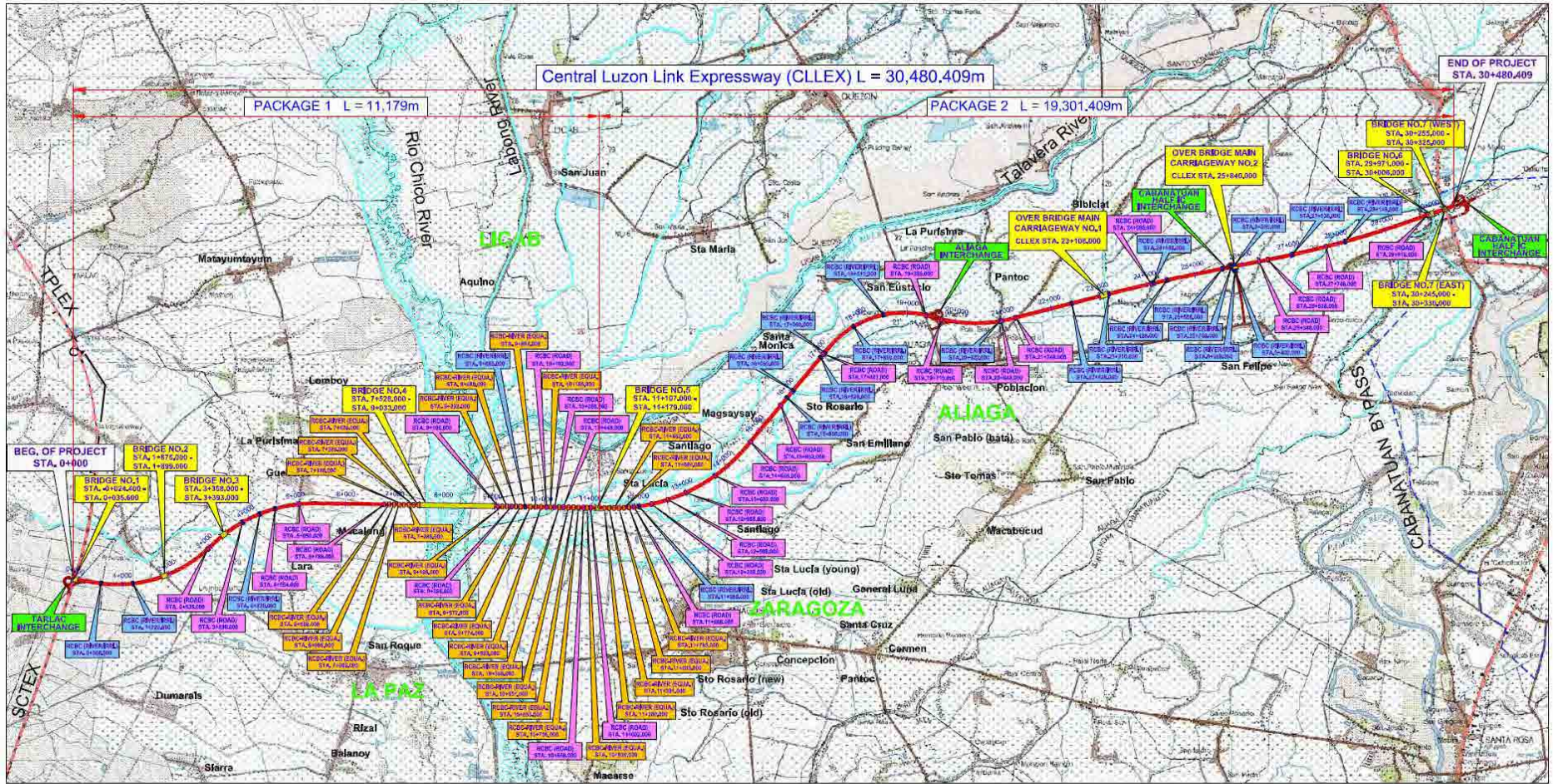


FIGURE 6.4.3-1 STRUCTURE LOCATION MAP



LEGEND:

INTERCHANGE	
BRIDGE	
RCBC (ROAD)	
RCBC (RIVER/IRRI)	
RCBC-RIVER (EQUA.)	

FIGURE 6.4.2-1 STRUCTURE LOCATION MAP

(2) **Structure Features**

Based on the discussion above, major points of technical approach for design of bridge and RCBC are described in **TABLE 6.4.2-1** through **TABLE 6.4.2-3**. General view of bridges are shown in **ATTACHMENT – GENERAL VIEW OF BRIDGES**.

TABLE 6.4.2-1 BRIDGE FEATURES – MAIN CARRIAGEWAY (1/3)

Bridge No.	Location	Features
1	SCTEX Junction <STA. -0+24.4 – 0+35.6>	<ul style="list-style-type: none"> - The bridge is part of Tarlac Interchange crosses over the main expressway of SCTEX, - Both abutments were set at 30m from the center line considering possible future widening to 3lanes and one pier is set in the median of SCTEX. The total bridge length is 60m (2@30m). - AASHTO girder type V and multi column (3 columns) type with circular section pier. - Based on soil survey result, pile foundation to 14m depth from the surface, - Large pile diameter with 2.0m pile for pier foundation considering to the construction to minimize operation of SCTEX and 1.2m diameter pile was adopted for the abutments, - Superstructure; 2 lanes (W=18.5m, 1 lane per each direction) with median ramp – 7 girders per each span
2	(National Road) Sta. Rosa – Tarlac Road <STA. 1+875.0 – 1+899.0>	<ul style="list-style-type: none"> - 24m bridge length (simple span) considering future road widening of this National Highway (W=18m) though existing width is only 7m, - RCDG was adopted. - Pile foundation (1.2m diameter) to 14m depth from the surface in accordance with soils survey result. - Each bound superstructure of 11.5m width (5 girders, 2 lanes carriageway), separated structure, each abutment is supporting both bound superstructure as one structure.
3	Tin Tin River Crossing <STA. 3+358.0 – 3+393.0>	<ul style="list-style-type: none"> - Existing river width is approximately 12m with maintenance road at both banks, therefore the bridge length was determined to cover those river facilities - 35m AASHTO girder type V was adopted - The required minimum bridge length is determined the following formula: $L = 20 + 0.005Q$ where; Q: design discharge (m³/sec) = 259.75m³/sec L: required minimum span (bridge) lenth (m) Therefore, L=21.3m - Based on the soil survey result, pile foundation (1.2m diameter) was selected because the assumed bearing strata is existing about 12m depth from the surface, - Each bound superstructure of 11.5m width (5 girders, 2 lanes carriageway), separated structure, each abutment is supporting both bound superstructure as one structure.

TABLE 6.4.2-1 BRIDGE FEATURES – MAIN CARRIAGEWAY (2/3)

No.	Location	Features
4	Rio Chico River Crossing <STA. 7+358.0 – 9+33.0>	<ul style="list-style-type: none"> – Proposed bridge length of 1,505m was determined to consider the following reasons: <ol style="list-style-type: none"> 1) minimum required length of 1,220m shown in Table 6.3.5-8, 2) length between existing both dikes in the proposed route is approximately 900m. 3) Existing dikes are not rehabilitated and a numbers of locations are damaged and causing leaking of water during heavy rain. 4) For such reasons, the bridge requires to take minimum margins to accommodate such over flow. – AASHTO girder type V and span length of 35m with the span arrangement 43@35m, – The required minimum bridge length to refer to standard in Japan is determined the following formula: $L = 20 + 0.005Q$ where; Q: design discharge (m³/sec) = 2,472.00m³/sec L: required minimum span (bridge) length (m) Therefore, L=32.4m – Pile foundation (1.2m diameter) considering strata layer existing ranged from 11 to 24m depth from the surface according to soil survey result. – Single cylindrical section column type pier considering to smooth river water flow, – Inhibition ratio to the river width by pier columns referring to standard in Japan (though no specified in the Philippines' standards) is recommended within 7% for the expressway bridges, this bridge is as follows: Assumed column width for streaming direction = 2.0m Number of piers = 42 nos. $42 \times 2.0 / 1,505 = 5.58\% < 7\%$ (OK) – Each bound superstructure of 10.5m width (4 girders, 2 lanes carriageway, applied road width for long span bridge) is separated structure, and each abutment is supporting both bound superstructure as one structure.
5	Natural Creek <STA. 11+107.0 – 11+179.0>	<ul style="list-style-type: none"> – This river has 106.81m³/sec of design discharge. The existing river channel is narrow and located within frequent flood prone area. – Considering to the above mentioned condition and the existing s-shaped river corridor, the required river width with maintenance road is set 72m (3@24m) . – RCDG was adopted because 24m span length is within the adoptable range, – The required minimum bridge length to refer to standard in Japan is determined the following formula: $L = 20 + 0.005Q$ where; Q: design discharge (m³/sec) = 106.81m³/sec L: required minimum span (bridge) length (m) Therefore, L=20.5m – Based on the soil survey result, pile foundation (1.2m diameter) was selected because the assumed bearing strata is existing about 20m depth from the surface, – Circular section column type pier was determined in consideration of smooth river water flow, – Inhibition ratio to the river width by pier columns is recommended within 7% for the expressway bridges referring to standard in Japan.

TABLE 6.4.2-1 BRIDGE FEATURES – MAIN CARRIAGEWAY (3/3)

No.	Location	Features
5	Natural Creek <STA. 11+107.0 – 11+179.0>	<ul style="list-style-type: none"> - The verification result for this bridge is as follows: Assumed column width for streaming direction = 1.8m Number of piers = 2 nos. $x 1.8 / 72 = 5.0\% < 7\%$ (OK) - Each bound superstructure of 11.5m width (5 girders, 2 lanes carriageway) is separated structure, and each abutment is supporting both bound superstructure as one structure.
6	Natural Creek <STA. 29+971.0 – 30+6.0>	<ul style="list-style-type: none"> - River width is only 10 to 12m with maintenance road at both banks, therefore the bridge length was determined to cover those river facilities – 35m AASHTO girder type V was adopted, - The required minimum bridge length to refer to standard in Japan is determined the following formula: $L = 20 + 0.005Q$ where; Q: design discharge (m³/sec) = 139.48m³/sec L: required minimum span (bridge) length (m) Therefore, L=20.7m - Based on the soil survey result, pile foundation (1.2m diameter) was selected because the assumed bearing strata is existing about 8m depth from the surface, - Each bound superstructure of 11.5m width (5 girders, 2 lanes carriageway) is separated structure, and each abutment is supporting both bound superstructure as one structure.
7	(Local Road) Cabanatuan Bypass and (National Road) Pan Philippines Highway	<ul style="list-style-type: none"> - This bridge is located above the two roads – the Cabanatuan Bypass and the Pan Philippines Highway at intersection with sharp angle. Due to these aspects, east and west bound bridge length and the span arrangement are designed separately. - 85m bridge length (span:30+25+30m) for east bound and 70m length (span:35+35m) for west bound, AASHTO girder type V were planned, - Based on the soil survey result, pile foundation (1.2m diameter) was selected because the assumed bearing strata is existing about 8m depth from the surface, - East bound superstructure of 11.5m width (5 girders, 2 lanes carriageway) and west bound of 15.0m width (6 girders, 3 lanes carriageway) are separated structure, and the each abutment is also individually planned.

