No. 4

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
RECONSTRUCTING THE VICTORIA BRIDGE
IN
THE DEMOCRATIC SOCIALIST REPUBLIC OF
SRI LANKA

OCTOBER 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan has decided to conduct a basic design study on Reconstructing the Victoria Bridge and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Sri Lanka a study team headed by Mr. Shoichi Saeki, Director, Structures and Bridge Department, Public Works Research Institute, Ministry of Construction from July 9 to August 4, 1988.

The Team had discussions on the Project with the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka and conducted a field survey in the Colombo Metropolitan area. After the team returned to Japan, further studies were made, and a draft report was prepared and a mission to explain and discuss it was dispatched to Sri Lanka. As a result, the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

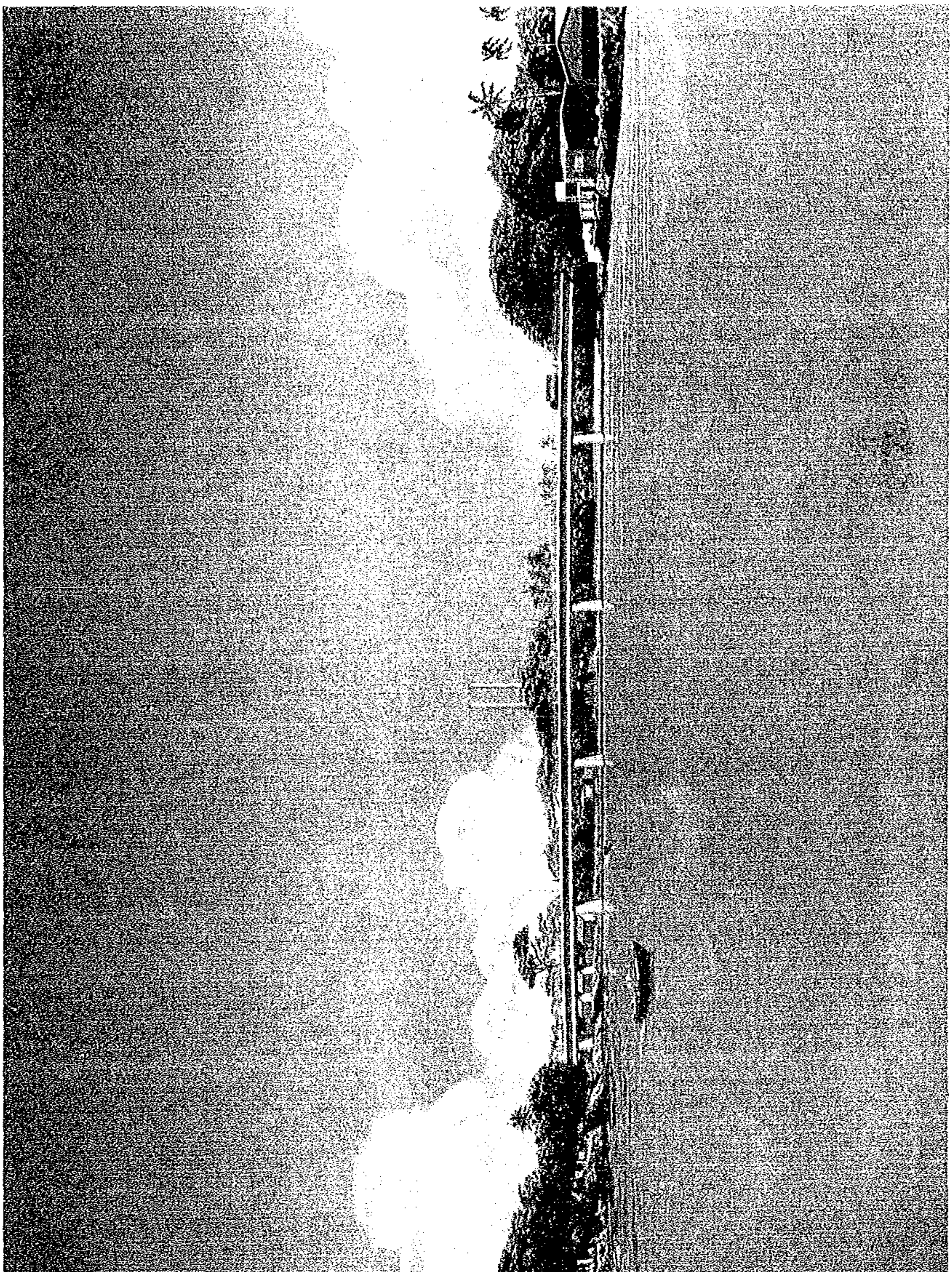
I wish to express my deep appreciation to the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka for their close cooperation extended to the team.

October 1988

Kensuke Yanagiya

Kensuke Yanagiya
President

Japan International Cooperation Agency



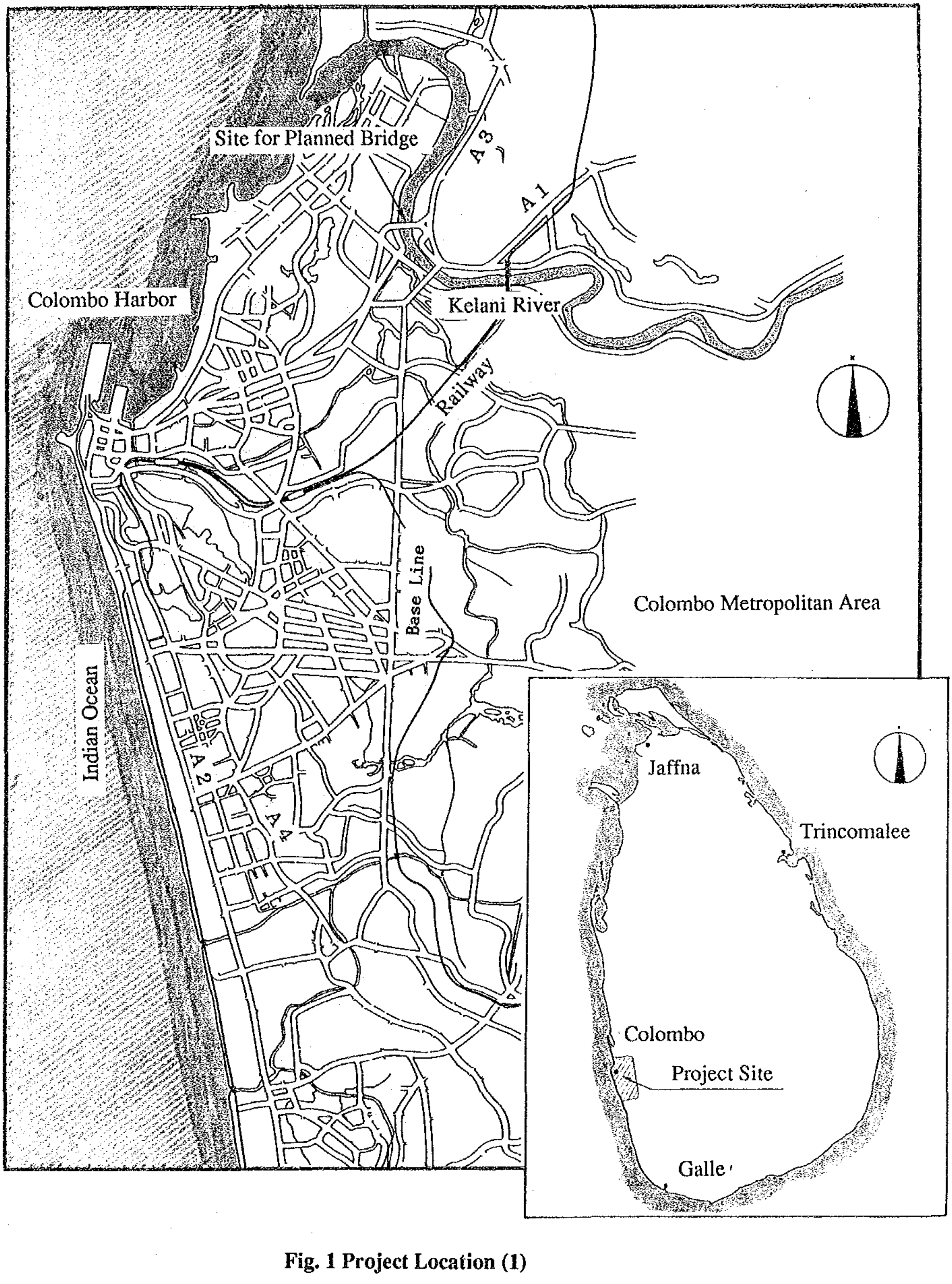


Fig. 1 Project Location (1)

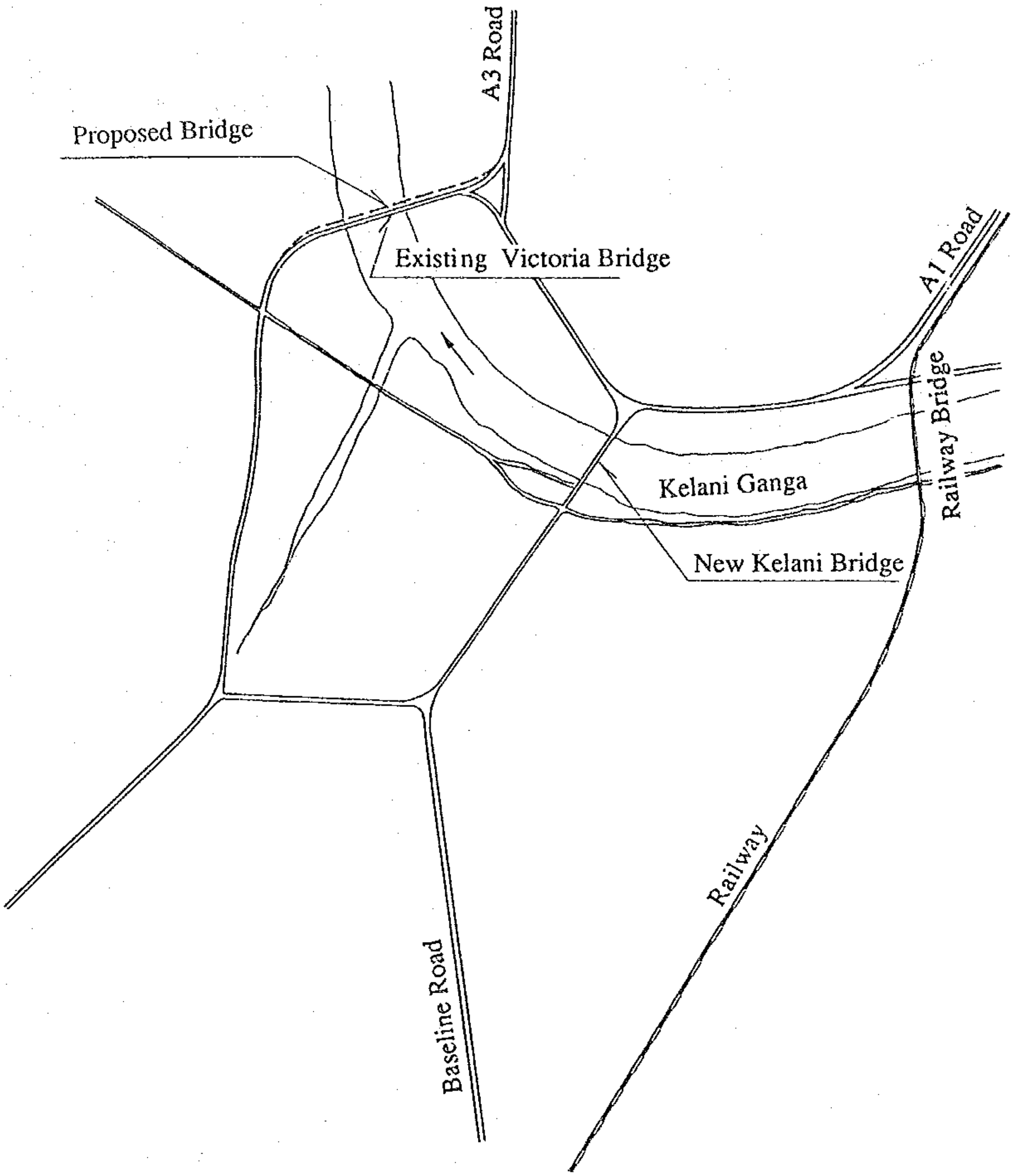


Fig. 2 Project Location (2)

SUMMARY

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Since 1977, the Government of Sri Lanka has been implementing a free economic policy, and public investment has been expanded to activate the economy and to strengthen the foundation of the nation.

The establishment of a road network is one of the important elements of this public investment expansion policy, and a five-year road improvement plan started in 1987 is now being implemented with of loans from the World Bank, the Asian Development Bank and foreign assistance from Japan and other countries.

The route that links the city of Colombo with the northern part of Sri Lanka must cross the Kelani River by either the Victoria Bridge or the New Kelani Bridge.

The Victoria Bridge was constructed approximately 90 years ago, and restructions on its use were set in 1986 with the result that heavy traffic is concentrated upon the New Kelani Bridge. This, combined with the increased amount of traffic that is accompanying economic expansion has led to chronic congestion along the approach roads to both bridges during peak periods.

In January of 1988 structural deficiencies were found in the New Kelani Bridge. If these deficiencies are left unattended, traffic restrictions will also have to be imposed on this bridge.

