NO.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR IMPROVEMENT
OF
THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND
IN
THE FEDERATED STATES OF MICRONESIA

MARCH 2003

JAPAN INTERNATIONAL COOPERATION AGENCY
KATAHIRA & ENGINEERS INTERNATIONAL

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PREFACE

In response to a request from the Government of the Federated States of Micronesia, the Government of Japan decided to conduct a basic design study on the Project for Improvement of the Circumferential Road around Pohnpei Island and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Micronesia a study team from November 26 to December 30, 2002.

The team held discussions with the officials concerned of the Government of Micronesia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Micronesia in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Federated States of Micronesia for their close cooperation extended to the teams.

March, 2003

Takao Kawakami
President
Japan International Cooperation Agency

March, 2003

Letter of Transmittal

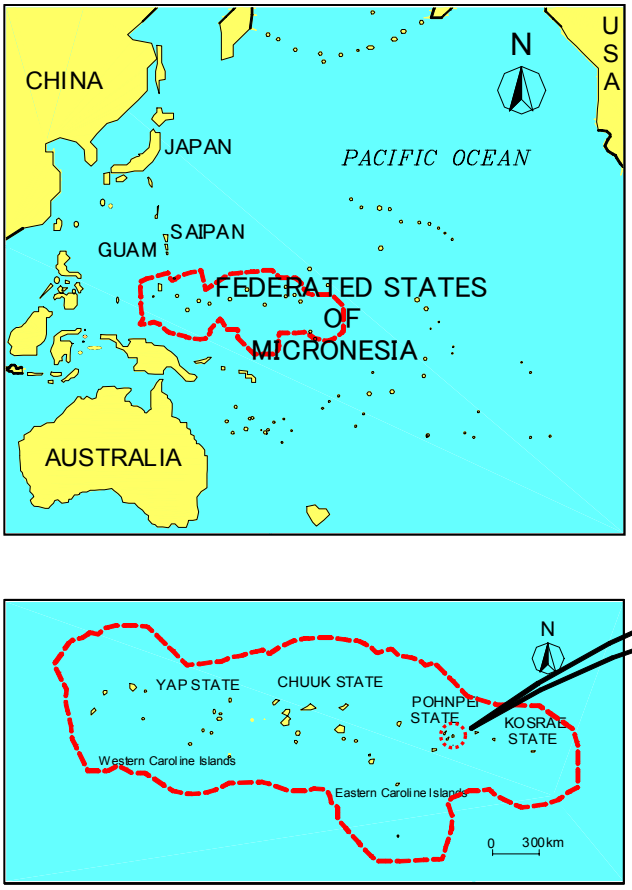
We are pleased to submit to you the basic design study report on the Project for Improvement of the Circumferential Road around Pohnpei Island in the Federated States of Micronesia.

This study was conducted by Katahira & Engineers International, under a contract to JICA, during the period from November, 2002 to March, 2003. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Micronesia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

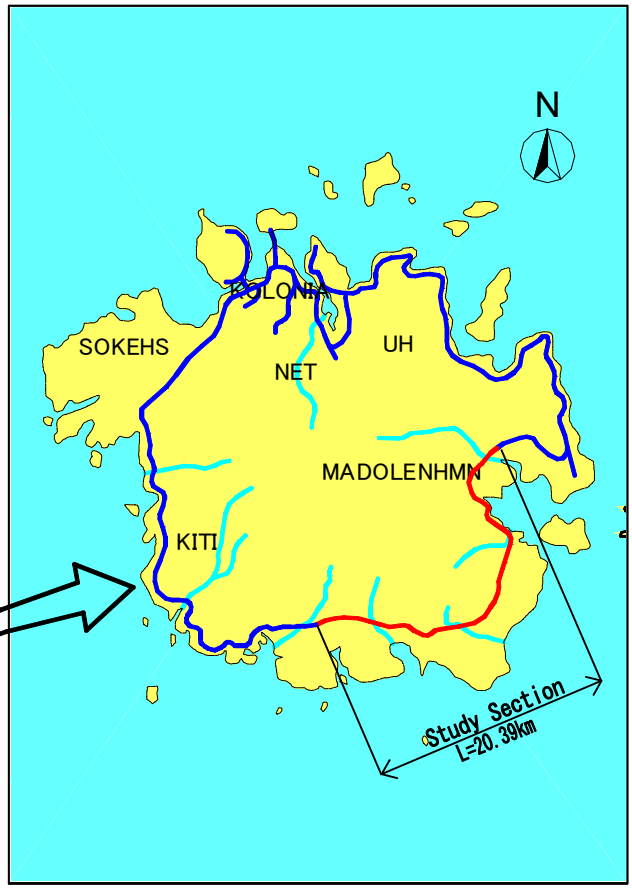
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

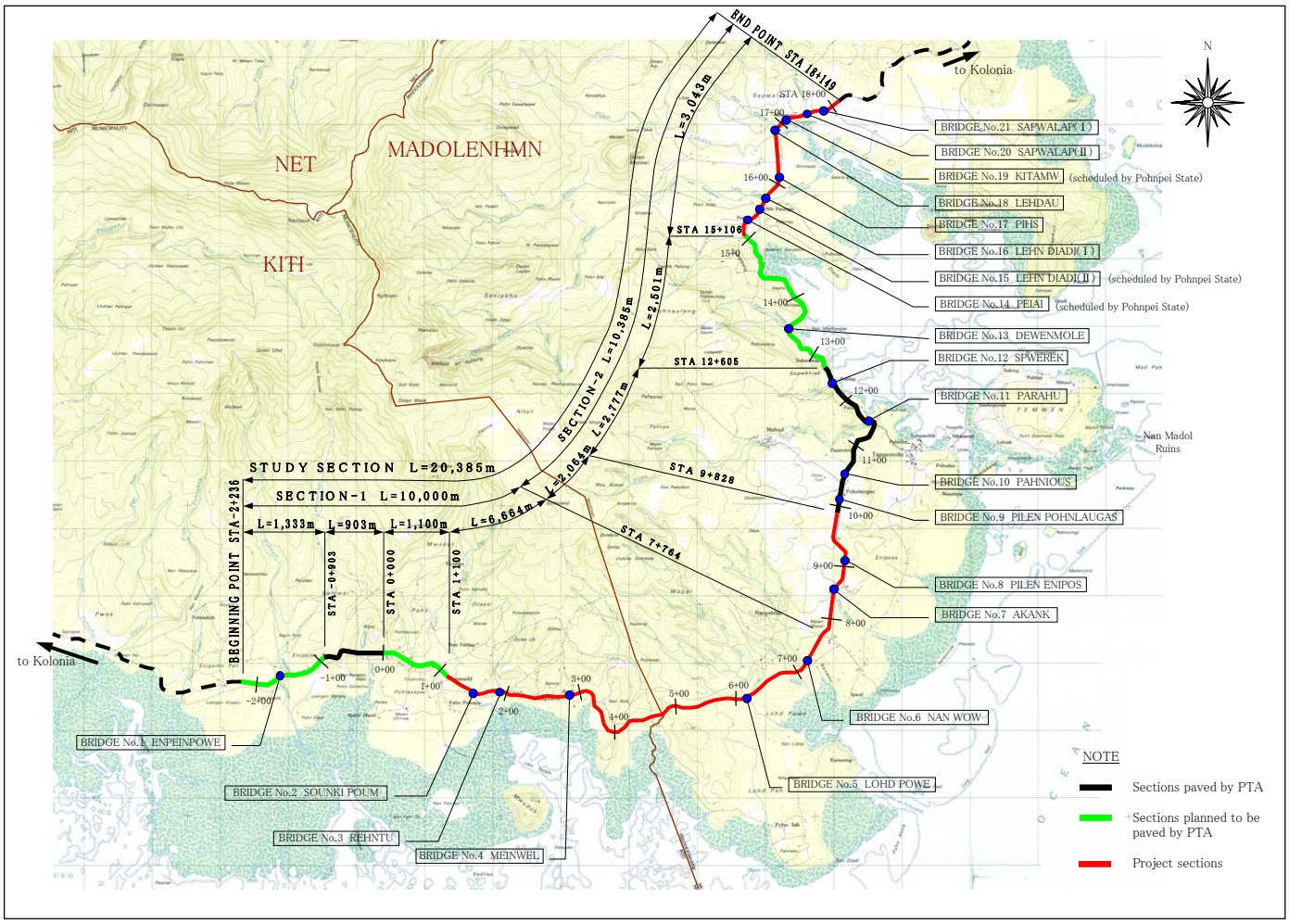
Kunihiko Sawano
Chief Consultant,
Basic Design Study Team on the Project for
Improvement of the Circumferential Road
around Pohnpei Island
Katahira & Engineers International



Federated States of Micronesia



Pohnpei Island



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Abbreviations

AASHTO	:	American Association of State Highway and Transportation Officials
C B R	:	California Bearing Ratio
C S P	:	Corrugate Steel Pipe
E L	:	Elevation
E S A L	:	Equivalent Single Axle Load
F S M	:	Federated States of Micronesia
G D P	:	Gross Domestic Product
P C	:	Prestressed Concrete
P S I	:	Present Serviceability Index
P T A	:	Pohnpei Transportation Authority
R C	:	Reinforced Concrete
R C P	:	Reinforced Concrete Pipe
S N	:	Structural Number
S P	:	Steel Pipe

SUMMARY

The Federated States of Micronesia (FSM) is an island country consisting of 607 islands located in Caroline archipelago with a total land area of 701 square kilometers. The FSM is composed of four States : Kosrae, Pohnpei, Truk and Yap. Pohnpei Island where the FSM capital and the Pohnpei State capital are situated is the largest island in Caroline archipelago with a land area of 334 square kilometers. The island is high, volcanic and roughly circular with an average diameter of about 24 kilometers.

Under the necessity of turning from assistance-dependent economy into self-reliant economy, the Government of the FSM is striving for economic reform such as downsizing of government organization, private sector development, acquisition of foreign currency by promotion of tourism and fishery, agricultural development and so on. To attain the economic reform, the development of transportation sector, especially road improvement, is of vital necessity. The road network in Pohnpei Island is composed of a circumferential road around the island and other roads branching thereoff. The circumferential road is regarded as a fundamental infrastructure to support economic activities and daily life of inhabitants being only arterial road in the island. Since 1989, the major thrust in the road development in Pohnpei State is to pave the circumferential road that has been urged year after year. Out of 78 km of the circumferential road, 61.3 km have been paved and 4.9 km are planned to be paved in 2003 by the Pohnpei Transportation Authority. Another 11.8km, which are located on steep terrain and crossing many rivers, are left unpaved due to the difficulty in the improvement by the government for the financial and technical reasons. In the unpaved section, damages of road surface and erosions of road shoulder have progressed and therefore vehicles are forced to drive at a low speed and a safety travel is not assured.

Under the above situation, the Government of the FSM made a request to the Government of Japan for grant aid for improvement of the unpaved section of the circumferential road.

In response to the request, the Government of Japan decided to conduct a basic design study on the said project and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to the FSM a study team from November 26 to December 30, 2002. The team held discussions with the officials concerned of the Government of the FSM and conducted field studies at the study area. After returning to Japan, the team prepared a basic design and implementation plan of the most appropriate scheme. The contents of the study was compiled into a draft report. Then, JICA sent to the FSM a draft report explanation team from February 21 to March 4, 2003.

Finally proposed plan is outlined as follows:

Project road section : unpaved section of the circumferential road, 11.772 km in length

Width : traveled way 6.0 m (2 lanes), shoulder 1.2 m (both sides)

Design speed : 50 km/h (total 4.166 km), 40 km/h (total 3.906 km), 30 km/h (3.700 km)

Major components :

Item		Contents
Earthwork	Widening	Whole length as necessary
	Raising of Road Elevation	3 submerged sections, total length 500m
	Improvement of Vertical Alignment	A section with a grade of over 16%, length 340m
Pavement		Whole length (11.772km)
Bridges	Reconstruction	3 bridges excluding 3 bridges to be reconstructed by the State Government, length 20.0m, 7.5m, 9.5m
	Replacement with Box Culvert	3 bridges
	Partial Repair	6 bridges
Culverts		Replacement at 15 locations, new installation at 5 locations, extension at 15 locations, repair at 4 locations and removal at 1 location
Surface Drainage		U shaped lined ditch with grouted riprap, total 9,711m
Subsurface Drainage		Approximately 300m section, installation of perforated pipes
Subsidiary Facilities	Slope Protection	Retaining wall with grouted stone masonry, total length 199m
	Pavement Marking	Centerline and sideline on whole length (11.772km), stop-lines at 41 places
	Traffic Signs	Regulatory signs at 34 places, warning signs at 56 places
	Guardrails	Total length 840m
	Guide Posts	Total number 364

If the Project is implemented under the Japan's grant aid, the periods for detailed design and construction are estimated at 5 months and 21.5 months respectively.

Direct beneficiaries of the Project are the population residing in Pohnpei Island, amounting to 32,395 in 2000. The major effects of the Project are as follows:

- Travel time for the 11.8 km project section will be shortened from about 36 minutes at present to 18 minutes as a result of improvement of travel condition by paving.
- Road maintenance cost will be reduced to about 1/7 by constructing durable pavement, while presently the road is unpaved and therefore requires frequent maintenance works to keep the road in passable condition such as refilling of gravel (coral materials), grading and compaction.

- At present, there are three sections (Total length: 500m) submerged during heavy rain for an insufficiency of capacity of the crossing drainage facility and unsuitable for the vertical alignment. The submergences will be eliminated and the road will always be passable.
- While coral materials are frequently being supplied at present for the maintenance of the road, little coral materials will be necessary after paving although considerable amount of coral materials will be used for paving. In the Future, total consumption of coral materials will decrease and environmental problems accompanied by coral dredging will be mitigated accordingly. Furthermore, water pollution of lagoon due to muddy water drained from the road and dust due to passage of vehicles will remarkably decrease.
- Development of economic activities in the Project area will be promoted in various sectors, i.e., tourism industry due to improved accessibility to tourist spots, agriculture and fishery due to improved accessibility to consuming areas, etc.

The project will have great effects as mentioned above and contribute to the reduction of the regional gap by the smooth movement of people / goods to the FMS capital and the State capital and to encouragement of social and economic activities in Pohnpei Island. Therefore it is appropriate to implement the Project under the Japan's grant aid. The system, personnel and budget of the State of Pohnpei for implementation of the Project and its maintenance after completion are considered to be well arranged and no problem is expected.

To realize and sustain the effects of the Project, the State of Pohnpei should undertake the adequate maintenance, especially cleaning of drainage facilities. Furthermore, if the other section of the circumferential road than the Project section is further improved by own efforts and thus the function of the road is upgraded as a whole, the effects of the Project will be much enlarged.

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CHAPTER 1 BACKGROUND OF THE PROJECT

In the Federated States of Micronesia (FSM), road is the only inland transportation means due to the absence of railway. The road development is however still in low level and the extension of road length and increase in paved roads are the major challenges in the transportation sector for economic development.

The road network in Pohnpei Island is composed of a circumferential road around the island and other roads branching thereoff. Out of 78 km of the circumferential road, 57.6 km had been paved by the end of 2001 using the road construction/paving equipment procured in 1987 under the Japan's grant aid, and the remaining section with an approximate length of 20.4 km were left unpaved. In the unpaved section, damages of road surface and erosions of road shoulder have progressed and therefore vehicles are forced to drive at a low speed and a safety travel is not assured. Such situation hinders the safe and smooth movement of people and goods between the areas covered by the section and FSM capital Palikir/ State capital Kolonia and also causes a regional gap in the island.

Under the above situation, the Government of the FSM made a request to the Government of Japan for grant aid for improvement of the unpaved section of the circumferential road.

Subsequently, out of the 20.4 km section requested to be improved, approximately 3.7 km have been paved and approximately 4.9 km are planned to be paved in 2003 by the Pohnpei Transportation Authority (PTA) is in charge of road construction and maintenance works under the Pohnpei States Government. Accordingly, the scope of this Project under the Japan's grant aid is changed to the improvement of the remaining unpaved sections with an approximate length of 11.8 km. These sections are somewhat difficult in construction, located on steep terrain and crossing many rivers.

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

1) Overall Goal and Objective of the `Project

Under the necessity of turning from assistance-dependent economy into self-reliant economy, the Federated States of Micronesia (FSM) is striving for economic reform such as downsizing of government organization, private sector development, acquisition of foreign currency by promotion of tourism and fishery, agricultural development and so on. To attain the economic reform, the development of transportation sector is of vital necessity.