TABLE 6.4.2-2 BRIDGE FEATURES – CROSSOVER BRIDGE FOR MAIN EXPRESSWAY

No.	Location	Features
8	CLLEX <STA. 23+108.0>	<ul style="list-style-type: none"> - Municipality road is crossing over to the CLLEX, the road width is 8m (2 lanes), - Both abutments were set at the CLLEX ROW limit and a pier was set in the median, therefore total bridge length of 60m (2@30m) was proposed, - AASHTO girder type V (3 nos. per each span) and single column type with circular section pier was determined, - Based on soil survey result, pile foundation was selected because the assumed bearing strata is existing about 12m depth from the surface,
9	CLLEX <STA. 25+840.0>	<ul style="list-style-type: none"> - Ramp A of Cabanatuan half IC is crossing over to the CLLEX, the road width is 9m (widened 1 lane), - Both abutments were set at the CLLEX ROW limit and a pier was set in the median, therefore total bridge length of 60m (2@30m) was proposed, - AASHTO girder type V (4 nos. per each span) and multi column (2 columns) type with circular section pier was determined, - Based on soil survey result, pile foundation was selected because the assumed bearing strata is existing about 12m depth from the surface,

TABLE 6.4.2-3 RCBC FEATURES

No.	Crossing Object	Features
1	Road or Road with Irrigation/River	<ul style="list-style-type: none"> - RCBC for road is considered the following points and proposed 10 types. Typical cross section is shown on FIGURE 6.4.2-2: <ul style="list-style-type: none"> o Crossing road categories – inner dimension is in accordance with the crossing road type; CLLEX Ramp, National Road, Provincial Road, Municipality Road, Farm Road, Barangay Road, o 2) With River/Irrigation – RCBC are provided to all major irrigation canals . Some minor canals are integrated into one.
2	River or Irrigation	<ul style="list-style-type: none"> - DPWH Standard type of RCBC was referred and 10 types were proposed. Typical cross section is shown on FIGURE 6.4.2-3, - Only minor river and all irrigation canal were applied by RCBC.
3	Equalizing Zone for Rio Chico River	<ul style="list-style-type: none"> - As mentioned Chapter 6.3.5, inner dimension of (3m x 3m) RCBC and every 100m was proposed in the flood prone area of the Rio Chico River, - 27 locations provided, - This could be utilized as the farm road.

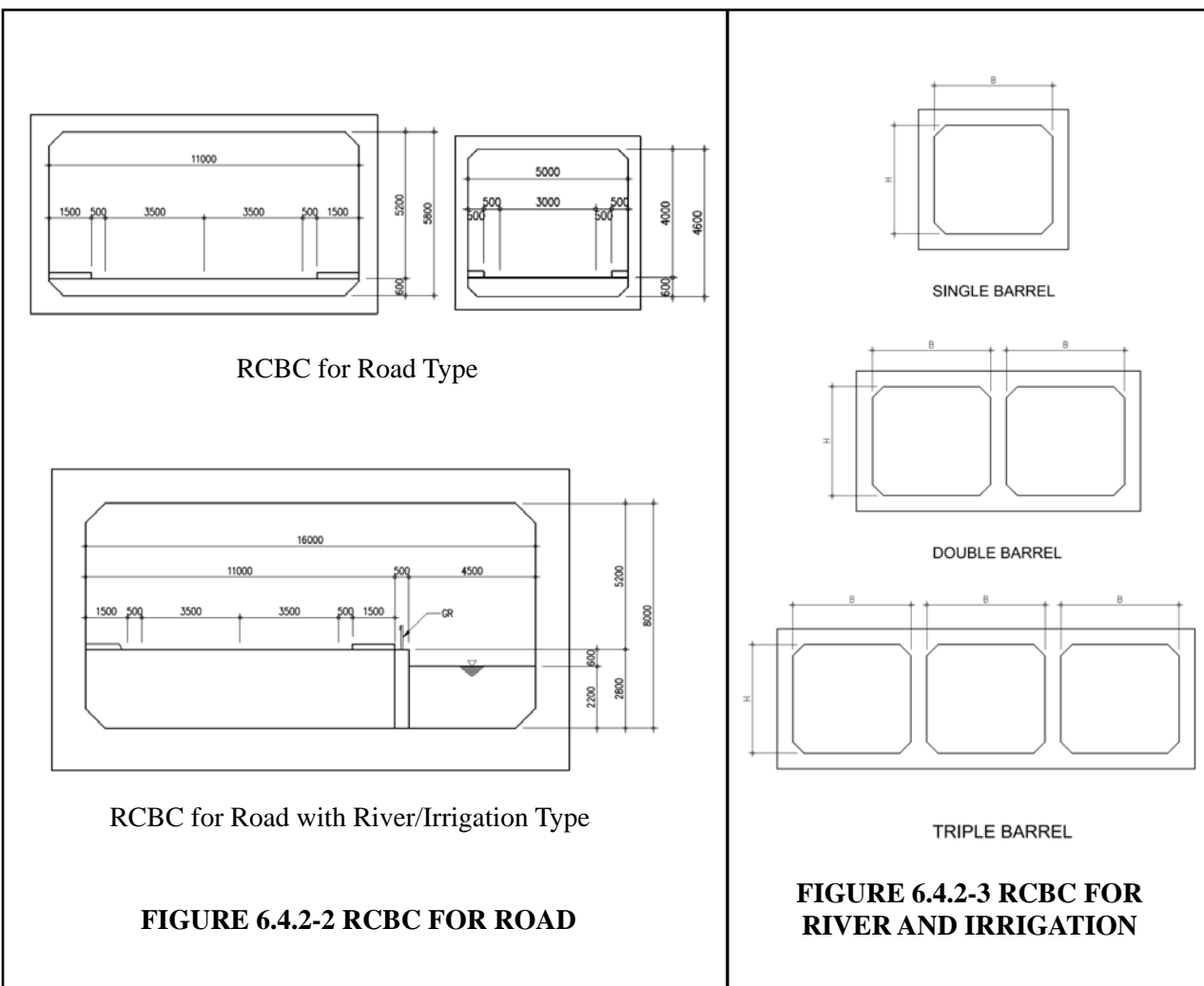
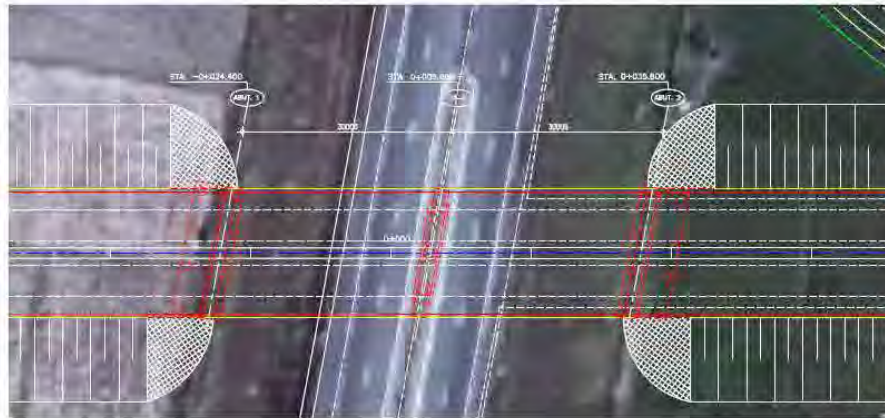


FIGURE 6.4.2-2 RCBC FOR ROAD

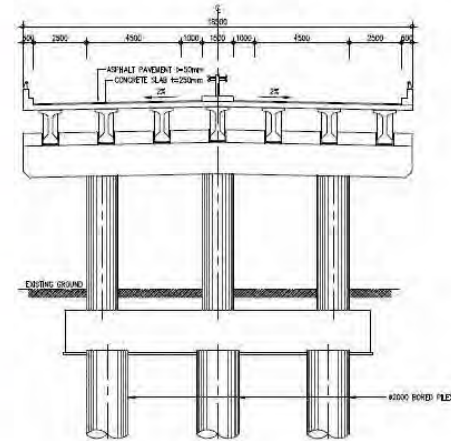
FIGURE 6.4.2-3 RCBC FOR RIVER AND IRRIGATION

ATTACHMENT – GENERAL VIEW OF BRIDGES

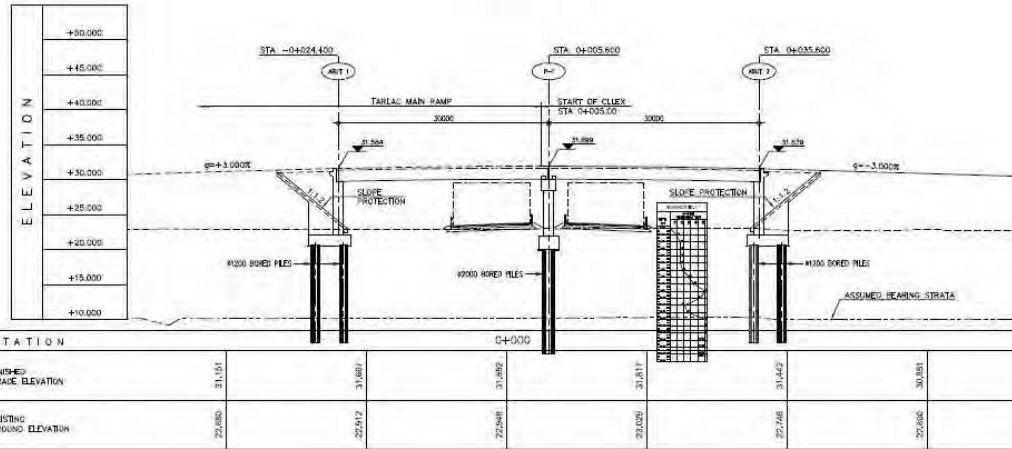
No.	Bridge Name	Station	Drawing No.
1	Ramp Bridge – SCTEX Junction	0+000.0	H-01
2	Sta. Rosa – Tarlac Road Crossing Bridge	1+887.0	H-02
3	Tin Tin River Crossing Bridge	3+375.5	H-03
4	Rio Chico River Crossing Bridge	8+280.5	H-04 – H-09
5	River (Natural River) Crossing Bridge	11+143.0	H-16
6	River (Natural River) Crossing Bridge	29+988.5	H-17
7	Cabanatuan Bypass, Pan-Philippine Highway Crossing Bridge	30+289.0	H-19, H-20
8	Crossover Bridge to CLLEX Main Carriageway	23+108.0	H-22
9	Crossover Bridge to CLLEX Main Carriageway	25+840.0	H-23



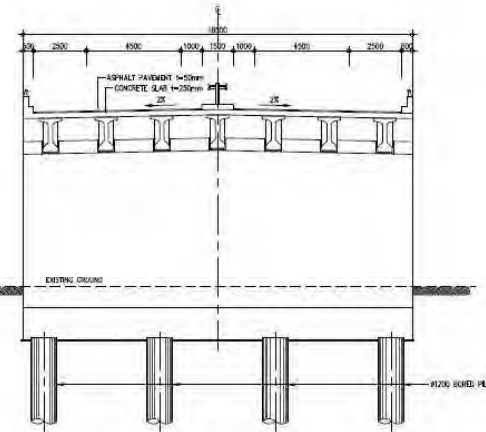
A GENERAL PLAN
SCALE 1:800



C CROSS SECTION - PIER
SCALE 1:200



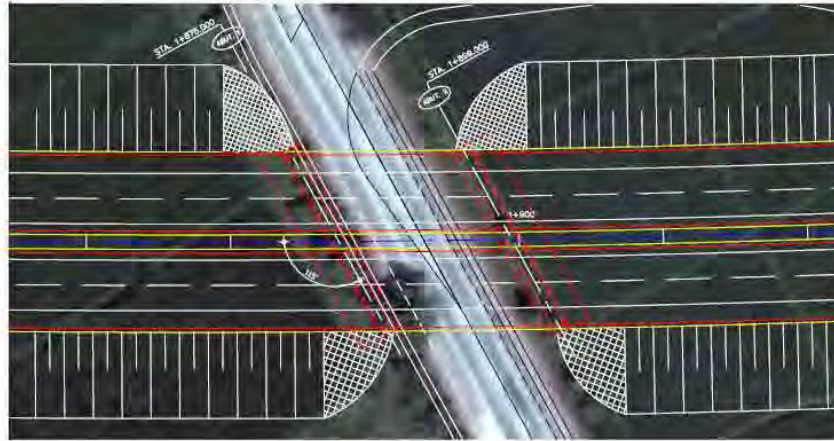
B GENERAL ELEVATION
SCALE 1:500



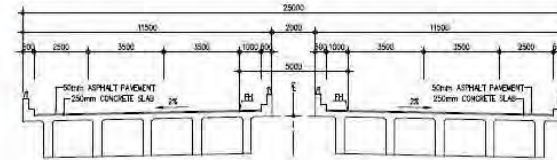
D CROSS SECTION - ABUTMENT
SCALE 1:200

STATION		0+000	0+024.400	0+079.300	0+035.600	0+060.000
FINISHED GRADE ELEVATION		31.151	31.082	31.082	31.817	31.817
EXISTING GROUND ELEVATION		22.082	22.012	22.046	22.026	22.746

