MINISTRY OF RESOURCES & DEVELOPMENT
THE REPUBLIC OF THE MARSHALL ISLANDS

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE IMPROVEMENT
OF
THE ROAD IN MAJURO ATOLL
IN
THE REPUBLIC OF THE MARSHALL ISLANDS

FEBRUARY 1997

JAPAN INTERNATIONAL COOPERATION AGENCY

KATAHIRA & ENGINEERS INTERNATIONAL

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE IMPROVEMENT OF THE ROAD IN MAJURO ATOLL IN THE REPUBLIC OF THE MARSHALL ISLANDS
FEBRUARY 1997

MINISTRY OF RESOURCES & DEVELOPMENT
THE REPUBLIC OF THE MARSHALL ISLANDS

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE IMPROVEMENT
OF
THE ROAD IN MAJURO ATOLL
IN
THE REPUBLIC OF THE MARSHALL ISLANDS

FEBRUARY 1997

JAPAN INTERNATIONAL COOPERATION AGENCY

KATAHIRA & ENGINEERS INTERNATIONAL

PREFACE

In response to a request from the Government of the Republic of the Marshall Islands the Government of Japan decided to conduct a basic design study on the Project for the Improvement of the Road in Majuro Atoll and entrusted the study to the Japan International Cooperation Agency (JICA).

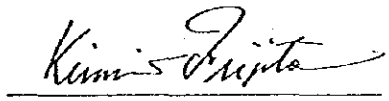
JICA sent to the Marshall Islands a study team from August 20 to September 18, 1996.

The team held discussions with the officials concerned of the Government of the Marshall Islands, 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 the Marshall Islands 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 Republic of the Marshall Islands for their close cooperation extended to the teams.

February 1997



Kimio Fujita
President
Japan International Cooperation Agency

February, 1997

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for the Improvement of the Road in Majuro Atoll in the Republic of the Marshall Islands.

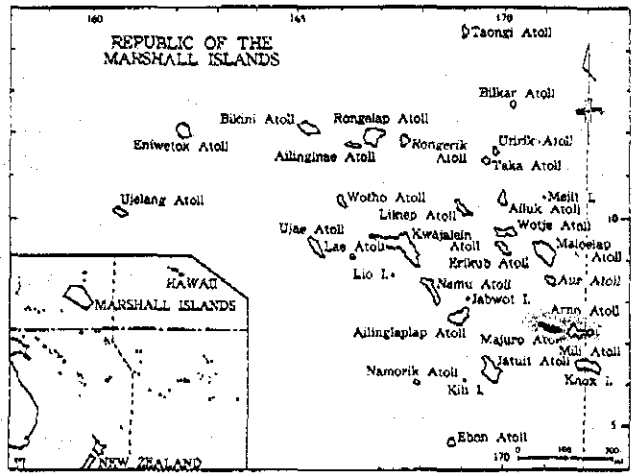
This study was conducted by Katahira & Engineers International, under a contract to JICA, during the period from August 13, 1996 to March 10, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of the Marshall Islands and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

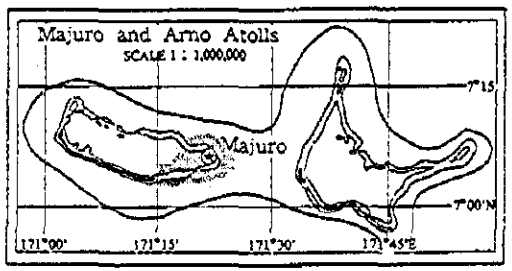
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

M. Miura

Minoru Miura
Chief Consultant
Basic Design Study Team on the Project for
The Improvement of the Road in Majuro Atoll
Katahira & Engineers International





PROJECT ROAD :

——— : Rita to Majuro Bridge : 8 km (Main road)

——— : Majuro Bridge to Majuro Airport : 8 km (Main road)

LOCATION OF THE PROJECT ROAD

ABBREVIATIONS

AASHTO	: American Association of State Highway and Transport Officials
ADT	: Average Daily Traffic Volume
CBR	: California Bearing Ratio
C.R.	: Crack Ratio
DUD	: Densely populated area in Majuro composed of Delap, Uliga and Darrit (Darrit is commonly called Rita.)
GOJ	: The Government of Japan
JICA	: Japan International Cooperation Agency
JRA	: Japan Road Association
MRD	: Ministry of Resources & Development
RMI	: The Republic of the Marshall Islands

CONTENTS

CHAPTER 1 BACKGROUND OF THE PROJECT

The main road in Majuro Atoll has an asphalt concrete surface which is in a very deteriorated condition and it lacks drainage facilities at present.

The deteriorated pavement is dangerous and inefficient for the traffic. Lack of drainage facilities causes pools on road shoulders during rain and it stays there around half a day. The pools obstruct vehicles and pedestrian traffic along the road.

More than twenty years have passed since the road was constructed and pavement rehabilitation is needed. The road condition is far from being satisfactory to support economic and daily activities in the area.

Against such road conditions, the Republic of the Marshall Islands planned the road improvement project (the Project) with high priority. To implement the Project, the Republic of the Marshall Islands requested Japan's grant aid assistance.

In response to the request, the Government of Japan decided to conduct a basic design study of the Project. The Japan International Cooperation Agency (JICA) dispatched the Basic Design Study Team from August 20 to September 18, 1996 for a field survey and discussions with the officials of the implementing agency in the Marshall Islands.

The Study Team, during its stay in Majuro, confirmed the background, objectives and contents of the Project, collected relevant data, and surveyed the Project site. After returning to Japan, the Study Team evaluated the Project in respect of necessity, socioeconomic effects, appropriateness and other factors, and studied a basic design and implementation plan.

As a result, a draft basic design of the improvement of the road section from Rita to the Majuro Airport was proposed. After explanation and consultation on the draft basic design to the officials of the Marshalls side, the basic design of the Project was developed.

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

The Project aims to improve the road section from Rita to Majuro Airport (16.7 km) of the main road in Majuro Atoll.

Major work of the Project is as follows:

- To construct drainage facilities along the road.
- To rehabilitate asphalt pavement.
- To install road markings and safety sign boards.
- To construct about 1 km long median with lighting in the vicinity of the Capitol Building.

2.2 Basic Concept of the Project

2.2.1 Conditions of the Existing Road

(1) Drainage condition

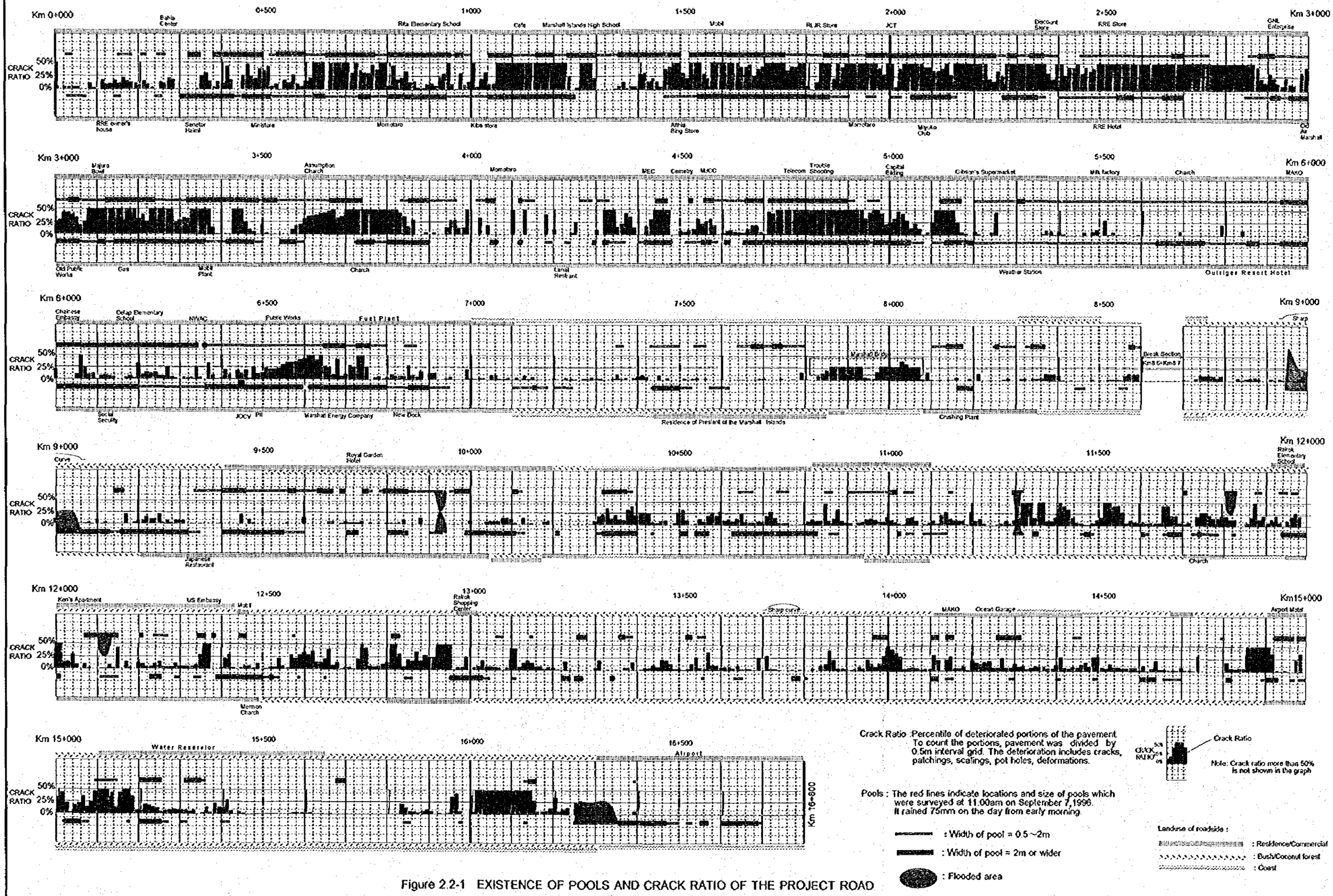
Rainwater pools on the road shoulders of the Project road when it rains. The locations and size of the pools observed at 11:00am on September 7, 1996 are shown in Figure 2.2-1. It rained 76mm on the day in the Project area from early in the morning. The Project area has such heavy rain around 10 times every year.

The figure shows that pools wider than 50cm existed continuously at both sides of the road in the DUD Section. While such pools were scattered in the Rairok Section, large pools flooded on the road existed at several sections. These pools obstruct traffic and pedestrians through the road during rain and it lasts around half a day. The major causes of the rainwater pools are as follows:

- No drainage facility is furnished for the road.
- The road and lands adjacent to the road are flat.
- The soil of the road shoulder is not very permeable.

(2) Pavement deterioration

About 20 years have passed since the pavement was constructed. The pavement is 6 to 7m wide 2 lane asphalt concrete. The DUD Section was



Crack Ratio :Percentile of deteriorated portions of the pavement. To count the portions, pavement was divided by 0.5m interval grid. The deterioration includes cracks, patchings, scalings, pot holes, deformations.

Pools : The red lines indicate locations and size of pools which were surveyed at 11.00am on September 7,1996. It rained 75mm on the day from early morning.

: Width of pool = 0.5~2m

: Width of pool = 2m or wider

: Flooded area

Crack Ratio

Note: Crack ratio more than 50% is not shown in the graph

Landuse of roadside :

: Residence/Commercial

: Bush/Coconut forest

: Coast

Figure 2.2-1 EXISTENCE OF POOLS AND CRACK RATIO OF THE PROJECT ROAD

paved with cold-mixed asphalt concrete, while the Rairok Section was paved with hot-mixed material. A typical cross section of the existing road which shows the pavement structure is shown in Figure 2.2-2.

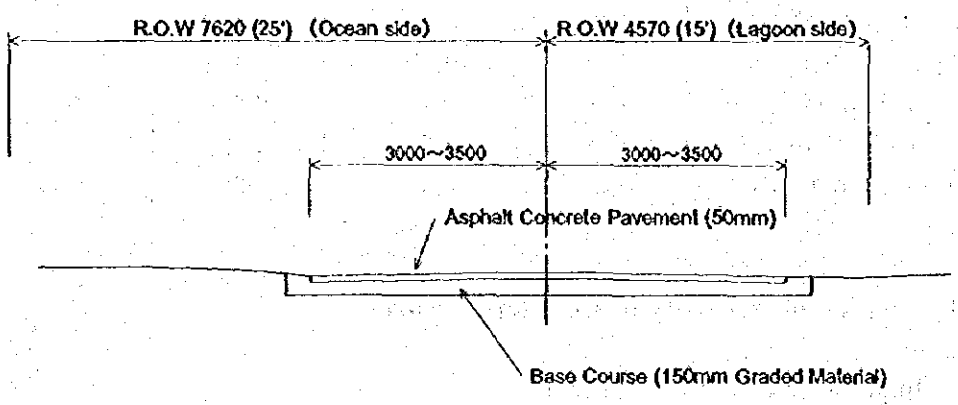


Figure 2.2-2 TYPICAL CROSS SECTION OF THE EXISTING ROAD

A sketch of the deterioration of the pavement is shown in Appendix 7. Based on the sketch, crack ratio (C.R.) of every 10m long section was counted and plotted as shown in Figure 2.2-1.

Based on the crack ratio graph, the Project road can be divided into following 3 sections regarding the condition of pavement deterioration.

- DUD Section : All sections are severely deteriorated (C.R.>25%).
- Km 6.9 to Km 13.3 : All sections are lightly deteriorated (C.R.<25%).
- Rairok Section : Severely deteriorated sections (C.R.>25) are scattered.

Major causes of the pavement deterioration are as follows:

- The asphalt pavement is dilapidated.
- The pavement structure is too weak to withstand the increased traffic.
- The pools on the road shoulders have caused pavement base course to become loose.
- Some unsuitable materials have been used for pavement base course.
- Restoration work was not properly executed after installing pipe lines under the pavement.

(3) Traffic volume

A traffic count survey at 5 stations along the Project road was carried out in the Study. The result of the survey is shown in Table 2.2-1 and Figure

2.2-3. The details of the survey are shown in Appendix 2.

Table 2.2-1 TRAFFIC VOLUME OF THE PROJECT ROAD (Veh./day/2dir.)