The road network in Pohnpei Island is composed of a circumferential road around the island and other roads branching thereoff. The circumferential road is regarded as a fundamental infrastructure to support economic activities and daily life of inhabitants being only arterial road in the island. Since 1989, the major thrust in the road development in Pohnpei State is to pave the circumferential road that has been urged year after year. At present, 61.3 km have been paved and about 4.9 km are planned to be paved in 2003 by the Pohnpei Transportation Authority (PTA). Another 11.8km, which are located on steep terrain and crossing many rivers, are left unimproved due to the difficulty in the improvement by the government for the financial and technical reasons.

This project aims at the social and economic development in the areas around not only the concerned section but also the whole circumferential road as well as the reduction of the regional gap by improving the unpaved section and thus completing the improvement of the circumferential road.

2) Basic Concept of the Project

This project aims to improve the unpaved section of the circumferential road with an approximate length of 11.8 km to achieve the above overall goal. The project is expected to show such effects as : reduction of travel time, savings in road maintenance cost, elimination of road closure caused by submergence, improvement of environment, increase of tourists, and so on. The Japan’s grant aid will be extended for improvement of the 11.8 km sections including pavement, reconstruction/repair of bridges, provision of drainage and incidental facilities, etc.

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

1) Scope of the Japanese Assistance

While the contents of the original request from the FSM Government were upgrading approximately 12 miles of existing unpaved road, provision of adequate drainage system along the roadway and restoration and repair of bridges and culverts, the following changes in situation were found during the field survey in the FSM:

- The length of the study section (originally requested section) is 20.385km, out of which two sections (total 3.679km) was paved recently by the PTA.
- The PTA further plans to pave the sections abutting the above sections (total 4.934km)in fiscal year 2003.
- A decrepit bridge located on the above section is planned to be reconstructed by the PTA.
- The Pohnpei State Government plans to reconstruct in fiscal year 2003 three decrepit bridges located out of the sections paved/ to be paved by the PTA.

There are six bridges on the sections paved/ to be paved by the PTA. One bridge needing reconstruction due to insufficient strength and width will be reconstructed by the PTA in 2003 and other five bridges are in sound condition. In addition, the paving project by the PTA will include the necessary improvement of drainage facilities like culverts and side ditches. Therefore, the scope of the Japanese Assistance Project is limited to the improvement of 11.772km sections (Project Sections) excluding the sections already paved and to be paved by the PTA and it includes paving, reconstruction and repair of bridges (excluding three bridges to be reconstructed by the Pohnpei State Government), provision of drainage facilities and traffic safety facilities and other necessary improvement works.

The Project Sections are shown in Figure 2.2.1-1.

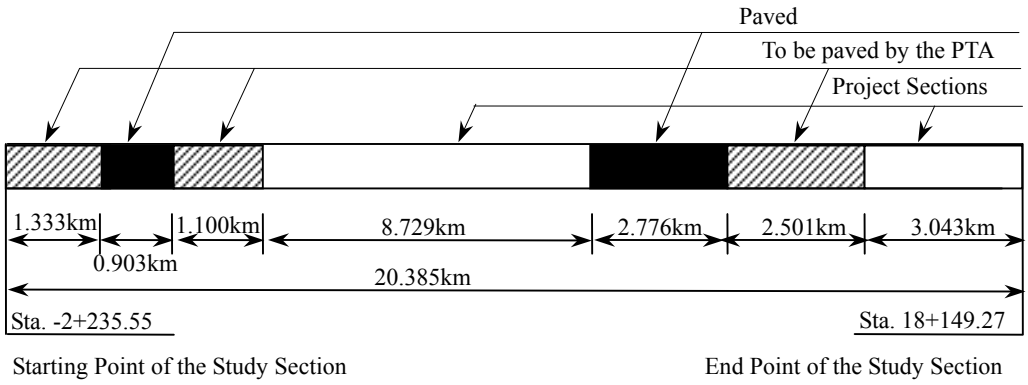

Figure 2.2.1-1 Project Sections

2) Sectioning

According to the traffic volume and roadside environment, the study section is divided into two sections as follows (Figure 2.2.1-2):

- Section 1 : from the starting point to Nanpahlap Intersection (exclusive)
- Section 2 : from Nahpahlap Intersection (inclusive) to the end point

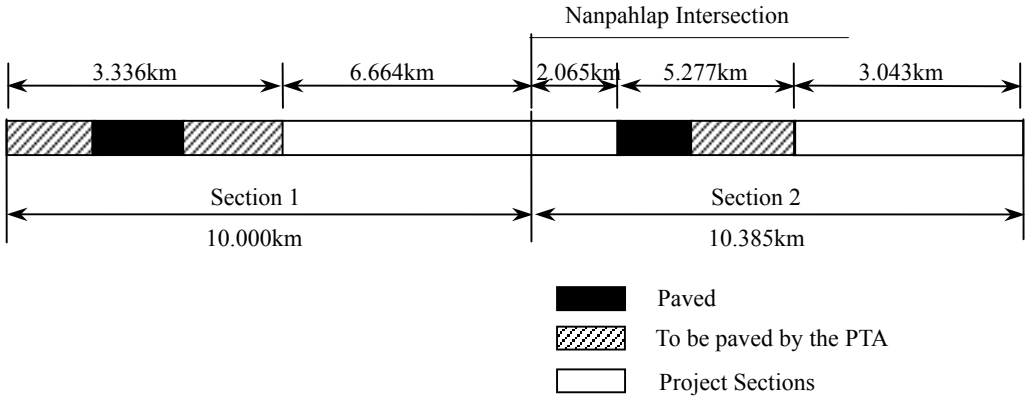

Figure 2.2.1-2 Sectioning

Characteristics of each section are summarized in Table 2.2.1-1. Section 2, with more traffic, population and public facilities, is considered to be given higher priority than Section 1.

Table 2.2.1-1 Characteristics and Priority of Each Section

	Section 1	Section 2
Design Traffic Volume	400 veh/day	900 veh/day
Roadside Population	2,306	3,270
Major Roadside Facilities	dispensary, school, church, etc.	Municipal office, health center, police station, ancient ruins, pilot farm, Pohnpei Agriculture and Trade School, etc.
Priority	2nd	1st

3) Design Traffic Volume

The projected traffic volume in year 2014 (10 years after completion of the Project) is used as the design traffic volume. The traffic volume in 2014 is projected based on the traffic survey conducted in this Study in 2002 and assuming the annual traffic growth rate of 3.0%, which is the average annual increase rate of vehicle registration in the Pohnpei State during the last 10 years (1993 - 2002).

The result is shown in Table 2.2.1-2.

Table 2.2.1-2 Design Traffic Volume

	Traffic Count Station	2002 Traffic Volume	2014 Projected Traffic Volume (3% growth per annum)	Design Traffic Volume
Section 1	Sta. 1+260	153 veh/day	218 veh/day	400 veh/day
	Sta. 7+780	269 veh/day	384 veh/day	
Section 2	Sta. 11+290	635 veh/day	905 veh/day	900 veh/day
	Sta. 17+440	565 veh/day	806 veh/day	

4) Class of Road

Basically, the AASHTO (American Association of State Highway and Transportation officials) Standards are applied to the road design in the FSM because of the absence of own standards. AASHTO classifies the roads into three categories according to the function in the road network : arterial road (linkage of cities), collector road (linkage of village with city or other village) and local road (linkage of individual farm to collector road). Since the study road is considered to have the function corresponding to the collector road in AASHTO, the design standards for the collector road in AASHTO are applied in principle. However, the design standards for the local road are

partly applied in case it is necessary to reduce the earthwork volume and thereby avoid the increase of the construction cost and environmental problem.

5) Design Speed

Mountainous terrain is predominant in Pohnpei Island. The circumferential road, with many sharp curves and steep ups and downs, is classified as the road in mountainous terrain. AASHTO recommends the minimum design speed of 50 km/h for collector roads with design traffic volume of 400 to 2,000 veh/day in mountainous terrain. Following the AASHTO recommendation, 50 km/h is applied to the Project as the standard design speed.

However, there are some portions where road alignment should be improved to meet the condition of the design speed of 50 km/h. The improvement of alignment involves the increase of earthwork volume and sometimes causes the necessity of additional land acquisition and occurrence of environmental problem. To avoid such situation, the reduced design speed of 40 km/h or 30 km/h is applied as design speeds in special case for the portions where existing road alignment does not meet the condition of the standard design speed of 50 km/h.

The speed limits presently applied to the improved section of the circumferential road are 30 mile/h (48 km/h), 25 mile/h (40 km/h), 20 mile/h (32 km/h) and 15 mile/h (24 km/h) depending on the section, out of which 15 mile/h is applied in front of schools. The design speeds in this Project are almost the same as those in the improved section.

6) Road Width

Standard width of the circumferential road is set by the PTA at 20 feet (6.096m) for traveled way and 4 feet (1.219m) for shoulder. Standard width of the bridge is 20 feet (6.096m) for traveled way and 1 feet 10 inches (0.559m) for sidewalk. To keep the continuity of the road, the standard values, converted to the metric system and rounded, are applied to this Project irrespective of the AASHTO standard values (Table 2.2.1-3).

Table 2.2.1-3 Road Width

	Minimum width of collector roads in AASHTO		PTA Standard	Adopted value for this Project
	design traffic volume 0～400veh/day	design traffic volume 400～1500veh/day		
traveled way (road, bridge)	6.0m	6.0m	6.096m	6.0m
shoulder (road)	0.6m	1.5m	1.219m	1.2m
sidewalk (bridge)	-	-	0.559m	0.6m

7) Road Alignment

Due to the steep mountainous terrain, the improvement of road alignment causes the extensive earthwork resulting in increase of construction cost, necessity of additional land acquisition and occurrence of environmental problems. To minimize the earthwork volume, road alignment, both horizontal and vertical, is designed following the existing alignment in principle. For the portions where the existing alignment does not satisfy the condition of the standard design speed of 50 km/h, the reduced design speed of 40 km/h or 30 km/h is applied. In case the existing alignment does not satisfy even the condition of the minimum design speed of 30 km/h, the alignment is improved to satisfy the minimum condition. The improved section of the circumferential road was designed on the same concept.

The geometric design standards are shown in Table 2.2.1-4. Basically they are based on the AASHTO standards for collector roads in mountainous terrain, except for maximum grades for the reduced design speeds which are based on the AASHTO standards for local roads in mountainous terrain to avoid the increase of earthwork volume.

Table 2.2.1-4 Geometric Design Standards

	AASHTO Standards for collector roads in mountainous terrain			Standards for this Project		
	Design Speed			Design Speed		
	50km/h	40 km/h	30 km/h	50 km/h	40 km/h	30 km/h
Minimum radius of curve [1)]	100m	60m	35m	100m	60m	35m
Maximum grade [2)]	10(14)%	11(15)%	12(16)%	10%	15%	16%
Stopping sight distance	65m	50m	35m	65m	50m	35m

1) : Maximum superelevation is 4%.
2) : Values in parentheses are maximum grades for local roads in mountainous terrain.

8) Pavement

The asphalt concrete pavement is commonly used in the FSM and applied to the improved section of the circumferential road. The asphalt concrete pavement is also applied to this Project considering the continuity, constructability and availability of materials.

Initial performance period (defined as the period of time that an initial pavement structure will last before it needs rehabilitation) is set at 10 years, because comparisons are made among three pavements with different initial performance periods: 6 years, 10 years and 17 years based on the life cycle cost analysis for analysis period of 20 years and as a result, the pavement with an initial performance period of 10 years is found to be the most economical.

This initial performance period is a standard value in the design of asphalt concrete pavement in Japan and also used in the Road Improvement Project for the State of Yap.

9) Reconstruction / Repair of Bridges

Deficiencies of bridge are categorized into structural deficiencies and partial damages. Structural deficiencies are identified from the following three aspects:

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i) Functional aspect : insufficient width hindering smooth flow of traffic and possibly causing traffic accidents.

ii) Hydraulic aspect : insufficient water discharge capacity due to insufficient length and/or insufficient height of bridge causing the flood.

iii) Structural aspect : insufficient loading capacity due to deficiency of main structure.

The bridges with the structural deficiencies are reconstructed and the bridges with partial damages are repaired on the damaged portions. For the bridges to be reconstructed, either construction of new bridge or replacement with box culvert is selected depending on the required length and site topography.

Table 2.2.1-5 shows the conditions of the existing bridges and their countermeasures.

10) Culvert

Design policy for improvement of culverts is as follows.

- Culverts with insufficient discharge capacity judged from the hydrological analysis are replaced.
- Corrugate steel pipes covered with rust and therefore considered to have a short remaining life are replaced with concrete pipes.
- New culverts are installed where they are necessary but absent resulting in the water crossing over the road surface.
- Culverts with insufficient length resulting from the widening of the road are extended.
- Culverts with deficiencies at inlets / outlets are repaired.
- Culverts placed at improper location and not functioning are removed.

Improvement plan of culverts is summarized as follows:

Replacement : 15 locations
New installation : 5 locations
Extension : 15 locations
Repair : 4 locations
Removal : 1 location

Table 2.2.1-5 Existing Condition of Bridges and Countermeasures

No.	Sta.	Bridge Name	Bridge Location			Dimension		Structural Deficiencies			Countermeasure			Remarks
			Paved Section	Section to be paved by PTA	Section to be improved under Japanese Assistance	Traveled WayWidth (m)	Length (m)	Functional Aspect	Hydraulic Aspect	Structural Aspect	Reconstruction: Bridge	Reconstruction: Box Culvert	Partial Repair *	
1	-1+783	ENPEINPOWE		○		6.2	24.8				-	-	-	Main structure is sound.
2	1+456	SOUNKIROUN			○	6.1	18.3				-	-	○ a+b+c	Main structure is sound.
3	1+855	REHNTU			○	5.9	6.1				-	-	○ a+b+c	Main structure is sound.
4	2+836	MEINWEL			○	6.1	6.0				-	-	○ a+b+c	Main structure is sound.
5	6+187	LOHD POWE			○	4.6	9.7	×	×	△	○	-	-	Submerged due to insufficient bridge length, new bridge L=20m
6	7+413	NAN WOW			○	5.9	10.7				-	-	○ a+c	Main structure is sound.
7	8+511	AKAHK			○	5.9	4.3			×	-	○	-	Decrepit, replace with box culvert
8	9+034	PILEN ENIPOS			○	5.6	4.3		×	×	○	-	-	Decrepit, insufficient freeboard, new bridge L=7.5m
9	9+945	PILEN POHNLANGAS	○			8.3	4.6				-	-	-	Main structure is sound.
10	10+427	PAHNIOAS	○			6.0	7.5				-	-	-	Main structure is sound.
11	11+418	PARAHU	○			5.9	17.7				-	-	-	Main structure is sound.
12	12+110	SAPWEHREK	○			6.1	8.8				-	-	-	Main structure is sound.
13	13+219	DEWENMOL		○		4.5	6.1	×		×	-	-	-	To be reconstructed by PTA in 2003.
14	15+654	PEIAI			●	3.2	9.1	×	×	×	-	-	-	To be reconstructed by Pohnpei State Gov. in 2003.
15	15+893	LEHN DIADI (II)			●	3.0	13.9	×	×	×	-	-	-	To be reconstructed by Pohnpei State Gov. in 2003.
16	16+049	LEHN DIADI (I)			○	6.1	39.8				-	-	○ a+c+d	Main structure is sound.
17	16+415	PIHS			○	3.4	4.4	×		×	-	○	-	Decrepit, insufficient width, replace with box culvert
18	17+216	LEHDAU			○	6.5	14.9				-	-	○ a	Main structure is sound.
19	17+317	KITAMW			●	3.0	9.9	×	×	×	-	-	-	To be reconstructed by Pohnpei State Gov. in 2003.
20	17+708	SAPWALAP (II)			○	5.3	5.3	×	×	×	○	-	-	Decrepit, insufficient width, insufficient bridge length , new bridge L=9.5m
21	17+938	SAPWALAP (I)			○	5.2	6.2	×		×	-	○	-	Decrepit, insufficient width, replace with box culvert

*: Type of repair
a) paving on bridge surface
b) painting of girders
c) installation/repair of railing
d) repair of wing wall

●: Excluded from the Project because it is planned to be reconstructed by the Pohnpei State Government.

11) Surface Drainage

Pohnpei Island is prominent in abundant rainfall and the adequate surface drainage is essential to retain the durability of the pavement.

It is often observed in the improved section of the circumferential road that surface water is not led to the roadside hindered by the higher shoulder due to vegetation and runs down on the traveled way. To prevent such situation, the height of shoulder is lower than the traveled way and cement treated base course material which is the same as the base course material for the pavement is used for the shoulder, and prime coat is put on top to prevent the erosion and vegetation on the surface of the shoulder.

Although the cross fall of the asphalt pavement is generally 1.5 to 2.0%, 3% cross fall is used for the circumferential road as the standard value considering a lot of rainfall. This Project also adopts 3% following the said standard. 3% cross fall is applied also to the shoulder because the prime coat is put thereon.