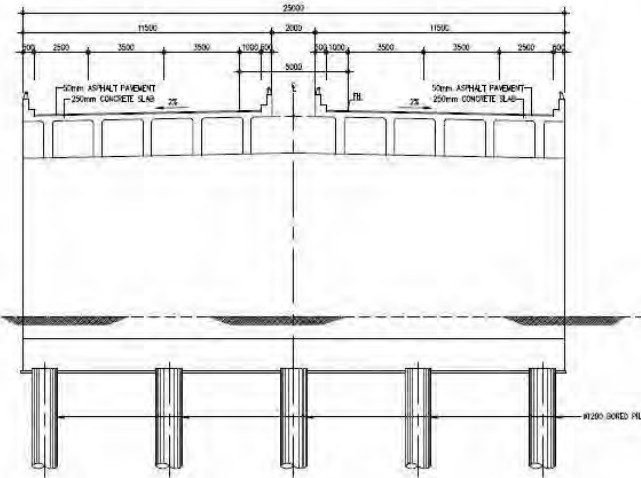
PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW	H-01
		SCTEX JUNCTION - RAMP BRIDGE MAIN CARRIAGEWAY BRIDGE NO.1 (PACKAGE - 1) (ULTIMATE 4 LANE)	SHEET NO.
			1 OF 23



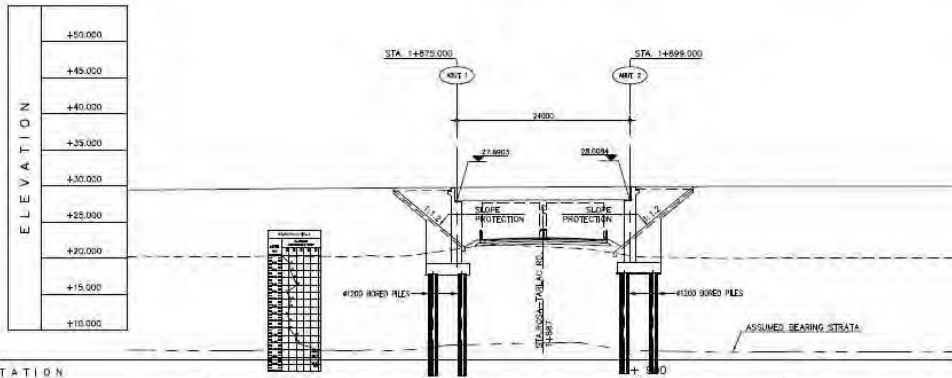
A GENERAL PLAN
SCALE 1:600



C CROSS SECTION - SUPERSTRUCTURE (RCDG)
SCALE 1:200



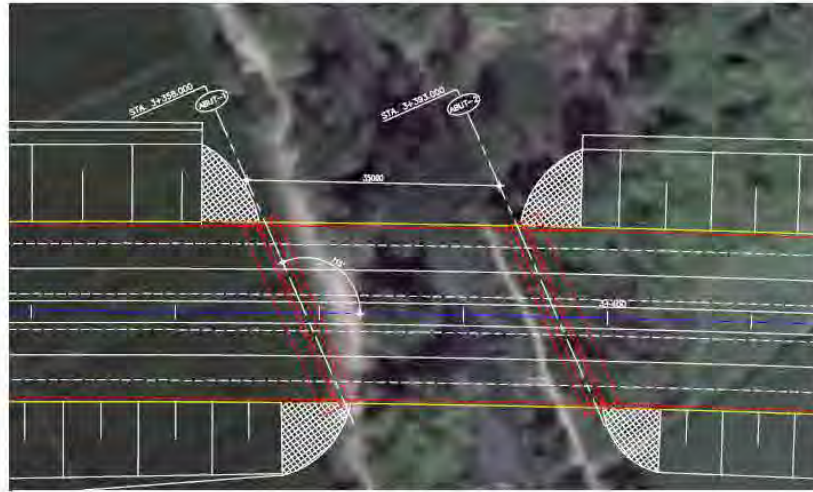
D CROSS SECTION ABUTMENT
SCALE 1:200



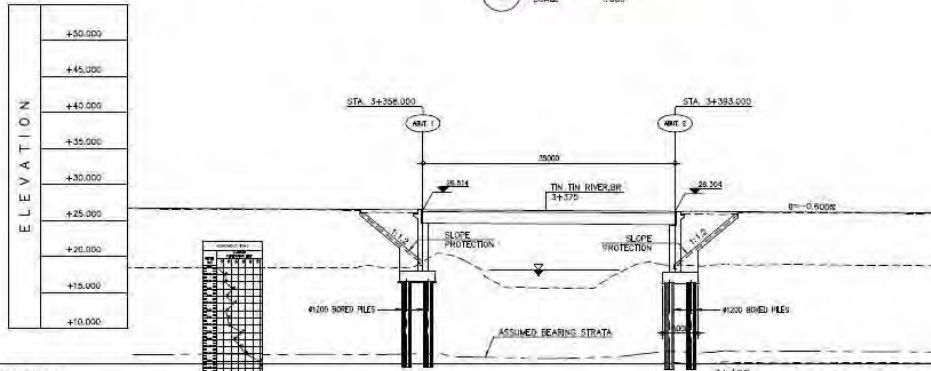
B GENERAL ELEVATION
SCALE 1:600

STATION		STATION		STATION		STATION	
FINISHED GRADE ELEVATION	20.545	20.770	20.835	20.923	20.977	20.943	
EXISTING GROUND ELEVATION	20.180	20.190	21.054	20.274	20.053	20.064	

PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW STA. ROSA-TARLAC ROAD CROSSING BRIDGE MAIN CARRIAGEWAY BRIDGE NO.2 (PACKAGE - 1) (ULTIMATE 4 LANE)	H-02
			SHEET NO.
			2 of 23

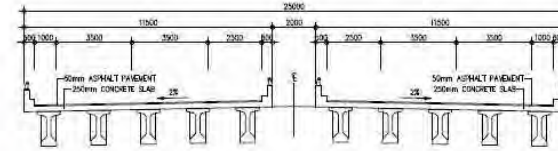


A GENERAL PLAN
SCALE 1:800

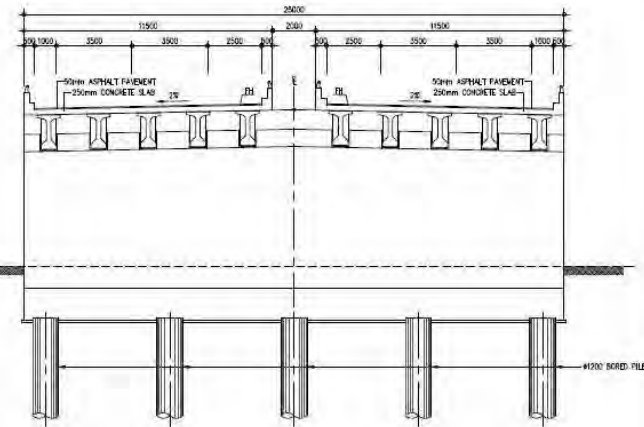


B GENERAL ELEVATION
SCALE 1:600

STATION		34+00					
FINISHED GRADE ELEVATION	20 802	25 742	25 622	25 502	20 352	20 252	
EXISTING GROUND ELEVATION	18 920	18 472	18 438	20 496	18 094	18 996	

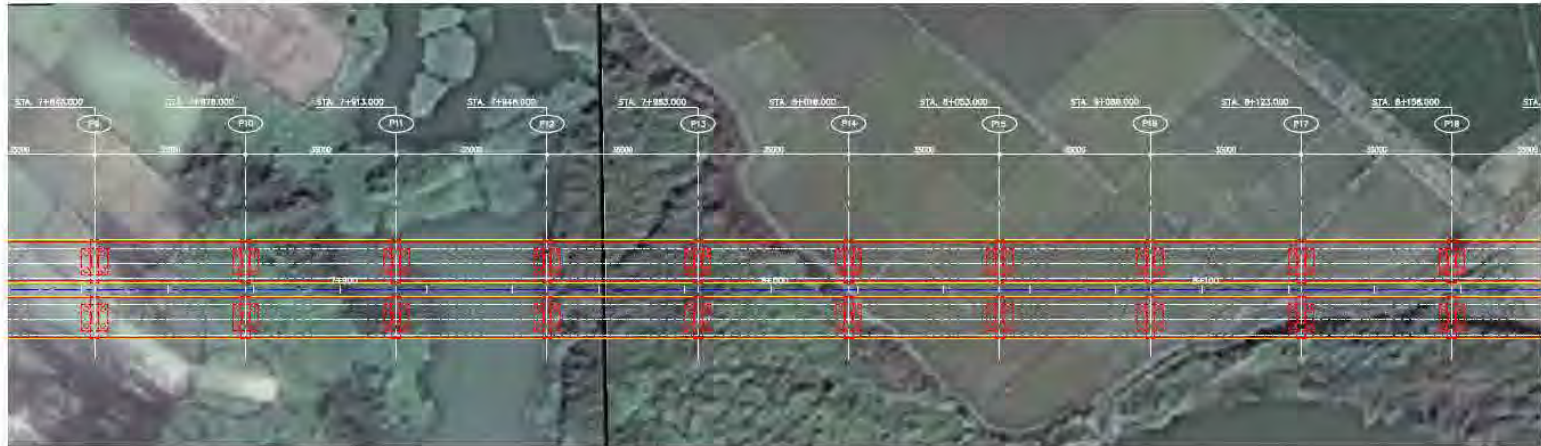


C CROSS SECTION - SUPERSTRUCTURE (PCDG)
SCALE 1:300

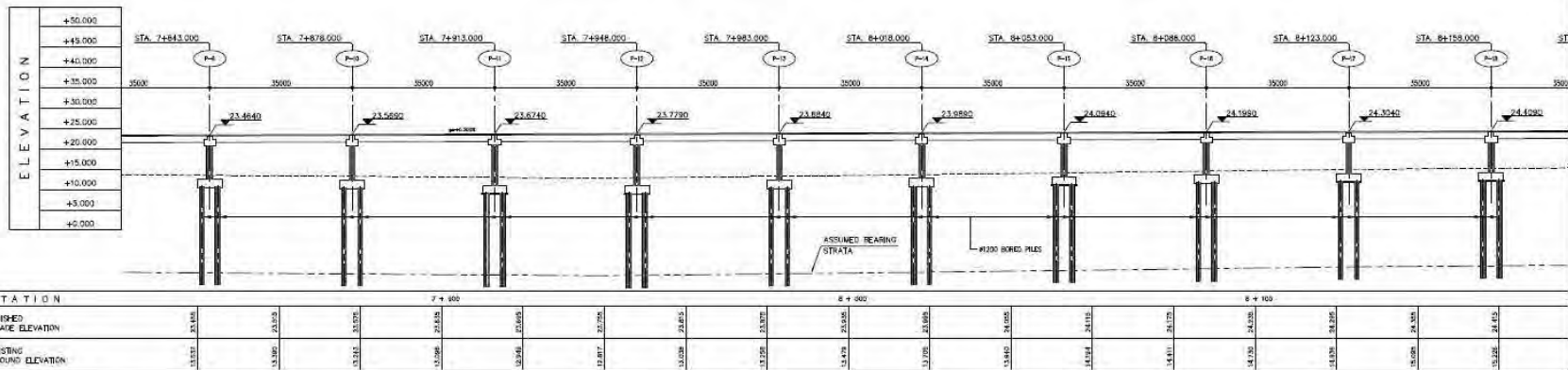


D CROSS SECTION (ABUTMENT)
SCALE 1:200

PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW TIN TIN RIVER CROSSING BRIDGE MAIN CARRIAGEWAY BRIDGE NO.3 (PACKAGE - 1) (ULTIMATE 4 LANE)	H-03
			SHEET NO. 3 of 23