Station	Heavy Veh.	Light Veh.	Total Veh.	Pedestrians
No.1 Rita (Km 1.25)	98	6,224	6,322	543
No.2 Uliga (Km 2.75)	90	10,691	10,781	665
No.3 Dalap (Km 5.80)	128	9,726	9,854	608
No.4 Majuro Br.(Km 7.80)	55	4,444	4,499	34
No.5 Rairok (Km 12.90)	45	2,852	2,897	233

2.2.2 Evaluation of Necessity of Countermeasures

(1) Importance of the Project road

The Project road is the busiest sections of the main road which penetrate Majuro Atoll. It is transporting great numbers of commuters, students, shoppers and goods to support economic and daily activities in Majuro. Therefore it is very important.

(2) Necessity of countermeasures to prevent pools on road shoulders

Major problems caused by the pools on the road shoulders are as follows:

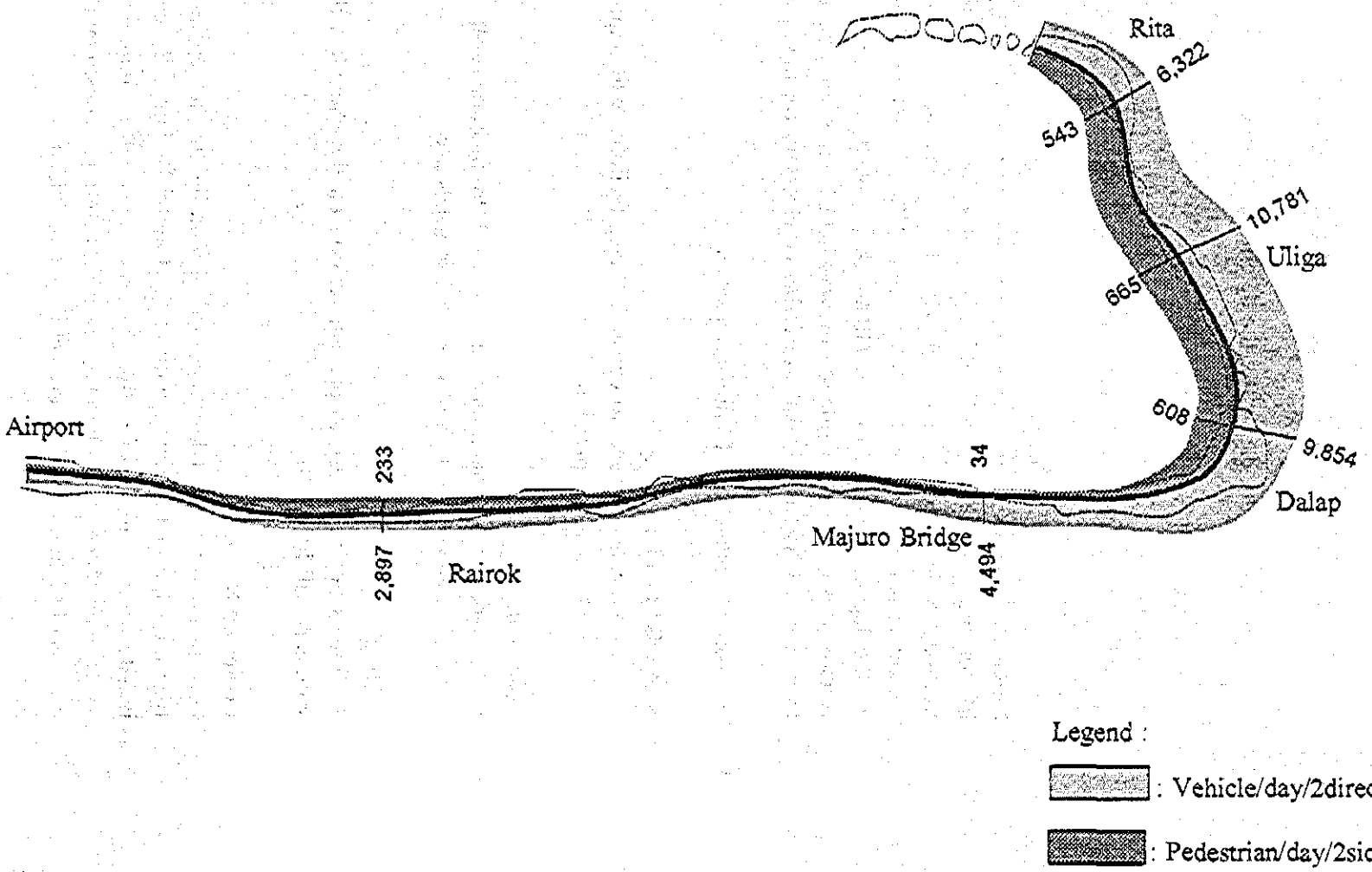
- Pools narrow the carriageway.
- Large pools flood over roads and stop traffic at the sagging sections.
- Vehicles easily encounter problems by passing into pools.
- Salty water shortens life of the vehicles.
- Pedestrians have no way to walk along the road.
- Muddy water splashes pedestrians.
- Pools erode shoulders.
- Pools deteriorate pavement.

The problems are being caused by the common amount of rain and affecting a great number of the population. Therefore countermeasures to drain pools on the road shoulders are urgently required.

Countermeasures are as follows:

- To construct road side ditches where pools are and to construct ditches, canals, pipes to drain this water to the sea.
- To elevate sagging sections by embankment.

Emergency drain facilities necessary to drain heavy flooding which may



Source: Traffic survey in this Study.

Figure 2.2-3 TRAFFIC VOLUME (1996)

be caused by high tides or typhoons were requested. However, since this Project aims to ease daily problems, it should not cope with such abnormal phenomena. Therefore, the drainage facilities sufficient to drain pools being caused by common rainfall should be provided.

(3) Necessity of countermeasures to prevent deteriorated pavement

Major problems being caused by the deteriorated pavement are as follows:

- Pot holes are dangerous for driving.
- Running cost is high.
- Driving is uncomfortable and slow.
- It is noisy and dusty.

Based on the crack ratio and visual inspections, it is judged that the usable life of the pavement of the DUD Section is over. And in the Rairok Section, severely deteriorated pavement sections are scattered. It is recommended, in the Road Maintenance and Rehabilitation Manual issued by the Japan Road Association (JRA), that asphalt overlay is a suitable countermeasure for rehabilitation of pavement having crack ratio of more than 20 or 30. Therefore, asphalt overlay is necessary for the Project.

(4) Necessity of other road facilities requested

Sidewalks and bus stops

It is not urgent, however, to construct these facilities will improve safety and comfort for the population.

Road centerline

Road markings are necessary for the road to function well. Sidelines, crosswalks, and safety sign boards are also necessary.

Turfing

Turfing is not necessary to prevent erosion on the shoulders if the road shoulders will be paved.

Boulevard Section

Construction of about 1 km long median with lighting to separate a 4 lane road are requested in the vicinity of the Capitol Building. By constructing it, safety and comfort for traffic and pedestrians will be improved and the road appearance will be improved. Therefore, construction of the boulevard section under the Project is recommended.

2.3 Basic Design

2.3.1 Design Concept

2.3.1.1 Design concept

The concepts of the basic design for the Project are as follows:

(1) General

- Local conditions should be reflected.
- The facilities should be easy to maintain.
- The facilities should be economical and durable.
- Labor intensive method should be taken into consideration.
- Attention should be paid to environment protection.
- Possibility of land acquisition and removal of encroachments should be clear.

(2) Drainage facilities

- Construction of ditches at both sides of the road is proposed.
- Drainage facilities under the Project include pipes and other facilities necessary to drain from the roadside to the sea.
- To minimize siltation in the lagoon, drain to the lagoon directly from the road should be avoided as much as possible.(Ditches will be made of porous concrete base. Drain to the ocean where possible. Infiltration basins will be installed to the drain pipes to the lagoon.)
- Size of the facilities should be planned based on discharge vs. capacity analysis.
- Rainwater on the private lots should not be taken into ditches.
- Several types of ditches should be studied and proposed to be optimum to the site conditions.
- The facilities should be usable for longer than 50 years.

(3) Pavement rehabilitation

- Asphalt concrete (AC) overlay for whole sections of the Project road is proposed. The AC overlay should be designed based on the conditions of existing pavement, traffic volume, subbase and others.
- Providing road markings, safety sign boards and a boulevard section is proposed.
- Width of the road and shoulders by section should be planned based on the conditions of traffic, pedestrians, land use, encroachments and others.(Wide shoulders should be provided for stopping of taxis in the

DUD Sections because traffic jams are frequently caused by stopping of taxis)

- The AC overlay should be designed so that further rehabilitation is not needed for more than 10 years after the Project.

2.3.1.2 Design criteria

Design standard

Standards of the JRA or American Association of State Highway and Transportation Officials (AASHTO) are adopted for the Project.

Unit system

Following commonly used international units are adopted:

Unit : km, m, cm, mm, kgf, second (sec), minutes (min) and hours (h)

Design rainfall

Design intensity of rainfall is 10 minutes duration intensity of 2 year return period. It was derived from an analysis based on the 10 minutes rainfall data in Majuro.

Tide level (Datum is the Mean Sea Level)

Highest high tide level=+1.0m
Lowest low tide level =-1.0m

Design traffic volume (Vehicle/day/2directions)

It was obtained based on the traffic count survey.
DUD Section : 11,000
Rairok Section : 4,500

Design speed

It is proposed based on the observation of actual running speeds and the traffic regulations.
DUD Section : 40 km/h
Rairok Section : 60 km/h

Right of Way (Width from the existing road center)

25' (7.5m) to the ocean side.
15' (4.5m) to the lagoon side.

2.3.2 Basic Design

2.3.2.1 Drainage facilities

(1) Design rainfall intensity

A 130 mm/h of design rainfall intensity was derived based on an analysis of rainfall data obtained from the Majuro Weather Station. Details of the analysis are reported in Appendix 8.

(2) Planning of ditches

The special criteria for planning of ditches are as follows:

- The base of the ditches should be porous to infiltrate water to the ground.
- To prevent depositing of mud and sand, the discharge velocity should be faster than 0.6 m/sec.
- The structures should be accommodated within the Right of Way.
- Top of the ditches should be passable for vehicles in the DUD Section since vehicles run across the road shoulders.
- Maintenance required is minimal. Neglecting of maintenance should not result in complete stopping of the drain.

A comparative study of the structures was made as shown in Figure 2.3-1. As a result, Ditch Type-A was selected for both sides of the DUD Section and the lagoon side of the Rairok Section. For the ocean side of the Rairok Section where vehicles seldom run across the road shoulders, Ditch Type-B as shown in Figure 2.3-2 was proposed. For the special cases, Ditch Type-C and D were proposed to cross different types of branch roads and Ditch Type-E was proposed to be installed where armor stone dikes are very close to the road. Ditch Type C, D and E are shown in Figure 2.3-2.

The calculation of discharge, infiltration and velocity of every span of ditches planned as shown on the layout of the drainage facilities is shown in Appendix 8. Since there is not much experience with the infiltration type ditches and the design method is not authorized, a trial construction for infiltration test is proposed. A scheme of the test is shown in Figure 2.3-3.

Since the land is very flat and it is infiltrate structure, the discharge velocity of some ditches are slower than required. Therefore, sand basins which collect mud and sand were proposed at around every 20m along Ditch Type-A. The proposed sand basin is shown in Figure 2.3-4. Periodic

cleaning of sand basins is required.

Precast concrete ditch covers were proposed for Ditch Type-A and C as a standard cover, while grating covers were proposed for Ditch Type-D as a heavy duty cover. The dimensions of the covers were proposed based on the commonly used Standard Design in Japan. The details of the ditch covers are shown in Figure 2.3-4. Grating covers were also proposed for sand basins because it is very easy for inspection and cleaning basins.

(3) Planning of culverts

Culverts to cross main roads

The special criteria for planning of culverts to cross main road are as follows:

- To drain well, the elevations of culvert inlets should not be higher than roadside ditch outlets and culvert outlets should not be lower than inlets of culverts draining to the sea.
- Top of the culverts should not be higher than bottom of pavement.
- The culverts should be structurally durable against main road traffic.
- The culverts should have capacity to drain discharge from the upstream ditches.
- To prevent depositing of mud and sand, the grade should be steeper than 0.2% and the discharge velocity should be faster than 0.6 m/sec.

As a result, Ditch Type-F as shown in Figure 2.3-5 was proposed for culverts to cross main roads. The calculation of discharge and velocity of every culvert planned as shown on the layout of the drainage facilities is shown in Appendix 8.

Culverts to drain from the road to the sea

The special criteria for planning of culverts to drain from the road to the sea are as follows:

- It should be culvert type but channeled due to the desire of the land owners .
- The culvert should have capacity to drain discharge from the upstream.
- The grade should be steeper than 0.2% and the discharge velocity should be faster than 0.6 m/sec.
- The outlet of the culverts should not be lower than the highest high tide level insofar as possible.

As a result of comparison between concrete culverts and PVC pipes, PVC pipes were selected. The sizes of the PVC pipes are shown in Figure 2.3-5.

Since the land is flat and low, the elevations of some of the outlets were planned lower than the highest high tide level. However, it will not be a problem since the highest high tide does not close any of the outlets completely.

The calculation of discharge and velocity of every culvert planned as shown on the layout of the drainage facilities is shown in Appendix 8.

(4) Planning of basins

Proposed basins are shown in Figure 2.3-6 and 2.3-7. Basin Type-A was proposed for connecting ditches and culverts. Basin Type-B was proposed for maintenance PVC pipe culverts. For inspection and maintenance, Basin Type-B was proposed at intervals of less than every 30m along PVC pipe culverts. The dimensions were considered for providing room for maintenance work. Grating covers were proposed for the convenience of inspection and maintenance.

As said in the design concept, it is undesirable to drain muddy water directly from the road to the lagoon, Basin Type-C was proposed for installation in the PVC pipe culverts which drain to the lagoon. The muddy water which discharges when rain starts will fall into the bottom of the basins and infiltrate into the ground. Basin Type-C should be installed close to the coast since it is very permeable.