Urgent measures are therefore necessary to restore the Victoria Bridge to full operating capacity in order to alleviate the current traffic congestion and to handle the further increases in traffic volume that will accompany continued economic expansion.

In addition, it is necessary that repairs be made on the New Kelani Bridge, and for this reason also, the Victoria Bridge must be reconstructed to extend the durability of the New Kelani Bridge.

This being the situation, the Government of Sri Lanka approached the Government of Japan in August, 1987 with a request for grant-aid cooperation to reconstruct the Victoria Bridge.

The Government of Japan accepted this request and decided to conduct a basic study, the implementation of which was assigned to the Japan International Cooperation Agency (JICA). JICA formed a study team headed by Mr. Shoichi Saeki (Director, Structure and Bridge Department, Public Works Research Institute, Ministry of Construction), and this study team was dispatched to Sri Lanka for 27 days from July 9th to August 4th, 1988.

The study team discussed with the Sri Lankan authorities concerned on the location, length and width of the bridge as well as the alignment of approach roads. They carried out geological and geographical surveys, and a survey on traffic volume passing over the Kelani River during rush hours, and also collected and analysed data relating to the Project.

The team conducted a detailed investigation and concluded that construction of the bridge and approach road as described below would be valid.

(1) Bridge ..... Length: 228.0 m, carriage way width: 7.5 m and pedestrian walkway width: 3.0 m

(2) Approach Road ...... Approach road connecting the bridge to the intersection on the left bank of the Kelani River, and the intersection on the right bank (= 372m)
(3) Facilities auxiliary to the bridge and the approach roads.

The Project was subjected to a comprehensive investigation as regards river maintenance, economic factors, constructability, and future bridge maintenance and management.

In order to work out the correct type of bridge, three types of bridges (two of pre-stressed concrete bridges and one steel bridge) were selected to make a comparative study, and it was concluded that a seven span continuous pre- stressed concrete box girder bridge is best for this project.

The commencement of construction will be approximately ten months from the conclusion of the Exchange of Notes between the Governments of Japan and Sri Lanka pertaining to engineering services i.e. detailed design, preparation of tender documents and evaluation of tenders.

Following the conclusion of the master Exchange of Notes between the Governments of Japan and Sri Lanka, construction work will commence. The time period for the construction will take about 27 months.

The expenses to be borne by the Government of Sri Lanka are estimated at Rs. 751,000 excluding land acquisition and compensation costs.

The implementing agencies on the Sri Lankan side for these operations will be the Ministry of Highways (MOH) and the Road Development Authority (RDA) which is a sub-agency under the MOH. The RDA will assume responsibility for the operation, operation, maintenance and maintenance management during the construction stage and following completion of the Project. The RDA has the proven experience in these areas having been responsible for major trunk roads of the national highway system and for the operation, maintenance and management of trunk roads for many years.

As the bridge is designed to be a concrete bridge with almost maintenance free ancillary parts, the annual maintenance and management expenses will be in the order of those for a normal paved road (Rs. 100,000). Therefore the costs to be borne by the Government of Sri Lanka are extremely light.

By implementing the Project, traffic volume passing over the Kelani River will be increased and smooth overall traffic operation will be assured between the regions north of Colombo, including the international airport, and the downtown area of Colombo. In addition, spin-off effect may be obtained from the stimulation of related industries, the increase of employment opportunities and the development of bridge construction technology.

Therefore, the implementation of the Project under grant-aid assistance will be of a great significance and immediate implementation is desirable.

CONTENTS

List of Figures

List of Tables

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

There are two bridges crossing the Kelani River: the Victoria Bridge and the New Kelani Bridge. All traffic between Colombo and the northern part of Sri Lanka must cross one or the other bridge. However, the Victoria Bridge is in a state of deterioration, having been constructed approximately 90 years ago, and heavy traffic is concentrated upon the New Kelani Bridge since restrictions on the use of the Victoria Bridge have been in effect since 1986. This, combined with the increased amount of the traffic that is accompanying economic expansion have led to congestion along the approach roads to both bridges in peak periods. In January of this year, there was found to be structural flaws in the New Kelani Bridge that is the primary bridge. The present situation is that if these flaws are left unattended, traffic restrictions will also have to be imposed for this bridge also.

The amount of traffic crossing the two bridges was approximately 47,000 vehicles per day in 1983 but since then the rate of growth of the amount of traffic has been estimated at approximately 4% per year. (In the last survey, a rate of approximately 55,000 vehicles per day was confirmed.) In order to handle this increasing amount of traffic, it is vital that the full capacity and functions of the Victoria Bridge be restored.

With the situation as such the Government of Sri Lanka aproached the Government of Japan in August, 1987 with a request for grant-in-aid cooperation for the plan to reconstruct the Victoria Bridge.

The Government of Japan approved the request and decidedto send a survey team to Sri Lanka to verify the content of the request, and to perform a basic design survey in order to confirm the validity of the Project in light of the conditions for grant-in-aid cooperation. The Japan International Cooperation Agency sent a survey mission headed by Mr. Shoichi Saeki, Director, Structures and Bridge Department, Public Works Research Institute, the Ministry of Construction, from July 9, 1988 to August 4, for a period of 27 days.

The survey group performed site surveys with respect to the content of the request put forth by the Government of Sri Lanka regarding the scale, structure, width, and approach roads of the bridge, and also held discussions with the related Sri Lankan authorities. Also, geological and field surveys were executed.

Minutes of meeting with the Government of Sri Lanka concerning this study was signed on July 15, 1988.

After study and analysis of data obtained during the site study, a Draft Final Report was prepared and JICA sent the Study Team to Sri Lanka again from September 24 to October 2, 1988 to explain and discuss the draft with Srilanka authorities. The minutes of these discussions were signed on September 29, 1988.

On the basis of the analysis of data obtained from the site surveys and the discussions with the Sri Lankan authorities, this basic design report details the background relating to the plan to reconstruct the Victoria Bridge, the objective of the Project, the basic designs for the bridge and approach roads, the orgaization for implementation of the Project, and the evaluation of the Project.

CHAPTER 2

BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1 Outline of Current Condition of Roads and Bridges

Roads of Sri Lanka have been under the influence of the U.K. for a long time, and road networks have been well provided since earlier times. The Government of Sri Lanka lays importance not only on daily maintenance and repairs of existing road networks but also on upgrading of existing roads.

National Highways controlled by RDA (Road Development Authority: To be explained later) are classified into A to B. Classes A and B are trunk roads, and Classes C to E are second-class national highways. The actual records of road maintained during one year of 1987 which RDA executed are as follows:

Classes A and B Roads . . . Repairment/extension of 904 km
Classes C and D Roads . . . Construction/extension of 1,491 km

Standards classified by class of the above-mentioned roads shall be as follows:

Class A . . . Trunk roads connecting the capital and regional central cities and also connecting regional central cities (paved roads having a total width of 10.8 to 16.8 m and a carriageway width of 7.2 to 10.8 m)

Class B . . . Main roads connecting main cities as well as main linking roads connecting trunk roads (gravel-paved and asphalt-paved roads having a carriageway width of 3.6 to 7.2 m)

Class C . . . Agricultural roads and regional roads (single carriageway roads, mostly gravel-paved roads and partially sand-paved roads)

Class D . . . Sand-paved roads having a width of 2.4 to 3 m which is generally passable only in the dry season

Class E . . . Carat roads, which are generally not passable by cars, but partially passable by jeep

The road traffic network of Colombo Metropolitan Zone consists of main trunk roads (of Standards A and B to be mentioned later) which extend radially and in all directions centering around Colombo City (refer to Fig. 2.1). Of these roads, A1, A2, A3, and A4 constitute the main frame-works of the trunk-roads of the Colombo Metropolitan Zone, and the Base-line Road has a function of connecting these main lines in a circle and extends in the south-north direction.

Current road traffic is in an inefficient condition, using mixed traffic of high-speed vehicles such as cars and slow-speed vehicles consisting of carts, motorcycles and bicycles. In addition, there are many cases of parking on the road, and safety facilities such as the separation of the carriageway from the sidewalk, central separation zones and signal

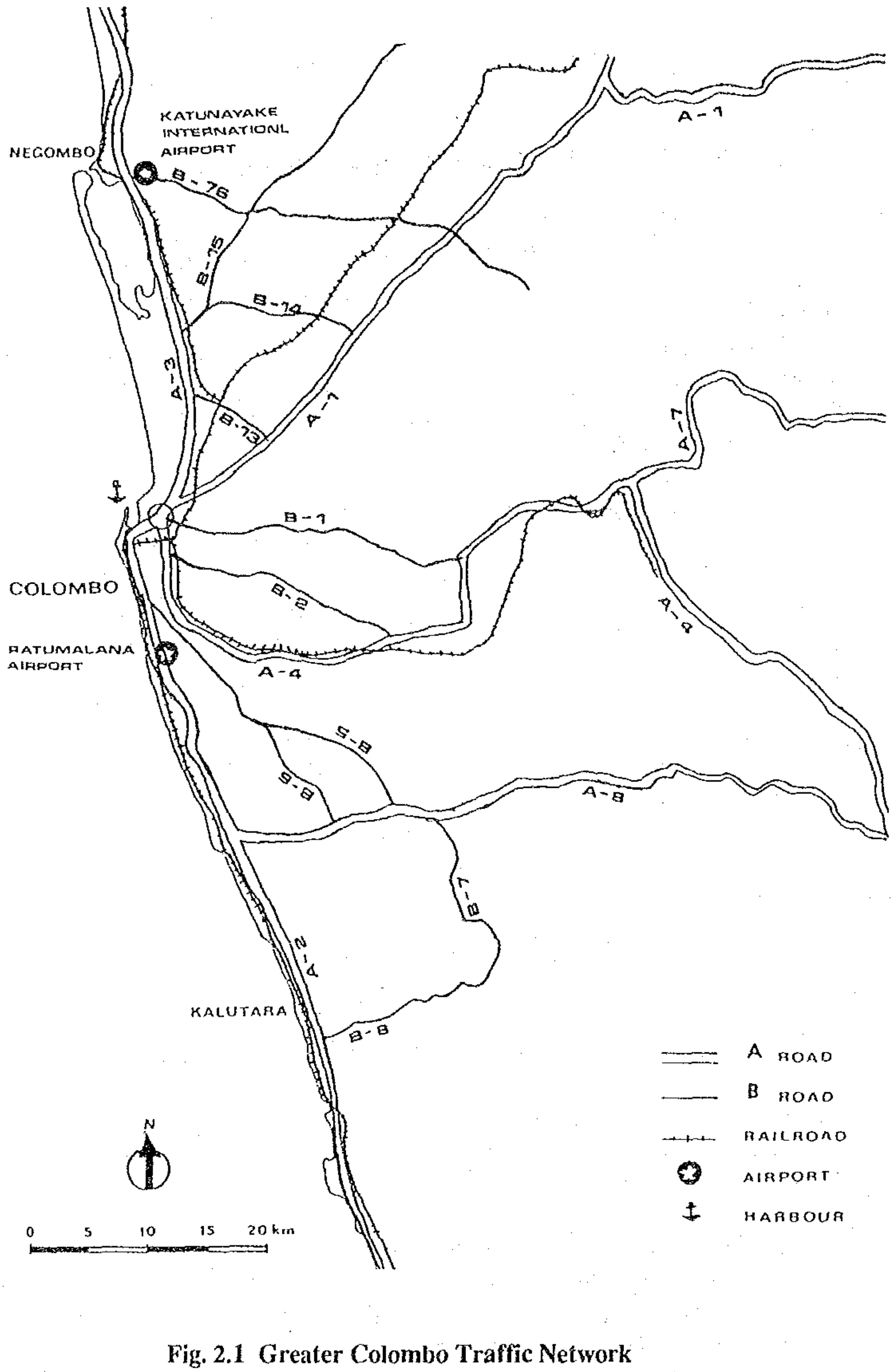

Fig. 2.1 Greater Colombo Traffic Network

equipment are lacking. Further, the systems of the intersections also pose problems. These are obstructing the traffic and causing traffic jams at many places.

Commodity distribution from Colombo Port is executed by the Base Line towards the south and is scattered from the Base Line to inland provinces. On the other hand, commodity distributions towards the north and north-east are executed by A3 and A1 Roads respectively. As the facilities of Colombo Port are improved, sizes of cargo-containers have increased, thereby increasing the cargo transportation quantity on the roads.

Along with the increase in the traffic volume and the sizes of vehicles, insufficient capacity of cross-section capacity of roads and damage to pavement surfaces have become problems. The following improvement projects are executed under the assistance of foreign financial organizations (such as the World Bank, Asian Bank, ODA of the U.K. and Yugoslavian organization).

(1) Level up of A1, A2, A4, A6 Roads

- Widening of roads
- Improved alignment
- By-passes for congestion areas
- Construction of meridians

(2) Extension of the Baseline Road
Including reconstruction bridges, widening and rehabilitation of super annulated bridges on the route.

2-2 Outline of Road Improvement Plan

2-2-1 Outline

The increases of road traffic in Sri Lanka in indicated in Table 2.1 showing the changes that have occurred in the number of vehicles registered from 300 thousand in 1982 to 500 thousand in 1987. The program for the maintenance and repair of the roads and bridges in order to cope with this increases is being implemented by the Road Development Authority (that was established to replace the Development of Highways of the Bureau of Roads in 1986).