Earth ditches and V shaped lined ditches are often utilized for side ditches in the circumferential road. Since the gradient of the Project Sections is steep, earth ditches would be easily eroded and V shaped lined ditches would require wider width increasing the cut volume and needing wider right of way. In view of the above, U shaped lined ditches with grouted riprap are adopted for this Project to prevent the erosion, reduce the cut volume and make the maintenance easier.

12) Subsurface Drainage

In about 300m section at Sta. 7+450 to 7+750, the groundwater springs on the road surface all the year round regardless of the weather. This phenomenon is observed also at approximately 1 km before the beginning point of the study section where water springs out through the asphalt surface course. This situation weakens the base course of pavement remarkably. It is necessary to prevent the penetration of groundwater to the base course.

The subsurface drainage with perforated pipes is adopted for this Project. Lateral perforated pipes are installed beneath the subbase course of pavement and longitudinal perforated pipes are put underground at the roadside. Groundwater is led to the longitudinal pipes through the lateral pipes and then drained through the longitudinal pipes. This method is commonly used for subsurface drainage. It has been adopted for the other section of the circumferential road than abovementioned and its effectiveness has been confirmed.

13) Measures for Submerged Sections

There are three sections submerged during the heavy rain. Submergence of the road causes not only the road closure but also the damage of the road. To prevent the submergence of the road, the road elevation is raised and the drainage capacity is improved. Table 2.2.1-6 shows the condition of submergence and measures to be taken.

Table 2.2.1-6 Condition of Submergence and Countermeasures

Sta.	Condition	Existing Drainage	Countermeasures
3+450	- Location: at and before the portion where a box culvert is installed - Depth: about 60cm - Frequency: about once a year - Duration: about half a day	Box culvert 1-2.0m x 2.0m, Insufficient capacity	- Raise the road elevation by 1.1m at maximum - Replace the culvert (2 - 4.0m x 3.0m)
6+200	- Location: valley where a bridge is built - Depth: about 30cm - Frequency: about once every 5 to 10 years - Duration: about 3 to 4 hours	Bridge L=9.6m, Insufficient bridge length and freeboard	- Reconstruction of the bridge (L=20.0m, raise the elevation of bridge surface by 1.9m)
17+000	- Location: about 400m sagged section before Lehdau Bridge - Depth: about 10cm - Frequency: about 5 to 6 times a year - Duration: about 3 to 4 hours	3 pipe culverts, not functioning due to little difference in elevation between road surface and roadside	- Raise the road elevation by 2.0m at maximum - Replace 3 culverts

14) Traffic Safety

The following traffic safety devices are installed:

- Pavement marking : centerline, sideline and stop-line
- Traffic signs : regulatory signs and warning signs
- Guardrails : at the sections with embankment higher than 4.0m
- Guide posts : at bridge approaches, neighborhood of culverts and riverside

15) Considerations for Environment

Land Acquisition and Relocation of Inhabitants

The width of the right of way of the circumferential road is basically 25 feet each on both sides from the road centerline totaling 50 feet (approximately 15m) but there are some sections where the top of cut slope or the toe of embankment slope is beyond the 50 feet width. In this Project, cut and embankment are necessary to widen the road. The following

points are taken into consideration to avoid the relocation of inhabitants and to minimize the additional land acquisition.

- The road alignment is not changed except in inevitable case (refer to Paragraph 7)).
- Retaining walls with grouted stone masonry are installed where necessary to reduce the slope length in case otherwise the slope length would be too long, and to avoid hitting the house or other obstruction which can hardly be removed.
- U shaped lined ditches are used to reduce the cut volume (refer to Paragraph 11)).

These measures minimize the earthwork volume resulting in the mitigation of environmental impacts on surrounding areas.

Minimizing Construction Waste

At present, the final waste disposing area is only one located in Dekehtik Island close to the airport where reclamation work is being done. To minimize the construction waste, the following considerations are given: minimization of earthwork volume, reuse of generated materials and so on.

Prevention of Water Pollution

To mitigate the water pollution caused by the surface drainage, such measures as utilization of side ditches with grouted riprap, improvement of inlet/outlet of culverts and so on are taken. Considerations are given to prevent water pollution during construction, especially in dredging coral materials (refer to Section 2.2.4.2).

16) Constructability

For local construction companies/engineers to easily participate in the Project, structures are made as simple and easy in quality control as possible and furthermore easy in maintenance after completion of the Project.

2.2.2 Basic Plan

Major components of the Project are as shown in Table 2.2.2-1.

Table 2.2.2-1 Major Components of the Project

Item		Contents
Earth-work	Widening	Whole length as necessary
	Raising of Road Elevation	3 submerged sections at around Sta.3+450, 6+200 and 17+000, total length 500m
	Improvement of Vertical Alignment	A section with a grade of over 16%, length 340m
Pavement		Whole length (11.772km)
Bridge	Reconstruction	6 bridges excluding 3 bridges to be reconstructed by the State Government, Reconstruction - 3 bridges (L=20.0m, 7.5m, 9.5m) and Replacement with box culvert - 3 bridges
	Partial Repair	6 bridges, paving on bridge surface, painting of girders, installation/repair of railing, repair of wing wall
Culvert	Replacement	15 locations
	New Installation	5 locations
	Extension	15 locations
	Repair	4 locations
	Removal	1 location
Surface Drainage		U shaped lined ditch with grouted riprap, Left side 5,983m, Right side 3,728m, total 9,711m
Subsurface Drainage		Approximately 300m section around Sta.7+450 - 7+750, Installation of perforated pipes
Subsidi-ary Facilities	Slope Protection	Retaining wall with grouted stone masonry, Sections where slope length needs to be reduced and the sections along the river, total length 199m
	Pavement Marking	centerline and sideline on whole length (11.772km), stop-lines at 41 places
	Traffic Signs	Regulatory signs (speed limit) at 34 places, warning signs (sharp curve, steep grade, school) at 56 places
	Guardrails	Sections with embankment higher than 4m, total length 840m
	Guide Posts	Approach of bridges, neighborhood of culverts and the section along the river, total number 364

2.2.2.1 Road Design

1) Geometric Design Standard

Table 2.2.2-2 shows the geometric design standard adopted for the Project.

Table 2.2.2-2 Geometric Design Standard

	Reference Standard			Standard for this Project			Remarks
	AASHTO, Collector Road (mountainous)						
	Design Traffic Volume (veh/day)			Design Traffic Volume (veh/day)			
	0 - 400	400 - 2,000		400 (Section 1) 900 (Section 2)			
Design speed	30 km/h	50 km/h		Standard 50 km/h Special Case 40km/h, 30 km/h			
	Design Traffic Volume (veh/day)						
	0 - 400	400 - 1,500					
Traveled way width	6.0m	6.0m		6.0m			Standard of the circumferential road
Shoulder width	0.6m	1.5m		1.2m			Standard of the circumferential road
	Design Speed (km/h)			Design Speed (km/h)			
	50	40	30	50	40	30	
Min. curve radius (Superelevation max. 4%)	100m	60m	35m	100m	60m	35m	AASHTO Standard
Max. grade*	10(14)%	11(15)%	12(16)%	10%	15%	16%	AASHTO Standard (collector road for standard design speed, local road for special case design speed)
Stopping Sight Distance	65m	50m	35m	65m	50m	35m	AASHTO Standard
Number of Lanes	2 lanes			2 lanes			Standard of the circumferential road
Cross Fall	1.5 - 2.5% (Asphalt pavement)			3%			Standard of the circumferential road

*: Values in parentheses are standard for local roads in mountainous terrain.

2) Standard Cross Section

Based on the design policy mentioned in Section 2.2.1 and the above geometric design standard, the standard cross section is developed as shown in Figure 2.2.2-1.

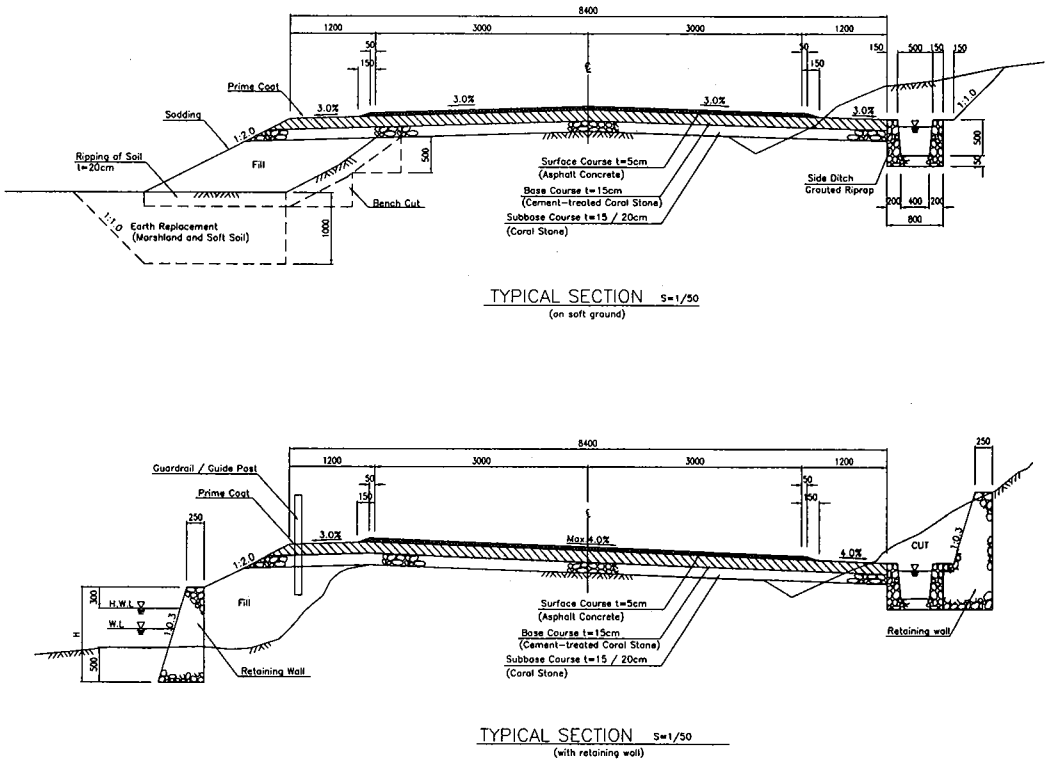


Figure 2.2.2-1 Standard Cross Section

The maximum superelevation on the curve is set at 4% in consideration of the low design speed and use of the road for daily life of inhabitants.

In case of embankment on the soft ground, 1.0m thick top layer is replaced with selected materials to prevent the consolidation settlement. In case of widening of embankment, the embankment is constructed after the bench cut of the existing slope to prevent the slipping settlement.

Considering the abundant rainfall, the prime coat is put on the shoulder to prevent the erosion and vegetation. Sodding is done on large embankment slopes to prevent the erosion and collapse right after the construction as short-term measures until the slopes are covered with natural plants.

3) Horizontal Alignment

Horizontal alignment is designed following the existing alignment. As a result, there are 25 curves where the reduced design speed of 40 km/h or 30 km/h is applied because they do not satisfy the condition of the standard design speed of 50 km/h, i.e., minimum radius of 100m. They are shown in Table 2.2.2-3.

Table 2.2.2-3 Curves with Reduced Design Speed

IP No.	Station	Curve Radius
IP 12	1+131	R=90m
IP 17	1+561	R=60m
IP 23	2+384	R=90m
IP 24	2+493	R=80m
IP 29	3+015	R=80m
IP 30	3+210	R=35m
IP 31	3+289	R=40m
IP 33	3+632	R=60m
IP 37	4+002	R=60m
IP 38	4+063	R=90m
IP 42	4+365	R=70m
IP 46	4+735	R=70m
IP 49	5+034	R=90m
IP 71	7+849	R=50m
IP 74	8+497	R=35m
IP 75	8+540	R=60m
IP 77	8+655	R=80m
IP 81	9+203	R=80m
IP 82	9+407	R=70m
IP 112	15+151	R=60m
IP 115	15+387	R=80m
IP 116	15+571	R=60m
IP 125	17+151	R=60m
IP 126	17+355	R=50m
IP 131	18+008	R=70m

4) Vertical Alignment

In principle, vertical alignment is designed raising the existing road elevation by the thickness of new pavement, except for a section with a grade exceeding 16% and three submerged sections where the vertical alignment is improved. Table 2.2.2-4 shows the sections where the vertical alignment is improved.

Table 2.2.2-4 Improvement of Vertical Alignment

Station	Length	Present Condition	Improved Items
3+400 - 3+500	100m	Submerged once a year, max. depth 60cm	Raise road level by 1.1m at maximum
4+740 - 5+080	340m	Steep grade over 16%	Reduce grade to 16.0%
6+130 - 6+250	120m	Submerged every 5 to 10 years, max. depth 30cm	Raise bridge level by 1.9m
16+820 - 17+100	280m	Submerged 5 to 6 times a year, max. depth 10cm	Raise road level by 2.0m at maximum

The reduced design speed of 40 km/h or 30 km/h is applied to the sections with grade over 10% which is the maximum grade at the standard design speed of 50 km/h. They are shown in Table 2.2.2-5.

Table 2.2.2-5 Steep Sections with Reduced Design Speed

Station	Length	Grade
3+820 - 3+990	170m	12.20%
3+990 - 4+180	190m	13.65%
4+740 - 5+080	340m	16.00%
5+930 - 6+130	200m	12.50%
6+250 - 6+370	120m	13.80%
6+500 - 6+600	100m	14.73%
6+725 - 6+915	190m	13.95%
7+040 - 7+170	130m	10.70%
7+410 - 7+560	150m	14.20%
15+240 - 15+340	100m	10.40%

5) Sections where Reduced Design Speed is Applied

The sections where the reduced design speed of 40 km/h or 30 km/h is applied are shown in Table 2.2.2-6.

Table 2.2.2-6 Sections where Reduced Design Speed is Applied (1/2)

Station	Design Speed	Factors of Determining Design Speed	
		Horizontal Alignment	Vertical Alignment*
1+100 - 1+585	40 km/h	1+131 (IP12), R=90m (allow 40 km/h) 1+561 (IP17), R=60m (allow 40 km/h)	
2+335 - 3+035	40 km/h	2+384 (IP23), R=90m (allow 40 km/h) 2+493 (IP24), R=80m (allow 40 km/h) 3+015 (IP29), R=80m (allow 40 km/h)	
3+035 - 4+240	30 km/h	3+210 (IP30), R=35m (allow 30 km/h) 3+289 (IP31), R=40m (allow 30 km/h) 3+632 (IP33), R=60m (allow 40 km/h) 4+002 (IP37), R=60m (allow 40 km/h) 4+063 (IP38), R=90m (allow 40 km/h)	3+820 - 3+990 I=12.20% crest K=4 (allow 30 km/h) 3+990 - 4+180 I=13.65% crest K=4 (allow 30 km/h) sag K=5 (allow 30 km/h)
4+240 - 4+720	40 km/h	4+365 (IP42), R=70m (allow 40 km/h)	
4+720 - 5+100	30 km/h	4+735 (IP46), R=70m (allow 40 km/h) 5+034 (IP49), R=90m (allow 40 km/h)	4+740 - 5+080 I=16.00% sag K=4 (allow 30 km/h)
5+900 - 6+440	40 km/h		5+930 - 6+130 I=12.50% sag K=8 (allow 40 km/h) 6+250 - 6+370 I=13.80% sag K=8 (allow 40 km/h) crest K=5 (allow 40 km/h)
6+440 - 7+875	30 km/h	7+849 (IP71), R=50m (allow 30 km/h)	6+500 - 6+600 I=14.73% sag K=4 (allow 30 km/h) 6+725 - 6+915 I=13.95% crest K=4 (allow 30 km/h) sag K=7 (allow 30 km/h) 7+040 - 7+170 I=10.70% sag K=5 (allow 30 km/h) crest K=3 (allow 30 km/h) 7+410 - 7+560 I=14.20% sag K=4 (allow 30 km/h)
8+485 - 8+680	30 km/h	8+497 (IP74), R=35m (allow 30 km/h) 8+540 (IP75), R=60m (allow 40 km/h) 8+655 (IP77), R=80m (allow 40 km/h)	
9+160 - 9+828	40 km/h	9+203 (IP81), R=80m (allow 40 km/h) 9+407 (IP82), R=70m (allow 40 km/h)	

Table 2.2.2-6 Sections where Reduced Design Speed is Applied (2/2)

Station	Design Speed	Factors of Determining Design Speed	
		Horizontal Alignment	Vertical Alignment*
15+106 - 15+605	40 km/h	15+151 (IP112), R=60m (allow 40 km/h) 15+387 (IP115), R=80m (allow 40 km/h) 15+571 (IP116), R=60m (allow 40 km/h)	15+240 - 15+340 I=10.40% crest K=9 (allow 40 km/h)
17+130 - 17+615	30 km/h	17+151 (IP125), R=60m (allow 40 km/h) 17+355 (IP126), R=50m (allow 30 km/h)	
17+615 - 18+149	40 km/h	18+008 (IP131), R=70m (allow 40 km/h)	

* Allowable design speed is controlled by not only grade but K value at the crest/sag of vertical curve. K is the length of curve per percent algebraic difference in intersecting grades. Allowable K values are as follows.