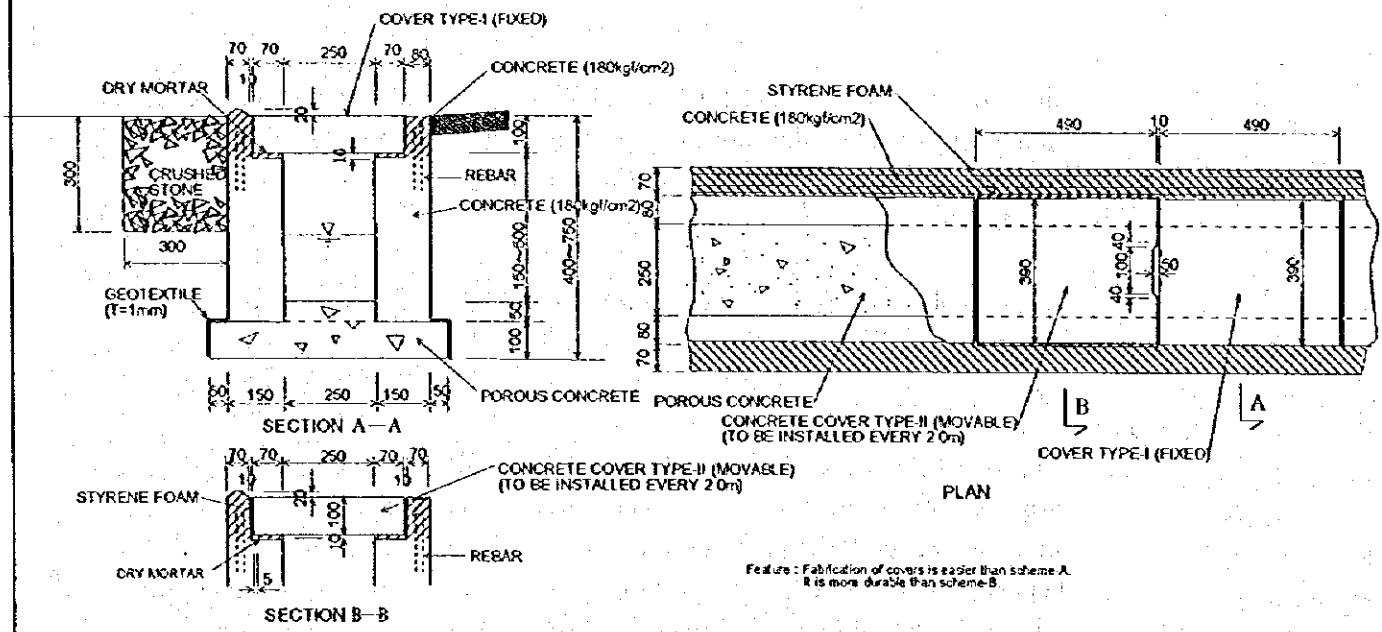
Fine grid type grating covers were proposed for Basin Type B and C to prevent dropping of objects into the basins since they are to be installed in private lots.

(5) Planning of outlets

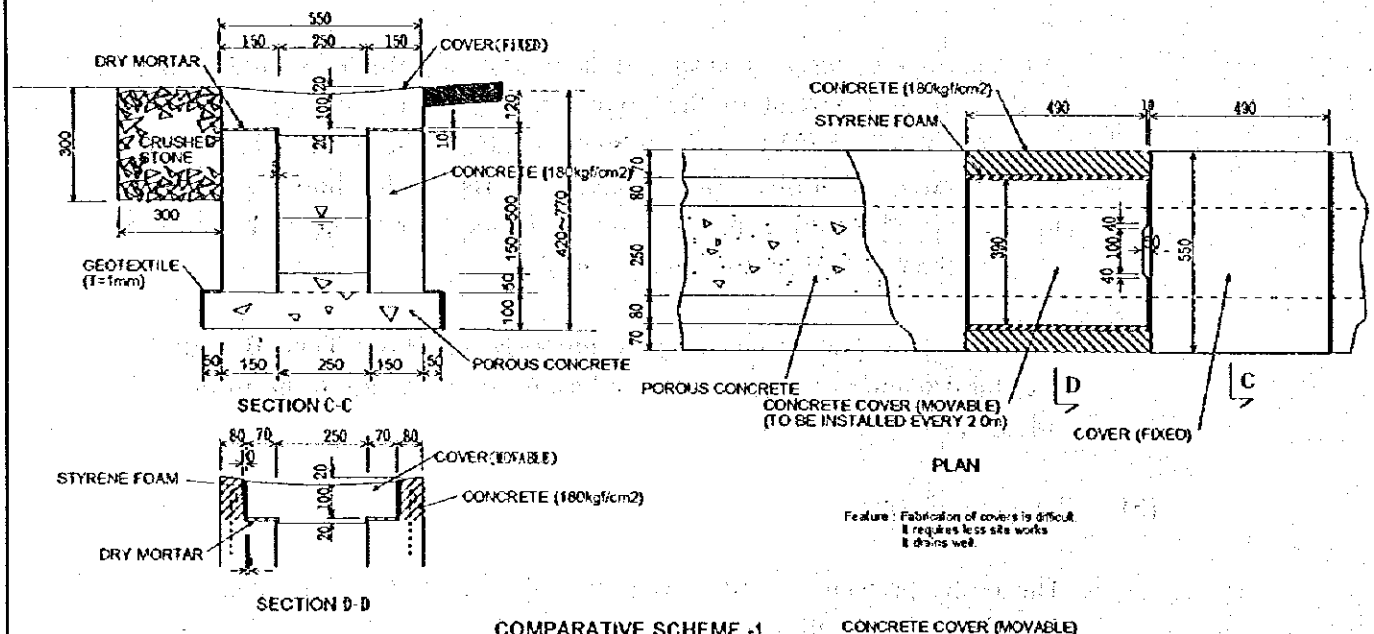
The outlet protection work was proposed to protect outlets from waves. The four types were proposed against different conditions of wave and ground as shown in Figure 2.3-8 and 9.

(6) Layout of drainage facilities

As a result of the basic design of the drainage facilities for the Project, the layout of drainage facilities was developed as shown in Figure 2.3-10.

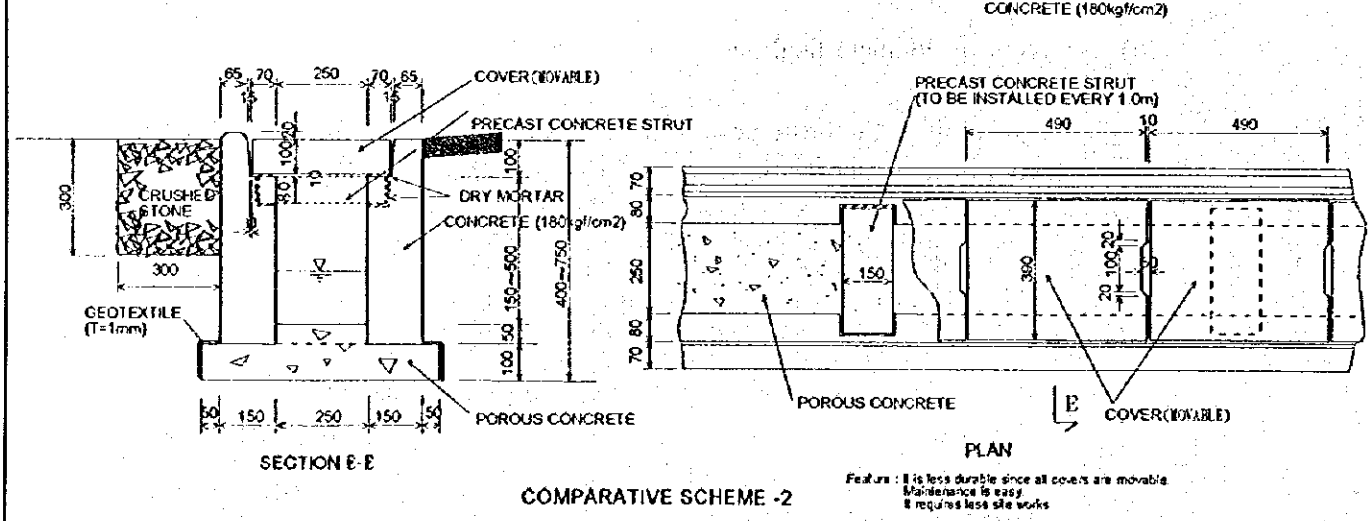


SELECTED SCHEME (DITCH TYPE-A)



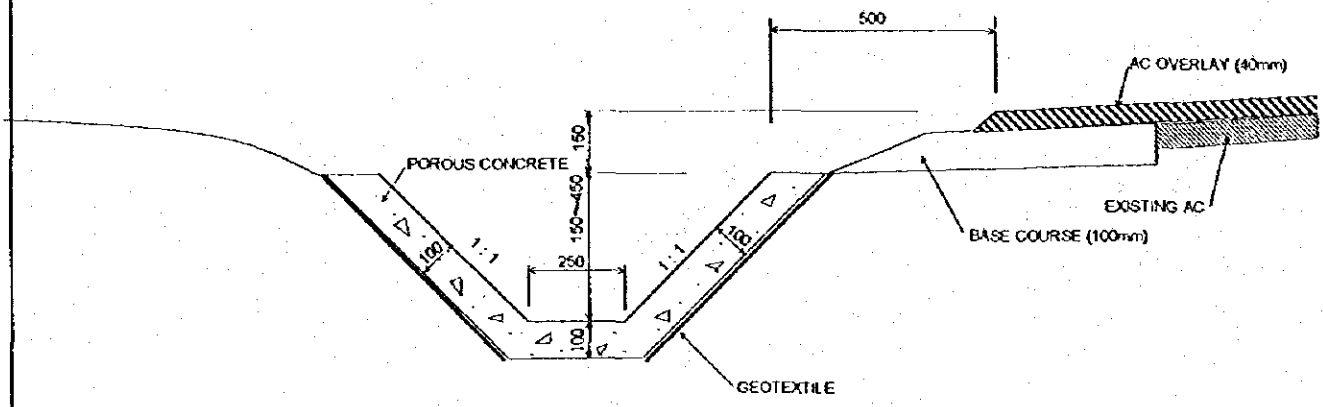
COMPARATIVE SCHEME -1

CONCRETE COVER (MOVABLE) (TO BE INSTALLED EVERY 2.0m)



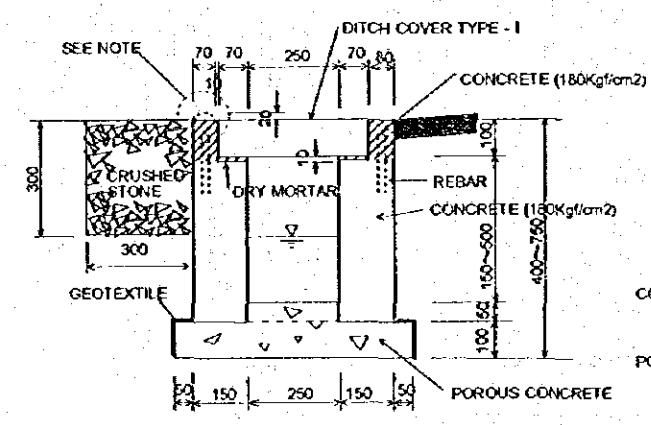
COMPARATIVE SCHEME -2

FIGURE 2.3-1 COMPARISION OF STRUCTURE OF DITCHES



DITCH TYPE - B

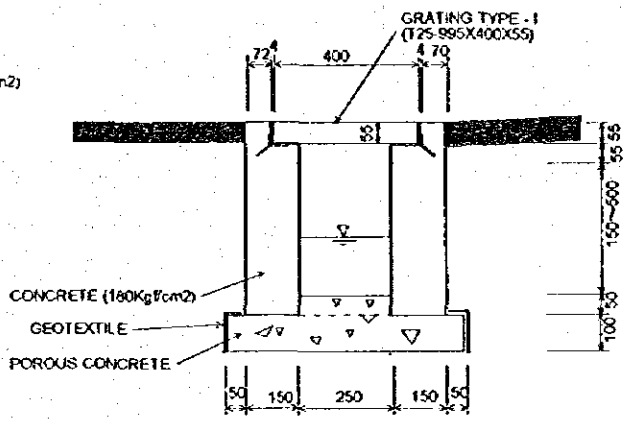
(FOR THE OCEAN SIDE OF THE RAIROK SECTION)



DITCH TYPE - C

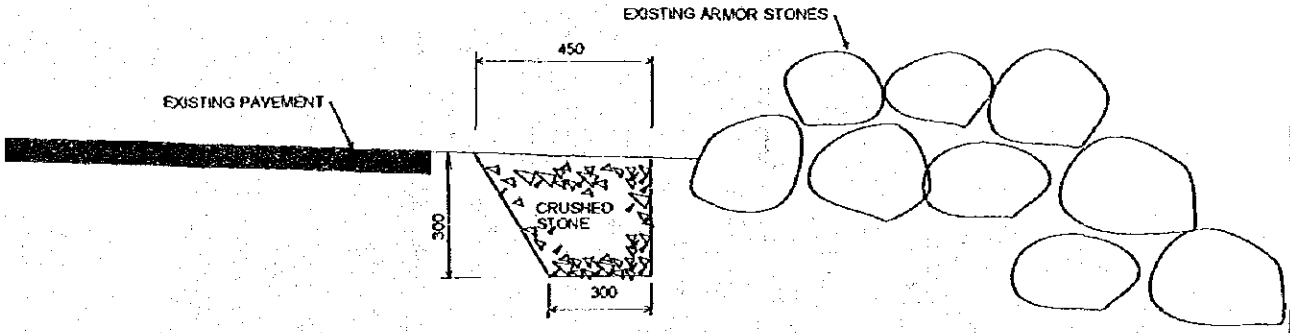
(FOR CROSSING FEEDER ROADS AND HOUSE ACCESS ROADS)

NOTE : - THE KEY FOR DRAIN SHALL BE FURNISHED WHERE NECESSARY.