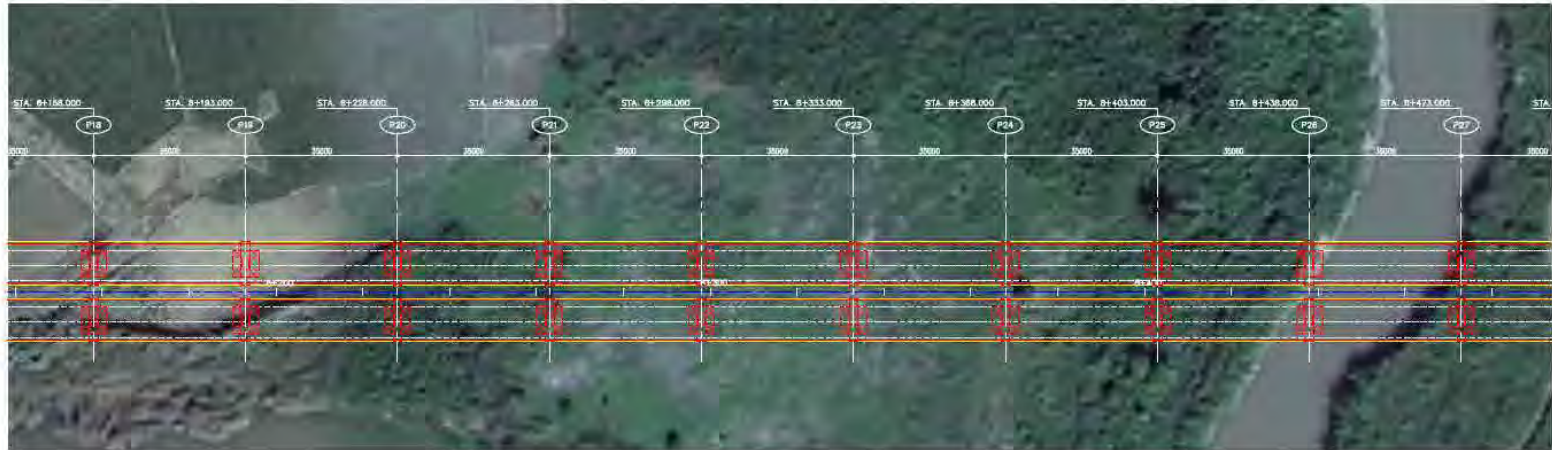


A GENERAL PLAN
SCALE 1:1000

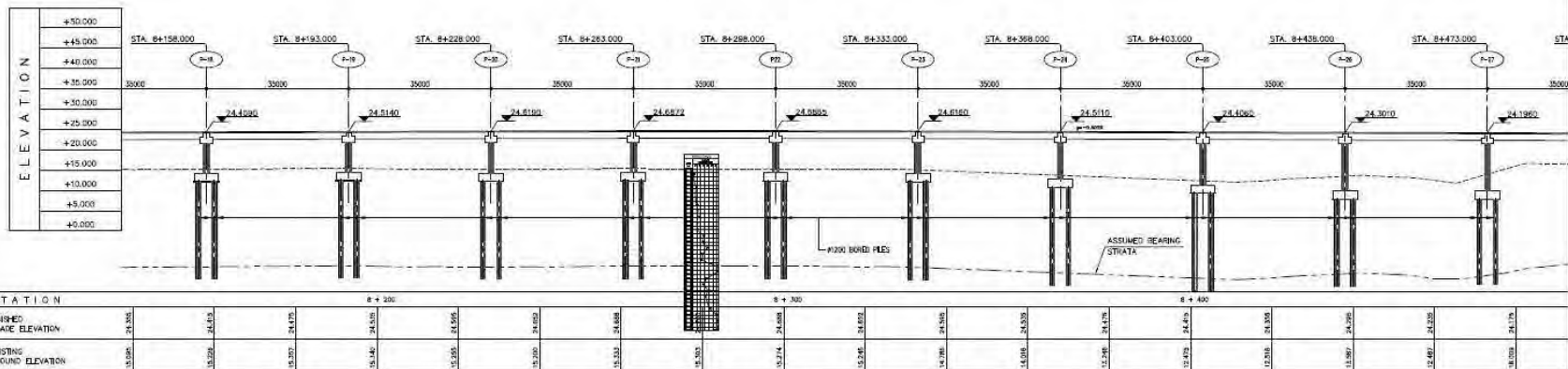


B GENERAL ELEVATION
SCALE 1:1000

PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW RIO CHICO RIVER CROSSING BRIDGE (2/5) MAIN CARRIAGEWAY BRIDGE NO.4 (PACKAGE - 1) (ULTIMATE 4 LANE)	H-05
			SHEET NO.
			5 OF 23

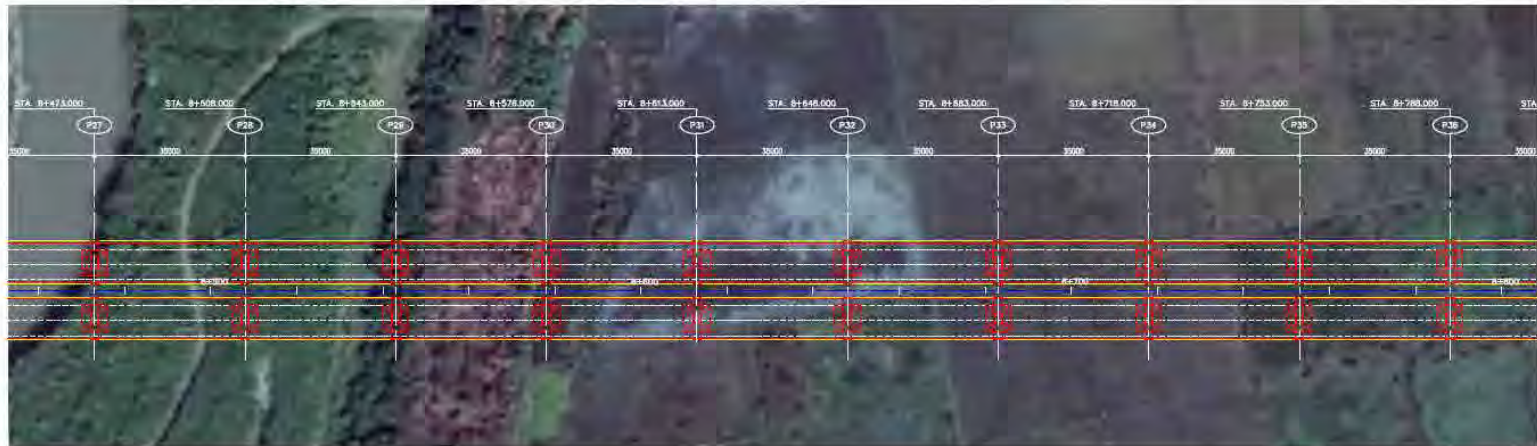


A GENERAL PLAN
SCALE 1:1000

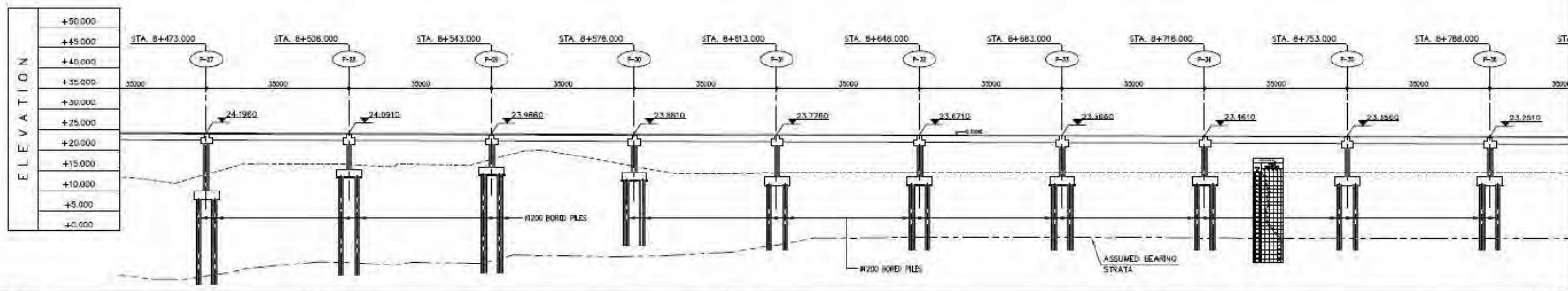


B GENERAL ELEVATION
SCALE 1:1000

PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW RIO CHICO RIVER CROSSING BRIDGE (3/5) MAIN CARRIAGEWAY BRIDGE NO.4 (PACKAGE - 1) (ULTIMATE 4 LANE)	H-06
			SHEET NO.
			6 OF 23