Design Speed	K in crest	K in sag
50 km/h	10	12
40 km/h	5	8
30 km/h	3	4

2.2.2.2 Pavement Design

Pavement design is carried out in accordance with "AASHTO Guide for Design of Pavement Structures 1993".

1) Design Conditions

Design conditions are as follows:

Performance Period : 10 years from 2005 to 2014

Traffic load (W_{18}) : predicated number of 18-kip equivalent single axle load (ESAL) applications, calculated based on the result of the traffic survey conducted in this Study

Reliability (R) : probability that traffic loadings and pavement performance are within the predicted range = 50% (standard normal deviate, Z_R=0, combined standard error of the traffic prediction and performance prediction, S_0=0.45)

Serviceability : initial design serviceability index, P_0=4.2 (result of AASHO Road Test)
terminal design serviceability index, P_t=2.5 (recommended value by AASHTO Guide for major highways)

Roadbed Soil Resilient Modulus (M_R) : calculated from M_R (psi)=1,500 x CBR, where CBR value is determined based on the soil investigation

Layer Coefficient : asphalt concrete surface course, a_1=0.390
cement-treated base course, a_2=0.145
granular subbase course, a_3=0.108

Drainage Coefficient : cement-treated base course, m_2=0.9
granular subbase course, m_3=0.8

2) Prediction of Traffic Loading (W_{18})

Based on the daily traffic volume in 2002 obtained from the traffic survey, the predicted number of 18-kip equivalent single axle load applications during the performance period (W_{18}) is calculated assuming the traffic growth rate of 3% per annum and load factors (average number of 18-kip equivalent single axle loads per vehicle) as shown in the Table below. The result of W_{18} calculation is shown in Table 2.2.2-7.

Table 2.2.2-7 Traffic Loading

Vehicle Type	ADT in 2002		ADT in 2005		Load Factor	ESAL in 2005		W18(2005 - 2014)	
	Sec.1	Sec.2	Sec.1	Sec.2		Sec.1	Sec.2	Sec.1	Sec.2
Passenger Car	56	131	61	143	0.003	67	157	768	1,797
Wagon/Pickup	38	83	42	91	0.023	349	761	3,996	8,728
Small Bus	10	24	11	26	0.063	251	603	2,880	6,913
Large Bus	22	45	24	49	0.366	3,211	6,569	36,816	75,306
Truck	12	14	13	15	1.547	7,404	8,638	84,896	99,027
Total	138	297	151	324		11,282	16,728	129,356	191,771

3) Required Structural Number

In accordance with the basic design equation for flexible pavements in AASHTO Guide, the required structural number (SN) is calculated as shown in Table 2.2.2-8.

Table 2.2.2-8 Required Structural Number (SN)

		Section 1	Section 2
Assumed Value	Predicted 18-kip ESALs (W_{18})	129,356	191,771
	Standard Normal Deviate (Z_R)	0	0
	Standard Error (S_0)	0.45	0.45
	Serviceability Loss($\triangle PSI = P_0 - P_t$)	1.7	1.7
	Roadbed Soil Resilient Modulus (M_R)	7,500 psi	6,750 psi
Required SN		1.981	2.206

4) Pavement Structure

Aggregates available in the Island are basalts excavated at the mountainside in the north of the Island and corals dredged from the reefs. Taking into account the production cost and transport cost, basalts are used only for asphalt concrete and coral materials for base and subbase courses. CBR value of coral materials is enough for the subbase course but not enough for the base course. Accordingly, base course materials are treated with cement.

Pavement thickness is as follows.

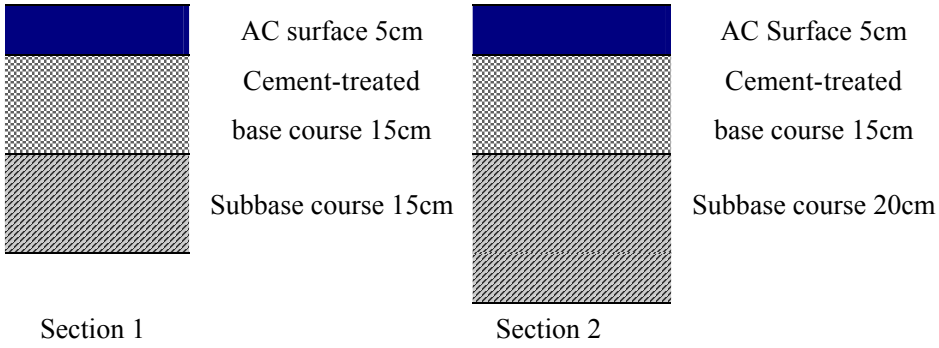


Table 2.2.2-9 shows the calculation of the structural number.

Table 2.2.2-9 Structural Number

	Layer Coefficient (a)	Drainage Coefficient (m)	Section 1		Section 2	
			Thickness in inch (D)	SN＝aDm	Thickness in inch (D)	SN＝aDm
AC Surface	0.390	―	1.969	0.768	1.969	0.768
Base	0.145	0.9	5.906	0.771	5.906	0.771
Subbase	0.108	0.8	5.906	0.510	7.874	0.680
Total				2.049		2.219

The structural number (SN) of each section is higher than the required.

2.2.2.3 Bridge Design

The Project involves reconstruction of three bridges, replacement of three bridges with box culverts and partial repair of six bridges (refer to Table 2.2.1-5).

1) Reconstruction of Bridge

Design criteria are as follows.

- Live Load : AASHTO HS-20-44 (standard in Pohnpei State)
- Seismic Load : none (standard in Pohnpei State)
- Design High Water Level : Past heist water level (equivalent to the water level of 50-year return period)
- Freeboard : 0.0m (little apprehension of damages by driftwood)

The design of each bridge is described as follows:

Lohd Powe Bridge

Length : 20.0m,
suited to the river width, while the existing bridge narrows the river.

Span : 1 span,
considering the river condition as the riverbed is deep at the center and it is unfavourable to place a pier.

Superstructure : RC Girder,
more economical than PC girder because the equipment for introduction of prestress is not available in the Island.

Design High Water Level : 0.3m above the existing bridge surface (E.L.=55.8m),
based on the interview at the site and hydrological analysis.

Bridge Surface Level : 1.94m above the existing bridge surface (E.L.=57.44m),
setting the girder bottom at the design high water level without freeboard.

Abutment : RC reversed T type,
suitable for the height of 7.55m. The footing is embedded 1.0m beneath the riverbed.

Foundation : Pile foundation (log pile),
because the bearing layer is located low. The length of piles is 2.3m. There is little apprehension of corrosion of piles since they are placed below the groundwater level.

Pilen Enipos Bridge

Length : 7.5m,
so as not to reduce the cross-sectional area of the river although the road crosses the river on the skew.

Span : 1 span,
because of the short length of the bridge.

Superstructure : RC slab,
being the most economical.

Design High Water Level : 1.2m under the existing bridge surface (E.L.=101.9m),
based on the interview at the site and hydrological analysis.

Bridge Surface Level : 0.4m above the existing bridge surface (E.L.=103.51m to 103.57m),
fitted to the approach road level raised by 0.4m of the pavement thickness.

Abutment : RC gravity type,
suitable for the height of 4.5m.

Foundation : Spread foundation,
because of the bearing layer located shallow from the riverbed.

Sapwalap II Bridge

Length : 9.5m,
considering the location of riverbanks after re-channeling the river. The river meanders in U-shape at the location of the existing bridge. The river is re-channeled connecting straight upstream and downstream sides.

Span : 1 span,
because of the short length of the bridge.

Superstructure : RC slab,
being the most economical.

Design High Water Level : 0.5m under the existing bridge surface (E.L.=55.7m),
based on the interview at the site and hydrological analysis.

Bridge Surface Level : 0.4m above the existing bridge surface (E.L.=56.58m),
fitted to the approach road level raised by 0.4m of the pavement thickness.

Abutment : RC gravity type,
suitable for the height of 5.0m.

Foundation : Spread foundation,
because of the bearing layer located shallow from the riverbed.

2) Replacement with Box Culverts

Refer to Section 2.2.2.4.

3) Partial Repair

The following bridges are partially repaired as indicated:

Sounkiroun Bridge	: paving on bridge surface, painting of girders, installation of railing
Rehntu Bridge	: paving on bridge surface, painting of girders, installation of railing
Meinwel Bridge	: paving on bridge surface, painting of girders, installation of railing
Nan Wow Bridge	: paving on bridge surface, repair of railing
Lehn Diadi I Bridge	: paving on bridge surface, installation of railing, repair of wingwall
Lehdau Bridge	: paving on bridge surface

2.2.2.4 Culvert Design

1) Design Criteria

Design criteria are as follows:

Rainfall Intensity	: 5 years return period
Discharge	: based on rational formula
Runoff Coefficient	: 0.50 to 0.75 depending on the topography of the catchment area
Time of Concentration	: based on Kirpich's formula
Effective Area for Discharge	: 80% of inner sectional area
Allowable Velocity	: 2.0m^3/s in principle
Water Velocity	: based on Manning's Formula
Roughness Coefficient	: 0.013 for precast concrete pipe, 0.015 for in-situ concrete surface

2) Improvement Plan

In accordance with the design policy mentioned in Section 2.2.1 10), replacement, new installation, extension, repair or removal is planned for each culvert. On the inlets/outlets, catch basin, straight headwall, wingwall, apron, gabion and/or rubblestone are installed depending on the condition of upstream/ downstream.

The improvement plan of culverts is shown in Table 2.2.2-10. The plan involves replacement at 15 locations, new installation at 5 locations, extension at 15 locations, repair at 4 locations and removal at 1 location. In addition, 3 bridges are replaced with box culverts.

Table 2.2.2-10 Improvement Plan of Culverts (Including Replacement of Bridges with Culverts)

	Existing Condition			Improvement					
No.	Sta.	Structure*	Discharge	Measures	New Structure*	Cap.	Inlet	Outlet	Remarks
1	1+407	1-ø900 CSP	0.54	Replace	1-ø900 RCP	1.04	Headwall	Headwall	Replace CSP
2	1+629	2-ø450 RCP	0.66	Extend		1.27	Catch Basin	Headwall/Gabion	
3	1+967	1-ø600 RCP	0.77	Extend		0.76	Headwall	Wingwall/Apron	Stagnate
4	2+117	1-ø550 RCP	0.91	Replace	2-ø900 RCP	2.08	Headwall	Wingwall/Apron	
5	2+197	2-ø450 RCP	1.23	Extend		0.75	Headwall	Headwall/Gabion	Flow to No4 Culvert
6	2+410	1-ø550 RCP	0.63	Extend		0.74	Wingwall	Wingwall/Apron	
7	2+650	2-ø600 RCP	3.12	Replace	3-ø900 RCP	3.12	Wingwall/Apron	Wingwall/Apron	
8	2+709	1-ø550 RCP	0.20	Extend		1.11	Catch Basin	Headwall	
9	3+196	3-ø600 RCP	3.32	Replace	1-2.0×1.5 Box	4.78	Wingwall/Apron	Wingwall/Apron	Rubble at outlet
10	3+360		0.36	Install	1-ø900 RCP	1.04	Catch Basin	Headwall	
11	3+510	1-2.0×2.0 Box	58.00	Replace	2-4.0×3.0 Box	74.3	Wingwall/Apron	Wingwall/Apron	
12	3+652	2-ø600 RCP	0.44	Repair		2.23	Catch Basin	Wingwall/Gabion	Repair inlet/outlet
12A	4+200		0.52	Install	1-ø900 RCP	1.04	Catch Basin	Wingwall/Gabion	
13	4+294	2-ø600 RCP	0.65	Extend		2.33	Catch Basin	Wingwall/Apron	
13A	4+360		0.58	Install	1-ø900 RCP	1.04	Headwall	Headwall	
14	4+552	2-ø600 RCP	0.19	Repair		1.55	Headwall	Headwall	Repair inlet/outlet
15	4+631	3-ø600 RCP	2.93	Replace	3-ø900 RCP	3.12	Wingwall/Apron	Wingwall/Apron	
16	4+699	1-ø1,800 CSP	3.78	Repair		10.3	Wingwall/Apron	Wingwall/Apron	Rubble at outlet
17	5+386	2-ø600 RCP	1.18	Extend		1.87	Headwall	Wingwall/Apron	
18	5+672	1-ø600 RCP	2.20	Replace	2-ø900 RCP	2.34	Wingwall	Wingwall/Apron	Skew
19	5+827	1-ø550 RCP	0.15	Extend		0.6	Catch Basin	Headwall/Gabion	Skew
20	6+045	2-ø550 RCP	0.25	Extend		2.39	Catch Basin	Headwall	
21	6+496	2-ø600 RCP	1.75	Extend		2.44	Wingwall/Apron	Wingwall/Apron	
22	6+918	1-ø1.80×1.10 CSP	6.95	Replace	1-2.0×2.0 Box	8.45	Wingwall/Apron	Wingwall/Apron	Rubble at outlet
23	7+044	2-ø450 CSP	0.40	Replace	1-ø900 RCP	1.04	Headwall	Headwall	Replace CSP
23A	7+860		0.42	Install	1-ø900 RCP	1.04	Catch Basin	Headwall	
24	8+220	2-ø600 RCP	2.27	Repair		2.33	Wingwall/Apron	Wingwall/Apron	Repair inlet/outlet
25	8+324	1-ø550 RCP	0.36	Extend		0.36	Headwall	Headwall	
BR#7	8+511	Akahk BR.	12.00	Replace	1-3.0×3.0 Box	14.4	Wingwall/Apron	Wingwall/Apron	
26	8+703	1-ø900 RCP	0.19	Extend		1.51	Catch Basin	Headwall	
27	8+977	1-ø550 RCP	0.47	Extend		0.91	Headwall	Wingwall/Apron	
28	9+249	1-ø550 RCP	0.55	Extend		0.75	Catch Basin	Headwall	
29	9+434	1-ø600 RCP	0.65	Extend		1.13	Headwall	Wingwall	
30	9+654	1-ø630 SP	3.44	Replace	3-ø900 RCP	3.51	Headwall	Wingwall/Apron	
32	16+123	Not functioning	0.00	Remove		0			
33	16+277	1-ø600×450 CSP	0.37	Replace	1-ø900 RCP	1.04	Catch Basin	Headwall	Replace CSP
BR#17	16+415	Pihs BR.	9.00	Replace	1-3.0×3.0 Box	14.4	Wingwall/Apron	Wingwall/Apron	
34	16+815	2-ø1,000 CSP	0.67	Replace	2-ø600 RCP	0.86	Headwall	Headwall	Replace CSP
35	16+903	2-ø600×450 CSP	0.84	Replace	1-ø900 RCP	1.04	Wingwall	Wingwall	Replace CSP
36	17+000	2-ø600×450 CSP	0.40	Replace	1-ø900 RCP	1.04	Headwall	Headwall	Replace CSP
37	17+820		0.19	Install	1-ø600 RCP	1.04	Catch Basin	Revetment	
BR#21	17+938	Sapwalap I BR.	21.00	Replace	2-3.0×3.0 Box	28.8	Wingwall/Apron	Wingwall/Apron	
38	18+092	1-ø900 CSP	0.29	Replace	1-ø900 RCP	1.04	Headwall	Headwall	Replace CSP

* CSP : Corrugate Steel Pipe
RCP : Reinforced Concrete Pipe
SP : Steel Pipe

2.2.2.5 Surface Drainage Design

In accordance with the design policy mentioned in Section 2.2.1 11), U shaped lined ditches with grouted riprap are installed for the surface drainage. Moreover cut-off wall and rubblestone are installed at the outlet of the ditches to prevent the erosion.

1) Design Criteria

Rainfall Intensity	: 3 years return period
Time of Concentration	: 10 minutes
Discharge	: based on rational formula
Runoff Coefficient	: 0.80 for paved surface
Water Velocity	: based on Manning's Formula
Roughness Coefficient	: 0.025 for grouted riprap

2) Installation Plan

Location of side ditches is listed in Table 2.2.2-11.

Length of side ditches is 5,983m on left side and 3,728m on right side totaling 9,711m.