DITCH TYPE - D

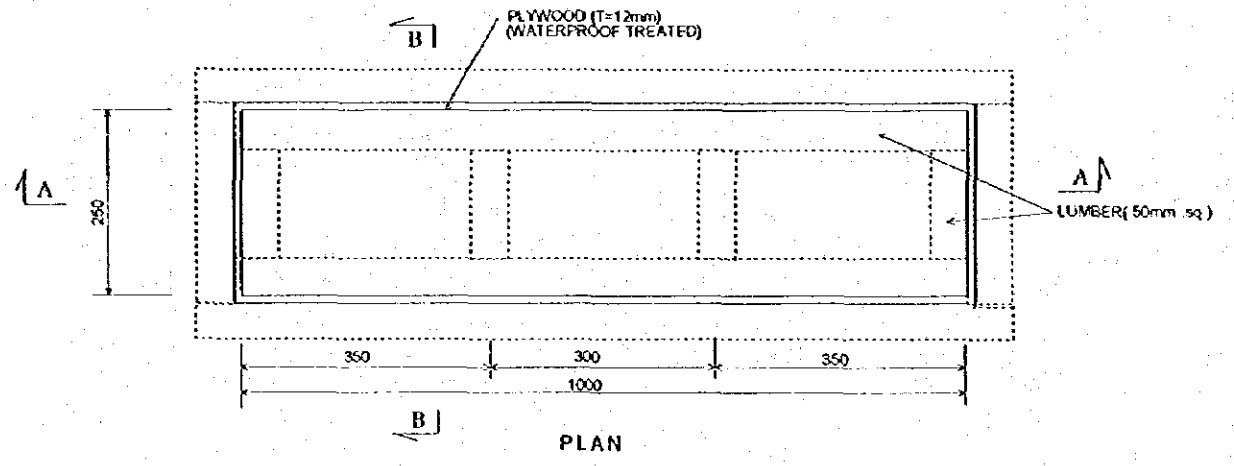
(FOR CROSSING SECONDARY ROADS AND HEAVY DUTY MACHINE ACCESS ROADS)



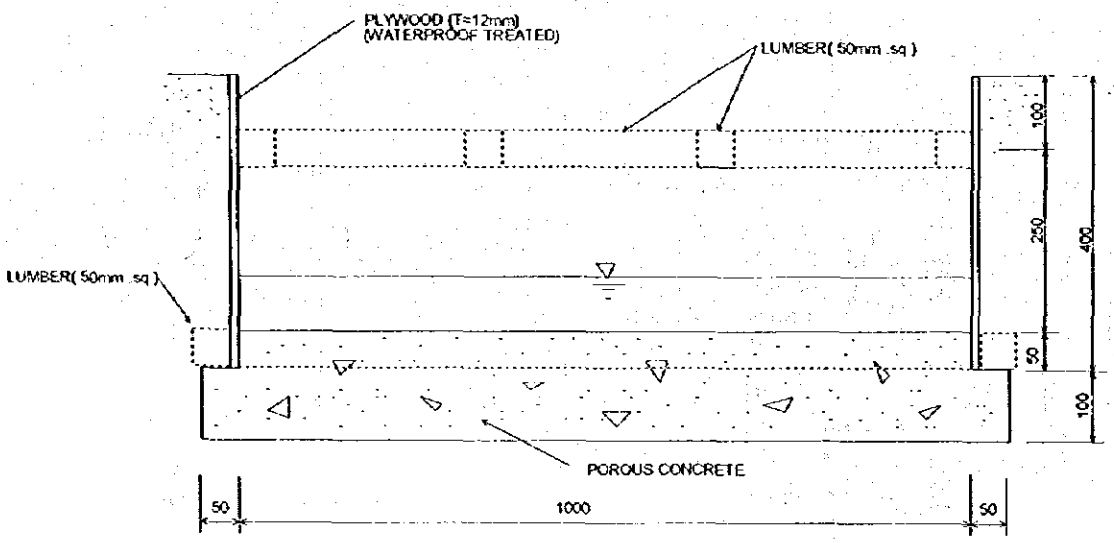
DITCH TYPE - E

(FROM KM 16+300 TO KM 16+700)

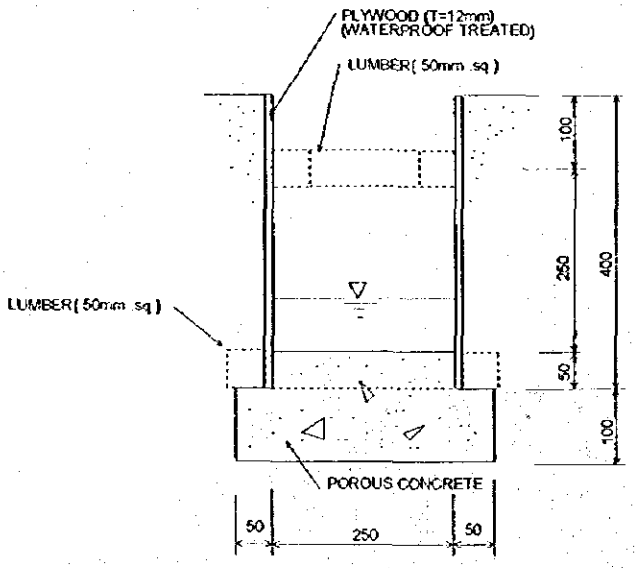
FIGURE 2.3 -2 OTHER TYPES OF DITCH



PLAN



SECTION A - A

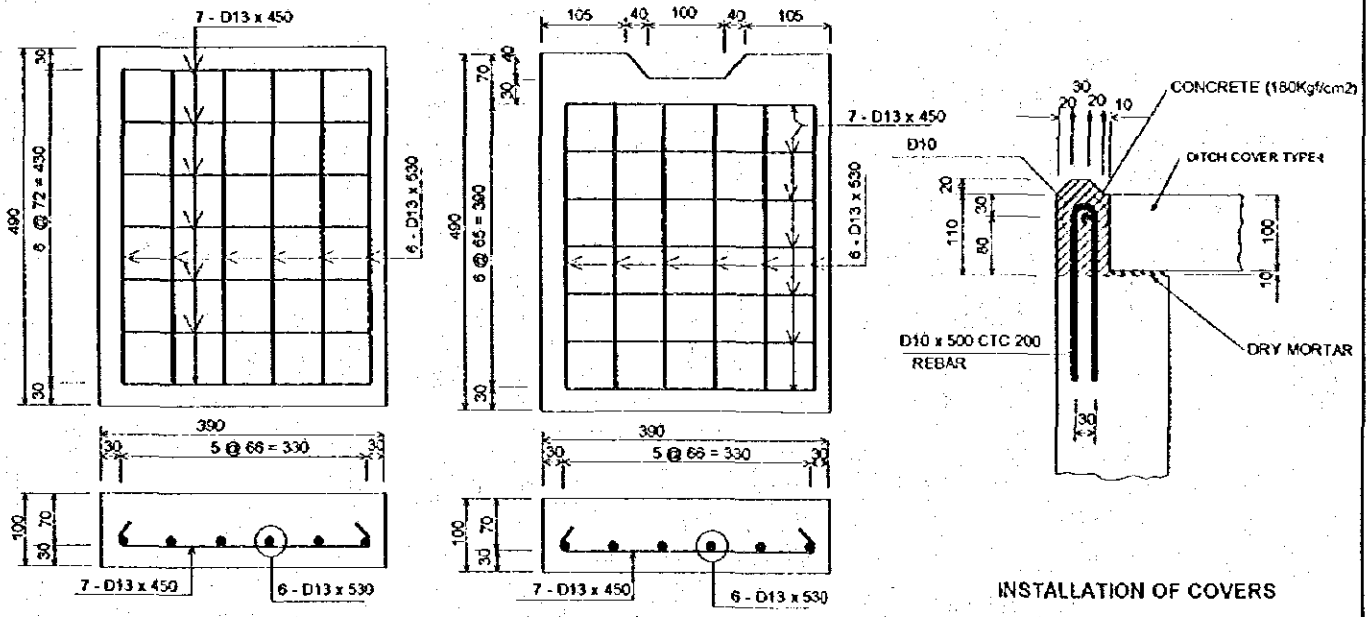


SECTION B - B

TEST ITEMS : 1) AMOUNT OF WATER TO FILL UP VOID OF POROUS CONCRETE AND SANDY GROUND WHEN IT IS DRY.
2) AMOUNT OF WATER TO BE INFILTRATED IN THE GROUND CONSTANTLY WHEN WATER IS 10CM DEEP.

TEST LOCATIONS : 5 SITES TO COVER VARIETIES OF SOIL CONDITIONS

FIGURE 2.3 - 3 SCHEME OF TRIAL CONSTRUCTION FOR INFILTRAION TEST OF DITCHES

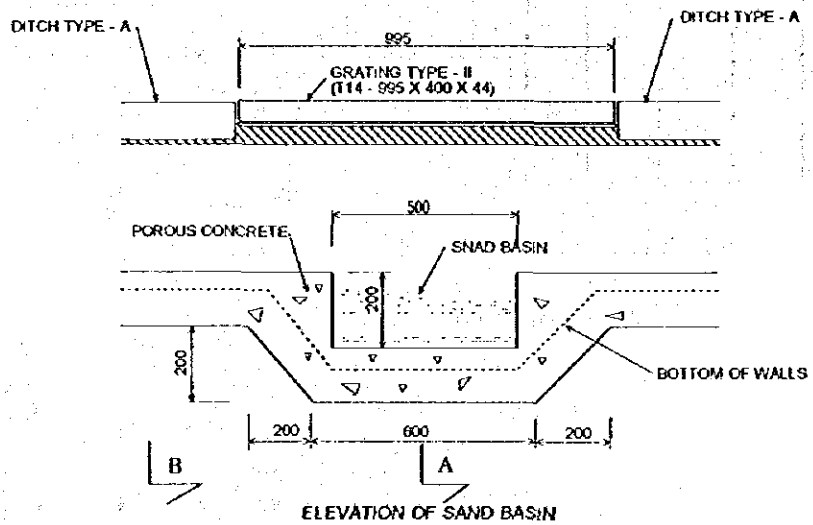


DITCH COVER TYPE - I (FIXED)

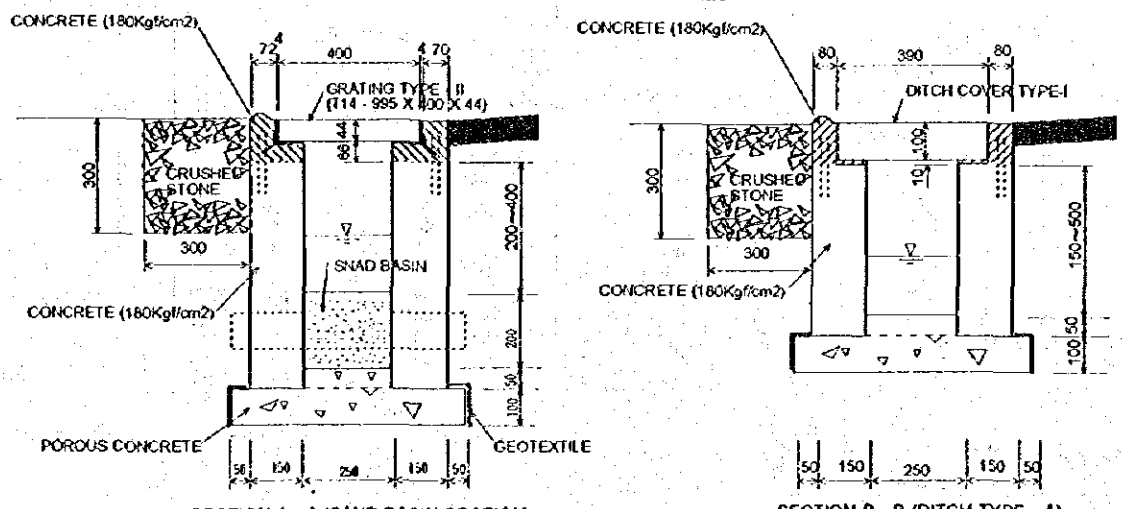
DITCH COVER TYPE - II (MOVABLE)

INSTALLATION OF COVERS

DITCH COVERS



ELEVATION OF SAND BASIN

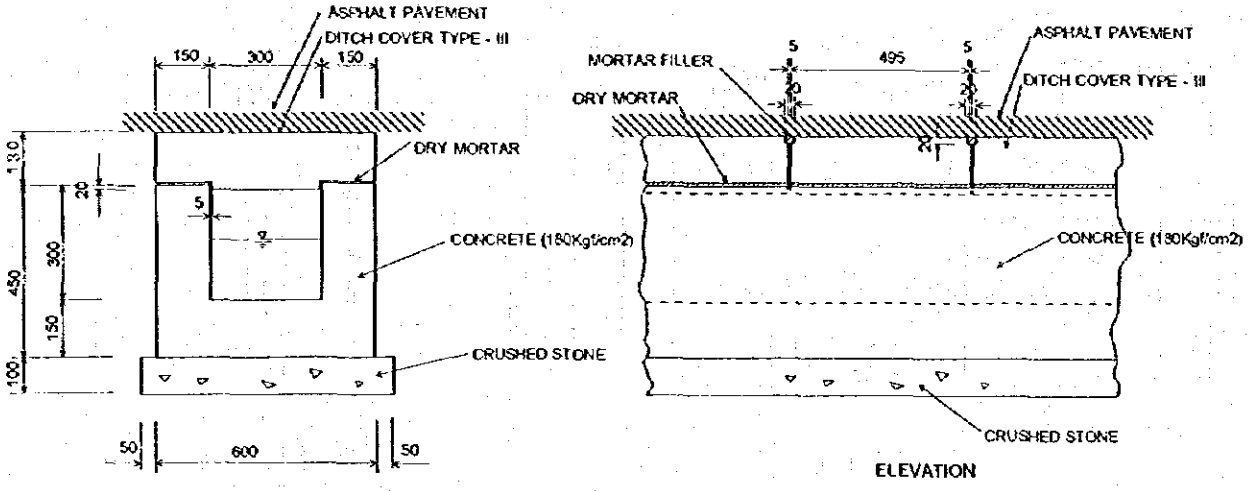


SECTION A - A (SAND BASIN SECTION)

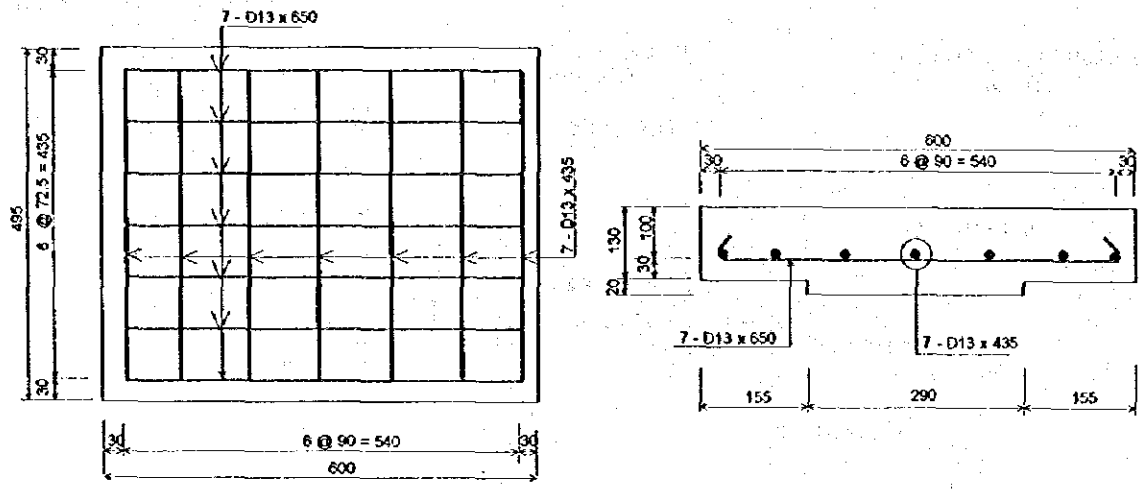
SECTION B - B (DITCH TYPE - A)