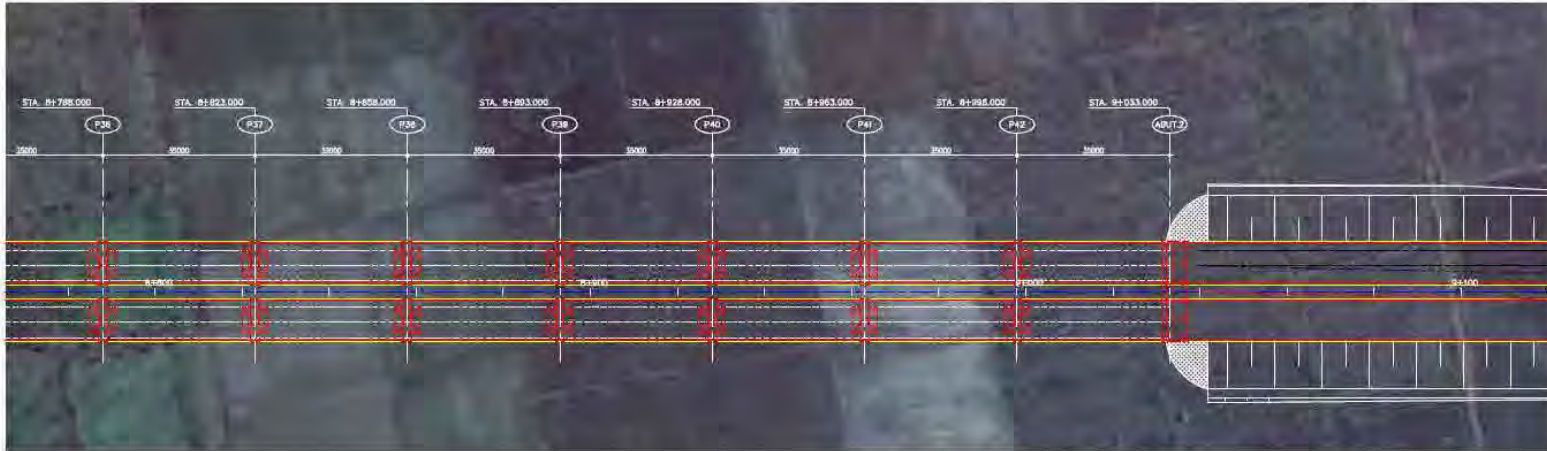
A GENERAL PLAN
SCALE 1:1000



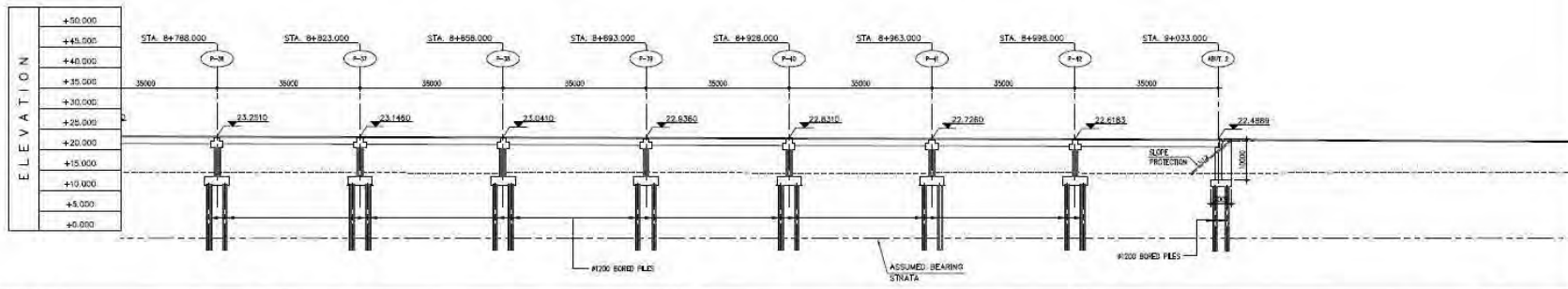
STATION	8 + 500				8 + 600				8 + 700				8 + 800		
FINISHED GRADE ELEVATION	31.87	31.93	34.15	34.55	34.95	35.35	35.75	36.15	36.55	36.95	37.35	37.75	38.15	38.55	38.95
EXISTING GROUND ELEVATION	31.87	31.93	34.15	34.55	34.95	35.35	35.75	36.15	36.55	36.95	37.35	37.75	38.15	38.55	38.95

B GENERAL ELEVATION
SCALE 1:1000

PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW RIO CHICO RIVER CROSSING BRIDGE (4/6) MAIN CARRIAGEWAY BRIDGE NO.4 (PACKAGE - 1) (ULTIMATE 4 LANE)	H-07
			SHEET NO.
			7 OF 23



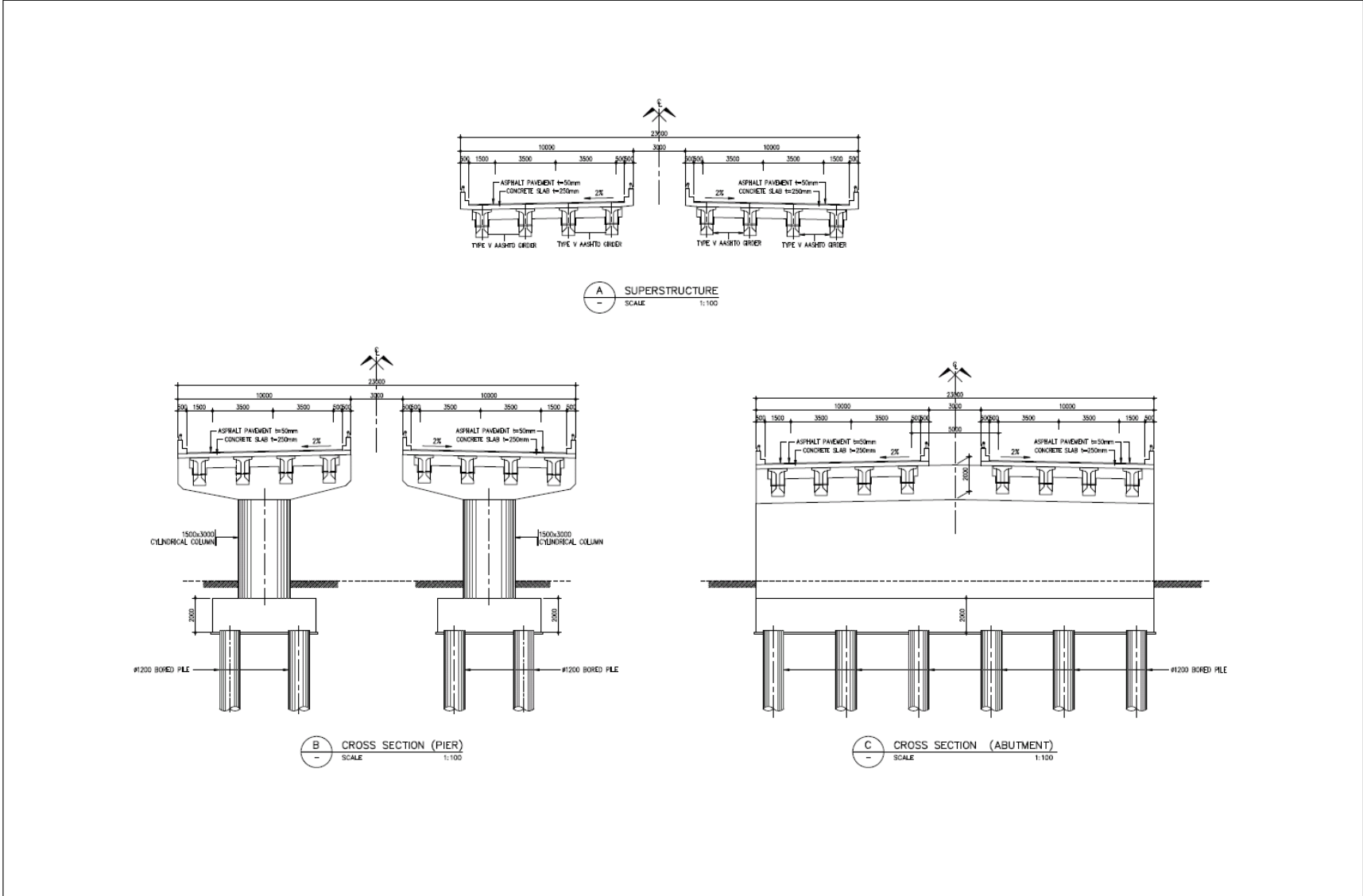
A GENERAL PLAN
SCALE 1:1000



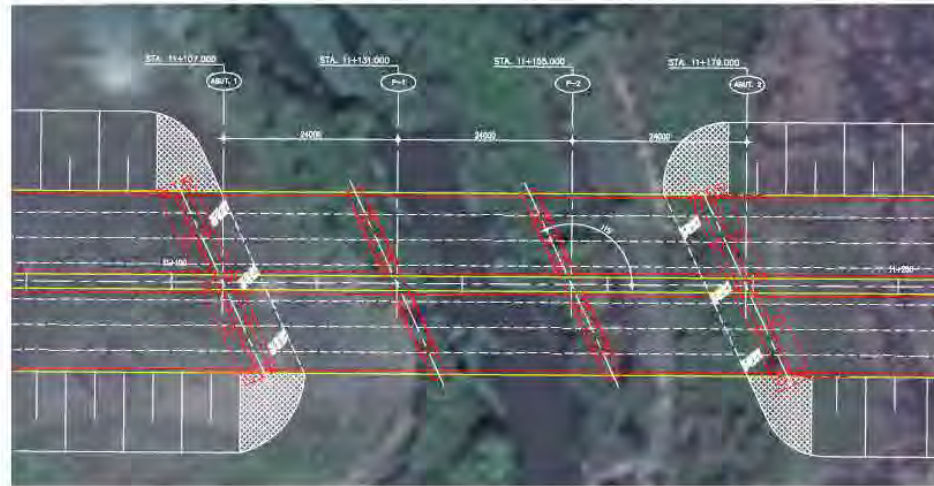
STATION	8 + 800				8 + 900				8 + 900				8 + 100			
FINISHED GRADE ELEVATION																
EXISTING GROUND ELEVATION	14.144	13.775	14.120	13.715	14.087	13.150	14.037	13.990	14.045	13.910	14.077	13.871	14.080	13.880	14.041	13.895

D GENERAL ELEVATION
SCALE 1:1000

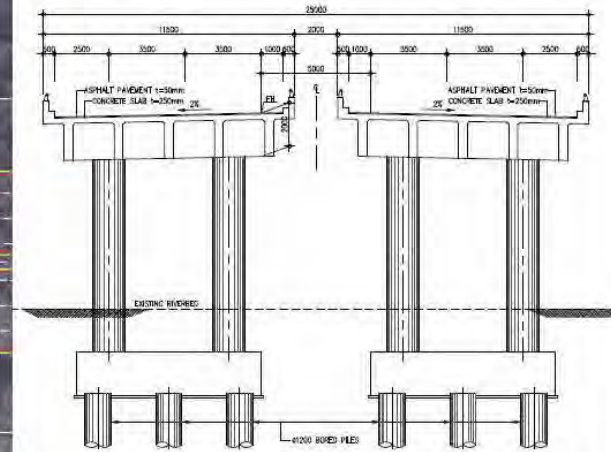
PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW RIO CHICO RIVER CROSSING BRIDGE (5/5) MAIN CARRIAGEWAY BRIDGE NO.4 (PACKAGE - 1) (ULTIMATE 4 LANE)	H-08
			SHEET NO.
			8 OF 23



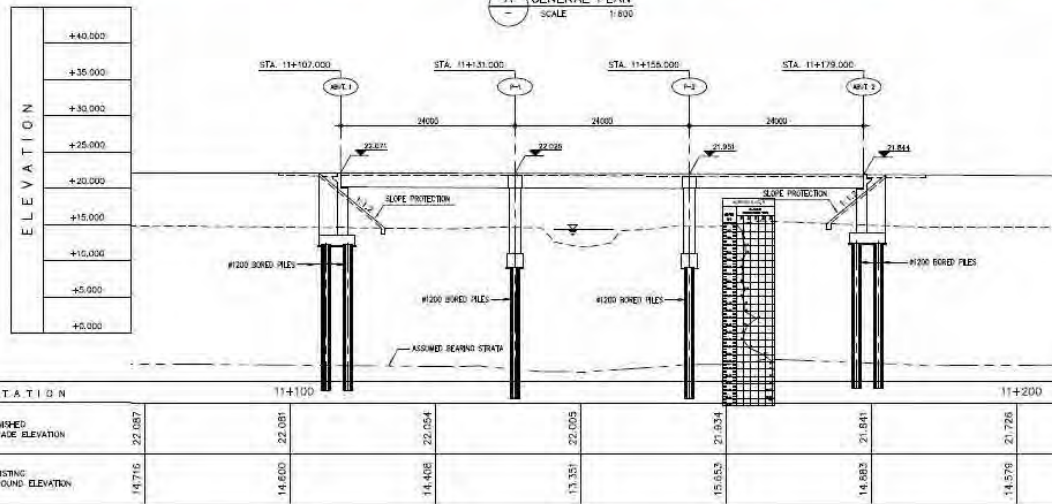
PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	STRUCTURE CROSS SECTION RIO CHICO RIVER CROSSING BRIDGE MAIN CARRIAGEWAY BRIDGE NO.4 (PACKAGE - 1) (ULTIMATE 4 LANE)	H-09
			SHEET NO. 9 OF 23