An organized RDA maintenance and repair plan was comenced using finance that was received from the World Bank, in 1981. These funds were used to improve about 500\km of major roads and about 40 bridges. In 1986, the second release of funds was used to continue these pojects. Moreover, in 1985 and 1987, funds from the Asian Development Bank were used for two road repair projects designed to repair and repave about 800\km of major roads and 30 bridges.

These projects were part of the five-year plan (1985 to 1989) for road maintenance and repair established by the Ministry of Highways in 1985, with a budget of 5 billion Rupees. Even when this maintenance and repair program will have finished, there will still be about 7,000\km of major roads and arterial roads in need of urgent repair, and less than 20% of the bridges will have been repaired. Because of this situation, a Revised Program A was decided upon for implementation from 1989 to 1992, and the annual budget (of 2.8 billion rupees) allocated.

In 1985, the Urban Development Authority received funds from the Overseas Development Authority of U.K., and on the basis of the cooperation of the City of Colombo and the RDA, and are implementing a program to alleviate traffic problems in the Greater Colombo region. This program has improved the majority of intersections within the city, and has widened the radial roads leading out of the city center.

Moreover, in April of 1988, Japanese loans totalling approximately ¥22.56 billion yen were allocated, and of this total, some ¥12.31 billion was spent on the purchase of machinery and materials for road rehabilitation.

As has been described above, the present program for road provision has been mainly concerned with rehabilitation,

and the only program for the construction of new roads has been for an expressway (of about 30km in length) linking Colombo and Katunayake, for which the feasibility study was implemented in 1984 by JICA.

Furthermore, one part of this is a 1.5km port access road within Colombo Port, and work on this is scheduled to start soon with loan funds from Japan.

Fig. 2.2 indicates the five-year rehabilitation program (1987-1991) for bridges.

Table 2.1 Vehicles According to the Records of the Registrar of Motor Vehicles

	1982		*1983*		*1984*		*1985*		*1986*		*1987*	
	No:	*Index*	*No:*	*Index*	*No:*	*Index*	*No:*	*Index*	*No:*	*Index*	*No:*	*Index*
Private & Hiring Cars	131657	100	136853	104	141730	108	148587	113	155246	118	159157	121
Motor Cycles	107550	100	121845	113	138637	129	161373	150	185557	173	204370	190
Bus – SLTB	15579	100	16100	103	16425	105	16516	106	16855	108	15664	101
Private Coaches	10593	100	14338	135	18256	172	21793	206	23582	223	246602	233
Lorries and Vans	69705	100	77714	111	85701	123	92703	133	96762	139	97124	139
Tractors registered as Lorries	1248	100	1252	100	1252	100	1253	100	1260	101	1283	103
Trailers	3385	100	3443	102	3571	105	3675	109	3702	109	3770	111
Others registered as Lorries	432	100	436	101	450	104	464	107	470	109	481	111
Total (other than the land vehicles)	340149	100	371981	109	406022	119	446364	131	483434	142	506509	149

2-2-2 Foreign financial assistance projects

(1) Projects implemented with funds from the World Bank -
The following is a list of the projects that have been carried out (or are currently being implemented) on the basis of funds provided by the World Bank. (See Fig. 2.3)

1. Colombo-Kandy		38.5	km
2. Campaha-Miriswatta		4.0	"
3. Gampaha-Yakkala		3.0	"
4. Approach road to Oil Refinery-Sapugaskanda		3.5	"
5. Kurunegala-Narammale-Madampe		61.2	"
6. Kandy-Katugastota		4.0	"
7. Negombo-Giviulla		34.5	"
8. Kelaniya-Mudungoda		28.5	"
9. Ekala-Gampaha		9.5	"
10. Minuwangoda-Grampaha		8.8	"
11. Colombo-Galle-Hambantota		126.8	"
12. Colombo-Horana (Kohuwala to Horana)		25.8	"
13. Panadura-Ratnapura		48.0	"
14. Kandy-Jaffna (Katugastota to Matale)		20.1	"
15. Kandy-Mahiyangana-Padiyatalawa		4.8	"
16. Katugastota-Kurunegala-Puttalam		11.2	"
17. Peradeniya-Badulla-Chenkaladdi		20.9	"
18. Kandy-Ritigala		32.0	"
	Total	485.1	km

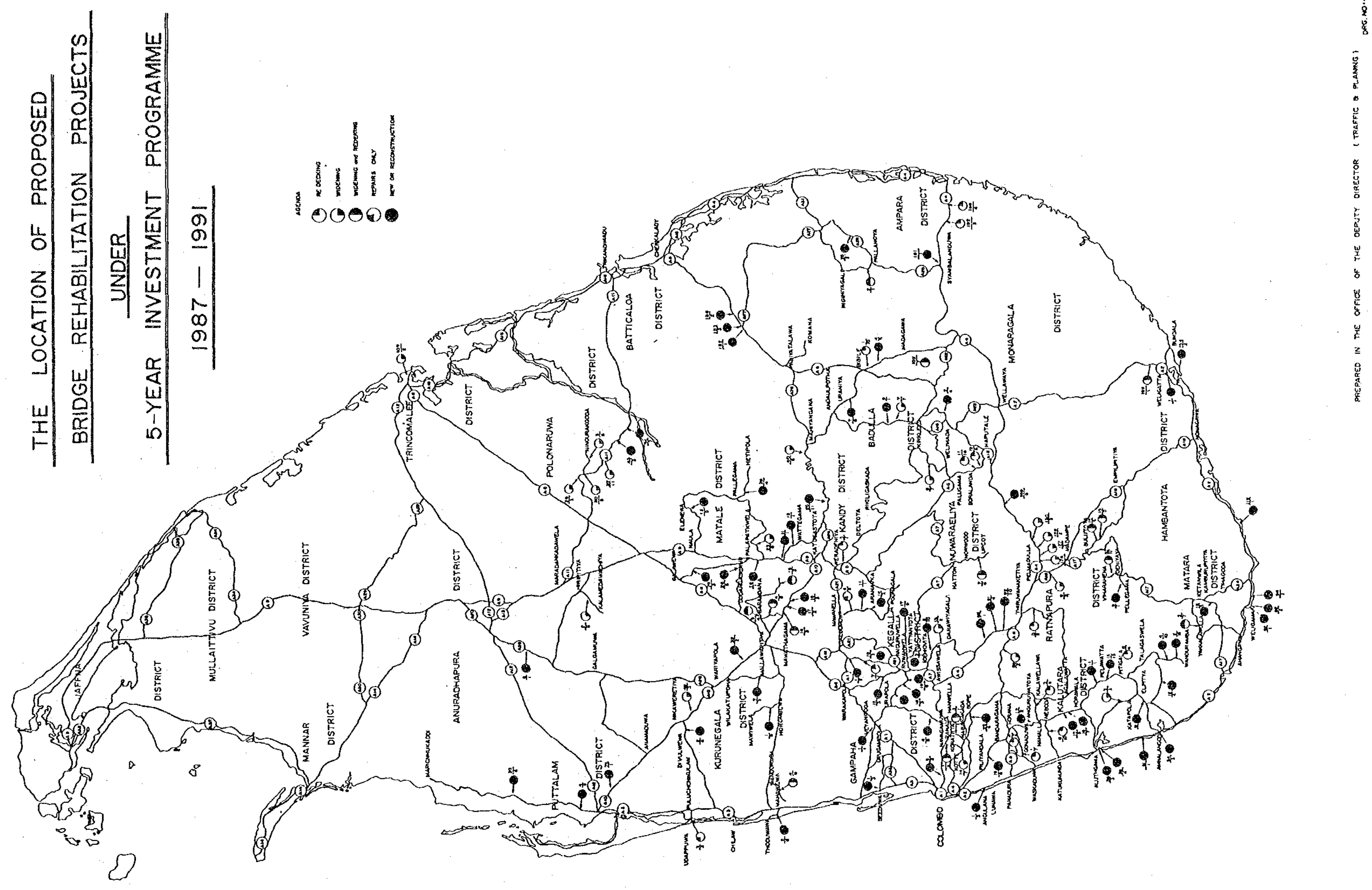

Fig. 2.2 Five-year Program for Bridge Rehabilitation

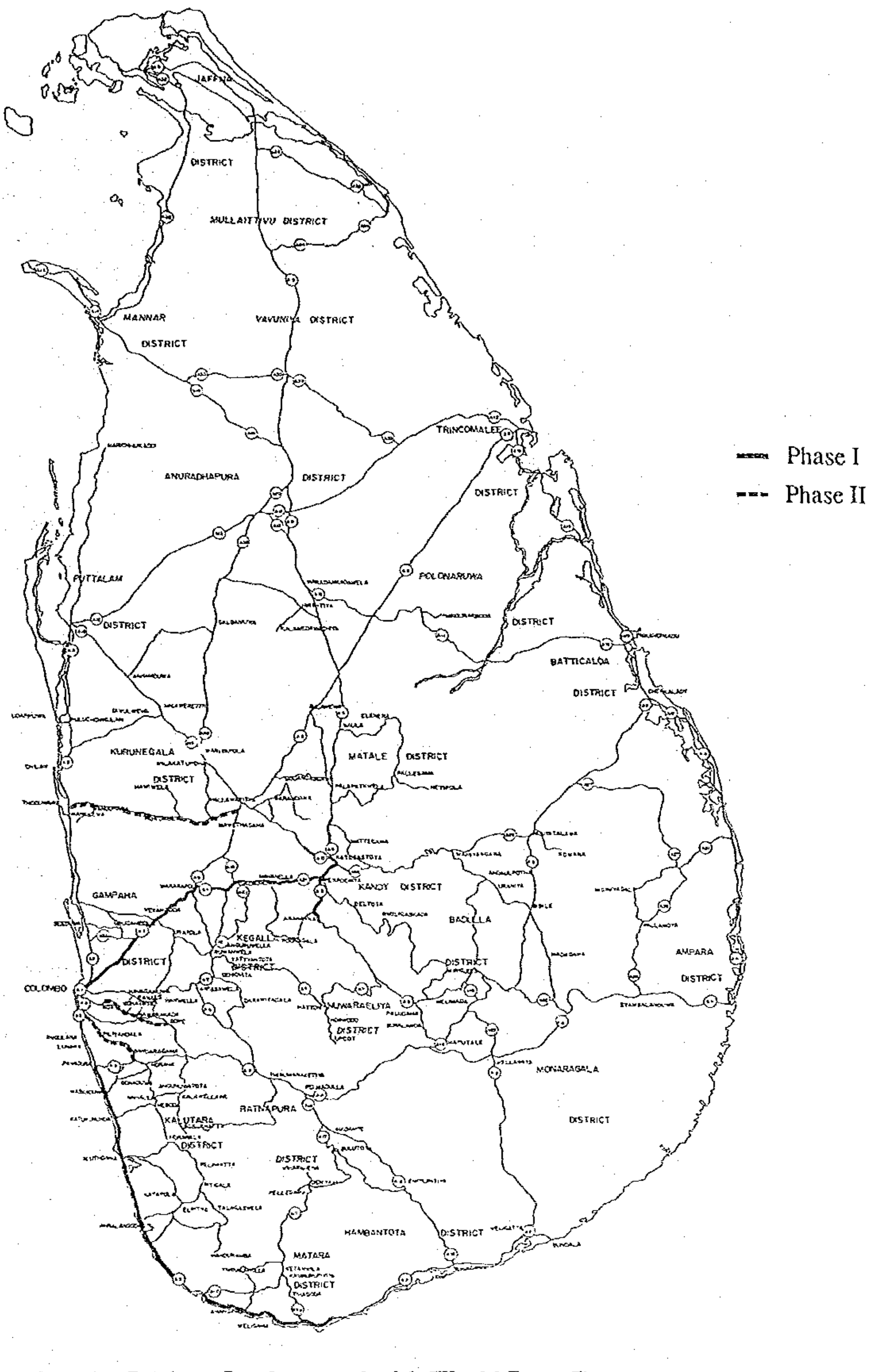

Fig. 2.3 Projects Implemented with World Bank Funds

(2) Projects implemented with funds from the Asian Development Bank -
The following is a list of the projects that have been carried out (or are currently being implemented) on the basis of funds provided by the Asia Development Bank. Those in Phase I are currently being implemented, while those in Phase II are in the stage of detailed design. (See Fig. 2.4)

(Phase I)

1.	Ambepussa-Kurunegala-Trincomalee		197	km
2.	Matale-Jaffna		94	"
3.	Galkulama-Anuradhapura		14	"
4.	Anuradhapura-Rambewa		15	"
5.	Kurunegala Circular Road		4	"
		Total	324	km

(Phase II)

1.	Colombo-Ratnapura Road-Batticaloa (Homagama-Beragala)		160	km
2.	Wellawaya-Monaragala		35	"
3.	Beragala-Haliela (A16)		40	"
4.	Peradeniya-Badulla-Chenkaladdi (Haliela-Badulla)		6	"
5.	Bandarawela-Welimada (B51)		22	"
6.	Avissdwella-Hatton-N'Eliya (A7)		121	"
7.	Hatton Maskeliya		19	"
		Total	403	km

(3) Projects implemented with funds from the Overseas Development Authority of U.K.-
The following is a list of the projects that are currently being implemented on the basis of funds provided by the Overseas Development Authority of U.K. (See Fig. 2.5)

1. Galle Road (Old Parliament Building-Dehiwela)
2. Prince of Wales Avenue
3. Sir Mohammed Macan Maker Mawatha, Justice Akbar Mawatha, Union Place Ward Place
4. Reid Avenue
5. Maradana Road
6. Symonas Road
7. George R. DE. Silve Mawatha
8. Centrdl Road

9. Bauddhaloka Mawatha
10. Aluthmawatha Road
11. Olcott Mawatha, Sri Sanaraja Mawatha

(4) Projects implemented with funds from Japan -
The following is a list of the road development projects that are currently being implemented on the basis of funds from Japan. Both projects are currently in the stage of preparations for tendering.