SAND BASIN

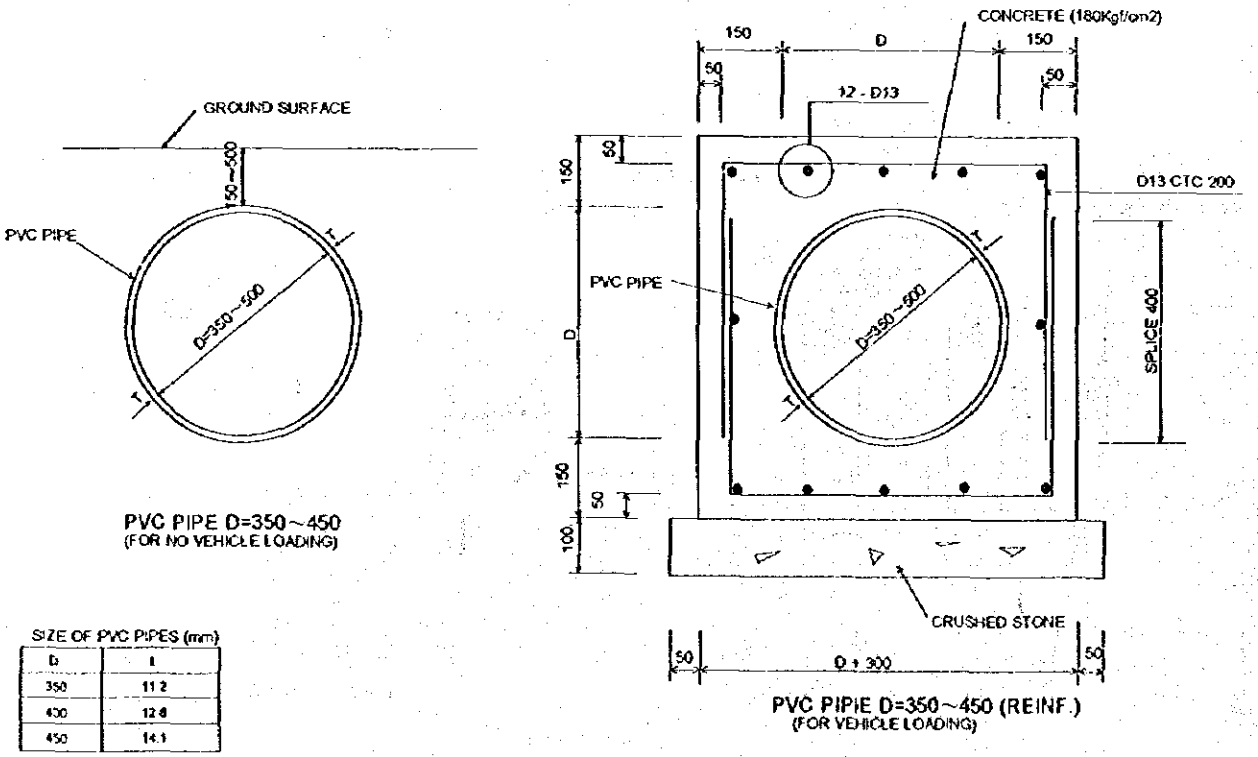
FIGURE 2.3 - 4 DITCH COVERS AND SAND BASIN



DITCH TYPE - F
(FOR CROSSING MAIN ROADS)



DITCH COVER TYPE - III



PVC PIPE D=350~450
(FOR NO VEHICLE LOADING)

PVC PIPE D=350~450 (REINF.)
(FOR VEHICLE LOADING)

SIZE OF PVC PIPES (mm)

D	t
350	11.2
400	12.8
450	14.1

FIGURE 2.3 - 5 CULVERTS

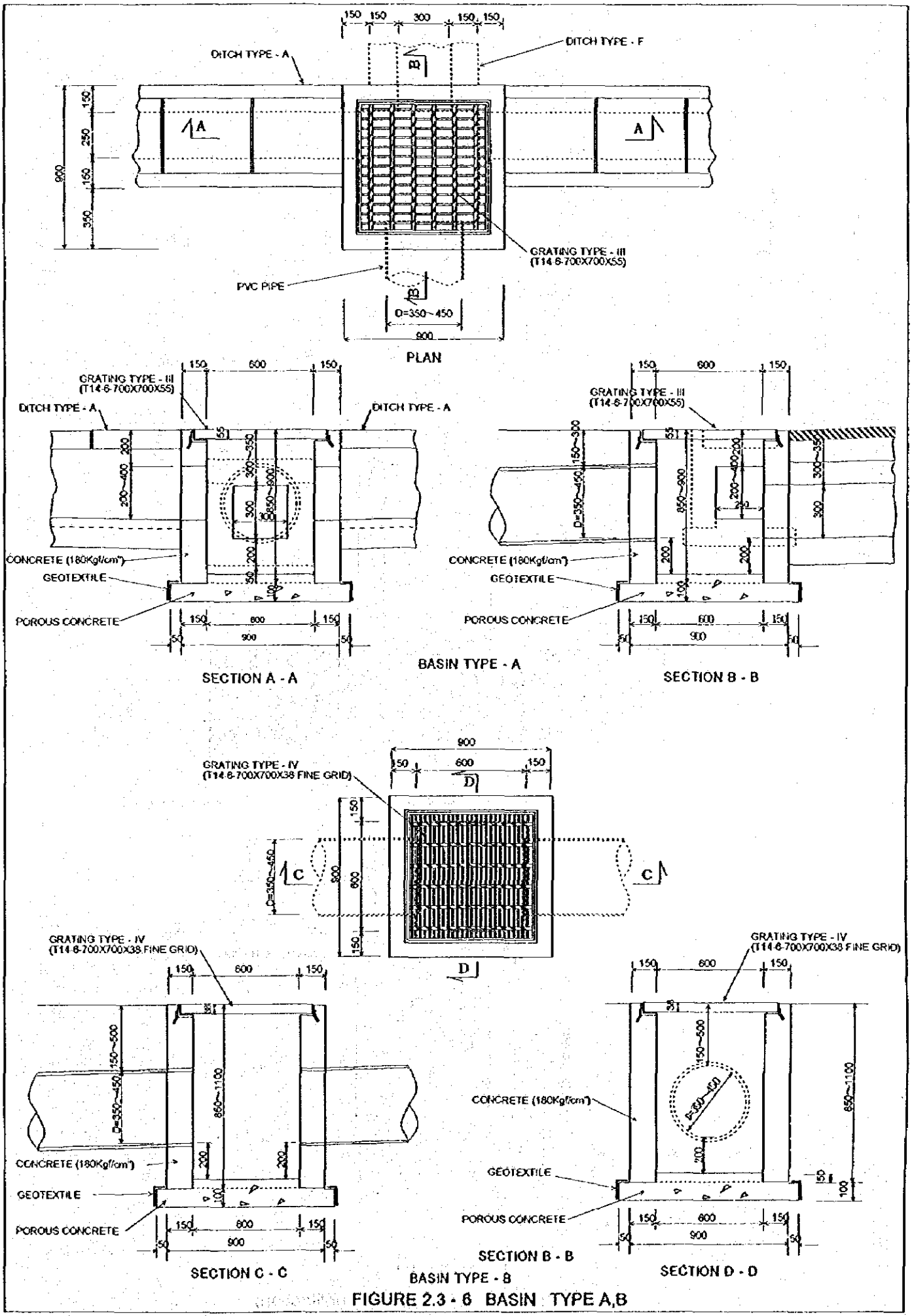


FIGURE 2.3 - 6 BASIN TYPE A,B

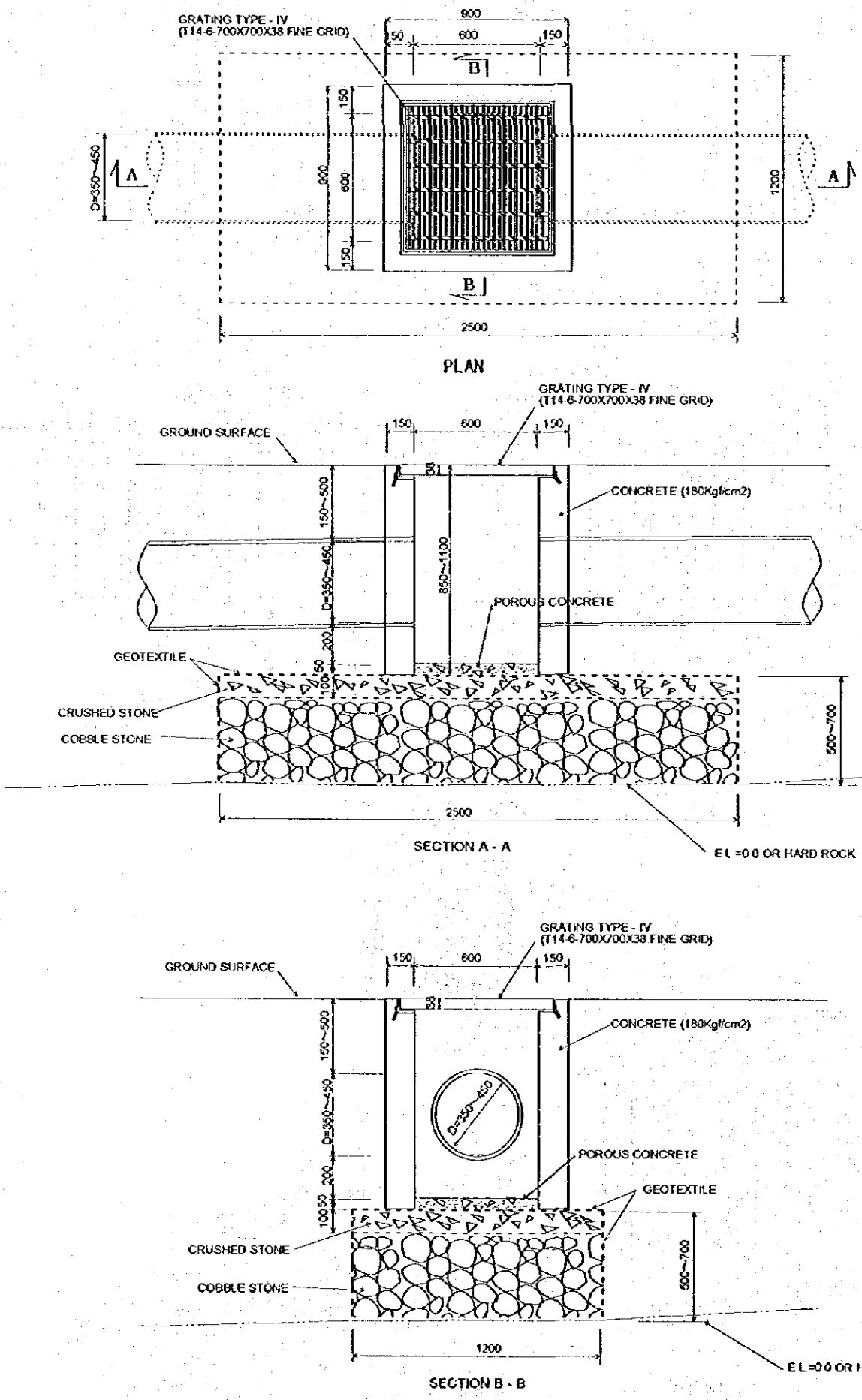
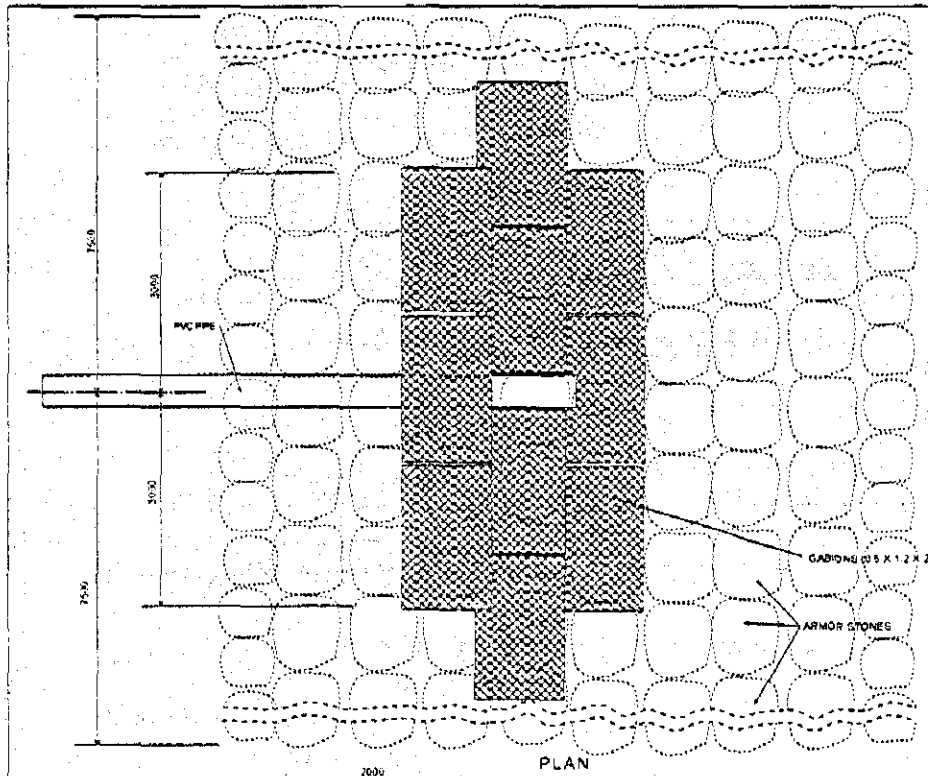
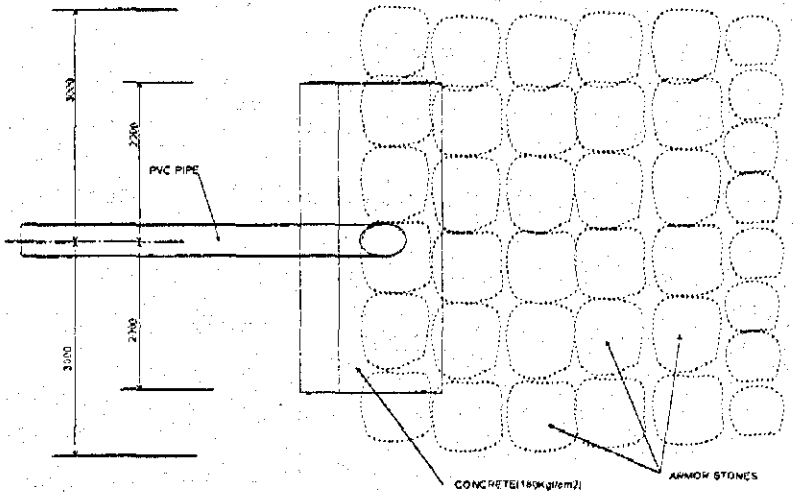