Table 2.2.2-11 Location of Side Ditches

Left Side			Right Side		
Station		Length	Station		Length
Start	End	L (m)	Start	End	L (m)
1+230	1+270	33.5	1+185	1+270	85.0
1+510	1+770	257.5	3+940	4+080	137.0
2+015	2+090	75.0	4+470	4+515	45.0
2+220	2+240	20.0	4+865	5+345	480.0
2+285	2+460	173.9	5+386	5+525	138.0
2+510	2+595	78.5	5+725	5+800	75.0
2+660	2+680	20.0	5+920	6+178	248.5
2+735	2+833	98.0	6+300	6+430	130.0
2+840	2+890	50.0	6+530	6+810	280.0
3+020	3+108	88.0	7+160	7+250	90.0
3+345	3+390	42.7	7+480	7+764	284.0
3+675	4+275	597.7	8+600	8+625	25.0
4+400	4+425	25.0	8+760	8+977	216.4
4+552	4+602	48.4	9+038	9+175	131.0
4+860	5+190	330.0	9+480	9+654	155.9
5+450	5+555	105.0	9+720	9+828	84.0
5+720	5+800	80.0	15+180	15+280	100.0
5+860	6+178	315.2	15+325	15+370	45.0
6+300	6+475	175.0	15+410	15+445	35.0
6+530	6+570	40.0	15+480	15+649	169.0
6+610	6+725	115.0	15+725	15+775	50.0
6+950	7+035	85.0	15+900	16+000	97.0
7+135	7+220	85.0	16+320	16+360	40.0
7+480	7+764	277.0	16+460	16+530	70.0
7+764	7+840	70.5	16+610	16+780	170.0
8+025	8+092	67.0	17+180	17+230	50.0
8+340	8+495	155.0	17+322	17+460	126.0
8+512	8+675	163.0	17+525	17+696	171.0
8+703	8+977	266.8			
9+038	9+654	605.0			
9+760	9+828	68.0			
15+130	15+160	30.0			
15+255	15+555	293.5			
15+740	15+768	28.0			
16+150	16+235	85.0			
16+340	16+400	54.0			
16+440	16+530	90.0			
16+605	16+795	183.0			
17+133	17+228	89.5			
17+322	17+400	72.0			
17+490	17+696	199.5			
17+760	17+860	98.0			
17+890	17+934	44.0			
17+960	18+060	97.3			
18+140	18+149	9.0			
Sub total		5,983.5	Sub total		3,727.8

2.2.2.6 Subsurface Drainage Design

In the section with springing water at Sta. 7+450 to 7+750, the subsurface drainage facility is installed to prevent the groundwater from penetrating to the subbase course. ϕ 150mm perforated pipes are placed beneath the subbase course as the lateral drain pipes and protected by the selected filter materials. Lateral drain pipes are placed on the skew to the road cross section because the road has the vertical grade. ϕ 300mm perforated pipes surrounded by the selected filter materials are placed longitudinally beneath the side ditches to drain the water led through the lateral drain pipes to the outlet.

The subsurface drainage is illustrated in Figure 2.2.2-2.

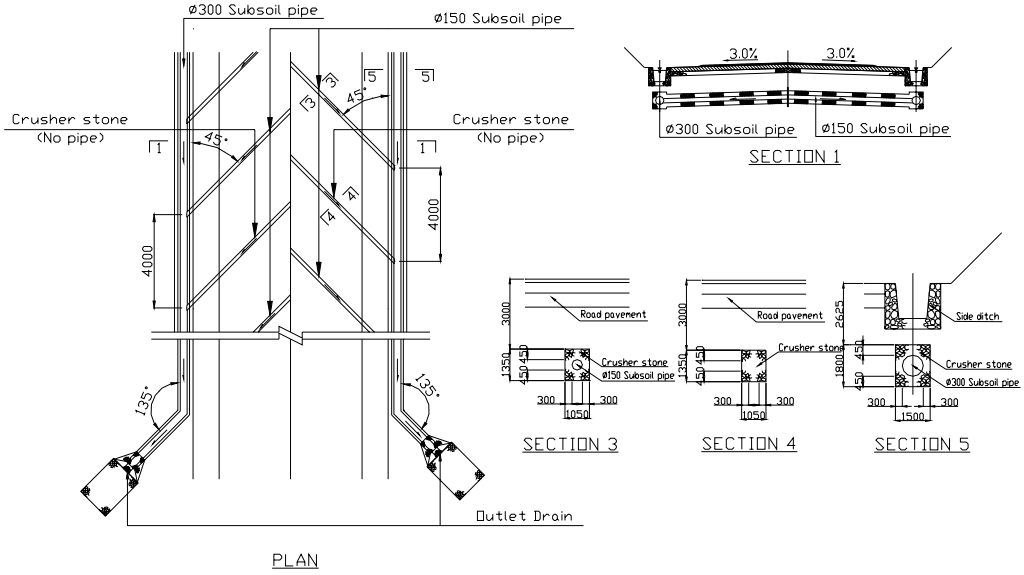


Figure 2.2.2-2 Subsurface Drainage Facility

Similar subsurface drainage facility was constructed in the improved section of the circumferential road and its effectiveness has been confirmed.

2.2.2.7 Subsidiary Facilities Design

1) Retaining Wall

Retaining walls with grouted stone masonry are placed at the sections where necessary to prevent the slope from being too long and from hitting the house or other obstruction and at the sections along the river. Location of retaining walls is listed in Table 2.2.2-12. Total length is 199m.

Table 2.2.2-12 Location of Retaining Walls

Station	Side	Length	Height	Purpose
3+760 - 3+780	Right	20m	1.5m	To reduce embankment slope length
4+965 - 4+990	Left	25m	2.5m	To reduce cut slope length
4+965 - 4+990	Right	25m	2.5m	To reduce cut slope length
6+195 - 6+230	Left	35m	2.5m	To avoid a grave otherwise located on the embankment slope
6+230 - 6+245	Left	15m	3.0m	To avoid a hut otherwise located on the embankment slope
15+622 - 15+649	Left	27m	2.0m	River revetment
15+658 - 15+675	Right	17m	3.0m	River revetment
17+815 - 17+850	Right	35m	1.0m	River revetment

2) Pavement Marking and Traffic Sign

Centerline, sideline and stop-line are drawn by pavement marking. Centerline and sideline are put on the whole length of the road and stop-lines are put on the intersecting roads at 41 places.

Traffic signs are placed for the purpose of traffic safety, including regulatory signs (speed limit) and warning signs (sharp curve, steep grade, school). They are fixed to the roadside poles. Numbers of regulatory signs and warning signs are 34 and 56 respectively.

3) Guardrails / Guide Posts

To prevent vehicles from falling down, guardrails are installed at the sections with embankment higher than 4m. For the purpose of visual leading, the guide posts are installed at the bridge approaches, neighborhood of culverts and riverside.

Location of guardrails and guide posts is shown in Table 2.2.2-13. Total length of guardrails is 840m and number of guide posts is 364.

Table 2.2.2-13 Location of Guardrails and Guide Posts

Guardrails

Left Side		Right Side	
Station	Length	Station	Length
4+730 - 4+790	60m	2+910 - 2+930	20m
6+230 - 6+290	60m	3+590 - 3+610	20m
6+470 - 6+510	40m	3+630 - 3+670	40m
6+830 - 6+910	80m	3+750 - 3+790	40m
7+370 - 7+410	40m	4+150 - 4+170	20m
7+430 - 7+450	20m	4+190 - 4+210	20m
		5+810 - 5+890	80m
		6+230 - 6+290	60m
		6+470 - 6+510	40m
		6+830 - 6+950	120m
		7+070 - 7+090	20m
		7+250 - 7+290	40m
		7+330 - 7+350	20m

Guide Posts

Station	Side	Number	Remarks
1+407	Both sides	4	Culvert
1+437 - 1+476	Both sides	16	Approach of Bridge(Sounkiroun Br)
1+629	Both sides	4	Culvert
1+842 - 1+868	Both sides	16	Approach of Bridge(Rehntu Br)
1+967	Both sides	4	Culvert
2+117	Both sides	4	Culvert
2+197	Both sides	4	Culvert
2+410	Both sides	4	Culvert
2+650	Both sides	4	Culvert
2+709	Both sides	4	Culvert
2+823 - 2+850	Both sides	16	Approach of Bridge(Meinwel Br)
3+196	Both sides	4	Culvert
3+360	Both sides	4	Culvert
3+510	Both sides	4	Culvert
3+652	Left	2	Culvert
4+200	Left	2	Culvert
4+294	Both sides	4	Culvert
4+360	Both sides	4	Culvert
4+552	Both sides	4	Culvert
4+631	Both sides	4	Culvert
4+699	Both sides	4	Culvert
5+386	Both sides	4	Culvert
5+672	Both sides	4	Culvert
5+827	Left	2	Culvert
6+045	Both sides	4	Culvert
6+169 - 6+205	Both sides	16	Approach of Bridge(Lohd Powe Br)
6+918	Left	2	Culvert
7+044	Both sides	4	Culvert
7+418 - 7+428	Both sides	8	Approach of Bridge(Nan Wow Br)
7+860	Both sides	4	Culvert
8+220	Both sides	4	Culvert
8+324	Both sides	4	Culvert
8+511	Both sides	4	Culvert
8+703	Both sides	4	Culvert
8+977	Both sides	4	Culvert
9+021 - 9+049	Both sides	16	Approach of Bridge(Pilen Enipos Br)
9+249	Both sides	4	Culvert
9+434	Both sides	4	Culvert
9+654	Both sides	4	Culvert
15+600 - 15+620	Left	5	Riverside
15+639 - 15+668	Both sides	16	Approach of Bridge(Peiai Br)
15+876 - 15+911	Both sides	16	Approach of Bridge(Lehn Diadi II Br)
16+019 - 16+079	Both sides	16	Approach of Bridge(Lehn Diadi I Br)
16+277	Both sides	4	Culvert
16+415	Both sides	4	Culvert
16+815	Both sides	4	Culvert
16+903	Both sides	4	Culvert
17+000	Both sides	4	Culvert
17+108 - 17+143	Both sides	16	Approach of Bridge(Lehdau Br)
17+301 - 17+332	Both sides	16	Approach of Bridge(Kitamw Br)
17+686 - 17+716	Both sides	16	Approach of Bridge(Sapwalap II Br)
17+820	Both sides	4	Culvert
17+830 - 17+920	Right	19	Riverside
17+938	Both sides	4	Culvert
18+092	Both sides	4	Culvert

4) Connection to Intersecting Roads and Roadside Facilities

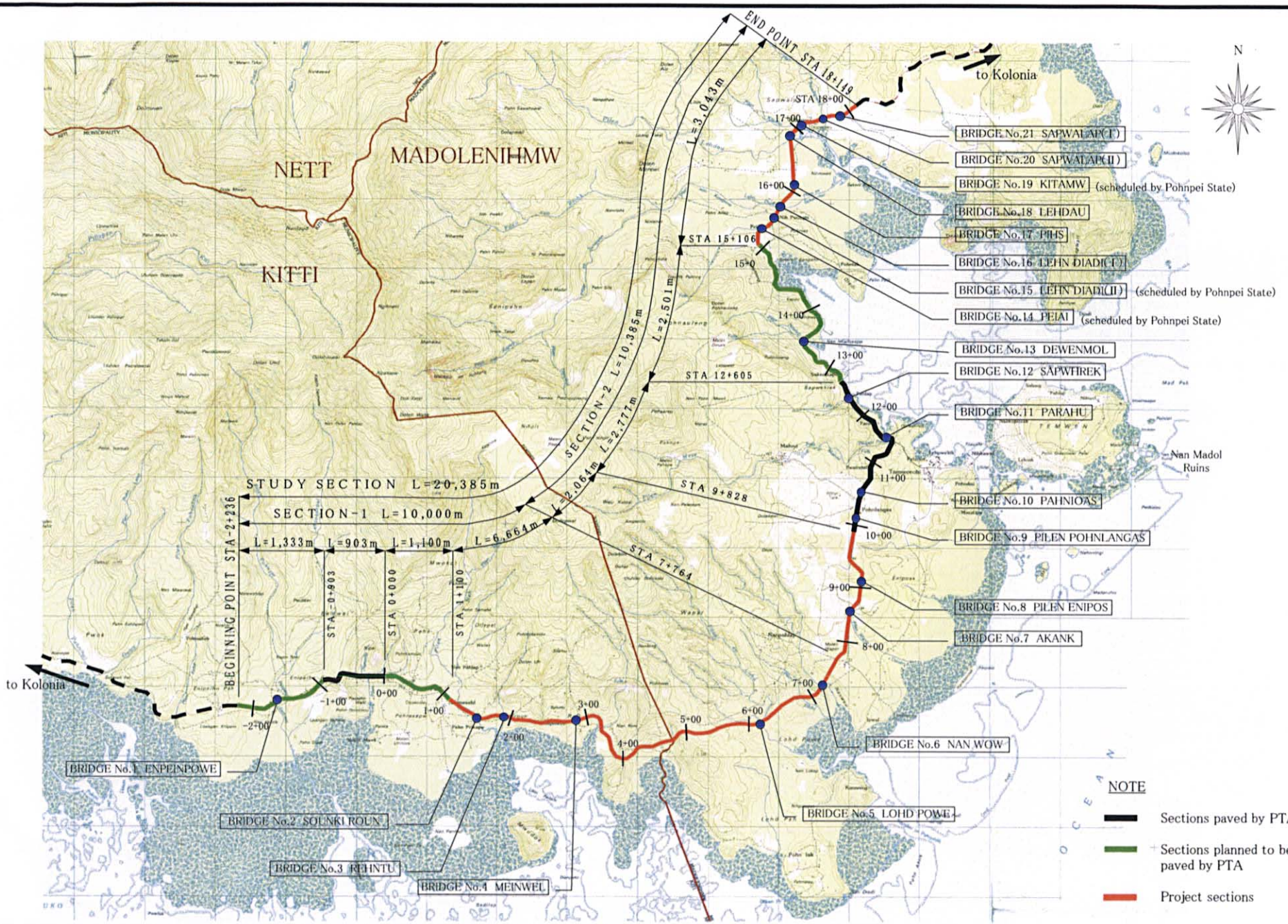
The connections to the secondary roads intersecting with the Project Sections and houses and public facilities located on the roadside are categorized depending on the importance of the roads/facilities into three types: Type A, Type B and Type C. The corner cut is made in Types A and B, but not in Type C. At the sections with side ditch, concrete pipes are installed or covers are placed on the ditch to secure the surface drainage.

The connections to the roads and facilities are summarized in Table 2.2.2-14.