1. Construction machinery and materials (Road construction machinery and equipment, and construction materials)

2. Colombo Port Access Road

In addition to all of these projects that have been listed above, there is also a planning study being performed by Yugoslavia for the Galle Road Corridor.

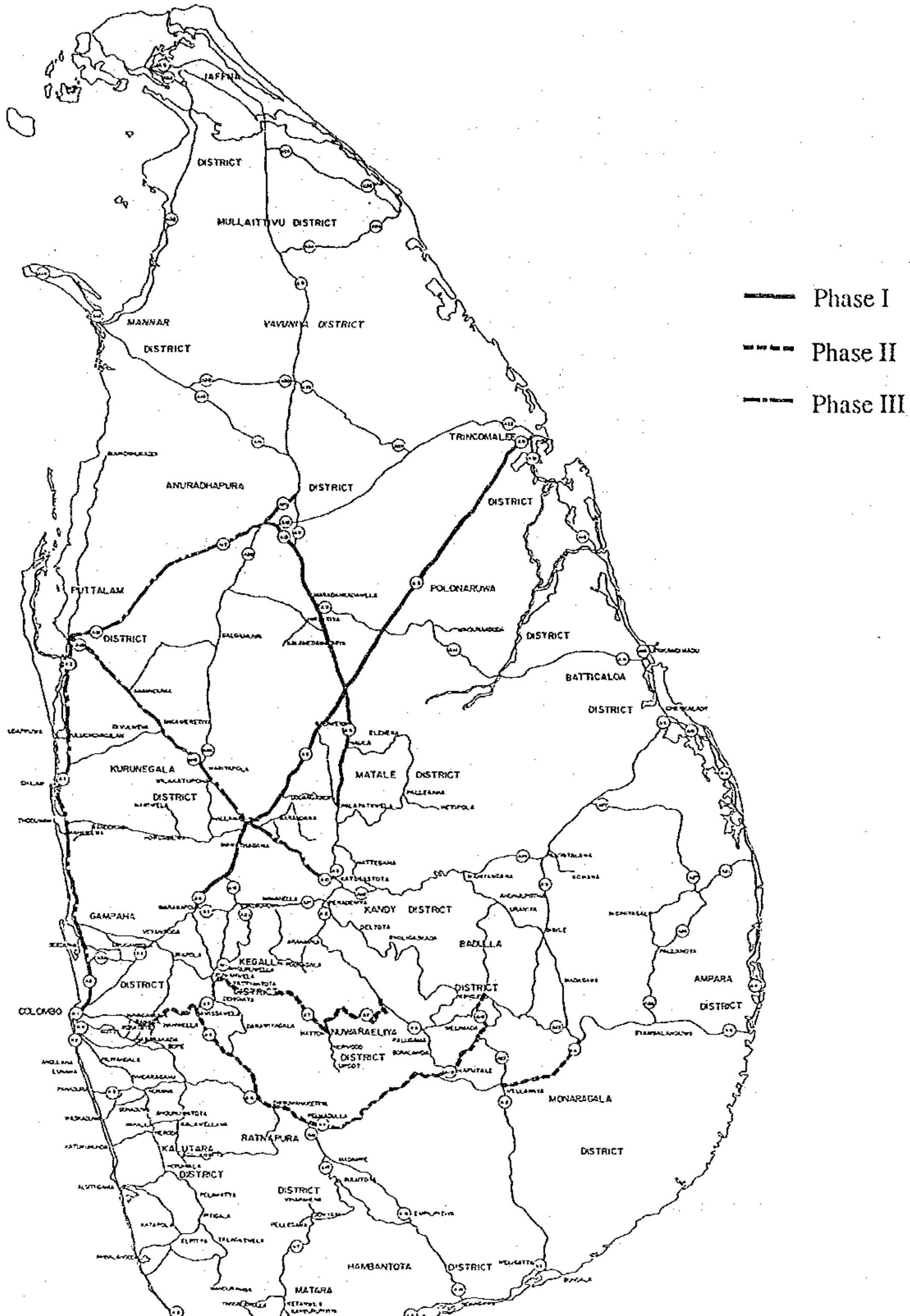

Fig. 2.4 Projects Implemented with Asia Development Bank Funds

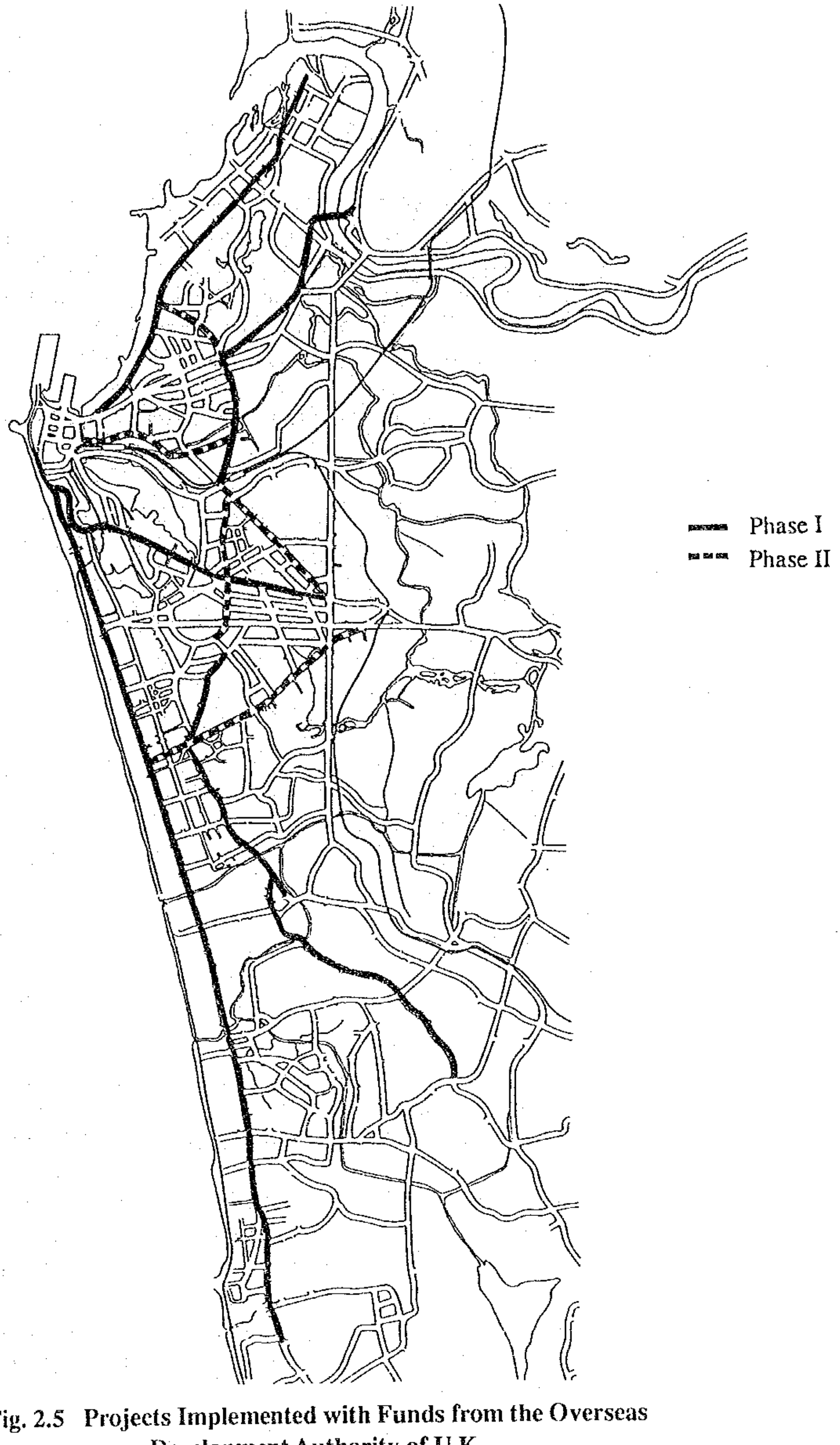

Fig. 2.5 Projects Implemented with Funds from the Overseas Development Authority of U.K.

2-3 Present Condition of the Victoria Bridge

The main flows of commodities and people from Colombo to the north of Colombo pass through A3 and A1 Roads and cross Victoria Bridge and New Kerani Bridge over the Kerani River. The traffic volume of these two bridges in fiscal 1985 (when Victoria Bridge was still sound) classified by vehicle type is shown in the Table below, which indicates that about 40% of the volume of sectional-area traffic that crosses the Kerani River is assigned to Victoria Bridge, and its daily traffic volume amounted to 20,650 vehicles.

Traffic Volumes by Vehicle Type over Two Bridges over the Kelani River

(Vehicle/day)

	Passenger Car	Government-operated Bus	Private-operated Bus	Lorry	Motor-cycle	Total
Victoria Bridge	7,656	1,624	4,408	4,410	2,552	20,650
New Kelani Bridge	13,038	1,445	1,918	6,034	5,365	27,800

As shown above, traffic demand to Victoria Bridge will more and more increase in the future, considering the augmentation of the traffic volume, and constitutes a key point to the above-mentioned improvement in main trunk roads in the Colombo Metropolitan Zone.

Victoria Bridge is a 2-carriageway truss bridge. It has a length of 228 m (32.5 m x 7 spans), a carriageway width of 7.5 m and a 1.0-m-wide sidewalk each out of both sides of the carriageway.

The condition of the main structure (upper beam, lower beam and lattice members) is as follows: The upper beam shows good condition and shows no changes in itself and its rivets, but the lower beam has developed corrosion around the drainage point provided at its lower flange, and the lattice member has developed severe corrosion and wear. The floor members also shows severe corrosion and wear due to leakage of drain from the floor plate. Further cracks run from the shoes of both abutments to the abutments bodies, and damage to the abutment of the Colombo side is particularly severe, thus requiring urgent repairs. Under such circumstances, traffic restrictions were enforced on heavy vehicles in 1986 by recommendation based on the survey conducted by Atkins International, a British consultant, using the fund of O.D.A. of the U.K. As a result, heavy-duty vehicles mainly made a detour to New Kelani Bridge, and Victoria Bridge was used only for the traffic of passenger cars, motor cycles, bicycles, etc. Thus its share-ratio of the traffic volume has dwindled to about 1/4 of that when the bridge was sound.

2-4 Background and Scope of the Request

2-4-1 Background of the request

There are two bridges crossing the Kelani River: the Victoria Bridge and the New Kelani Bridge. All traffic between Colombo and the northern part of Sri Lanka is therefore concentrated on the two bridges. The amount of traffic crossing the two bridges was approximately 55,000 vehicles per day in 1988, and as shown in Table 2.1, there have been rapid increases in the number of registered vehicles, and the number is estimated to have further great increases in the future. Both bridges are becoming increasingly important to the traffic network.

However, the Victoria Bridge is in a state of deterioration, having been constructed approximately 90 years ago, and a survey and report performed by the British consultant group of WS Atkins International on the funds of the Overseas Development Authority of U.K., resulted in the implementation of restrictions for heavy traffic. As a consequence, heavy vehicle traffic became further concentrated upon the New Kelani Bridge, and currently, there is heavy congestion along the approach roads to both bridges in peak periods.

Moreover, in January of this year (1988), there was found to be structural flaws in the New Kelani Bridge. The present situation is that if these flaws are left unattended, traffic restrictions will also have to be imposed for this bridge also. It is therefore urgent that the full operating capacity of the Victoria Bridge be restored as soon as possible.

Since 1981, the Government of Sri Lanka has been dealing positively with the task of providing the traffic network through the use of many types of fund cooperation, as was explained in Section 2-1, and is formulating a five-year plan on the premise that the replacement of the Victoria Bridge will be performed through foreign fund cooperation.

With the situation as such, the Government of Sri Lanka approached the Government of Japan in August, 1987 with a request for grant-in-aid cooperation for the plan to replace the Victoria Bridge.

The Government of Japan approved this request and, JICA formed a survey group, and this survey group was dispatched to Sri Lanka.

After the decision for the basic design survey had been made, documents supplementing the description of this request that was received from the RDA who will be the executing agency for this project. Since a bridge larger than that suggested in the initial request was indicated, a site survey and discussions with the related authorities of the Government of Sri Lanka was conducted, and the scope was suitably adjusted.

2-4-2 Scope of the request

The scope of the request of the Govenment of Sri Lanka for the Reconstruction of the Victoria Bridge is as follows.

- The construction of a brdige to replace the existing Victoria Bridge to the following criteria.

  Bridge length .... 238 m
  Carrage way width ..... 7.5 m
  Pedestrian way .... 3.0 m

- Approach roads .... 230.0 m + 160.0 m = 390.0 m
- Improvement of intersections

CHAPTER 3

NATURAL CONDITIONS

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The following are the results of site surveys of natural conditions for the basic design.

- Meterological Conditions: Data essential for the planning of the roads and the substructure and superstructure of the bridge.
- Hydrological Conditions: Data necessary for planning the route alignment and the substructure of the bridge.
- Geological Conditions: Data necessary for planning the bridge foundation work.