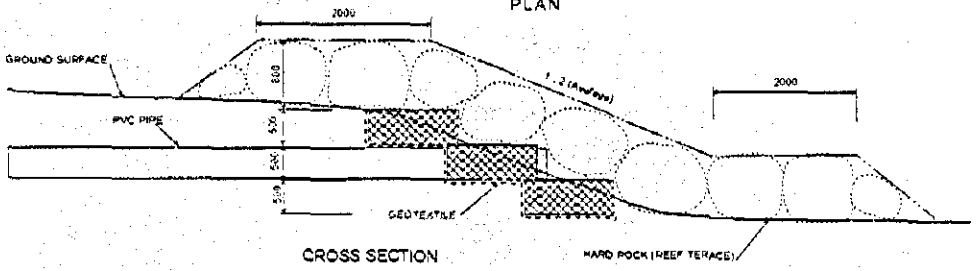
FIGURE 2.3-7 BASIN TYPE C (infiltration)



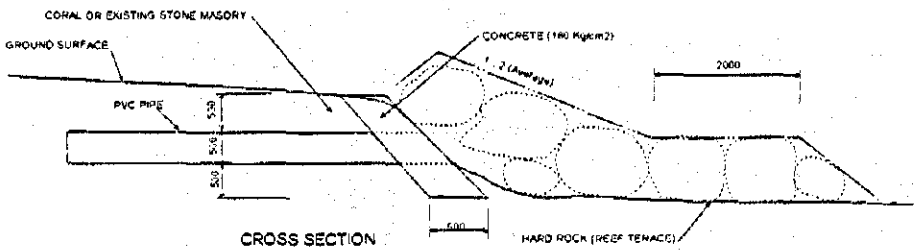
PLAN



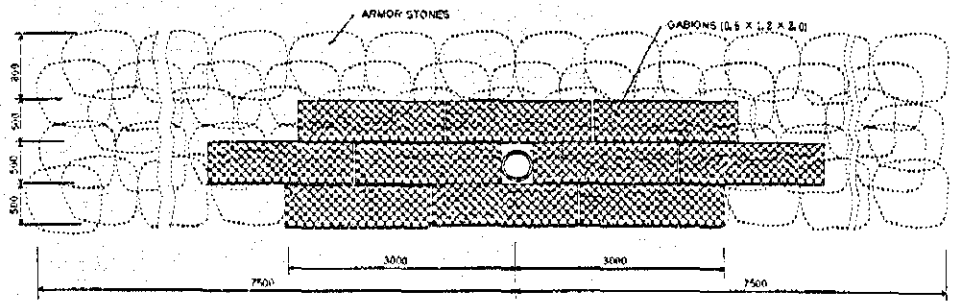
PLAN



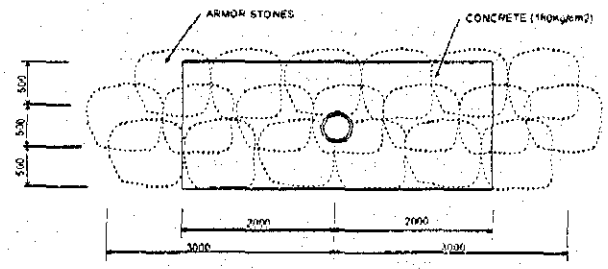
CROSS SECTION



CROSS SECTION

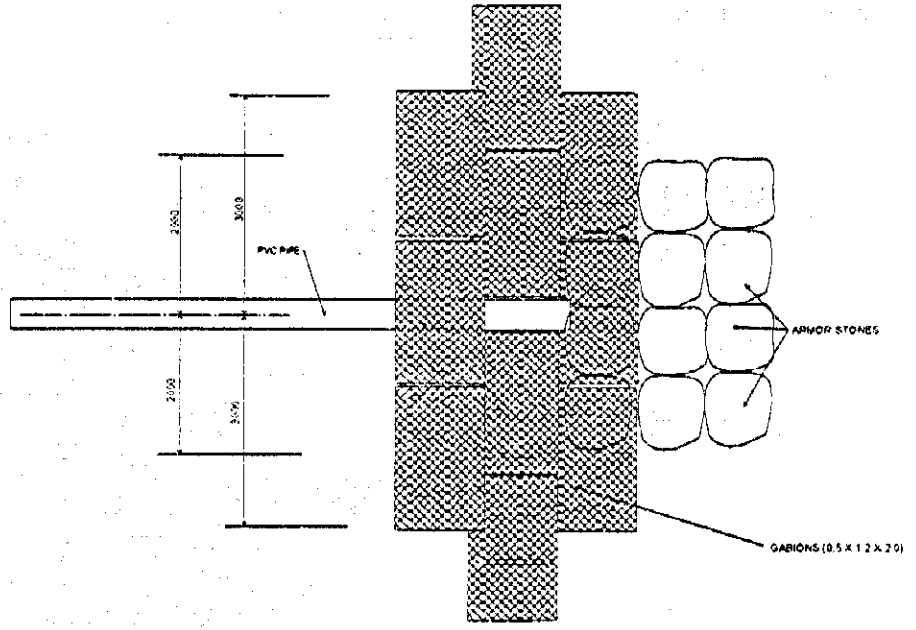


ELEVATION
PROTECTION WORK TYPE - A
(FOR OCEAN SIDE SANDY OR GRAVELY SITES)

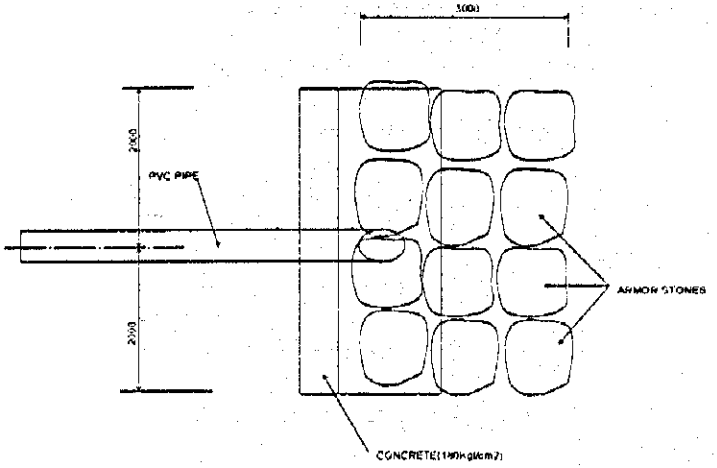


ELEVATION
PROTECTION WORK TYPE - B
(FOR OCEAN SIDE CORAL OR STONE MASONRY SITES)

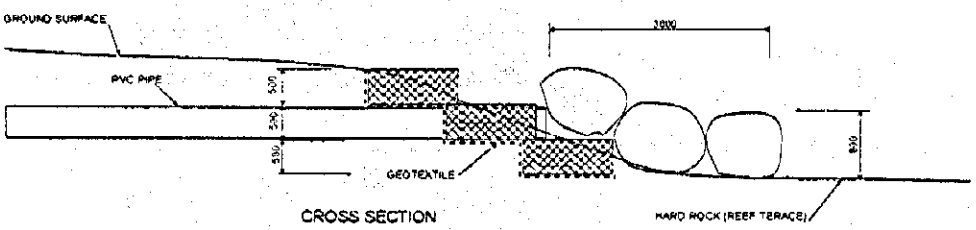
FIGURE 2.3 - 8 OUTLET PROTECTION WORK (1/2)



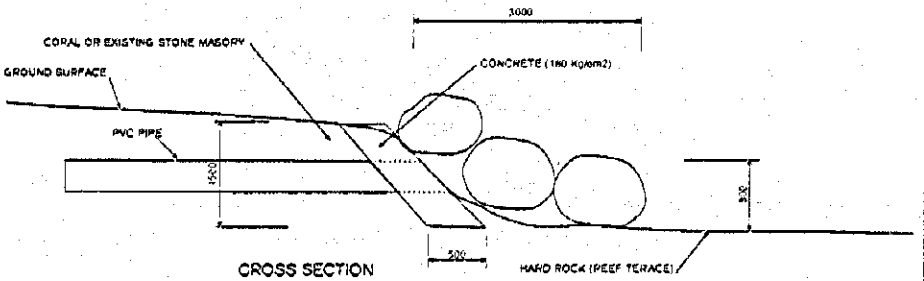
PLAN



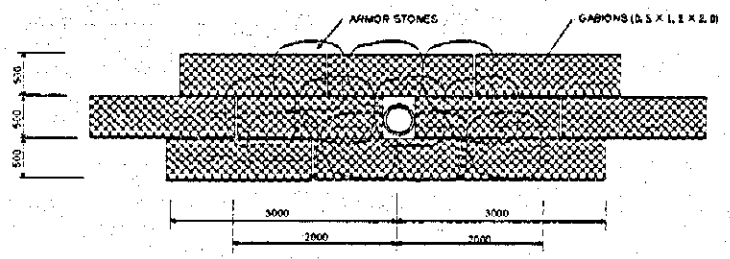
PLAN



CROSS SECTION

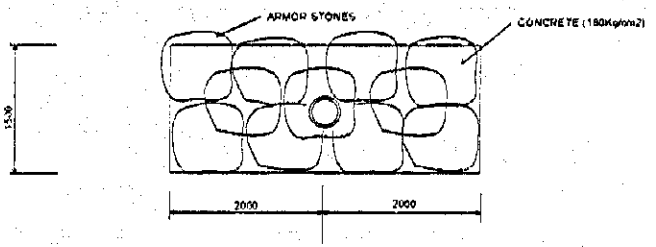


CROSS SECTION



ELEVATION

PROTECTION WORK TYPE - C
(FOR LAGOON SIDE SANDY OR GRAVELY SITES)



ELEVATION

PROTECTION WORK TYPE - D
(FOR LAGOON SIDE CORAL OR STONE MASONRY SITES)

Figure 2.3-9 OUTLET PROTECTION WORK (2/2)

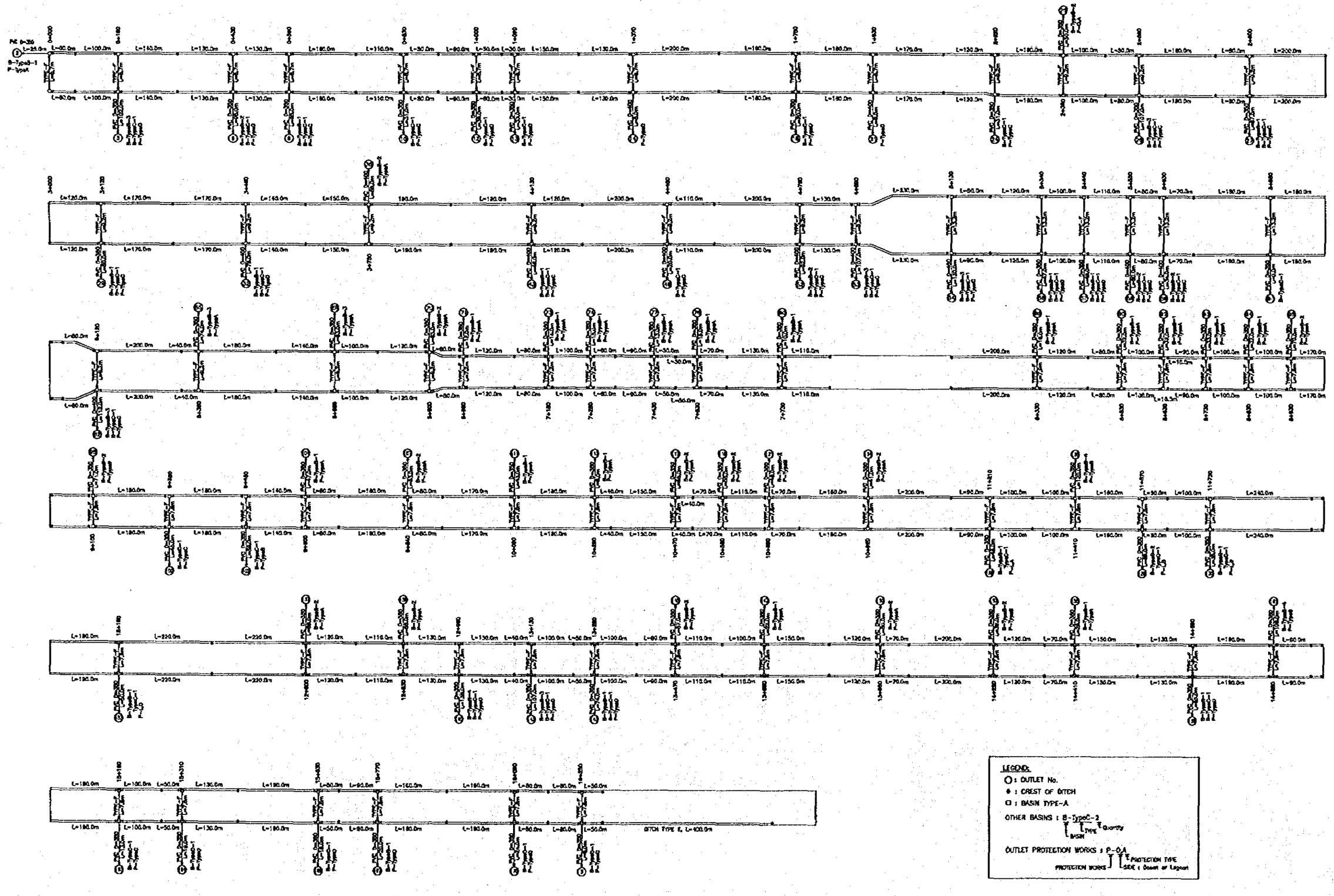


Figure 2.3-10 LAYOUT OF DRAINAGE FACILITIES

2.3.2.2 Pavement Rehabilitation

(1) Design conditions by design section

Since the conditions are very different, the Project road was divided into 3 sections for the pavement rehabilitation design. The deteriorated pavement conditions are summarized as shown in Table 2.3-1. The results of an In-situ CBR test of the subgrade are shown in Table 2.3-2. The Design traffic volumes are shown in Table 2.3.-3.