Table 2.2.2-14 Connections to Intersecting Roads and Roadside Facilities

Type	Number	Corner Cut	Drainage
Type A	2	R=10m	Concrete pipe, total length 16.0m
Type B	39	R= 3m	Concrete pipe, total length 185.5m
Type C	92	none	Side ditch with cover, total length 324.0m

2.2.3 Basic Design Drawing



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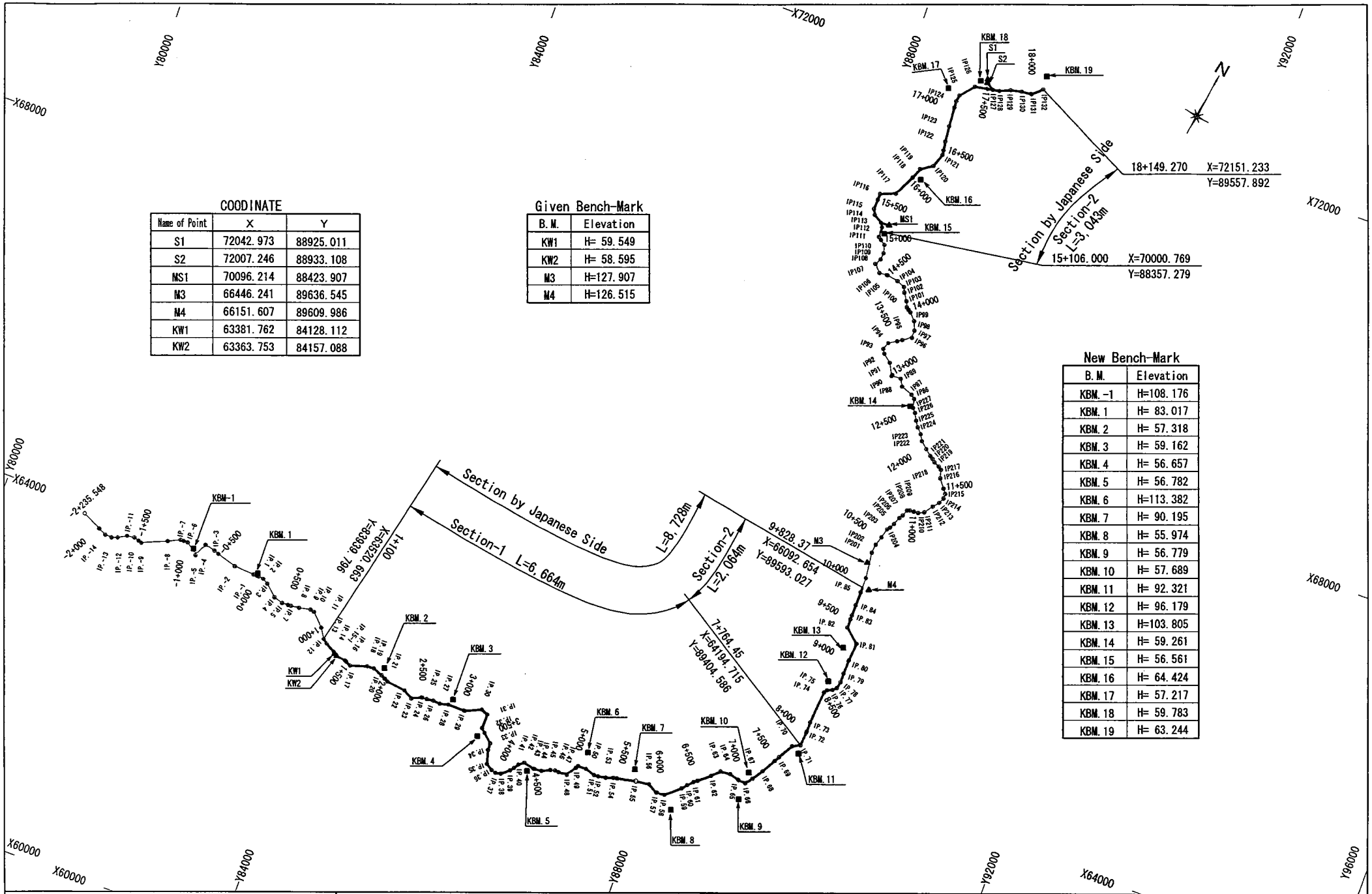

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New Traverse / Intersection Point

T.P.	I.P.	X	Y
T.12	IP.12	63494.433	83956.252
T.13	IP.13	63456.682	84005.795
T.14	IP.14	63401.055	84111.923
T.15-1	IP.15-1	63365.454	84159.162
T.16	IP.16	63349.871	84267.199
T.17	IP.17	63314.323	84340.758
T.18	IP.18	63373.531	84525.410
T.19	IP.19	63379.429	84605.698
T.20	IP.20	63334.867	84714.893
T.21	IP.21	63291.572	84801.139
T.22	IP.22	63264.692	85015.591
	IP.23	63204.480	85123.232
T.23-1	IP.23-1	63218.124	85098.787
T.23-2	IP.23-2	63213.593	85141.998
T.24	IP.24	63255.350	85227.753
T.25	IP.25	63256.148	85288.617
T.26	IP.26	63267.111	85367.877
T.27	IP.27	63258.693	85447.743
T.28	IP.28	63282.709	85543.507
T.29	IP.29	63280.766	85747.201
T.30	IP.30	63361.697	85924.910
T.31	IP.31	63330.140	85999.567
	IP.32	63167.002	85999.011
T.32-1	IP.32-1	63200.401	85999.114
T.32-2	IP.32-2	63142.896	86024.785
T.33	IP.33	63034.823	86140.632
T.34	IP.34	62958.010	86144.835
	IP.35	62805.356	86187.413
T.35-1	IP.35-1	62827.979	86181.074
T.35-2	IP.35-2	62791.866	86208.187
T.36	IP.36	62757.469	86261.406
T.37	IP.37	62742.271	86312.480
T.38	IP.38	62755.122	86373.083
T.39	IP.39	62828.190	86462.451
T.40	IP.40	62870.117	86494.741
T.41	IP.41	62924.632	86529.034
	IP.42	62968.308	86583.974
T.42-1	IP.42-1	62959.346	86572.747
T.42-2	IP.42-2	62963.294	86604.906
T.43	IP.43	62939.756	86704.457
T.44	IP.44	62946.319	86800.006
T.45	IP.45	62990.348	86891.742
T.46	IP.46	63003.540	86944.822

New Traverse / Intersection Point

T.P.	I.P.	X	Y
T.47	IP.47	62999.466	86989.548
	IP.48	63006.065	87087.819
T.48-1	IP.48-1	63003.698	87053.258
T.48-2	IP.48-2	63032.326	87104.611
	IP.49	63145.361	87176.713
T.49-1	IP.49-1	63121.943	87161.806
T.49-2	IP.49-2	63144.578	87205.216
T.50	IP.50	63142.912	87272.602
T.51	IP.51	63109.813	87380.992
T.52	IP.52	63112.233	87431.634
T.53	IP.53	63128.278	87516.880
T.54	IP.54	63156.819	87599.125
T.55	IP.55	63210.812	87852.139
	IP.56	63232.038	88005.540
T.56-1	IP.56-1	63228.570	87981.010
T.56-2	IP.56-2	63222.488	88022.357
	IP.57	63169.830	88116.227
T.57-1	IP.57-1	63181.395	88095.472
T.57-2	IP.57-2	63171.844	88134.474
T.58	IP.58	63180.738	88211.637
T.59	IP.59	63316.417	88371.794
T.60	IP.60	63372.984	88419.934
T.61	IP.61	63429.911	88476.910
T.62	IP.62	63560.530	88641.329
	IP.63	63646.891	88726.539
T.63-1	IP.63-1	63609.553	88689.754
T.63-2	IP.63-2	63649.496	88762.439
T.64	IP.64	63655.507	88842.062
T.65	IP.65	63626.390	88954.685
	IP.66	63621.962	89035.724
T.66-1	IP.66-1	63623.111	89013.222
T.66-2	IP.66-2	63647.316	89056.042
T.67	IP.67	63697.636	89096.204
T.68	IP.68	63812.349	89176.010
T.69	IP.69	64029.220	89297.029
T.70	IP.70	64192.384	89392.919
T.71	IP.71	64236.779	89477.750
T.72	IP.72	64406.632	89492.501
T.73	IP.73	64514.087	89494.030
T.74	IP.74	64887.260	89525.585
T.75	IP.75	64923.308	89550.437
T.76	IP.76	64950.543	89607.942
T.77	IP.77	64986.779	89645.637

New Traverse / Intersection Point

T.P.	I.P.	X	Y
T.78	IP.78	65061.043	89664.830
T.79	IP.79	65165.759	89662.888
T.80	IP.80	65316.291	89669.633
	IP.81	65533.008	89688.217
T.81-1	IP.81-1	65512.579	89686.502
T.81-2	IP.81-2	65548.198	89671.393
T.82	IP.82	65669.465	89527.506
T.83	IP.83	65811.818	89551.232
T.84	IP.84	65939.327	89569.904
T.85	IP.85	66092.654	89593.027
T.112	IP.112	70046.451	88356.032
T.113	IP.113	70088.804	88328.277
T.114	IP.114	70149.902	88229.654
T.115	IP.115	70212.689	88196.425
	IP.116	70398.331	88204.505
T.116-1	IP.116-1	70378.264	88203.633
T.116-2	IP.116-2	70406.898	88227.394
	IP.117	70462.339	88375.509
T.117-1	IP.117-1	70449.882	88342.230
T.117-2	IP.117-2	70496.484	88392.413
T.118	IP.118	70704.521	88495.403
T.119	IP.119	70818.079	88541.084
T.120	IP.120	70904.109	88675.313
T.121	IP.121	71057.419	88727.505
T.122	IP.122	71215.868	88703.380
T.123	IP.123	71390.285	88689.122
T.124	IP.124	71686.737	88671.453
T.125	IP.125	71759.330	88682.122
T.126	IP.126	71915.132	88815.650
T.127	IP.127	71952.524	89021.227
T.128	IP.128	71965.319	89096.027
T.129	IP.129	72018.512	89214.737
T.130	IP.130	72045.116	89336.136
T.131	IP.131	72056.032	89451.972
T.132	IP.132	72151.239	89557.898

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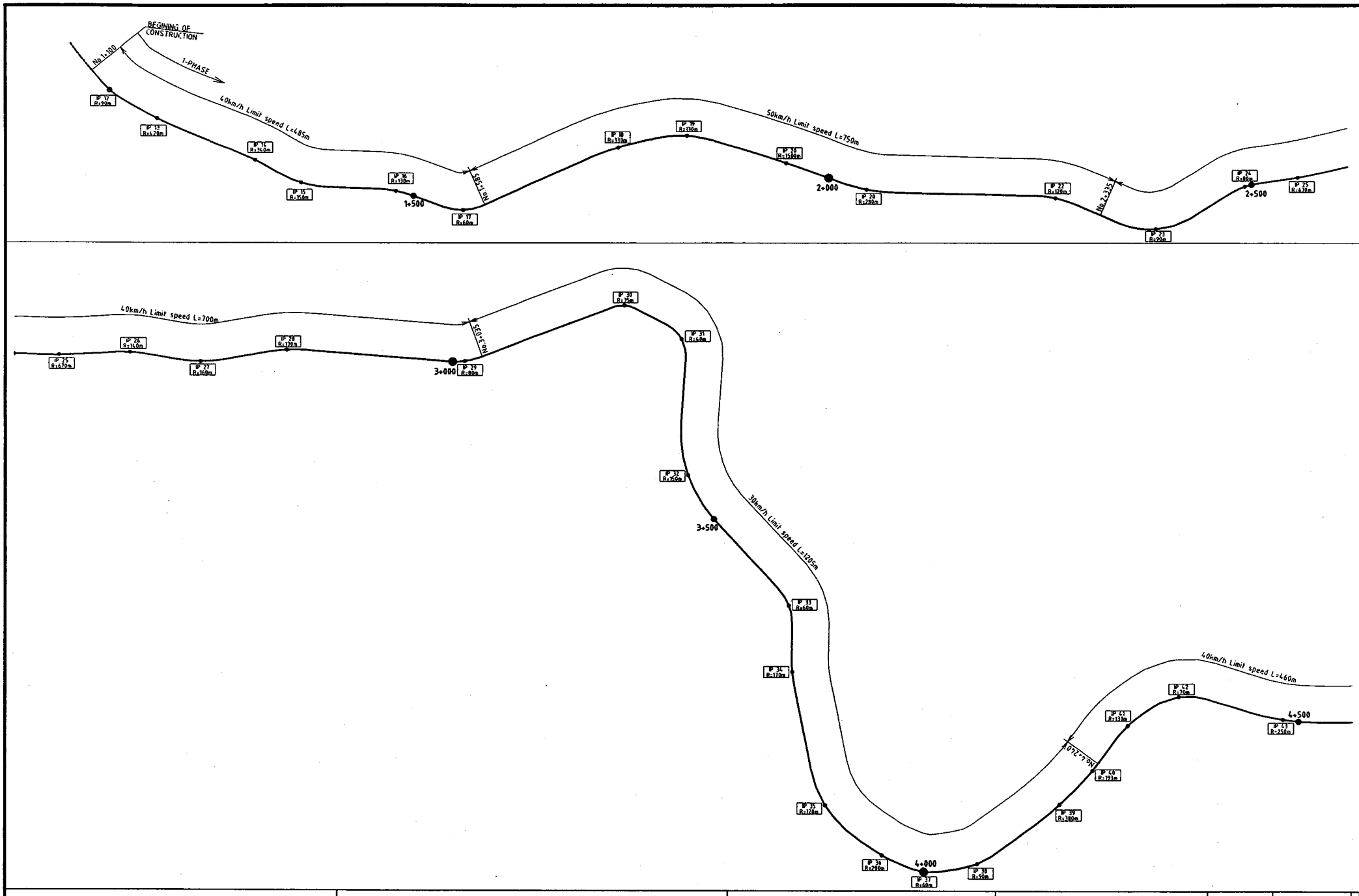

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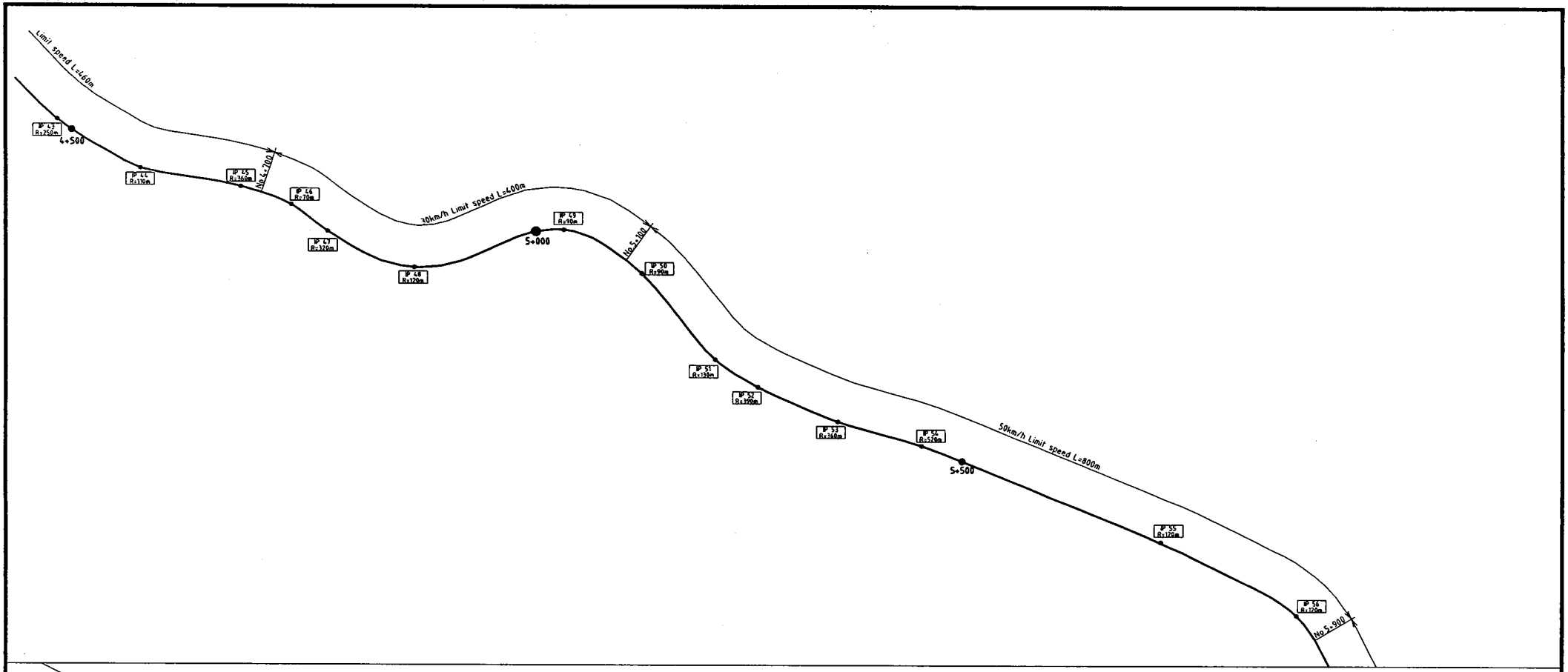