3-1 Meteorological Conditions

The meterological conditions were determined on the basis of data (in the appended materials) for the two years of 1986 and 1987 of Colombo City.

(1) Atmospheric temperature*1: The average values for the daily maximum atmospheric temperature and the daily minimum atmospheric temperature were 30°C to 32°C, and 22°C to 26°C, respectively. There are no large seasonal changes in the amount of rainfall.
(2) Humidity*2: The average daytime and nighttime humidities are 76% and 89%, respectively, and there is also little seasonal change.
(3) Rainfall*3: The maximum monthly rainfall and the maximum daily rainfall are 509\mm/day and 151\mm/day, respectively.
(4) Peak wind velocity*4: The maximum wind speed is 30m/sec.

*1 This is basic data used to calculate the amount of contraction and expansion of the bridge superstructure due to temperature.
*2 This is basic data used to estimate the amounts of concrete creep coefficient and shrinkage.
*3 This is basic data used to work out a drainage plan for the bridge and the roads.
*4 This is basic data used to calculate the wind load that will act on the bridge.

3-2 Hydrological Conditions

The hydrological data used was "HYDROLOGICAL DATA OF KELANI GANGA" (contained in the appended materials). These materials were compiled from 1927 to 1987, but only the data for 1960 and later was used because maximum value for the water level is now lower due to the influence of dams constructed in 1960 and 1970.

- Catchment area: A = 2,305 km*[2]
- Maximum elevation inside the catchment area: 240m M.S.L.
- High water level: H.W.L. = 2.80m M.S.L.
- Average water level: H.W.L. = 1.62m M.S.L.
- Maximum discharge: Q = 4500 m*[3] year

Moreover, the flow speed is extremely slow and the velocity is estimated to be about 0.3 m/sec normally, but changing to approximately 3.0 m/sec when there is release from the dams. The design flow was set at the following values that were determined through discussions with RDA.

After public use is permitted: v = 3.6 m/sec
During construction: v = 3.0 m/sec

3-3 Geological Conditions

(1) Outline -

Geological survey and four borings have already been carried out at the location as shown in Fig. 3.1 (No. 1 to No. 4) by the Sri Lanka Government.

Supplementary two borings and laboratory tests were done at the another location (No. 5, No. 6 See Fig. 3.1) to ascertain the location of sound bearing stratum and to get useful information about physical properties of soil stratum.

The bores were performed by the water flush rotary drill with 75mm diamter.

From the results of the survey, it was confirmed that there was a relatively well compacted sand layer between 15 and 20 meters from the surface except for small areas of marshy land on the Colombo side.

Below this sand layer, there was a fresh layer of hardened metamorphic rock that could be the bearing stratum for the bridge foundation.

(2) Method of the survey -

The survey was conducted according to British Standard 1377 using water Flush rotary boring.

(3) Results of the survey

The results of the survey are shown in the soil profile (Fig. 3.2) and attached in the appendix (Testing data of core samples)

The major results are summarized below.

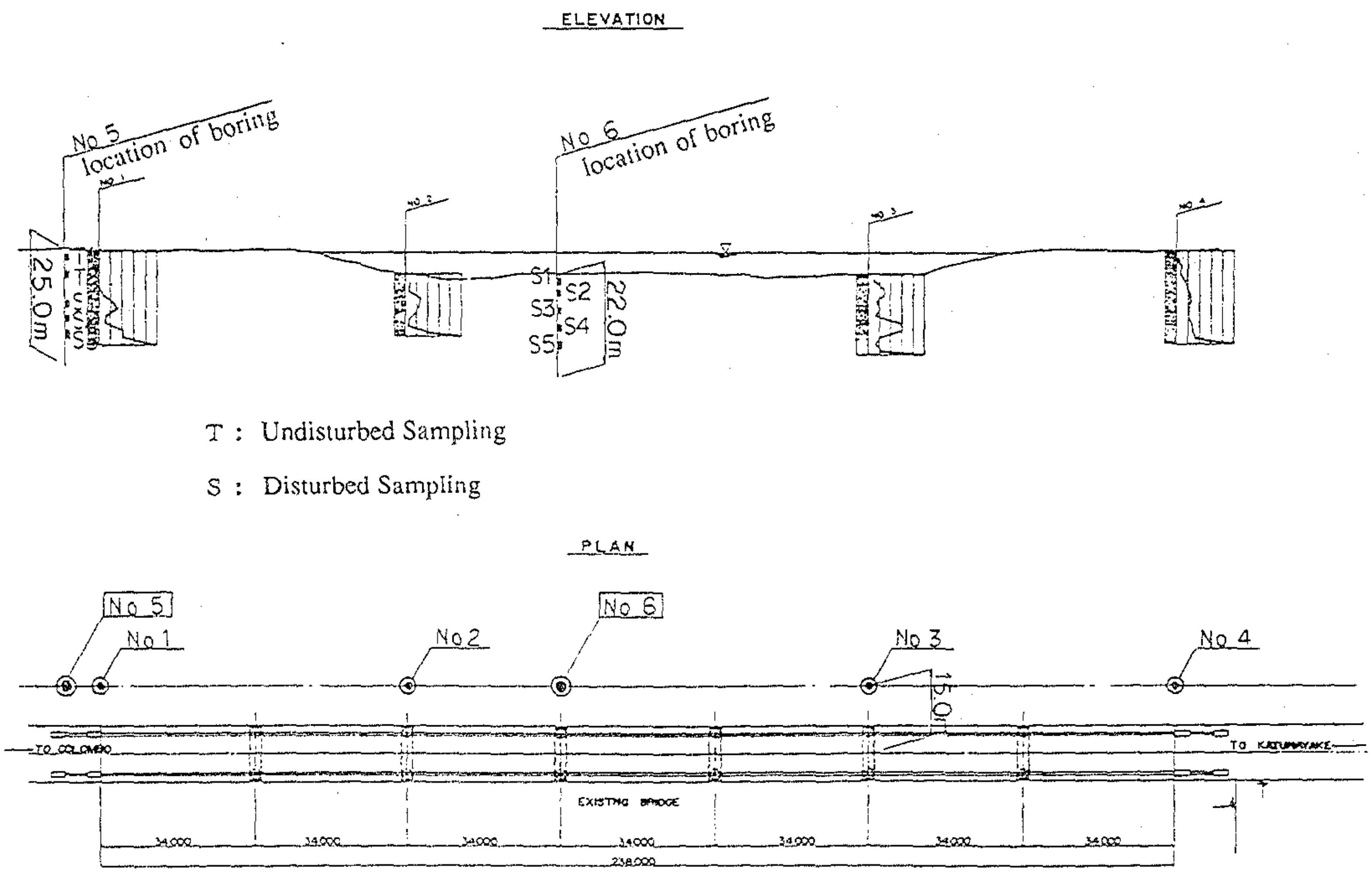


Fig. 3.1 Geological Survey Location Map

- The bedrock forming the bearing stratum for the bridge construction exists at a depth of about -20.0 M.S.L. same as the RDA's boring results, and lies practically horizontal to the cross section of the river.
- The bedrock is of rock that has been rather recently formed, and is judged to be hard rock.
- The sandy soil comprising the greater part of the ground surveyed has a poor grain size distribution having uniform grain size (equivalent coefficient Uc = 3). And hence its coefficient of permeability is expected to be large.
- The clay soil on the Colombo side is showed an N-value of over 0 for standard penetration tests, but care should be taken to maintain the stability of earth fill for banking will be required.

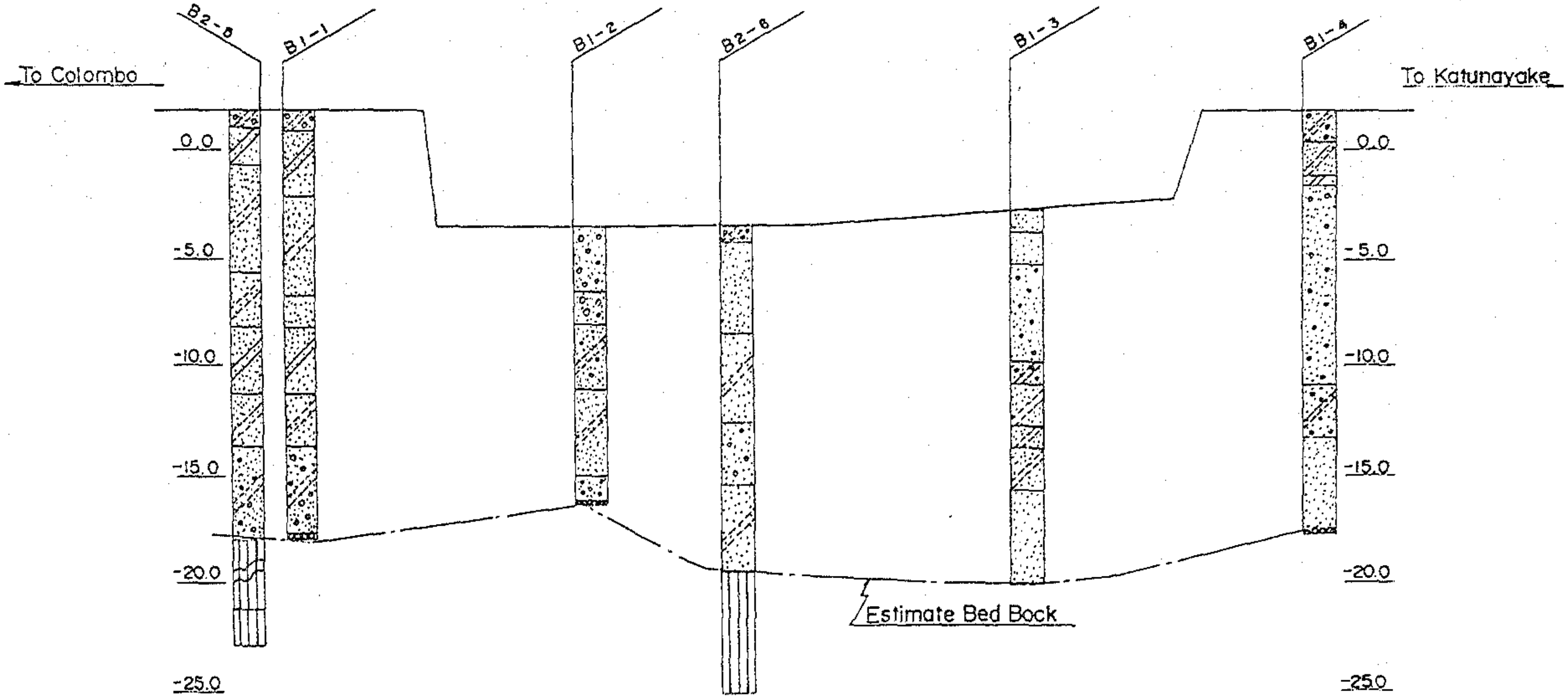


Fig. 3.2 Soil Property Chart

CHAPTER 4

DESCRIPTION OF THE PROJECT

CHAPTER 4 DESCRIPTION OF THE PROJECT

4-1 Objective of the Project

The purpose of this project is to construct a bridge to replace the Victoria Bridge that has deteriorated to the extent that it cannot handle the passing of large and heavy vehicles, and in doing so, improve the traffic condition i the Greater Colombo Area.

4-2 Investigation of the Content of the Request

The results of the investigation on the basis of discussions with the Government of Sri Lanka and the site surveys relating to the content of the request from the Government of Sri Lanka, are described in the following.

(1) Position of the bridge -

Constructing the new bridge upstream of the existing Victoria Bridge (hereinafter called the existing bridge), will require the replacement or movement of the service road running along the approach road to the existing bridge on the left bank, and will also cause many problems relating to the purchase of houses concentrated nearby the intersection on the left bank. Alternatively, if the new bridge were located downstream, houses would still have to be purchased and compensation made but this would be relatively easier and cost relatively less when compared to the situation for the upstream. Not only this, the handling of the traffic after the completion of the bridge would also be more rational and far easier if the new bridge were to be constructed downstream. For these reasons, it is valid that the new bridge be constructed downstream of the existing bridge.

(2) Width of the roads -

The width of the roads as described in the request documents is to be about the same as the existing bridge, and this was also judged to be appropriate since the minimum conditions of traffic volume to achieve the purpose of the Project are met.

	Carriage way width	Pedestrian path width
Exsiting bridge	7.35 m	Upstream side 1.35 m Total: 2.70 m Downstream side:1.35m
New bridge	7.50 m	3.00m

On the other hand, the RDA which is to be authority implementing this project, also raised the possibility separate from the formal request, of constructing a 6-lane road with two pedestrian lanes.

The existing bridge is deteriorated and in order to alleviate the current state of restrictions being imposed on heavy traffic, the construction of a new bridge and the urgent recovery of the former functions of the existing bridge are to be given priority. Moreover, the Project is to be an integral part of the traffic network for the Colombo area and since it will make an effective contribution to other road provision programs the urgent implementation of the Project based on the original request was therefore considered appropriate.

However, it is still nevertheles desirable that the present design be one for which widening can be easily performed in the future if such a plan is realized.

(3) Bridge length and approach roads -

From considering the aspects of river maintenance and the site conditions, the position of the new bridge is to be alongside the exsiting bridge, and the length is to be 228 meters (227.95 meters from actual measurements). The approach roads to the new bridge are to be sited alongside those to the existing bridge.