Table 2.3-1 PAVEMENT DETERIORATION CONDITION

Section	Chainage	Deterioration
DUD	Km0.0 ~ 6.90	All sections are severely deteriorated. Crack ratio (C.R.) is more than 25% as a whole.
Around Majuro Br.	km 6.9 ~ 13.3	Lightly deteriorated. C.R. is less than 25% as a whole.
Rairok	km13.3 ~ 16.7	Severely deteriorated sections (C.R.>25%) are scattered.

As the special sections among the above, pavement surface is deformed like waves at km15.115 ~ 15.280 and km16.010 ~ 16.150 in the Rairok Section.

Table 2.3-2 DESIGN CBR

Section	In-situ CBR	Design CBR
DUD	10, 17, 20, 15, 35	8
Majuro Br.	-	8*
Rairok	45, 30	20
km 15-16	8, 5, 8	4

Note :- Design CBR with * was assumed as same as DUD since there is no data for the section and the deterioration condition is similar.
- Design CBR was derived according to the Standard.

Table 2.3-3 DESIGN TRAFFIC VOLUME

Section	Present ADT	Heavy Vehicle ADT	Percentile of Heavy Vehicles
DUD	5,500	68	1.24%
Majuro Br.	2,250	32	1.41%
Rairok	2,250	32	1.41%

Note : ADT ; Vehicles/day/direction

(2) Design of AC overlay

Based on the existing pavement structures, subgrade CBRs and traffic volume (Only heavy traffic is incorporated in the pavement design.), required thickness of AC overlay was calculated as shown in Table 2.3-4. The proposed thickness of the AC overlay was decided considering the requirements in construction. Details of the calculation is reported in Appendix 9. The calculation was made based on the JRA design standards and 10 years of the design life span.

Table 2.3-4 AC OVERLAY THICKNESS

Section	Required Thickness	Proposed Thickness
DUD	55 mm	55 mm
Majuro Br.	20 mm	30 mm
Rairok	38 mm	40 mm
km 15-16	85 mm	85 mm

(3) Design of pavement reconstruction and grade rising

Reconstruction of pavement was proposed for the sections shown in Table 2.3-5. Reconstruction is necessary for the sections around km2.50 since the pavement is severely deteriorated and deformed and some permanent structures exist at pavement surface level. For the sections around km15-16, the reconstruction method is also suitable. (A 85mm AC overlay was proposed in this study.) Grade rising by overlay of base courses and AC was proposed for sagging sections (Dips and flood sections).

Table 2.3-5 PAVEMENT RECONSTRUCTION SECTIONS

Section	Chainage	Conditions
km2.5	km2.400 ~ 2.870 km2.08 ~ 3.285	Base course is also deteriorated. Design CBR is 8.
km15-16	km15.115 ~ 15.280 km16.010 ~ 16.150	Subgrade is loose. Design CBR is 4.
Grade Rising	10 sections in DUD 16 sections in Rairok	Existing pavement is sound. Design CBR is 20.

Based on the design CBRs, traffic volume and base and subbase materials, proposed thicknesses of each layer of pavement were calculated. Details of the calculation is reported in Appendix 9. The proposed structure of the pavement for reconstruction and grade rising sections are shown in Table 2.3-6.

Table 2.3-6 PAVEMENT FOR RECONSTRUCTION

Section	Surface Course (AC)	Base Course (Graded material)	Subbase Course (Granular material)
km2.5	55	10	15
km15-16	40	15	25
Grade Rising (DUD)	55	10	15
Grade Rising (Rairok)	40	10	20

Note : It is better for the AC thickness to be same as adjacent AC overlay.

(4) Planning of road width

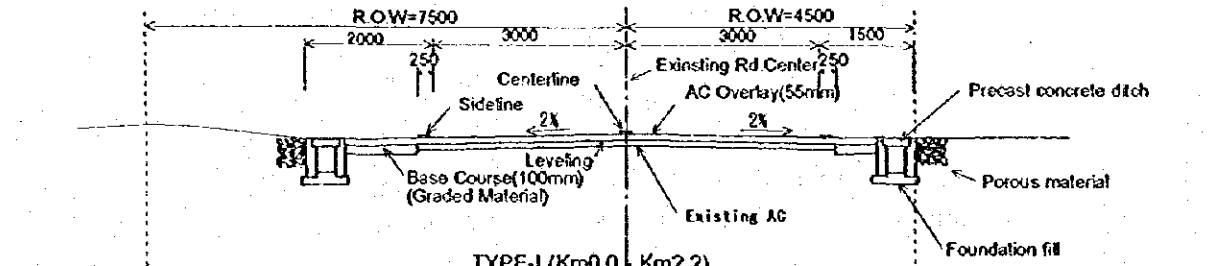
Widths of the Project road were proposed based on the Standards. A 3m wide carriageway was proposed for all sections since it is optimum for 40 to 60 km/h design speed sections. Shoulders 2.0m wide are proposed for the DUD Section, and 1.0m for the Rairok Section. As said in the design concepts, wide shoulders are necessary for taxis stopping in the DUD Section.

As a special case, a 1.5m wide shoulder was proposed for the lagoon side of the Rita Section (km0.0 ~ km2.2) so as not to remove many encroached houses within the Right of Way.

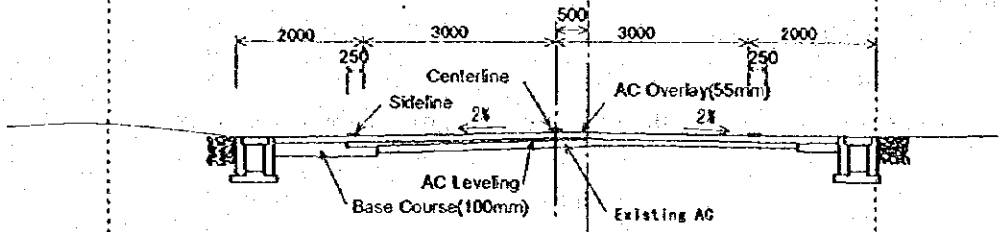
For the boulevard section (km4.9 ~ km6.1), a 2.5m wide median and 2.5m wide shoulders are proposed since a 2m wide extra lot beyond the Right of Way to the lagoon side is available for the Project.

(5) Typical cross sections of the Project road

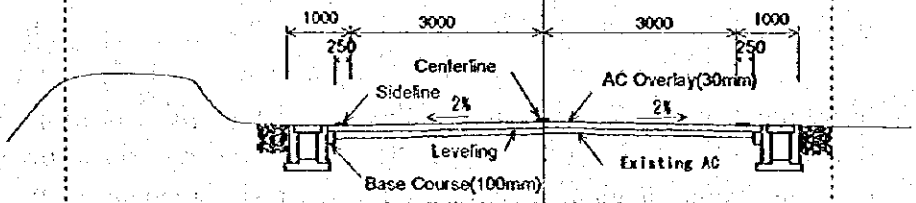
As a result of the basic design of the pavement rehabilitation, typical cross sections for the Project road are shown in Figure 2.3-11.



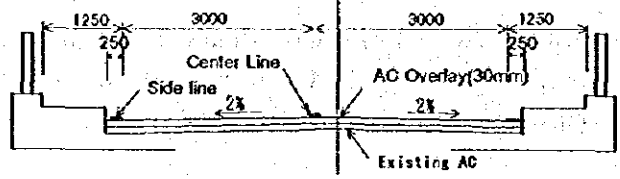
TYPE-I (Km0.0 - Km2.2)



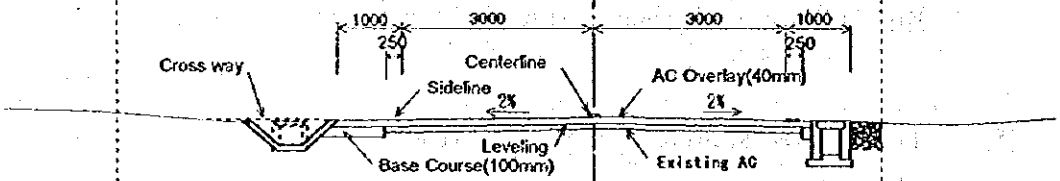
TYPE-II (Km2.2 - Km6.9)



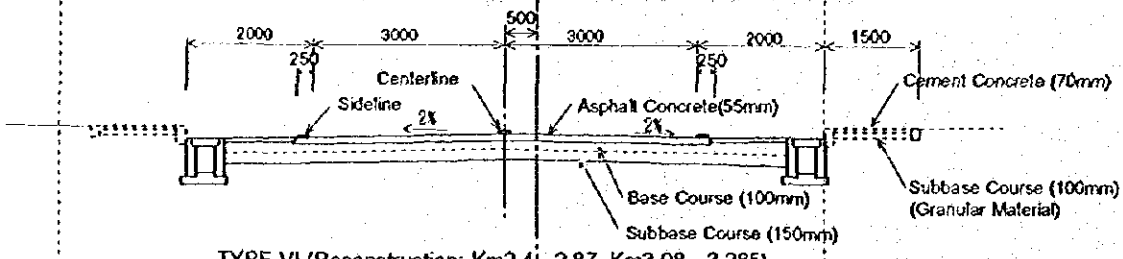
TYPE-III (Km6.9 - Km7.81)



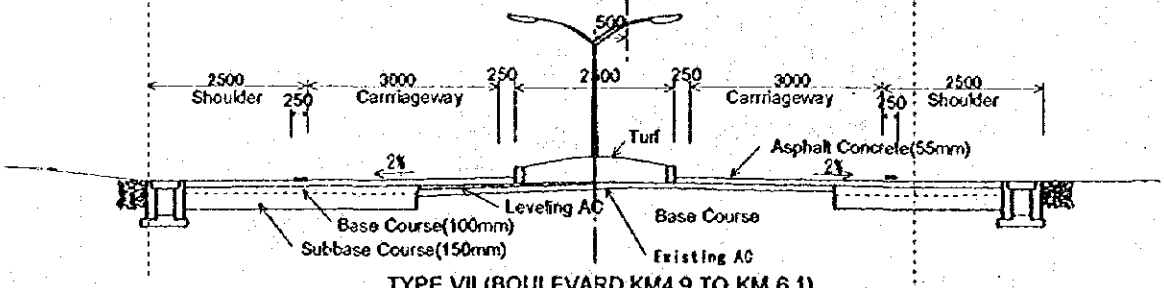
TYPE-V (Km7.81 - Km8.08)



TYPE-IV (Km8.08 - Km16.3)



TYPE-VI (Reconstruction: Km2.4 - 2.87, Km3.08 - 3.285)



TYPE VII (BOULEVARD.KM4.9 TO KM 6.1)

Figure 2.3 -11 TYPICAL CROSS SECTIONS

2.3.2.3 Other Road Structures

(1) Road markings

As shown in the typical cross sections, the road centerline and the sidelines were proposed for all sections of the Project road. The marking of crosswalks were proposed for the 21 sites.

(2) Safety sign boards

Instalation of safety sign boards along the Project road were proposed as shown in Table 2.3-7. Safety sign boards made of aluminum plates attached to the painted steel poles were proposed.

Table 2.3-7 SAFETY SIGN BOARDS

Type	No. of site	Quantity
5 mph	2	4
15 mph	12	24
25 mph	19	38
Curve ahead	7	14
Pedestrian crossing	21	42
Stop	6	12
School zone	13	26

(3) Lighting

Lighting to be installed along the median of the boulevard section was proposed. Mercury-vapor lamps (200 Watt x 2 lamps) attached to aluminum poles were proposed at every 30m. The lighting system was planned in accordance with the JRA standards to be the proper brightness.

2.3.2.4 Summary of Quantity of Work

The summary of quantity of major work for this Project is shown in Table 2.3-8.

Table 2.3-8 SUMMARY OF QUANTITY OF WORK

Work Item			Unit	Quantity	Remarks
Drainage Facilities Construction	Ditches	Type-A	m	20,541	U-shaped ditch
		Type-B	m	8,170	Concrete lined ditch
		Type-C	m	1,437	For crossing light access road
		Type-D	m	660	For crossing heavy access road
		Type-E	m	400	Crushed stone filled ditch
		Type-F	m	651	For crossing main road
		Total	m	31,859	
	Basins	Type-A	Each	77	For connecting ditches & culverts (upstream)
		Type-A'	Each	77	For connecting ditches & culverts (downstream)
		Type-B	Each	105	For maintenance of PVC pipes
		Type-C	Each	39	Permeative type basin (Lagoon side only)
		Sand Basin	Each	1,074	For every 20 m of Type -A ditch
		Total	Each	1,372	
	PVC Pipes	D=350	m	2,965	Drain pipes from the road to the sea
		D=400	m	590	ditto
		D=450	m	130	ditto
		D=350 (Reinf.)	m	100	For pipes under roads
		D=400 (Reinf.)	m	100	ditto
		Total	m	3,513	
	Outlet Protections	Type-A	Each	31	Gabion protection for ocean side
		Type-B	Each	5	Concrete protection for ocean side
		Type-C	Each	19	Gabion protection for lagoon side
		Type-D	Each	21	Concrete protection for lagoon side
		Total	Each	76	
Pavement Rehabilitation	Pavements	AC Overlay on Roadway	m	16,300	Area is 128,258 m2, weight is 14.3 ton
		AC Overlay on Junction	Site	22	Area is 2,406 m2, weight is 0.3 ton
		Cocrete Pave. on Sidewalk	m	340	Concrete volume is 117.3 m3
Other Structures		Road Marking	m	49,202	Width of lines is 15 cm
		Safety Sign Board	Each	160	Locations are shown in Table 1.3-7
		Median	m	981	A 2.5 m wide turfed median
		Lighting	Each	40	Double mercury-vapor 200 W light

CHAPTER 3 IMPLEMENTATION PLAN

3.1 Implementation Concept

The following are the main concepts in the implementation plan:

- The construction will be undertaken by a contractor employing labor from local subcontractors.
- Materials and equipment necessary for the project will be procured in Majuro as far as available. Items unavailable locally will be procured from Japan or third countries. Third countries will be selected based on their cost, quality and required delivery time.
- The construction method and schedule of the project will be planned reflecting local conditions of climate, topography, geology, transportation and others.
- Easy and low cost methods of construction will be adopted for the project.
- Detours for vehicles and pedestrians will be provided during construction when necessary.