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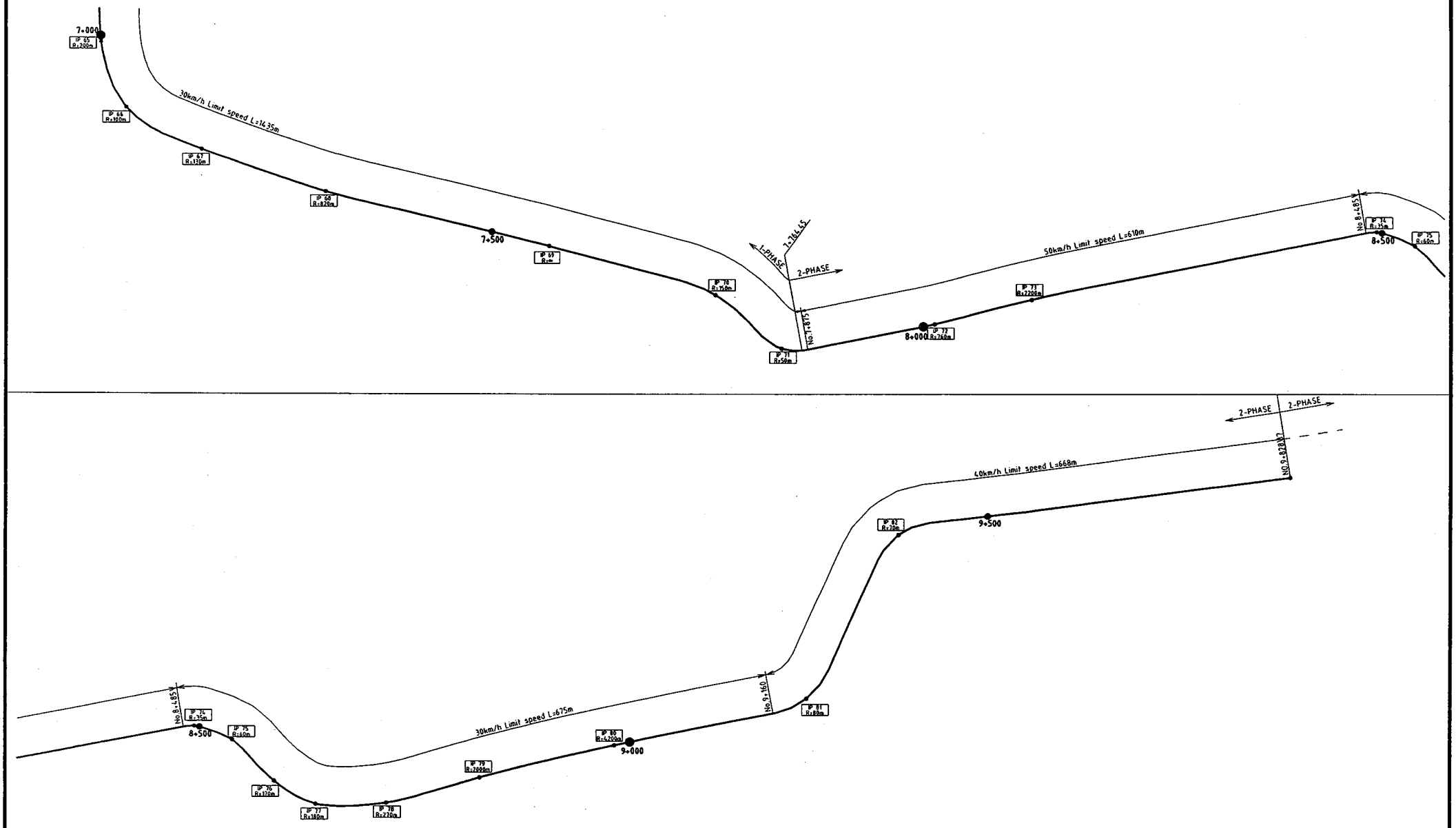
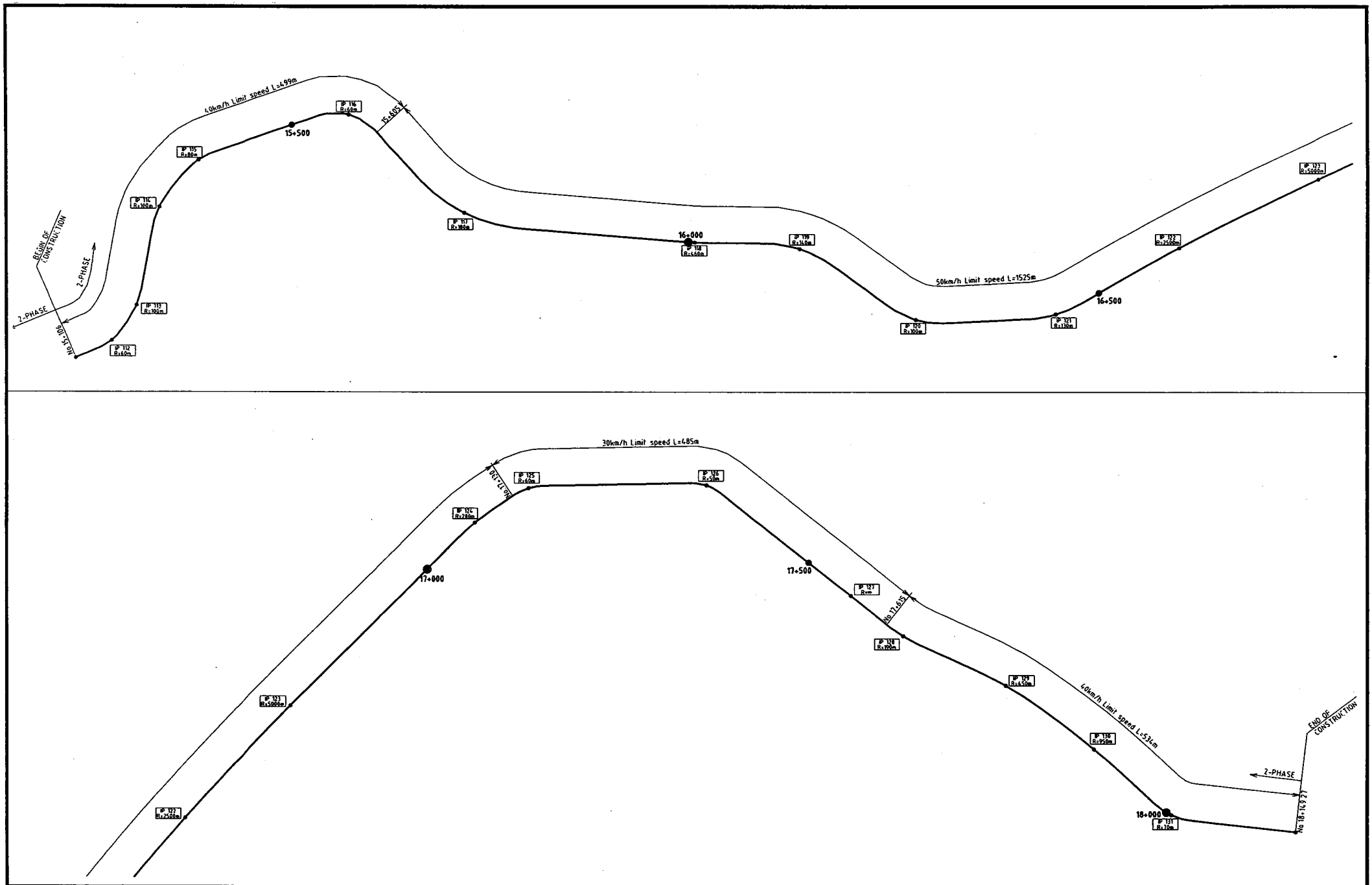
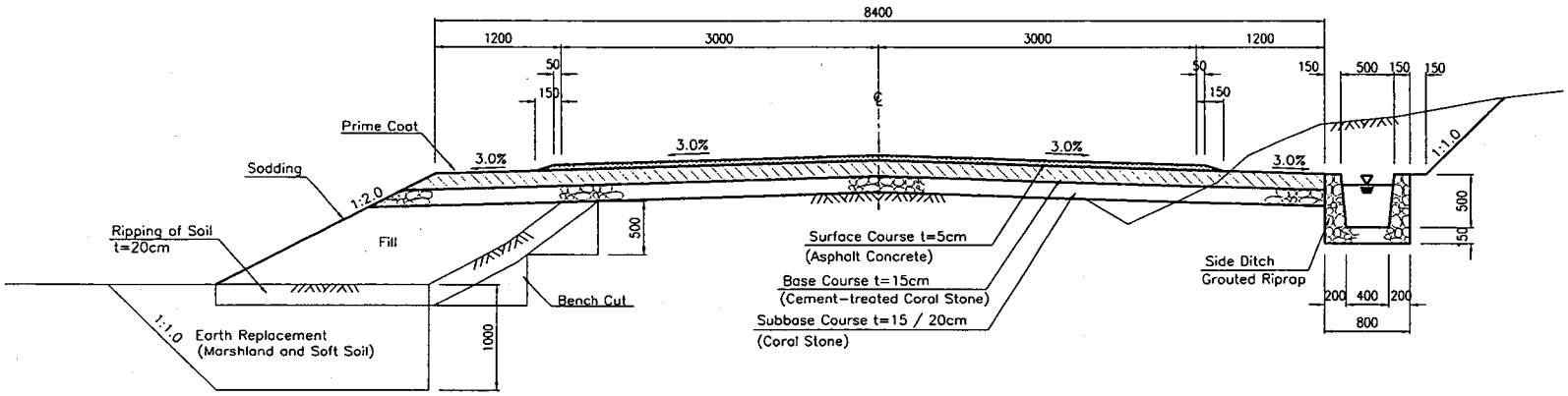


POHNPEI TRANSPORTATION AUTHORITY POHNPEI STATE , FEDERATED STATES OF MICRONESIA	BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE: KEY PLAN (3/4)	SCALE : S=1:1000	DRAWING No: G-06

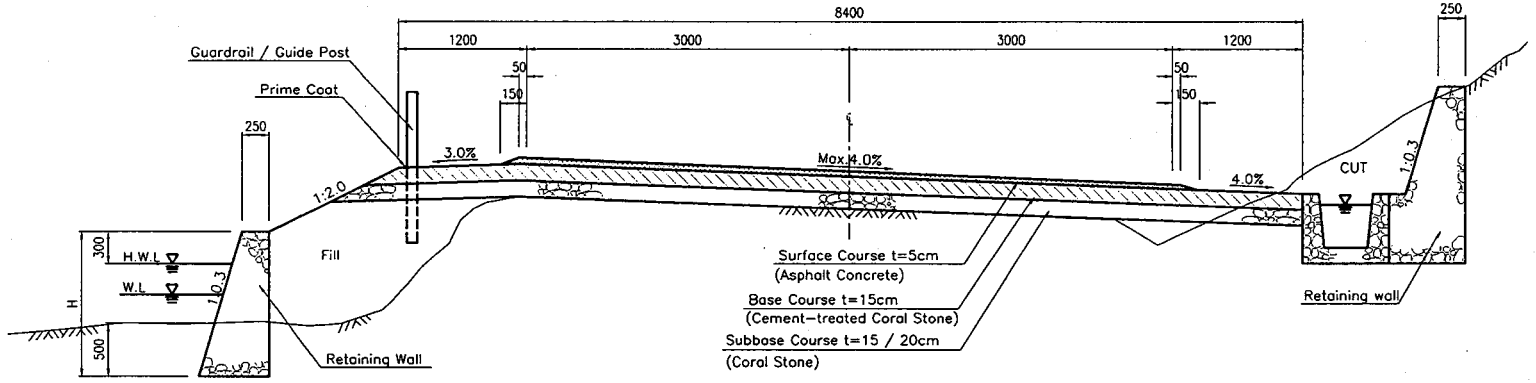


POHNPEI TRANSPORTATION AUTHORITY POHNPEI STATE , FEDERATED STATES OF MICRONESIA	BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE: KEY PLAN (4/4)	SCALE : S=1:1000	DRAWING No: G-07



TYPICAL SECTION S=1/50

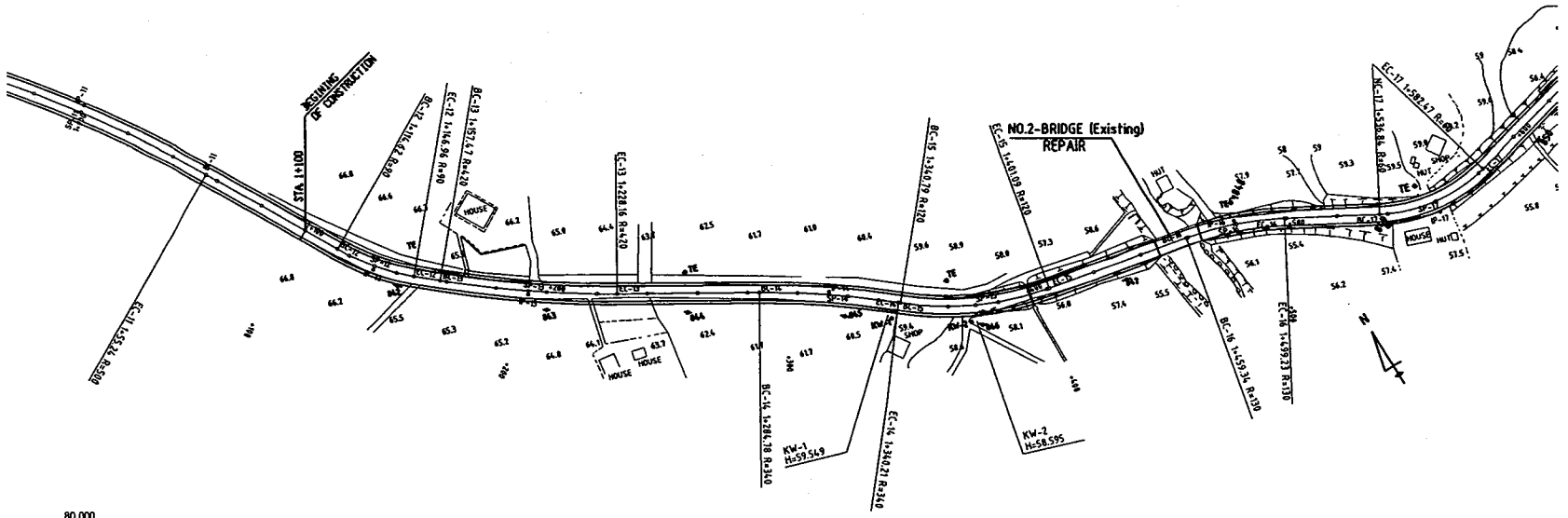
(on soft ground)