(4) Improvement of the intersections -

The intersections are to adopt the "runabout" system which is the preference of the Government of Sri Lanka. In the case of the use of this system, the existing intersection can be used without great modification, and without major improvement works having to be carried out. The design for the approach roads can be performed so that traffic for the new bridge merges smoothly into the existing intersection.

4-3 Contents of the Project

4-3-1 Present situation of the project site

About 20% of the Colombo Metropolitan Area (CMR) is accounted for by low-swampy places, and about 65% by farming land Industrial sites highly concentrate in the Fort District having Colombo Harbor in its back and the Pettah Special District.

Major commercial functions concentrate in the Fort District and Pettah District. As a whole, however, the commercial functions are scattered all over the districts in line with the population distribution.

Residential quarters are scattered widely in the districts, and concentratedly scattered around roads. The CMR District, that has grown around Colombo City, is expanding greately to the outside due to the outward expansion of urban functions and selective land utilization policy such as Kotte. New Administrative City Planning. Under such circumstances, the project site is located about 2 km away from the Fort District, the center of Colombo City, thus being incorporate in the urban district.

In the current project site on the Colombo side, which is the left coast of Kelani River, markets, houses and residents concentrate heavily, whereas on the Katunayake Side, there are rather spacious sites with sparcely scattered villages.

On the upstream, side of Victoria Bridge, there are many markets and public facilities which are difficult to be withdrawn.

With the Colombo urban area (Fort Area) as a center, Road A-3 runs in the direction of northern Negombo, and Road A-2 in the direction of southern Galle, thus major trunk roads running in a radiating pattern. The traffic in the urban area is rather heavy, and its inefficiency due to caotic congestion of walkers, two-wheed vehicles, wagons, trucks, buses, etc., as well as the absence of traffic control by signals have been pointed out.

4-3-2 Outline of the facilities

The outline of the bridge and the approach roads are indicated in Fig. 4.3.

- Bridge ... This has a standard section as is indicated in Fig. 4.3, and a length of 228.0 m.
- Approach roads ... A road having the standard section indicated in Fig. 4.3 are to be constructed from the intersection of the left bank of the Kelani River, to the intersection on the right bank of the Kelani River.
- Accessories ... The accessories for the bridge (supports, expansion/contraction joints, newel post, hand rail, drainage facilities, etc.) illumination facilities, open space at the end of bridge, road drainage facilities, retaining walls, etc.

4-3-3 Executing agency

The executing agency for this project is the RDA, for which the organization is indicated in Fig. 4.1. Fig. 4.2 shows the organization of that part of the RDA that will be directly in charge with the implementation of the project.

Fig. 4.1 Organization of the RDA

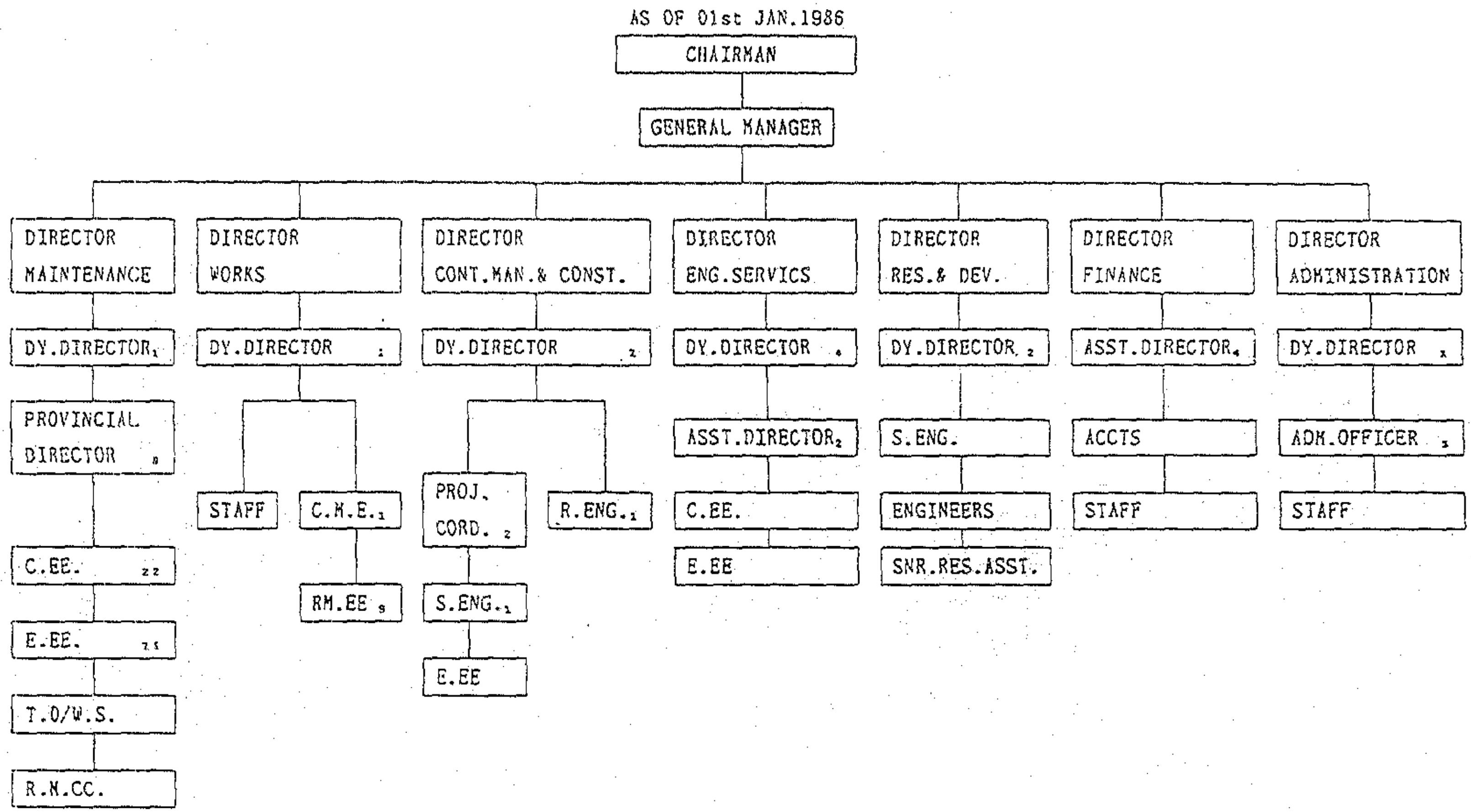
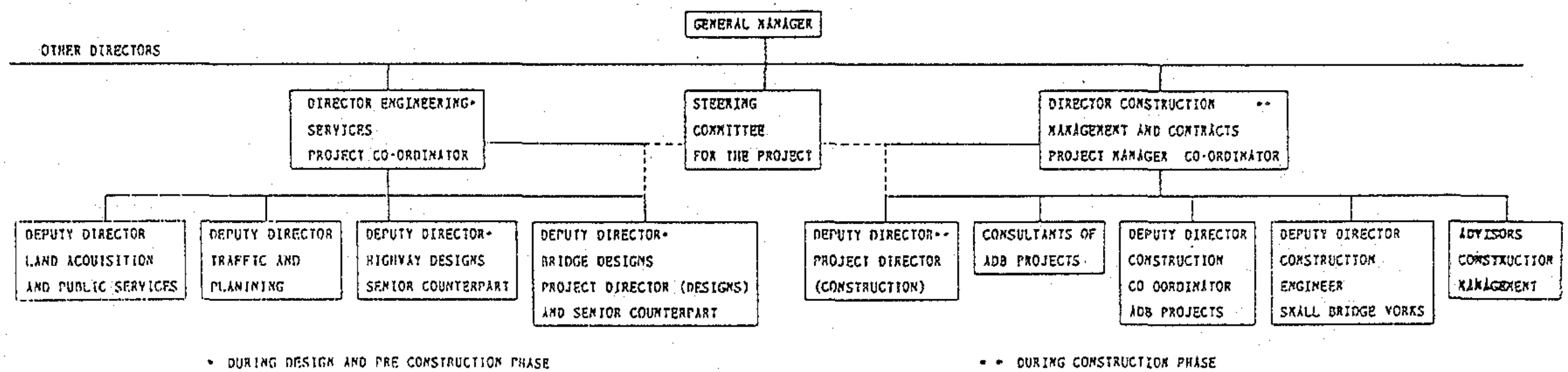


Fig. 4.2 RDA Organization for the Implementation of the Project



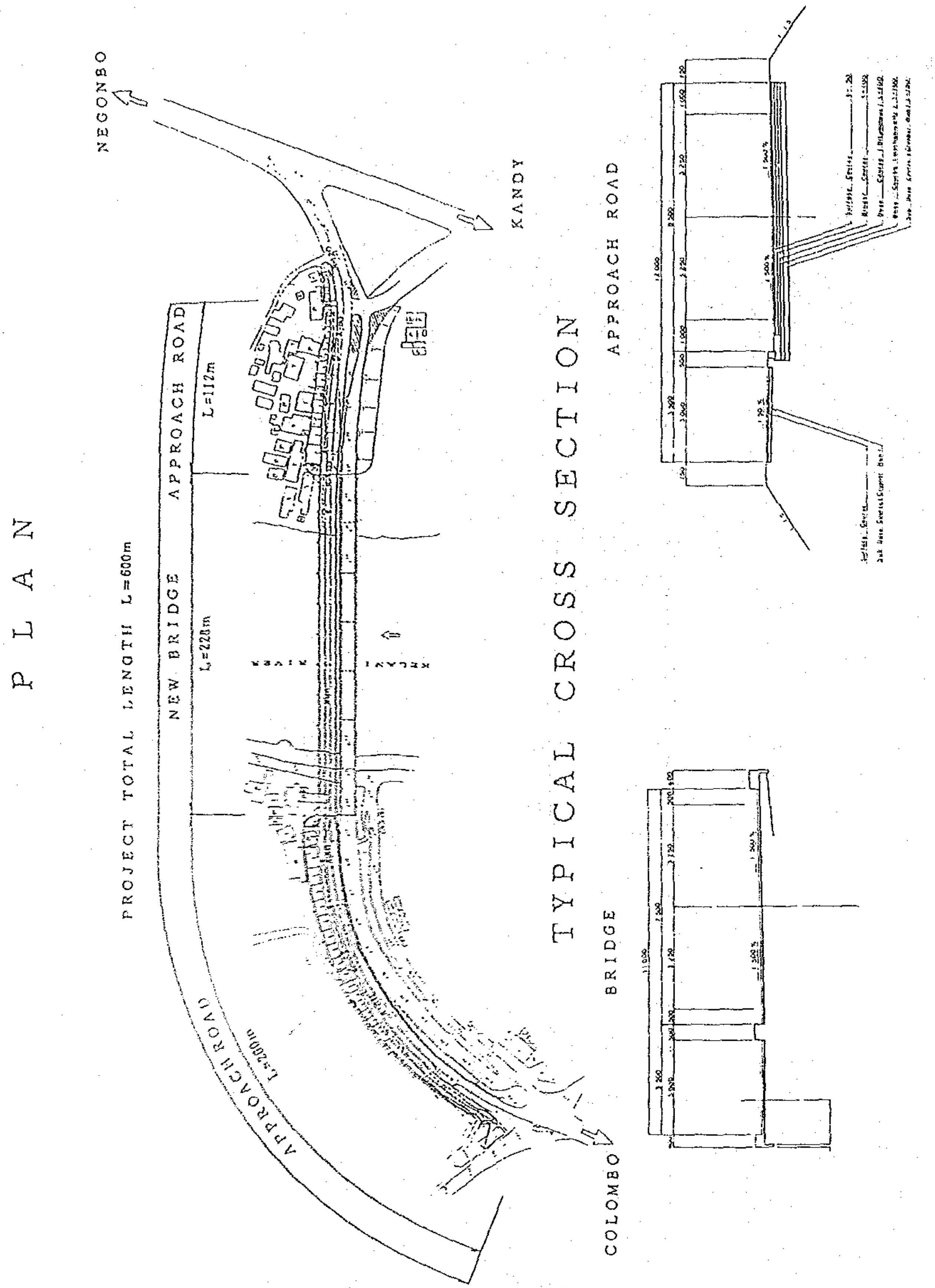


Fig. 4.3 Bridge and Approach Roads

CHAPTER 5

BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5-1 Considerations in the Basic Design

The major considerations incorporated in the basic design are as follows.

(1) Early completion of the project -

The basic design will incorporate the following features so that it can be completed as early as possible.

* For the work to be performed by the Government of Sri Lanka, information for preparations necessary for prompt land acquisition will be prepared as soon as possible.
* Selection of the construction method so that the construction can be completed at an early date.

(2) Reducing the maintenance expenses -

This involves the selection of a simple bridge type that facilitates maintenance, and also design with sufficient consideration paid to the possible influence of saline water.

(3) Utilization of local labor, machines and materials -

The type of bridge and the construction method will be selected so that the regional economy is activated through the use of local labor,machines and materials to the greatest extent possible.

(4) Design and execution with a high level of technical transfer involved

(5) Provision for future widening of the carriage way

The design is to be performed so that any future widen- ing that may become necessary in the future, can be performed easily and smoothly.