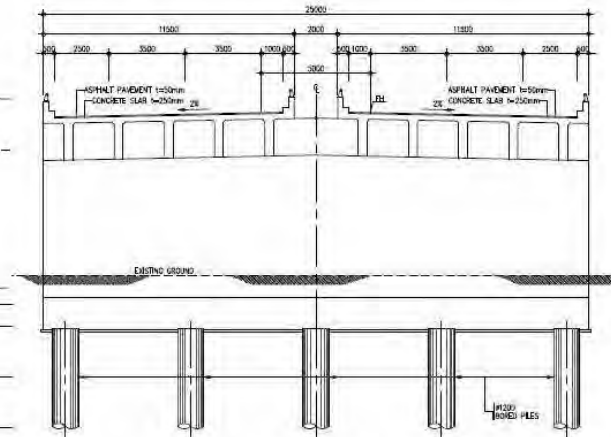
A GENERAL PLAN
SCALE 1:500



C CROSS SECTION - PIER
SCALE 1:200

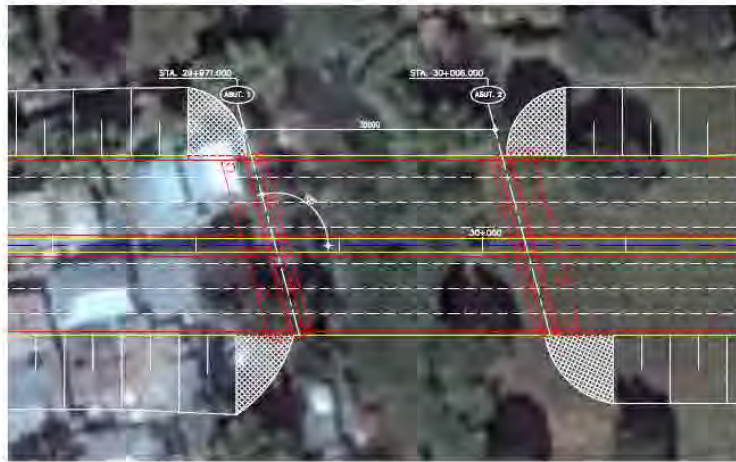


B GENERAL ELEVATION
SCALE 1:500

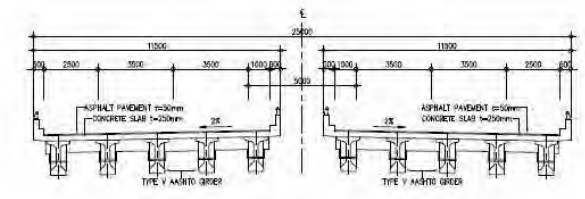


D CROSS SECTION - ABUTMENT
SCALE 1:200

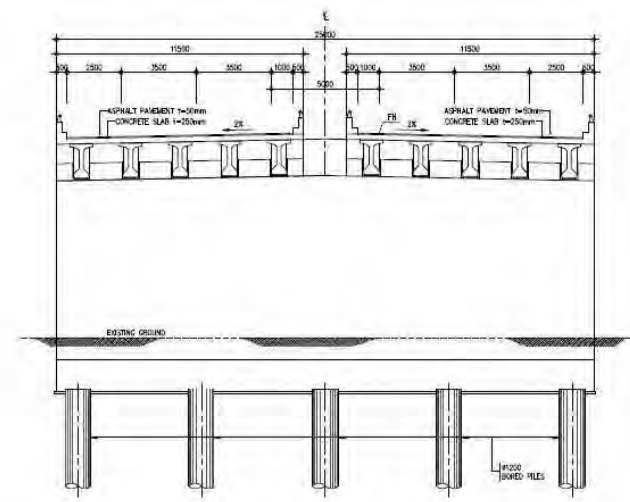
PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW	H-16
		NATURAL CREEK CROSSING BRIDGE	SHEET NO.
		MAIN CARRIAGEWAY BRIDGE N.O.S (PACKAGE -1) (ULTIMATE 4 LANE)	16 OF 23



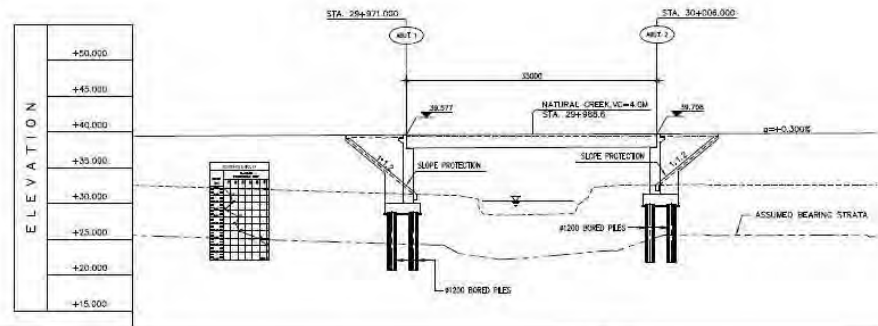
(A) GENERAL PLAN
SCALE 1:500



(C) SUPER STRUCTURE CROSS SECTION (PCDG)
SCALE 1:200



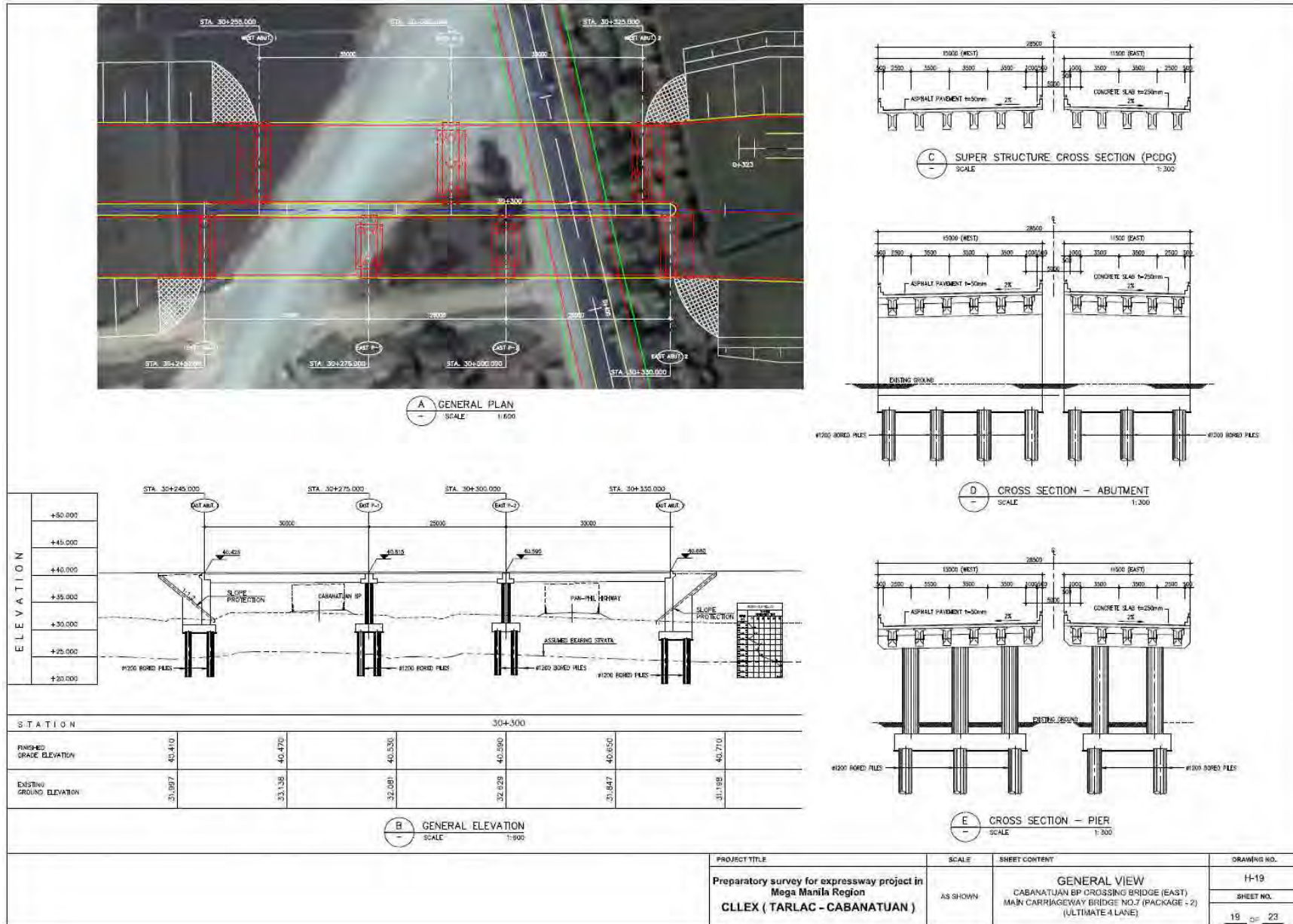
(D) CROSS SECTION - ABUTMENT
SCALE 1:200

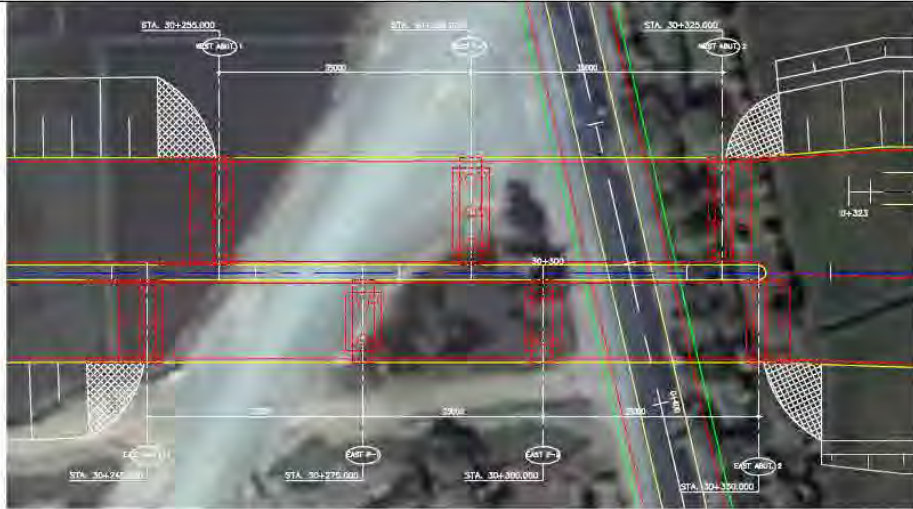


(B) GENERAL ELEVATION
SCALE 1:500

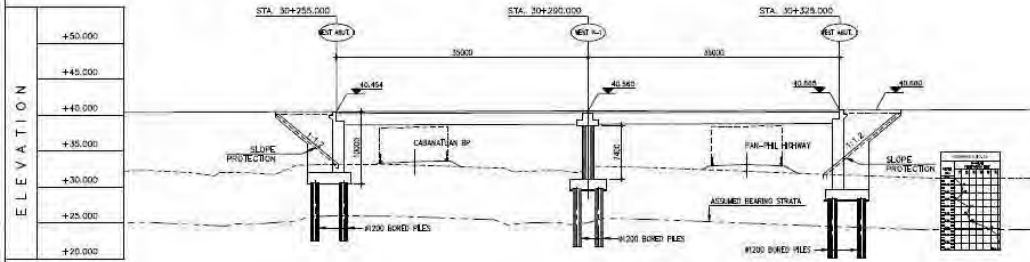
STATION		30+000				
FINISHED GRADE ELEVATION	35+400	35+525	35+619	35+694	35+750	
EXISTING GROUND ELEVATION	32.201	31.851	31.653	32.850	32.513	

PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW NATURAL CREEK CROSSING BRIDGE MAIN CARRIAGEWAY BRIDGE NO.6 (PACKAGE - 2) (ULTIMATE 4 LANE)	F-17
			SHEET NO.
			17 of 23