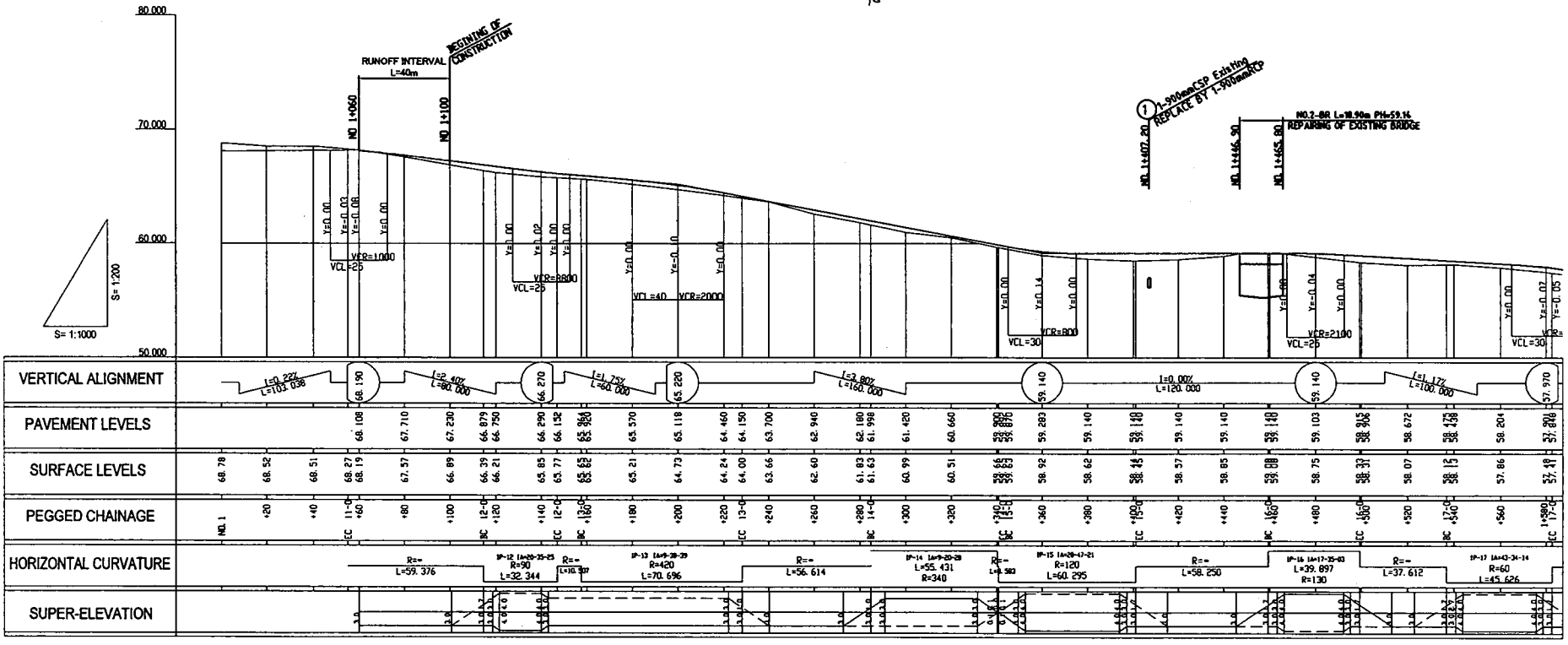


TYPICAL SECTION S=1/50

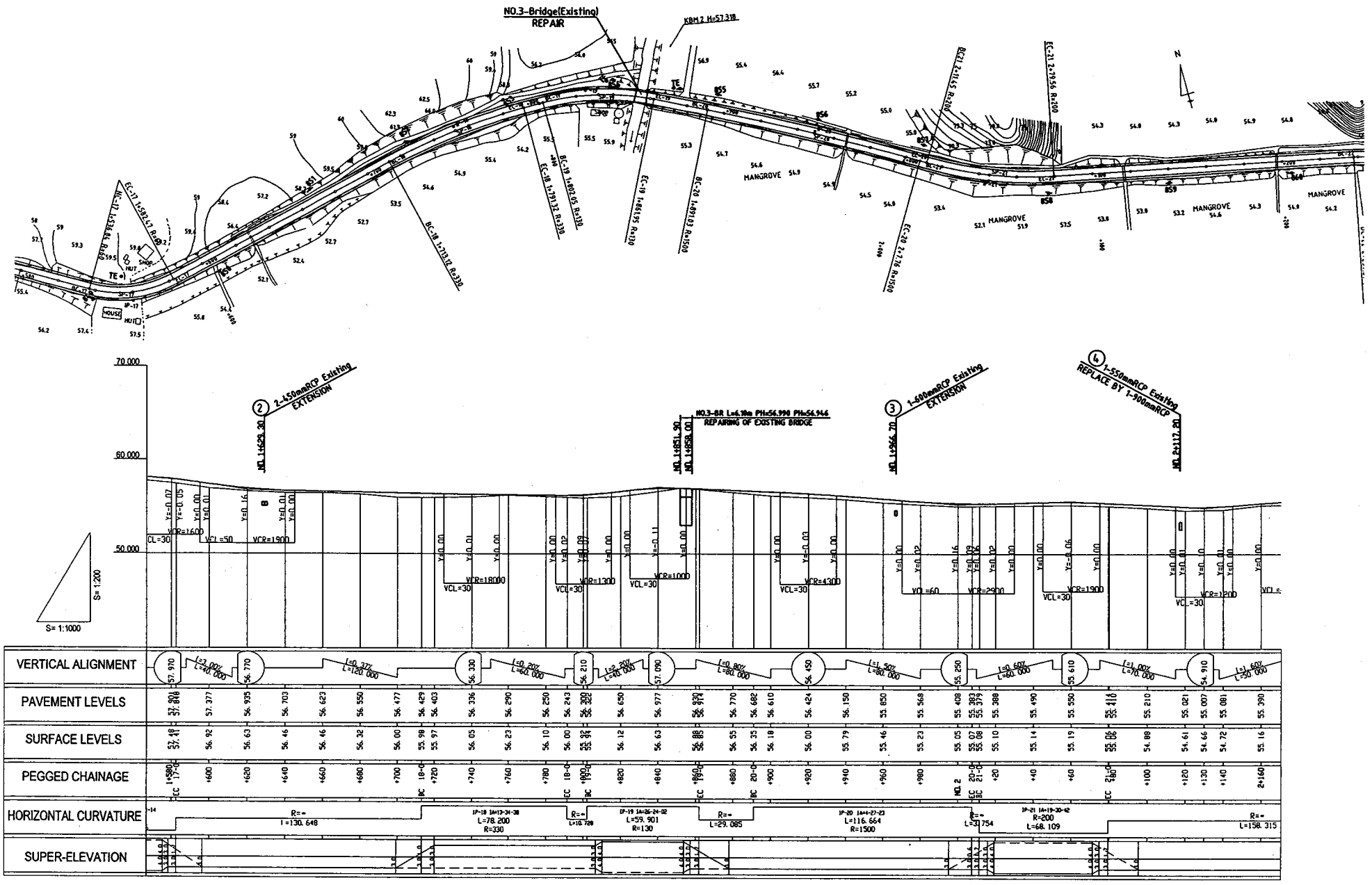
(with retaining wall)

POHNPEI TRANSPORTATION AUTHORITY POHNPEI STATE , FEDERATED STATES OF MICRONESIA	BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE: TYPICAL CROSS SECTION	SCALE : S=1:25	DRAWING No: G-08

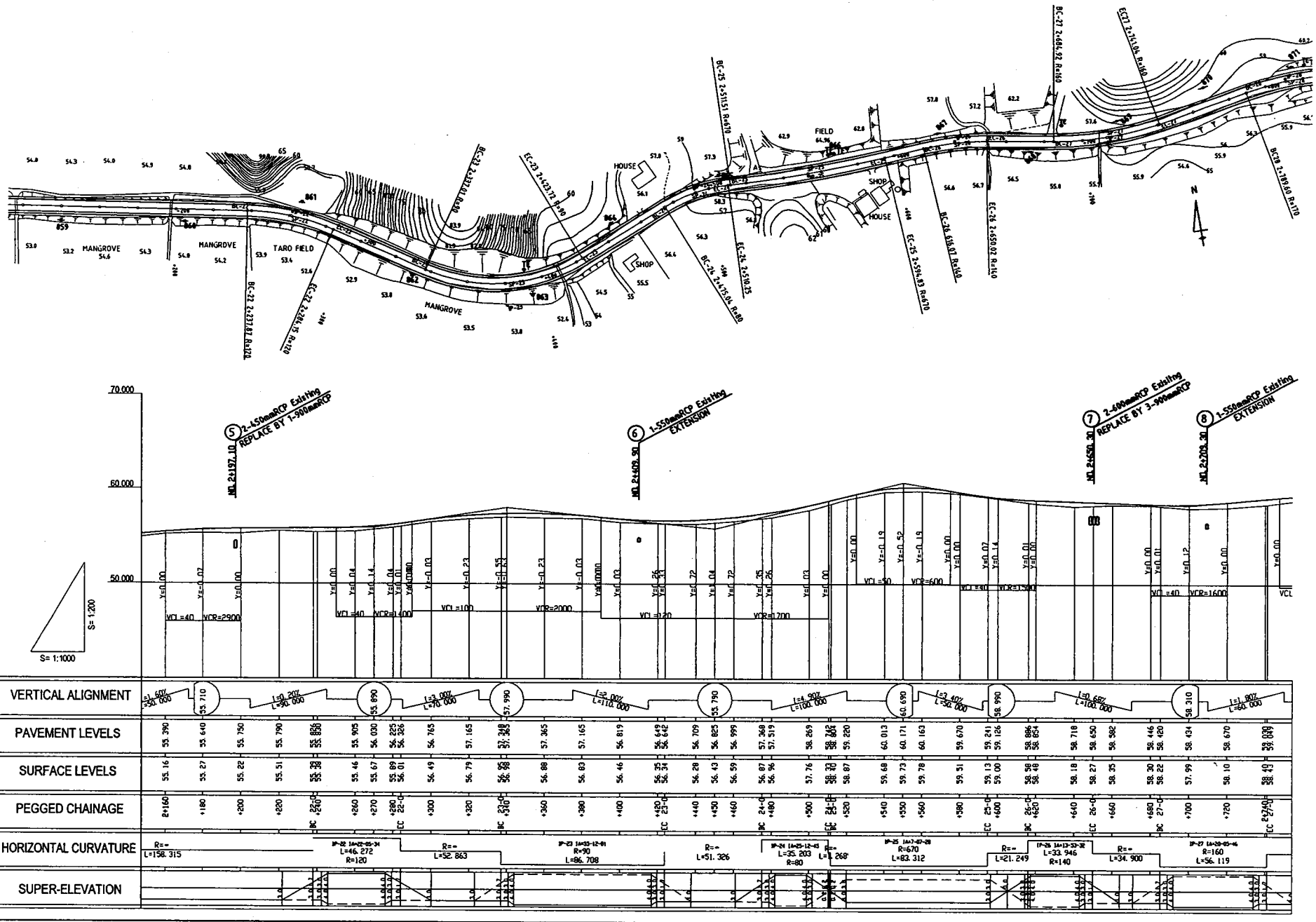




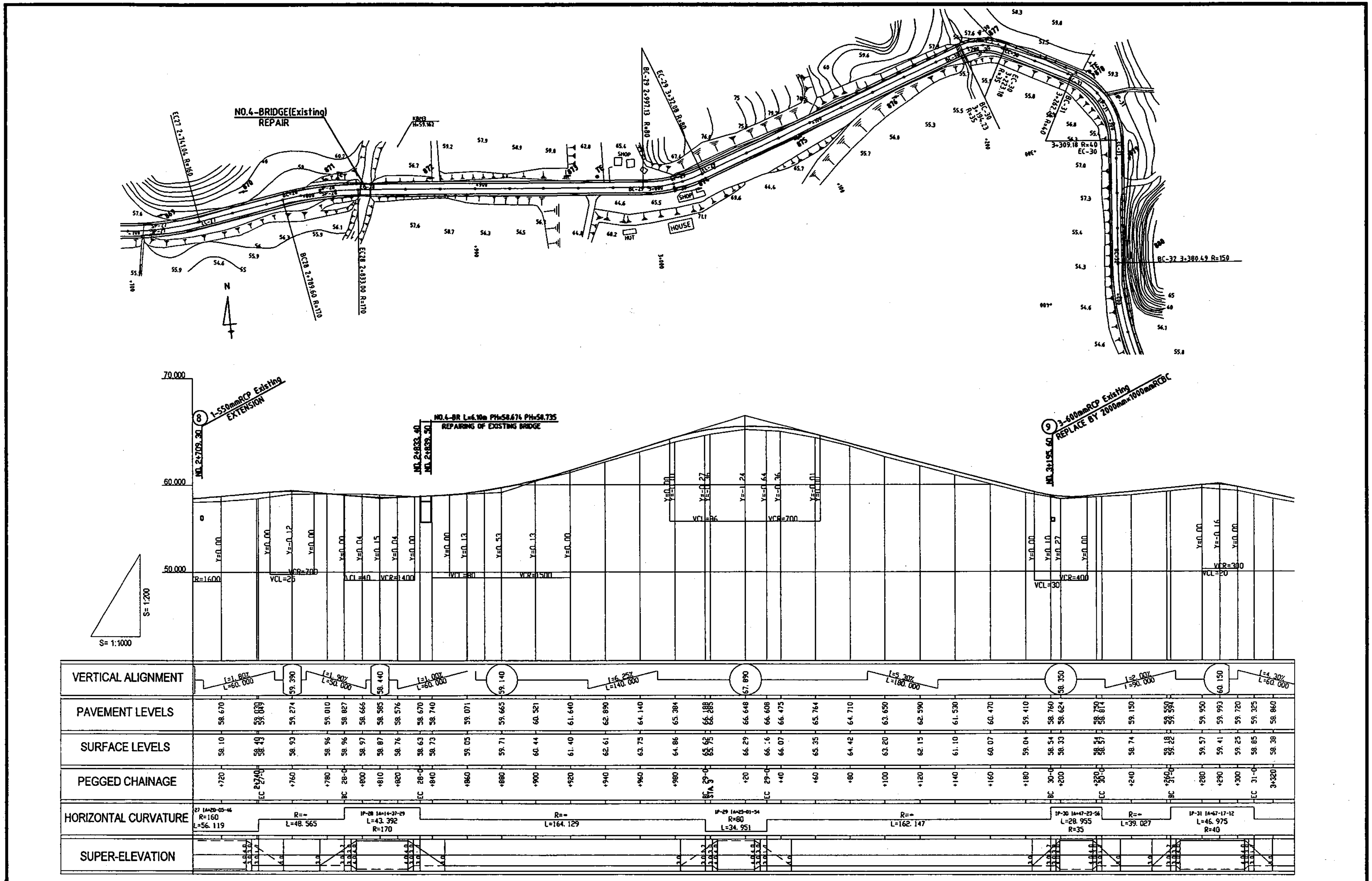
POHNPEI TRANSPORTATION AUTHORITY POHNPEI STATE , FEDERATED STATES OF MICRONESIA	BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE: PLAN&PROFILE (CH. 1+000 - CH. 1+580)	SCALE : H=1:1000 V=1:200	DRAWING No: PL-01



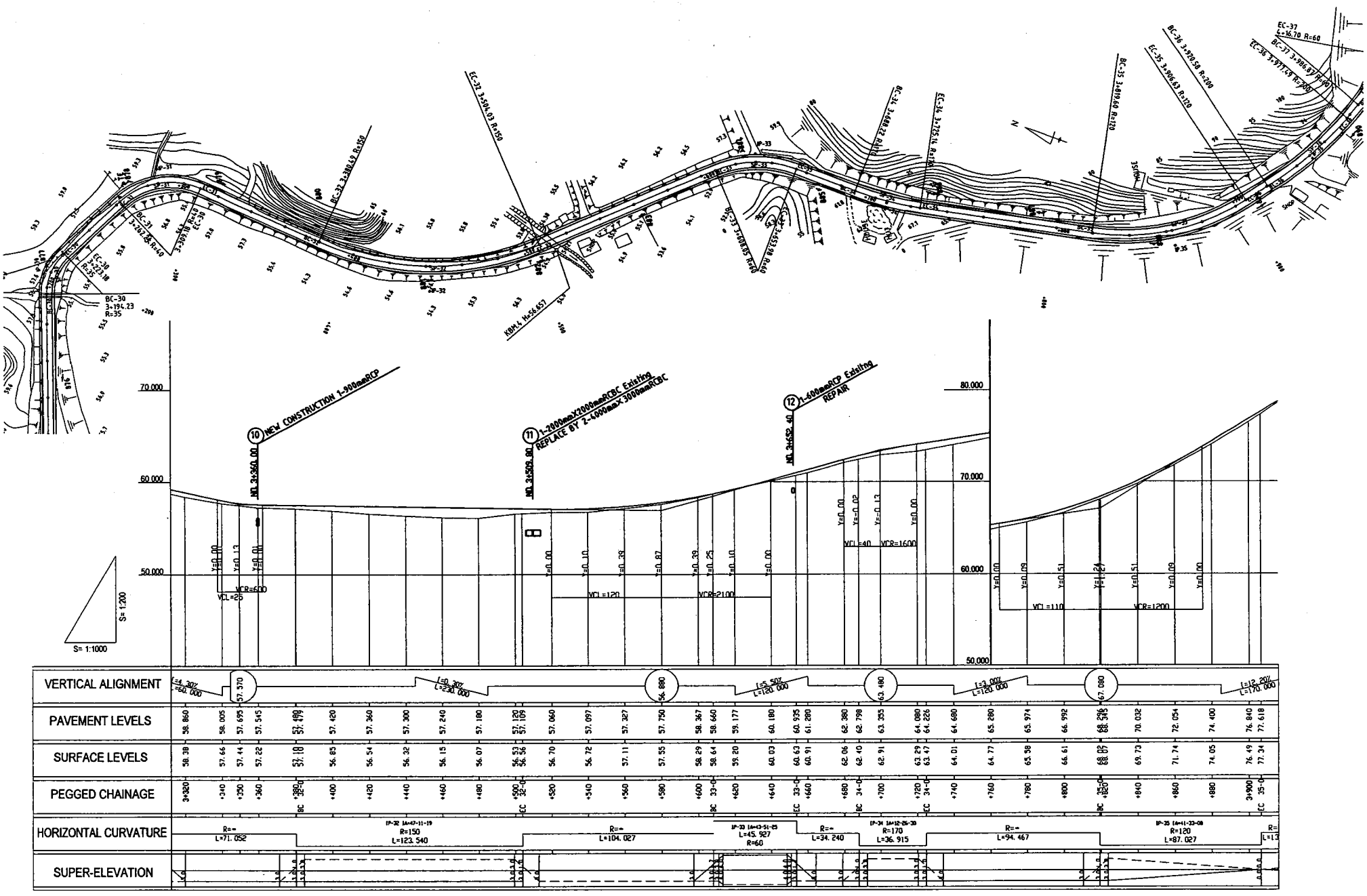
POHNPEI TRANSPORTATION AUTHORITY POHNPEI STATE , FEDERATED STATES OF MICRONESIA	BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE: PLAN&PROFILE (CH. 1+580 - CH. 2+160)	SCALE : H=1:1000 V=1:200	DRAWING No: PL-02



POHNPEI TRANSPORTATION AUTHORITY POHNPEI STATE , FEDERATED STATES OF MICRONESIA	BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE: PLAN&PROFILE (CH. 2+160 - CH. 2+740)	SCALE: H=1:1000 V=1:200	DRAWING No: PL-03



POHNPEI TRANSPORTATION AUTHORITY POHNPEI STATE , FEDERATED STATES OF MICRONESIA	BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE: PLAN&PROFILE (CH. 2+740 - CH. 3+320)	SCALE : H=1:1000 V=1:200	DRAWING No: PL-04



POHNPEI TRANSPORTATION AUTHORITY POHNPEI STATE , FEDERATED STATES OF MICRONESIA	BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF THE CIRCUMFERENTIAL ROAD AROUND POHNPEI ISLAND	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE: PLAN&PROFILE (CH. 3+320 - CH. 3+900)	SCALE : H=1:1000 V=1:200	DRAWING No: PL-05