3.2 Implementation Conditions

The following are the basic conditions for implementing this project:

- This project, if approved, will be implemented in accordance with the provisions of Japan's Grant Aid Program after the signing of the Exchange of Notes between the Governments of Japan (GOJ) and the Republic of the Marshall Islands (RMI).
- The Ministry of Resources & Development (MRD) is the responsible agency for implementing the project.
- The detailed design, tenders and construction supervision of the road project will be undertaken by a Japanese consulting firm in accordance with a contract between the MRD and the consultant.
- The construction of the road will be undertaken by the successful Japanese tenderer in awarding the contract with the Ministry of Resources & Development.

3.3 Scope of Works

Undertakings of both governments, Japan and the Marshall Islands, are listed in Table 3-1.

Table 3-1 UNDERTAKINGS OF BOTH GOVERNMENTS

Item	Item	Undertaken by		Remarks
		Japan	Marshalls	
Procurement of materials and equipment	Procurement	◎		
	Customs clearance		◎	
Temporary work	Acquisition of lots		◎	Lots for field office, storage yard, asphalt plant and work shop
	Works other than the above	◎		
Right-of-way acquisition and replacement of existing facilities	Acquisition of ROW		◎	Extra lot for boulevard and for drainage pipes
	Removal/replacement of encroachment existing in ROW		◎	Trees, hedges, fences, houses, power post, telephone switchboard
	Adjustment of existing properties	◎		Manholes, valves, etc.
	Replacement of underground facilities		◎	Power cables, etc.
Main work	Disposal of waste materials arising from existing facilities		◎	
	Works other than the above	◎		

The lots for field office, storage yard, asphalt plant and work shop to be prepared by the RMI are estimated at 0.5 ha. It is necessary to be located at the Project roadside.

Encroachments within the Right of Way to be removed or replaced by the RMI are as shown in Table 3-2.

About 20 of the secondary power cables are laid at a very shallow depth under the Project road. Replacing them to deeper levels is required by the RMI.

Table 3-2 ENCROACHMENT TO BE REMOVED/REPLACED

Chainage (km)	Distance to center (m)	Item
Ocean side		
1.8	4.8	Hedge
2.1	4.5	Fence
2.4	5	Flower base
2.5	4.6	House roof
10.3	4.7	Power post
13.0	4.5	Hedge
13.5	5.0	Hedge
15.1	5.0	Fence
Lagoon side		
1.6	4.2	Hedge
1.7	4.3	Hedge
1.9	4.3	Telephone switchboard
1.9	4.2	Power post
7.0	4.0	Hedge
8.3	3.5	Tree
8.4	3.5	Tree
8.5	3.5	Tree
9.3	3.8	House roof
10.2	3.5	Hedge
10.8	3.8	Hedge
13.8	3.3	Hedge
14.7	3.5	Hedge
14.9	3.5	Hedge

3.4 Consultant Supervision

A Japanese consulting firm will supervise the implementation of the project on behalf of the Ministry of Resources & Development. The consultant will carry out the detailed design, assistance in tendering and construction supervision in accordance with the consultant contract.

3.4.1 Detailed Design

The major works in the detailed design to be carried out by the consultant are as follows:

- Supplementary site survey
- Detailed design of the road and related structures

- Preparation of drawings and specifications
- Construction planning and cost estimation
- Preparation of tender documents
- Preparation of a pavement and drainage maintenance manual

The necessary time for the detailed design is 3 months.

3.4.2 Assistance in Tendering

This task includes the following items:

- Tender publication
- Pre-qualification
- Tendering
- Tender evaluation
- Contract facilitation

The necessary time for assistance in tendering is 4.5 months.

3.4.3 Construction Supervision

The main work items to be executed by the consultant are as follows:

- Inspection and approval of site surveys
- Inspection and approval of construction planning
- Quality control
- Progress control
- Measurement of work
- Inspection of safety aspects
- Final inspection and turnover

The construction period is 23.5 months. To successfully carry out supervision, the consultant personnel are required to be stationed on the site during the entire construction period.

3.5 Procurement Plan

In principle, materials, equipment and labor necessary for the project are planned to be procured locally as far as available. Items which are not available from local sources with required quality, quantity or cost are planned to be procured from Japan or third countries.

3.5.1 Materials

Procurement plan of the major materials is shown in Table 3-3.

Table 3-3 MATERIAL PROCUREMENT PLAN

	Procured from			Remarks
	Marshalls	Japan	Third Country	
Material for Structure				
Base course material	◎			
Ready mixed concrete	◎			
Cement	◎			Imported
Sand for concrete	◎			
Aggregate for concrete	◎			
Aggregate for asphalt concrete	◎			
Bitumen for asphalt concrete	◎			Imported
Joint filler	◎			Imported
Prime coat material	◎			Imported
Road marking paint		◎		
Reinforcing steel		◎		
Precast concrete products	◎			
PVC pipes	◎			Imported
Armor stones	◎			
Filter sheets		◎		
Gabions		◎		
Lighting		◎		
Safety sign boards		◎		
Material for temporary work				
Timber for forms	◎			Imported
Plywood for forms	◎			Imported
Nails	◎			Imported
Annealed wire	◎			Imported
Timber for staging	◎			Imported
Sandbags	◎			Imported
Electric welding bars	◎			Imported
Fuel, oil and fat	◎			Imported
Oxygen and acetylene	◎			Imported
Safety facilities		◎		

3.5.2 Equipment

In principle, equipment is planned to be procured from local contractors under lease contract. Equipment which is not available locally is planned to be procured from Japan or third countries.

Procurement plan of the major equipment is shown in Table 3-4.

Table 3-4 EQUIPMENT PROCUREMENT PLAN

	Procured from		Remarks
	Marshall Islands	Japan or Third Country	
Bulldozer(s)	◎		
Backhoe excavator(s)	◎		
Hydro-club	◎		
Wheel loader	◎		
Dump truck(s)	◎		
Cargo truck(s)	◎		
Mobile crane(s)	◎		
Crawler crane(s)	◎		
Crawler drill(s)	◎		
Breaker(s)	◎		
Rock drill(s)	◎		
Concrete cutter(s)	◎		
Motor grader(s)	◎		
Macadam roller(s)	◎		
Tire roller(s)	◎		
Water tank truck(s)	◎		
Vibration roller(s)	◎		
Tamper(s)	◎		
Vibro plate(s)	◎		
Concrete plant(s)	◎		
Mixer mobile(s)	◎		
Concrete mixer(s)	◎		
Concrete vibrator(s)	◎		
Asphalt plant(s)		◎	
Asphalt finisher(s)		◎	
Air compressor(s)	◎		
Submerged pump(s)	◎		
Generator(s)	◎		
Welding machine(s)	◎		
Rebar cutter		◎	

3.6 Implementation Schedule

The Implementation schedule of this Project was proposed as shown in Table 3-5.

3.7 Obligations of the Republic of the Marshall Islands

The following necessary measures should be taken by the Government of the Marshall Islands on condition that the Grant Aid by the Government of Japan is extended to the Project:

(1) To provide data and information necessary for the Project.

(2) To secure the land necessary for the execution for the Project, such as the land for drainage facilities, temporary offices, construction works, storage yards, asphalt concrete plant and others.

(3) To clear the sites prior to the commencement of the construction.

(4) To remove existing obstacles such as trees, hedges, etc. in the right of way.

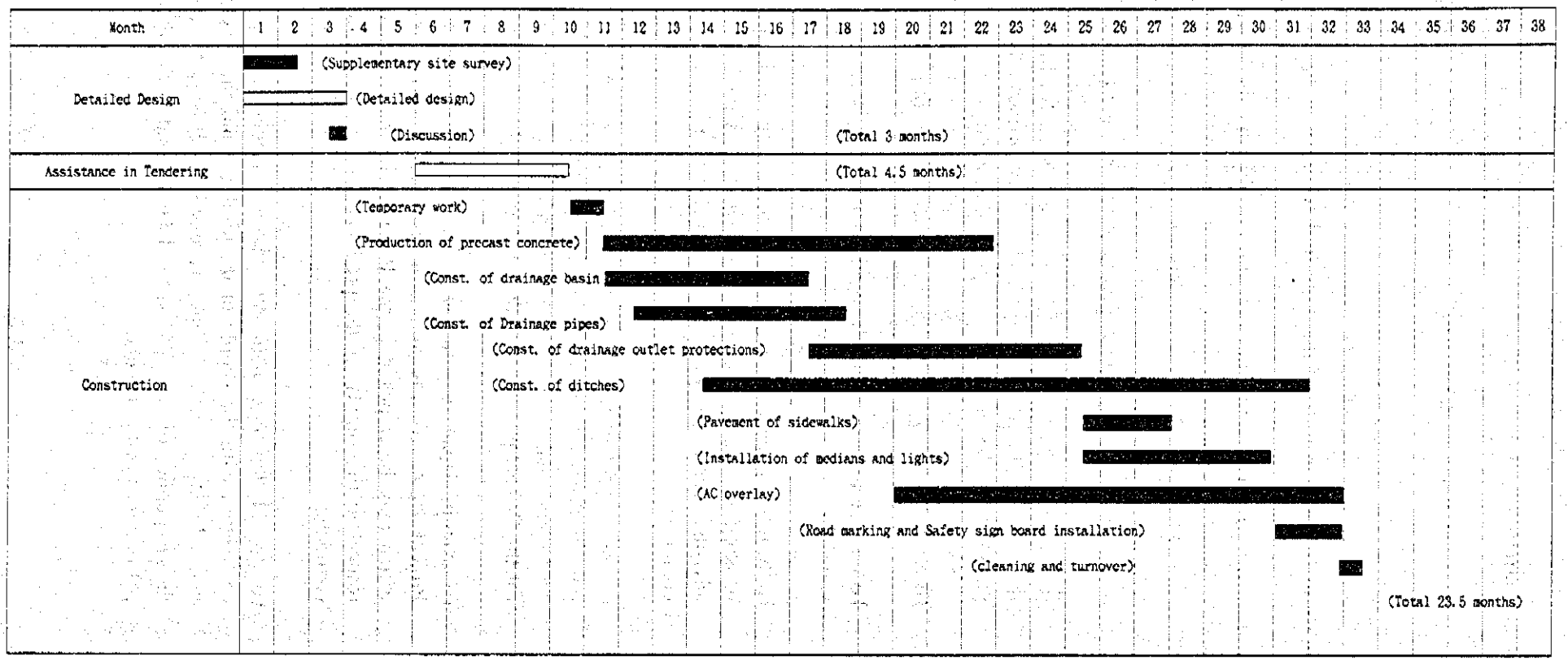
(5) To bear commissions to the Japanese foreign exchange bank for its banking services based upon the Banking Arrangement, namely the advising commission of the "Authorization to Pay" and payment commission.

(6) To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation in the Republic of the Marshall Islands and prompt internal transportation therein of the materials and equipment for the Project purchased under the Grant Aid.

(7) To exempt Japanese juridical and physical nationals engaged in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in the Republic of the Marshall Islands with respect to the supply of the products and services under the verified contracts.

(8) To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into the Republic of the Marshall Islands and stay therein for the performance of their work.

Table 3-5 IMPLEMENTATION SCHEDULE



(9) To provide necessary permission, licenses and other authorizations for implementing the Project, if necessary.

(10) To maintain and use properly and effectively the facilities constructed under the Project.

(11) To coordinate and solve any issues related to the project which may be raised from third parties or inhabitants in the Project area during implementation of the Project.

(12) To bear all the expenses, other than those covered by the Japanese Grant Aid, necessary for the Project.

Of the above obligations, the cost to rent the land for the Project is roughly estimated as follows. The cost for maintenance of the Project facilities is explained in the following Section.

Cost for land rent

- Temporary yards (plant, storage, etc.) : 0.50 ha (US$3,700/year)
- Extra lot for boulevard (1,030 m x 2.5 m) : 0.26 ha (US$1,900/year)
- For drainage pipes (3,885 m x 2.0 m) : 0.78 ha (US5,800/year)

CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATION

4.1 Project Effect

The major direct effects of implementing the Project are as follows:

Safe and comfort for traffic
- Driving will be safe and comfortable on the road without deformations and holes.
- Walking will be safe and comfortable on the road shoulders without pools.

Efficient transportation
- Running on smooth pavement will result in less cost and prolong life of vehicles.
- Wide shoulders and smooth pavement will enable traffic to move more smoothly.

Environment protection
- Erosion on road shoulders will be stopped by paving them with AC.
- Siltation in the lagoon will be less by reducing muddy water drain from the road to the lagoon.

Less road maintenance cost
- Pavement rehabilitation will not be needed for around 10 years after the Project.

Promotion of local economy
- Local materials, equipment and labor will be employed for the Project for around 2 years. (Total cost about US$7million, total labor-day about 700,000)

Technology transfer
- Construction technology will be transferred to engineers and skilled workers.
- Road maintenance technology will be transferred by providing a manual.

4.2 Recommendation

Since the Project will greatly contribute to improve residents' living standards and traffic conditions in the area, and the implementation organization is considered to have sufficient capacity to manage the Project, it is concluded to be appropriate to implement this Project under Japan's grant aid.

For the smooth implementation of the Project, coordination with other public works

related to the Project is necessary. Specially, to coordinate the ADB assisted water supply project which is to be implemented so as to preclude conflicts in the construction activities of the two projects.

For effective use of the Project facilities, it is essential that proper maintenance will be carried out by the responsible organization. To explain the details of the required maintenance, a maintenance manual will be prepared in the detailed design stage of the Project.