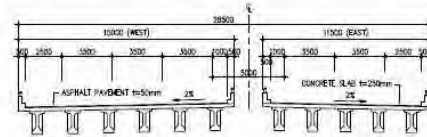


A GENERAL PLAN
SCALE 1:500

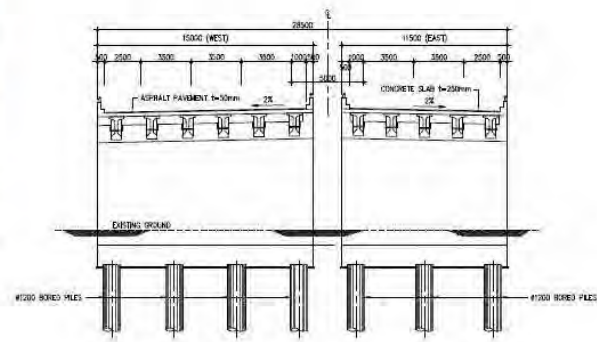


B GENERAL ELEVATION
SCALE 1:500

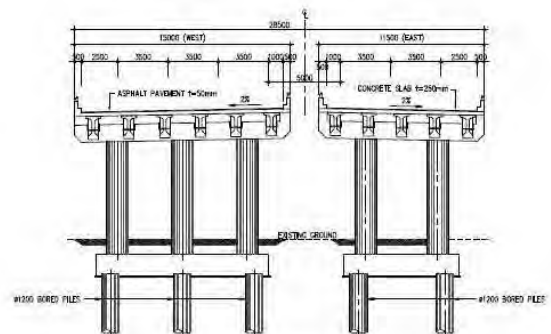
STATION		30+300					
FINISHED GRADE ELEVATION		40.410	40.470	40.530	40.590	40.650	40.710
EXISTING GROUND ELEVATION		31.997	33.135	32.081	32.629	31.847	31.198



C SUPER STRUCTURE CROSS SECTION (PCDG)
SCALE 1:300



D CROSS SECTION - ABUTMENT
SCALE 1:300

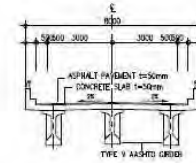


E CROSS SECTION - PIER
SCALE 1:300

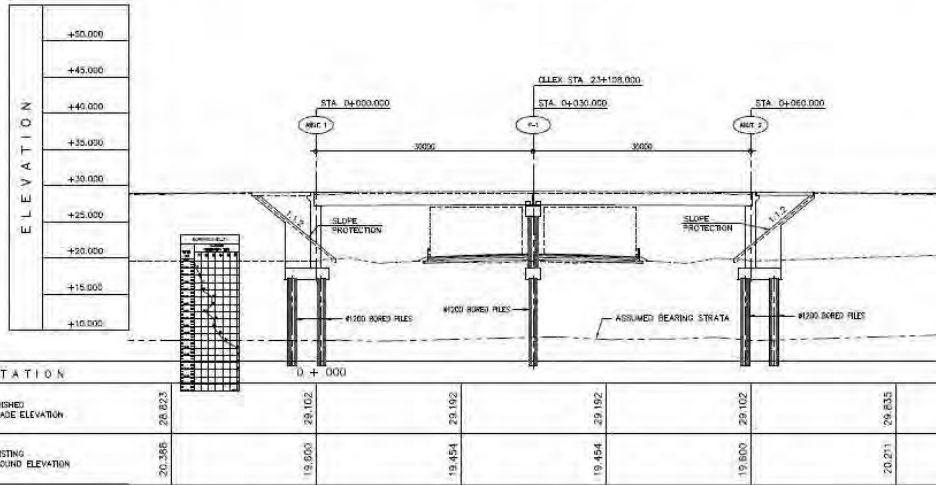
PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW CABANATUAN BP CROSSING BRIDGE (WEST) MAIN CARRIAGEWAY BRIDGE NO.7 (PACKAGE - 2) (ULTIMATE 4 LANE)	H-20
			SHEET NO.
			20 OF 23



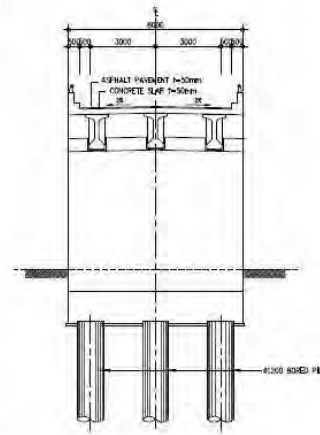
A GENERAL PLAN
SCALE 1:600



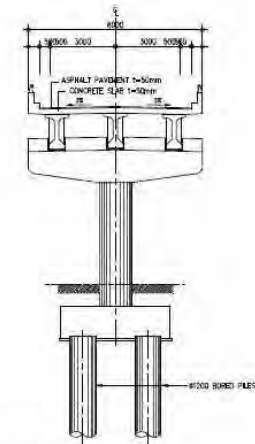
C CROSS SECTION - SUPERSTRUCTURE (RCDG)
SCALE 1:200



B GENERAL ELEVATION
SCALE 1:600



D CROSS SECTION - ABUTMENT
SCALE 1:200

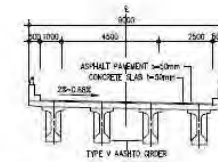


E CROSS SECTION - PIER
SCALE 1:200

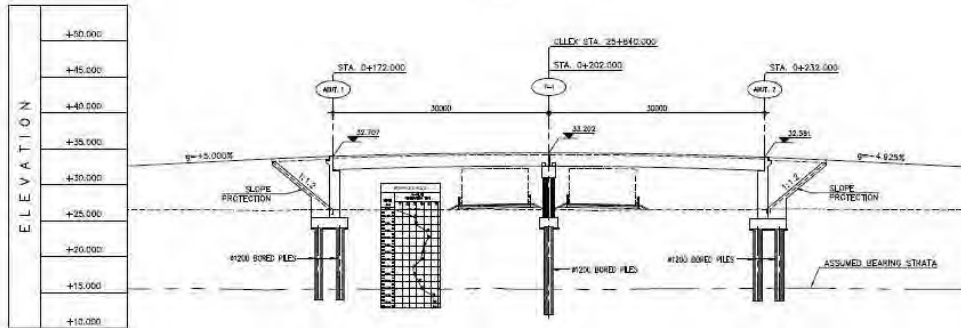
PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW MUNICIPALITY ROAD BRIDGE OVER BRIDGE MAIN CARRIAGEWAY NO.1 (PACKAGE - 2) (ULTIMATE)	H-22
			SHEET NO.
			22 OF 23



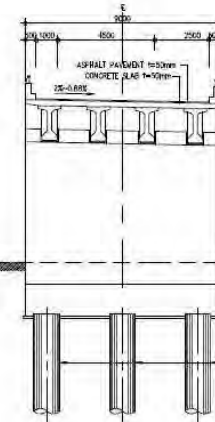
A GENERAL PLAN
SCALE 1:300



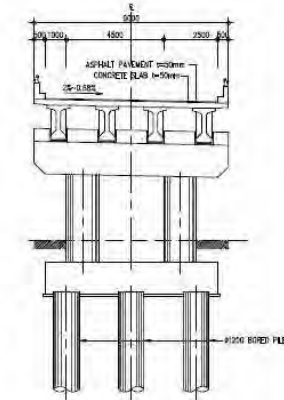
C CROSS SECTION - SUPERSTRUCTURE (PCDG)
SCALE 1:200



B GENERAL ELEVATION
SCALE 1:300



D CROSS SECTION - ABUTMENT
SCALE 1:200



E CROSS SECTION - PIER
SCALE 1:200

STATION		0 + 200					
FINISHED GRADE ELEVATION	32.200	32.500	33.000	33.500	33.800	34.200	34.500
EXISTING GROUND ELEVATION	25.000	25.021	25.214	25.516	25.818	26.276	26.513

PROJECT TITLE	SCALE	SHEET CONTENT	DRAWING NO.
Preparatory survey for expressway project in Mega Manila Region CLEX (TARLAC - CABANATUAN)	AS SHOWN	GENERAL VIEW CABANATUAN HALF INTERCHANGE (RAMP A) OVER BRIDGE TO MAIN CARRIAGEWAY NO.2 (PACKAGE -2) (ULTIMATE)	H-25
			SHEET NO.
			23 OF 23

6.5 PAVEMENT DESIGN

6.5.1 General

This section describes pavement design for the project expressway. The pavement design are based on the following;

- 1) The results and findings of the subgrade characteristics over which the road is to built;
- 2) The traffic load anticipated to traverse the proposed road alignments over the selected design life; and
- 3) The type of pavement to be adopted based on the technical and economical advantages.

6.5.2 Pavement Design Standards

The pavement design are in accordance with the "Guide for Design of Pavement Structures, 1993" by the American Association of State Highway and Transportation Officials and in reference also to "Design Guidelines, Criteria and Standards for Public Works and Highways" by the Department of Public Works and Highway.

6.5.3 Technical Approach

The design parameters used in the pavement design includes time constrains, traffic, design serviceability loss, reliability, subgrade strength and material properties for pavement structure design.

Followings are major design conditions;

1) *Design period*

20 years

It is assumed that the design life of pavement consummates the 20-year design period before rehabilitation is performed.

2) *Traffic*

The structural design of the pavement is based on fatigue loads. Fatigue loading is taken as the cumulative number of passes of an Equivalent Standard Axle Load (ESAL) of 8,300kgs (18kips) per axle, to which the pavement structure will be subjected throughout its design life.

6.5.4 Recommended Pavement Structures

(1) Pavement Structure for Main Expressway

1) *Main Carriage Way*

The recommended pavement structures for both directions of the expressway main carriageway is as below;

No.	Thickness	Pavement Structure
1	50 mm	Asphalt Concrete Surface Course
2	50 mm	Asphalt Concrete Binder Course
3	150 mm	Cement Treated Base Course
4	250 mm	Crushed Aggregate Base Course
5	350 mm	Crushed Sub-Base Course

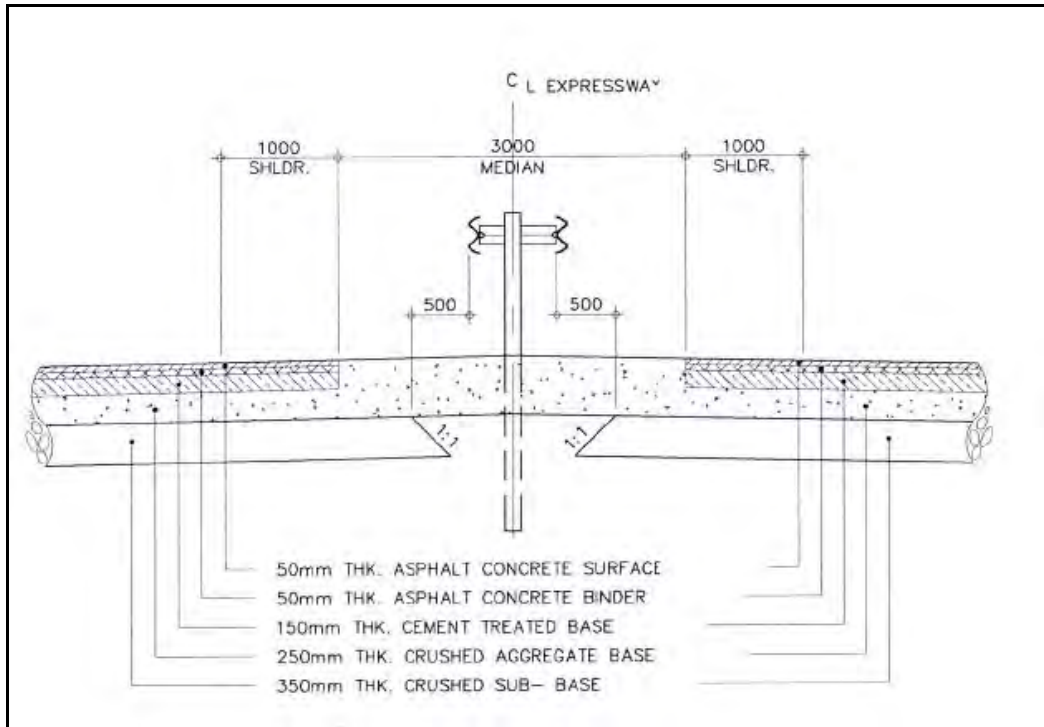


FIGURE 6.5.4-1 PAVEMENT STRUCTURE OF MAIN CARRIAGEWAY

2) *Shoulder of Main Expressway*

The pavement structure for shoulder followed the designed for the main carriageway. However, the surface course is not applied because shoulders is not subjected to carry full traffic on the expressway but only to accommodate vehicle emergency parking and temporary use of maintenance activities.