(6) Application of the design standards of Japan -

In principle, the design will be performed in accordance with the design criteria of Japan but as requested by the R.D.A., a comparison with the B.S. 5400 design standards will be presented for approval. In addition, in instances where it is not suitable to apply the

Japanese design standards as they are, special consideration will be made so that an extravagant design is not made.
Design standards to be utilized

a) Specifications for Highway Bridges (Part I-IV)
b) Japanese Road Structure Code
c) Asphalt pavement specifications (Japan Road Association)
d) Drainage engineering instructions (Japan Road Association)

5-2 Basic Bridge Plan

5-2-1 Configuration of the span

Special attention should be paid to the selection of the new pier location for river maintenance reasons. Therefore the new piers shall be at least located in line with the existing ones.

As a result of the above consideration, two types of span configuration could be considered as shown in Fig. 5.1, 7 spans and 3 spans.

(a) 7 span case

(b) 3 span case

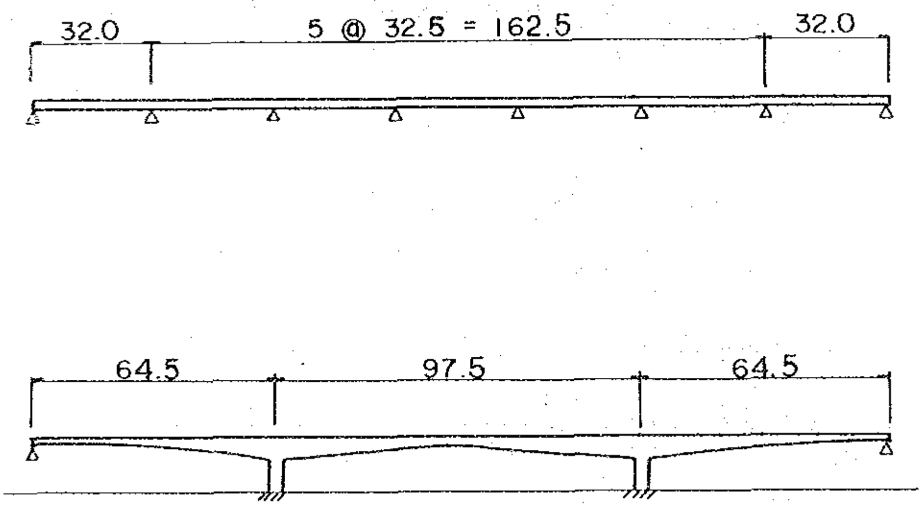


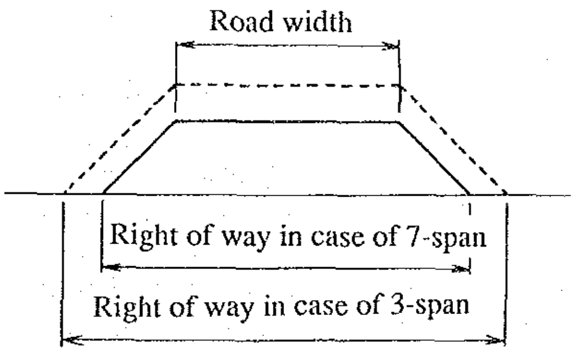
Fig. 5.1 Different Configurations of Span

Table 5.1 indictes the structural types that are considered to be appropriate for those respective spans.

Table 5.1 Number of Spans and Structural Types

	Steel bridge	Conrete bridge
7-span	Continuous plate girder with equal height	Continuous T-girders, continuous box girders
3-span	Continuous box girders with variable height	Continuous girder with variable height

So far as the superstructure is concerned, the three- span bridge is uneconomical when compared to the seven span bridge. Also, since the girder height becomes greater, the height of the approach roads is also increased and will require more cost for the approach roads and the purchase of land.



The construction costs for the substructure may possibly be less for three-span bridge when compared to those for the seven-span bridge because of the fewer piers, but this would still not be to the degree of compensating for the higher cost of the superstructure work involved.

Moreover from the point of view of river maintenance, there is no necessity to adopt a long-sapn bridge such as the three-span proposal.

As stated above, there is no specific reason to adopt a three-span bridge over a seven-span bridge and hence the seven-span bridge with the piers in the same positions as the existing bridge was selected.

5-2-2 Selection of the bridge type

The type of bridge shall be selected not purely on the basis of economic criteria but comprehensive decision on the construction period, maintenance costs, degree of utilization of local labor, materials, machinery and equipment, suitability of technical transfer, as well as the desires of the Government of Sri Lanka.

Comparative study shall be made between a 7-span continuous steel girder bridge and two types of concrete bridges, a 7-span continuous PC box girder bridge and 7-span continuous PC composite girder bridge. As shown in Table 5-2, a concrete bridge is superior to a steel bridge from an overall point of view. Accordingly, a concrete bridge shall be selected, which coincidentally meets the needs of the Government of Sri Lank.

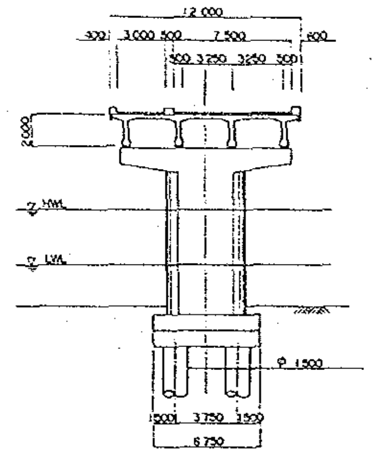
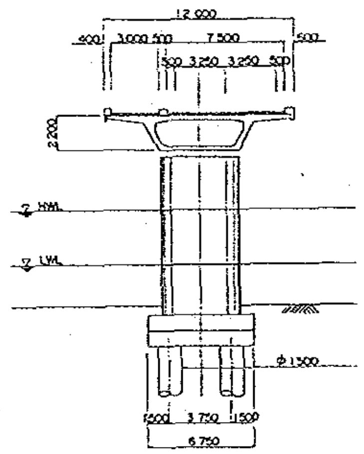
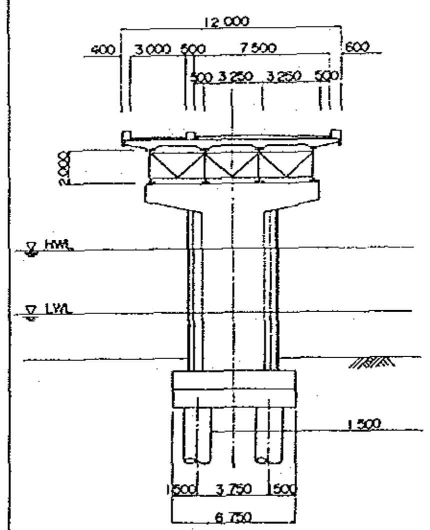
Merits of a concrete bridge are shown below.

- A steel bridge requires slightly smaller initial costs. However, when the maintenance cost (Assuming the design life of a steel bridge is 50 years and painting is to be repeated every 7 years, 20 million yen/painting x 7 times = 140 million yen will be necessary.) is to be borne by the Government of Sri Lanka, a concrete bridge seems to be superior from an economical point of view.
- The construction periof for a steel bridge is 6 months shorter.
- Adoption of steel finger joints, rubber bearings and simple drainage system dispenses with most of maintenance costs.
- The degree of utilization of local workers and local labor, material, machinery and equipment is high.
- Most of the bridges now planned in Sri Lanka are concrete bridges, and thus a concrete bridge will enhance the efficiency of technical transfer.

In comparison with a continuous box girder bridge, a PC composite girder bridge requires a larger machine for main girder errection and is definitely inferior economically due to high widening costs, etc. From the point of view of technical transfer, a PC composite girder bridge will also be inferior to a continuous box grider bridge that needs a variety of new techniques such as the incremental lauching method, box girder design, peculiar errection method, etc. Having large surface area, a PC composite girder bridge is vulnerable to salt damage.

Accordingly, a concrete bridge with 7-span continuous box girders shall be adopted.

Table 5-2 Comparisons of Bridge Types

	Cross section	Quantities				Comparison items	Evalu-ations	Characteristics and overall evaluations
PC composite girder		Superstructure Substructure 	Concrete PC steel Reinforcement Formworks Concrete $\sigma ck = 240\ kg/m^2$ Reinforcement Formworks Pile length (ø1500)	2100m³ 70t 180t 9000m² 1600m³ 100t 1700m² 520m	before widening 1.01 after widening 1.11	Profitability Constructability Construction period Technology transferability Aesthetic Job opportunities Maintenance	3 2 2 2 3 1 2	• Since girders can be fabricated locally, employment in Sri Lanka will be promoted. • It will be possible to undertake the construction only if such materials as PC steel, reinforcement and erecting machinery are procurable. • Maintenance-free • 160 million yen will be necessary to widen the carrage way in the future. • Its appearance is monotonous. • Large erecting machinery will be needed. • Construction period: 27 months 2
PC box girder		Superstructure Substructure 	Concrete PC steel Reinforcement Formworks Concrete $\sigma ck = 240\ kg/m^2$ Reinforcement Formwaorks Pile length (ø1500)	1800m³ 120t 250t 6000m² 1500m³ 90t 1600m² 520m	before widening 1.01 after widening 1.01	Profitability Constructability Construction period Technology transferability Aesthetic Job opportunities Maintenance	1 2 2 1 1 1 1	• All the construction work can be performed on site, and as a result, employment in Sri Lanka will be promoted. • Cyclic operations will enhance worker's proficiency. • The technological level of Sri Lanka could be raised. • It is possible to undertake the construction only if such materials as PC steel, reinforcement and erecting machinery are procurable. • Maintenance-free • The carrageway may easily be widened in the future. (It will cost 50 million yen) • It is aesthetically superior. • Construction period: 27 months 1
Steel composite girder		Superstructure Substructure 	Steel Concrete Reinforcement Painting area Concrete $\sigma ck = 240\ kg/m^2$ Reinforcement Formworks Pile length (ø1500)	510t 940m³ 60t 1200m² 1600m³ 100t 1700m² 520m	before widening 0.97 after widening 1.07	Profitability Constructability Construction period Technology transferability Aesthetic Job opportunities Maintenance	2 1 1 3 3 3 3	• Steel girders will be fabricated in Japan, and then they will need to be transported to the site. • Most of the materials will be imported from Japan. • Inferior in terms of employment promotion and technology transfer. • Periodical maintenance will be necessary. • Superior constructability • Fugure widening of the carrage way will require 150 million yen. • Its appearance is monotonous. • Construction period: 25 months 3

5-2-3 Study of Construction Method of Superstructure

The construction methods of continuous box girder includes, the ground-contact type timbering errection method, which is the most common, errection method where movable timbering is used, cantilever errection method, and incremental lauching method. Of these, the errection method where movable timbering is used is obviously uneconomical in view of the length (number of spans) of the bridge in question. The cantilever errection method is also uneconomical and unsuitable because spana are short.

The ground-contact type timbering errection method will pose problems in river control, and require difficult work to remove the timbering in the running water after girders have been errected, thus being unsuitable.

Accordinly, the incremental launching method, which poses no problem in river control and excells in workability and economic efficiency, shall be adopted for errection of superstructure.

5-2-4 Study of pier foundation types

Of many types of pier foundations, the following four types were compared with respect to workability and economical efficiency, and Type C was selected.

Concrete piles were adopted as foundation piles in view of employment of local labor, utilization of local material and technical transfer. The pneumatic caisson, the safety of which is questionable because of unstable power supply due to power failure, etc., was out of the scope of the current study.

A: Single-pile foundation type with a PC well (Pile dia.: 4.0 m)
B: Multi-pile foundation type with a footing placed above water level (Cast-in-place pile dia.: 1.5 m)
C: Ordinary pile foundation type with a footing under the riverbed (Cast-in-place pile dia.: 1.5 m)
D: Multi-pile foundation type with a large-diameter projecting pile (Cast-in-place pile dia.: 3.0 m)

The result of the comparative study is shown in Table 5-3, which offers the following conclusions.

1) Type C will pose no problem in river control, followed by Type D, Type A and Type B in the order of increasing number of problems. The difference between Type C and the other types is substantially large.
2) The most excellent in economical efficiency is Type B, followed by Type A, Type D and Type C in this order. When the costs required for constructing the extention after removing the old bridge is taken into consideration, the difference will lbe negligibly small, because the P3 and P4 piers in Type A and Type D will be of special type and large in scale, while the present P3 and P4 piers are made of three columns.

Type A:

The dimensions of P3 and P4 pier in the right-angle direction will be extremely large.

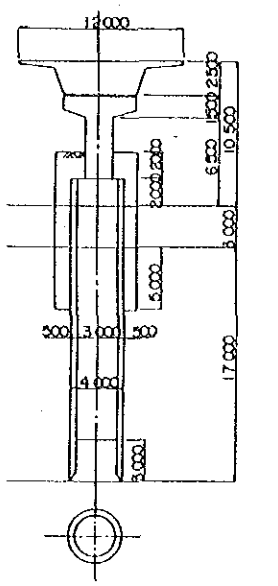
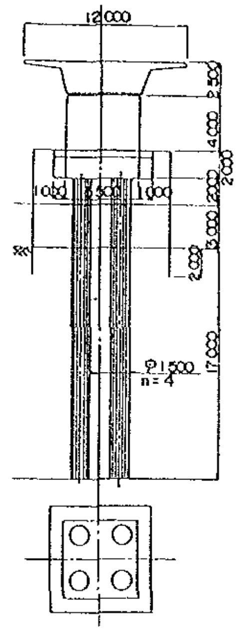
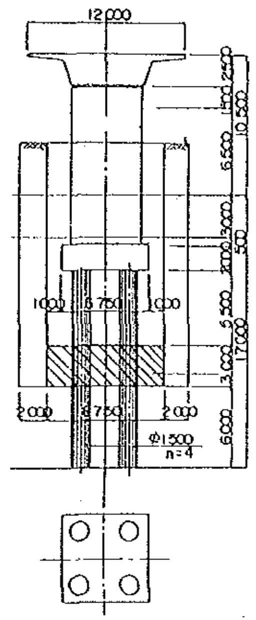
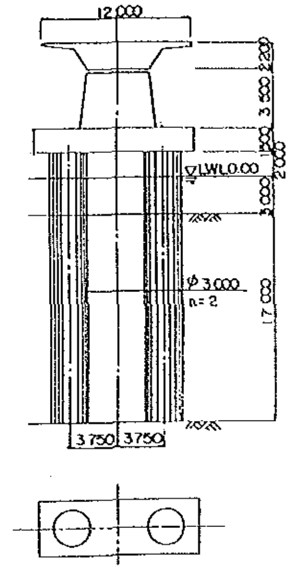
Type D:

P3 and P4 piers require steel well foundation, so double construction equipment will be necessary.