No.	Thickness	Pavement Structure
1	50mm	Asphalt Concrete Binder Course
2	150mm	Cement Treated Base Course
3	250mm	Crushed Aggregate Base Course
4	350mm	Crushed Sub-Base Course

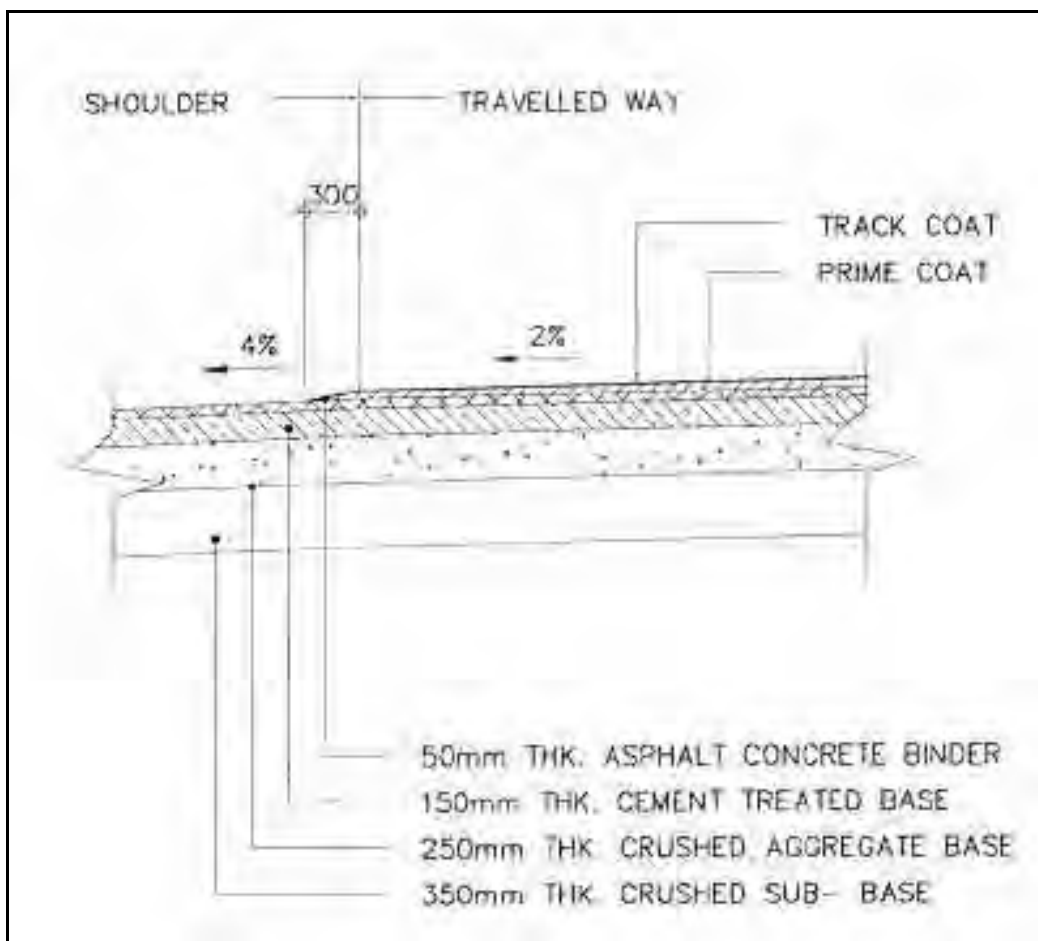


FIGURE 6.5.4-2 PAVEMENT STRUCTURE OF SHOULDER

(2) Pavement for Interchange Ramps

1) Carriage way of Ramp

The pavement structure of carriage way of ramp follows the same as the expressway.

2) Shoulder of Ramp

The pavement structure of carriage way of ramp follows the same as the expressway.

3) Toll plaza

Portland Cement Concrete Pavement (PCCP) will be used at least 50m both side from the center of toll gate.

No.	Thickness	Pavement Structure
1	350mm	Portland Cement Concrete Pavement
2	200mm	Crushed Aggregate Base Course
3	200mm	Crushed Aggregate Sub-Base Course

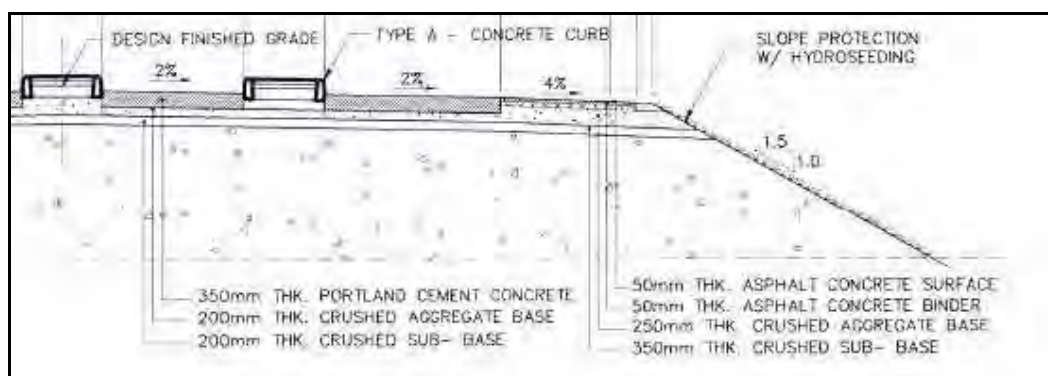


FIGURE 6.5.4-3 PAVEMENT STRUCTURE OF TOLL PLAZA

6.5.5 Pavement Design Calculation

Pavement calculation is shown as follows;

Traffic Volume and Cumulative Equivalent Standard Axle Load (ESAL)(W18kips)

[Design Period : 20 years]

Project Title: Central Luzon Link Expressway (CLLEX)

Year	Vehicle Type		Total	Large V/Total	Large V	Class 1	Class 2		Class 3	Total
	Traffic Volume in 2017 *		11,236	2%	219	8,441	2,576		219	
	Load Equivalence Factor (LEF)**				-	0.0001	5.7000		15.4000	
	Growth Rate*		6.50%			0.035	0.050		0.053	
	2017	1	Open			0.84	14,683.20		3,372.60	18,056.64
1	2018	2				0.87	15,417.36		3,551.35	18,969.58
2	2019	3				0.90	16,188.23		3,739.57	19,928.70
3	2020	4				0.94	16,997.64		3,937.77	20,936.34
4	2021	5				0.97	17,847.52		4,146.47	21,994.96
5	2022	6				1.00	18,739.90		4,366.23	23,107.13
6	2023	7				1.04	19,676.89		4,597.64	24,275.57
7	2024	8				1.07	20,660.74		4,841.32	25,503.13
8	2025	9				1.11	21,693.77		5,097.91	26,792.79
9	2026	10				1.15	22,778.46		5,368.09	28,147.71
10	2027	11				1.19	23,917.39		5,652.60	29,571.18
11	2028	12				1.23	25,113.25		5,952.19	31,066.68
12	2029	13				1.28	26,368.92		6,267.66	32,637.85
13	2030	14				1.32	27,687.36		6,599.84	34,288.53
14	2031	15				1.37	29,071.73		6,949.64	36,022.73
15	2032	16				1.41	30,525.32		7,317.97	37,844.70
16	2033	17				1.46	32,051.58		7,705.82	39,758.87
17	2034	18				1.51	33,654.16		8,114.23	41,769.91
18	2035	19				1.57	35,336.87		8,544.28	43,882.72
19	2036	20	in 20 years			1.62	37,103.72		8,997.13	46,102.47
Cummulative ESAL										600,658.18

$$600,658.18 \times 365 \text{ days} \times 0.5 \times 1.0 = 109,620,118 \text{ (Design ESAL)}$$

* Based on Traffic Demand Forecast

** Source: Feasibility Study for the Proposed Central Luzon Expressway, January 2010, DPWH, KEI

CY2008, Summary of Traffic Data by Project Evaluation Division, Planning Service, Report as of January 31, 2009

SV03243LZ_AL, S00935LZ, Daang Maharika Highway (LZ), Nueva Ecija 2nd District Engineering Office

Flexible Pavement Design

Design Standard: Guide for Design of Pavement Structures, 1993, American Association of State Highway and Transportation Officials
 Design Case: 2017 to 2036 (20 years)
 Project Title: CLLEX

1. Calculation of Structural Number

(1) Basic Formula

The formula shown below is applied for flexible pavement design in accordance with AASHTO design guideline.
 Design Condition is shown in Table 1.
 Structural Number is computed to accommodate the basic formula.

$$\log_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}(\Delta PSI(4.2-1.5))}{\text{---}} + 2.32 \times \log_{10}(MR) - 8.07$$

(2) Design Condition

Design Condition	Index	Value	Grounds	Remarks
1. Traffic	Design Period Design ESAL	20 109,620,118	2017 ~ 2036 (20 Years)	Design life of pavement of initial pavement structure
2. Level of Reliability	Reliability Standard Normal Deviate Overall Standard Deviation	R(%) ZR S0	85 -1.037 0.45	Interstate and other Freeways (AASHTO) Value corresponding to R=85% Average of Flexible Pavement
3. Serviceability	Initial Serviceability Index Terminal Serviceability Index Present Serviceability Index	P0 P1 ΔPSI	4.2 2.5 1.7	Standard of AASHTO Standard of AASHTO PSI = P0 - Pt
4. Pavement Support Layer	CBR(%) Resilient Modulus	CBR MR	8 12,000	FS2010 MR=1,500×CBR Soil Subgrade Strength

(3) Computation of SN

1. Left side of Basic Formula	$\log_{10}(W_{18})$	8.040
2. Value of Right side of Basic Formula		8.040
3. SN Value required	SN	5.737

2. Pavement Structure

1(inch)=2.540(cm)

Pavement Structure	Layer Coefficient (a)	Thickness D (cm)	Thickness d (inch)	Drainage Coefficient (m)	Structural Number SN=a×m×D1	Remarks
Asphalt Concrete Surface	new 0.390	5.00	1.969	-	0.768	
Asphalt Concrete Binder	new 0.390	5.00	1.969	-	0.768	
Cement Treated Base	new 0.230	15.00	5.906	1.0	1.358	Cement treated base course
Crushed Aggregate Base	new 0.140	25.00	9.843	1.0	1.378	Crushed aggregate, CBR>20
Crushed sub-base	new 0.110	35.00	13.780	1.0	1.516	Crushed aggregate
Evaluation	Required SN		5.737	<	5.787	OK

W18 : Predicted number of 18-kip equivalent single axle load applications
 ZR : Standard normal deviate
 S0 : Combined standard error of the traffic prediction and performance prediction)
 MR : Resilient modulus (psi)
 D : Layer thickness(inches)
 m : Layer drainage coefficient
 SN is equal to the structural number indicative of the total pavement thickness required:
 $SN = a1D1 + a2D2m2 + a3D3m3$