3) Type B and Type D require the shortest construction period, and Type B requires the longest construction period, which is only about three months longer than that of Type B and Type D, its influence on the entire schedule being small.

As shown above, Type C in view of river control River control is most important when flood disaster is taken into consideration. Therefore, in selecting optimum substructure errection method, Type C shall be adopted which poses no problem in river control and provides aesthetically excellent piers.

Tabel 5.3 Comparative Study of Foundation Types

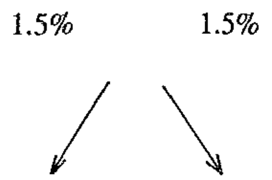
Type	A	B	C	D
Typical cross sections				
Provisional equipment	- Provisional landing stage - Earth-fill cofferdam - Special jacking equipment, earth anchors	- Provisional landing stage - Reverse circulation drill with a diameter of 1500mm - Earth-fill cofferdam	- Provisional landing stage - Reverse circulation drill with a diameter of 1500mm - Double wall cofferdam	- Provisional landing stage - Standing pipes - Reverse circulation drill with a diameter of 3000mm
Characteristics	- The longest construction period - Superior in constructability - Necessity of heavy equipment to handle precast elements	- Less aesthetic - Large disturbance of river flow - Shortest construction period - Lowest construction cost	- Expensive double wall cofferdam and chemical grouting - More aesthetic - Least disturbance to river flow	- Less aesthetic - Large disturbance of river flow
Appearance	○	△	◎	△
Impact on rivers	○	△	◎	○
Construction period	△ 28 months	◎ 25 months	○ 27 months	◎ 25 months
Construction cost ratio	○ 1.10	◎ 1.00	△ 1.23	○ 1.17
Evaluation	○	○	◎	△

LEGEND: ◎ Optimum: ○ Fair: △ Not Recommended

5-3 Design Requirements

5-3-1 Bridge

(1) Bridge type : PC Highway Bridge
(2) Structural type : 7 span continuous box girder
(3) Bridge length : 228.0 m (32.0 + 5 @32.5 + 32.0)
(4) Width : Total width: 12.0 m
Effectie width -
Carriage way : 7.5 m
Pedestrian way : 3.0 m
(5) Girder vartical curve : R = 5,560 m
(6) Vertical slope :



(7) Live load
Vehicle live load : TL-20
Sidewalk live load : During design of the main girder 350 kg/m^2
: During design of the deck 500 kg/m^2
(8) Temperature:
Variation ±15°C
Difference +5°C
(9) Design seizmic coefficient
Seizmic consideration is not taken into account during design as there are no earthquakes.
(10) Wind load
30 m/sec wind velocity
(11) River flow speed
V = 3.6 m/sec.
(12) Materials
1) Main concrete girder:
Regular Portland concrete:
Designed strength: 6 ck = 350 kg/cm^2
Elasticity coefficient: Ec = 3.25 x 10^5 kg/cm^2
Unit content weight:p=2.5 t/m^3
2) PC Tendons
① Reinforcement tendons for falseworks, sheering deck

SBPR 95/120, ø32

② Continuous tendons for permanent works

SWPR 7B 12T12.7

3) Reinforcements SD35

Allowable tensile stress

$\sigma sa = 1800$ kg/cm^2 (general)

1400 kg/cm^2 (deck)

1500 kg/cm^2 (underwater)

Yielding point strength

$\sigma sy = 3500$ kg/cm^2

4) Others

① Pier, abutment, footing concrete

Design strength $\sigma ck = 240$ kg/cm^2

Elastic coefficient

$Ec = 2.70 \times 10^5$ kg/cm^2

② Wheel guard

Designed strength

$\sigma ck = 240$ kg/cm^2

Elastic coefficient

$Ec = 2.70 \times 10^2$ kg/cm^2

③ Asphalt pavement

Unit content weight $p = 2.3$ t/m^2

④ Pile

Reverse pile ø1,500

Allowable bearing capacity 380 t/pile

Design strength $\sigma = 240$ kg/cm^2

5-3-2 Access road

(1) Design speed

V = 60 km/h

(2) Width

Carriage way 3.25 m

Shoulder 1.00 m

Pedestrian way 3.00 m

(0.5 m will be reserved for guard rails)

(3) Pavement design

Latelite (CBR = 12) as tested for the Colombo Port Access Road.

5-4 Design of Access Roads

5-4-1 Design requirements

(1) Design requirements

a) Design speed: v = 60 km/hr
b) The carriageway, shoulder, sidewalk are 3.25m, 1.00m and 3.00m respectively in width. It should be assured that there will be space enough to install guardrails between the lane and the sidewalk.
c) The pavement design shall be made on the basis of CBR = 12 obtained from the test results of filling material (latelite) during the designing stage of the port access roads.
d) Intersections on both sides of the bridge are in principle not included in the scope of design. Consideration must be given, however, to allow the roads to fit perfectly to previously-built curbe stones.

(2) Route selection

a) An alignment plan must be prepared that will permit future increase of lanes.
b) It is necessary to assure smooth traffic flow during construction after completion.

5-4-2 Roadway diagraph

The following roadway diagraph will be used in the designing of the access road.

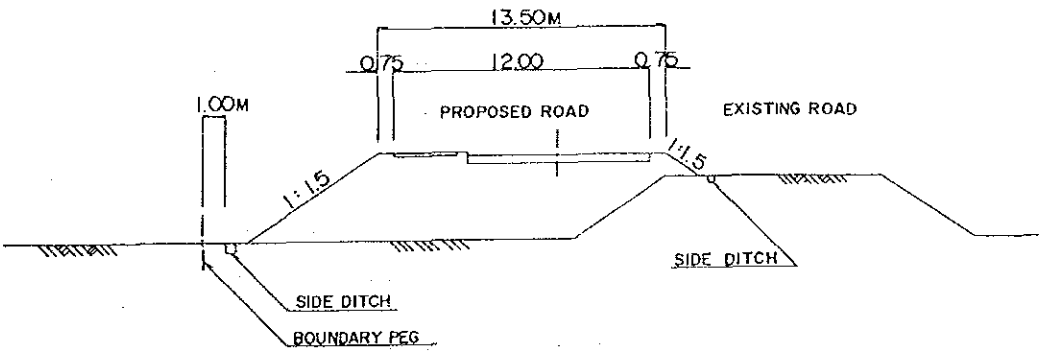


Fig. 5.2 Roadway Diagraph

5-4-3 Pavement design

The pavement has been designed taking into considera- tion the traffic of heavy vehicles. The number of heavy vehicles passing through the Victoria Bridge was 2,500 a day according to the 1983 traffic survey conducted by the JICA F/S. Consequently, it has been assumed that more than 3,000 vehicles will pass each day, anticipating a future increase.

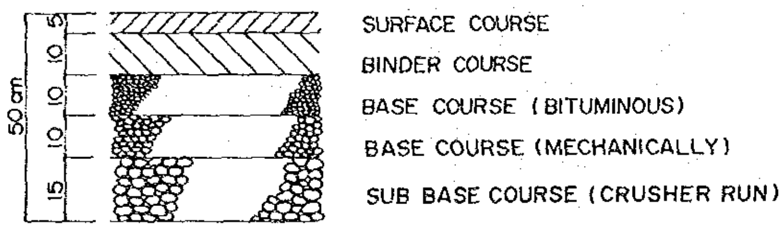


Fig. 5.3 Composition of Pavement

5-4-4 Drain design

(1) Drainage from the road surface -
Water from the road surface is received by the street gutters installed between the sidewalk and lane, and collected through the drainage placed underneath the side walk and then to the river.

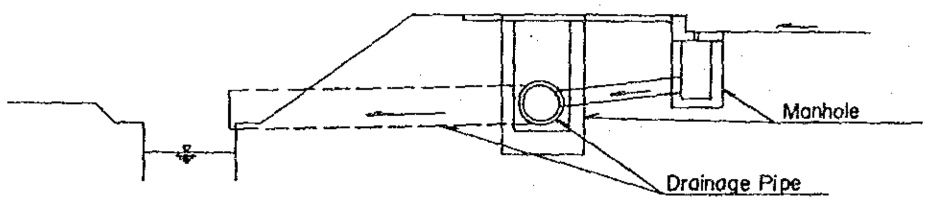


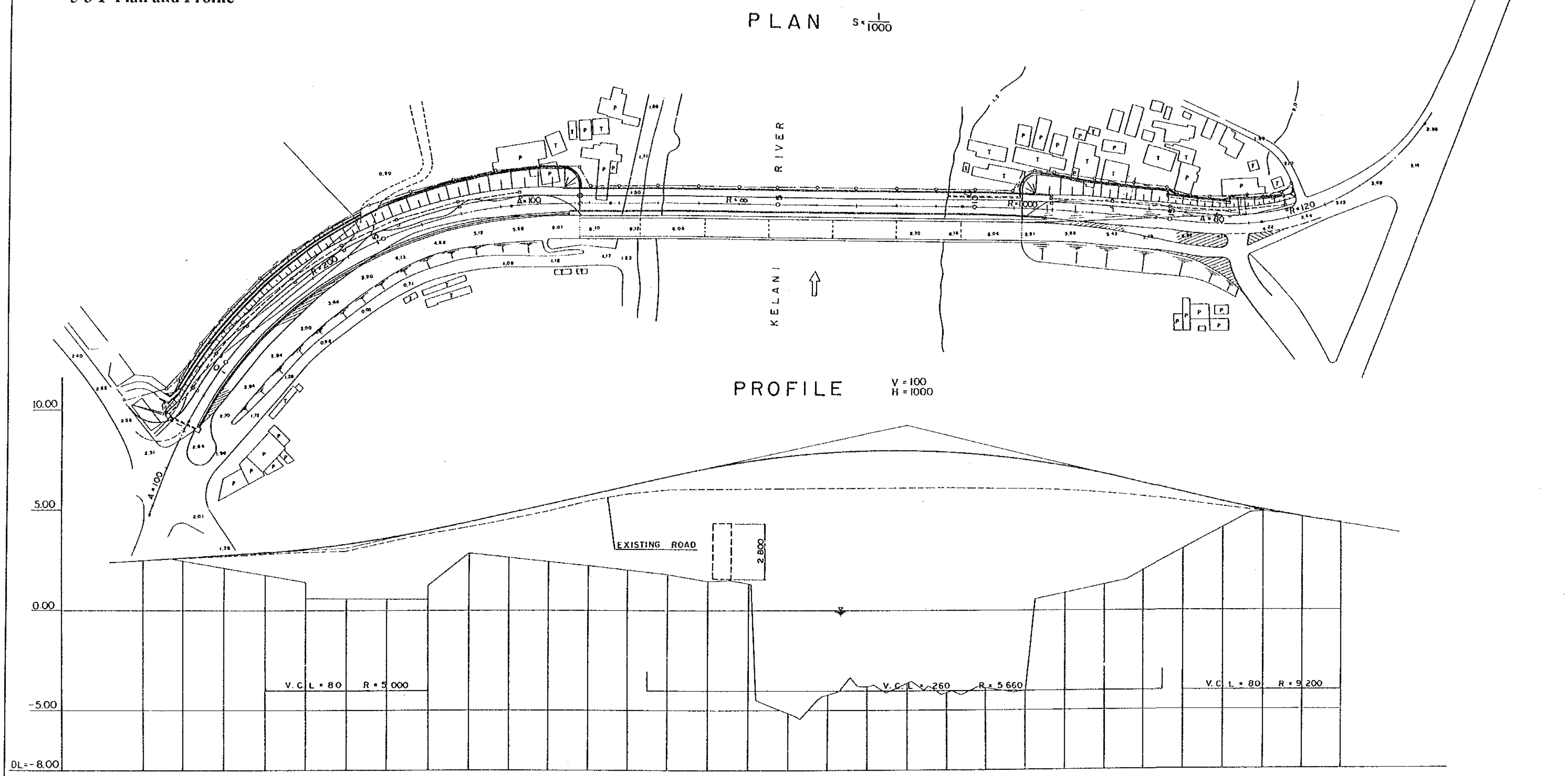
Fig. 5.4 Drainage from the Road Surface

(2) Improvement of existing channels -
New fenced sewers of 1.2m in witdth and 1.0m in depth will be connected to the channels.

5-5 Basic Design Drawing

5-5-1 Plan and Profile

VICTORIA BRIDGE RE-CONSTRUCTION PROJECT



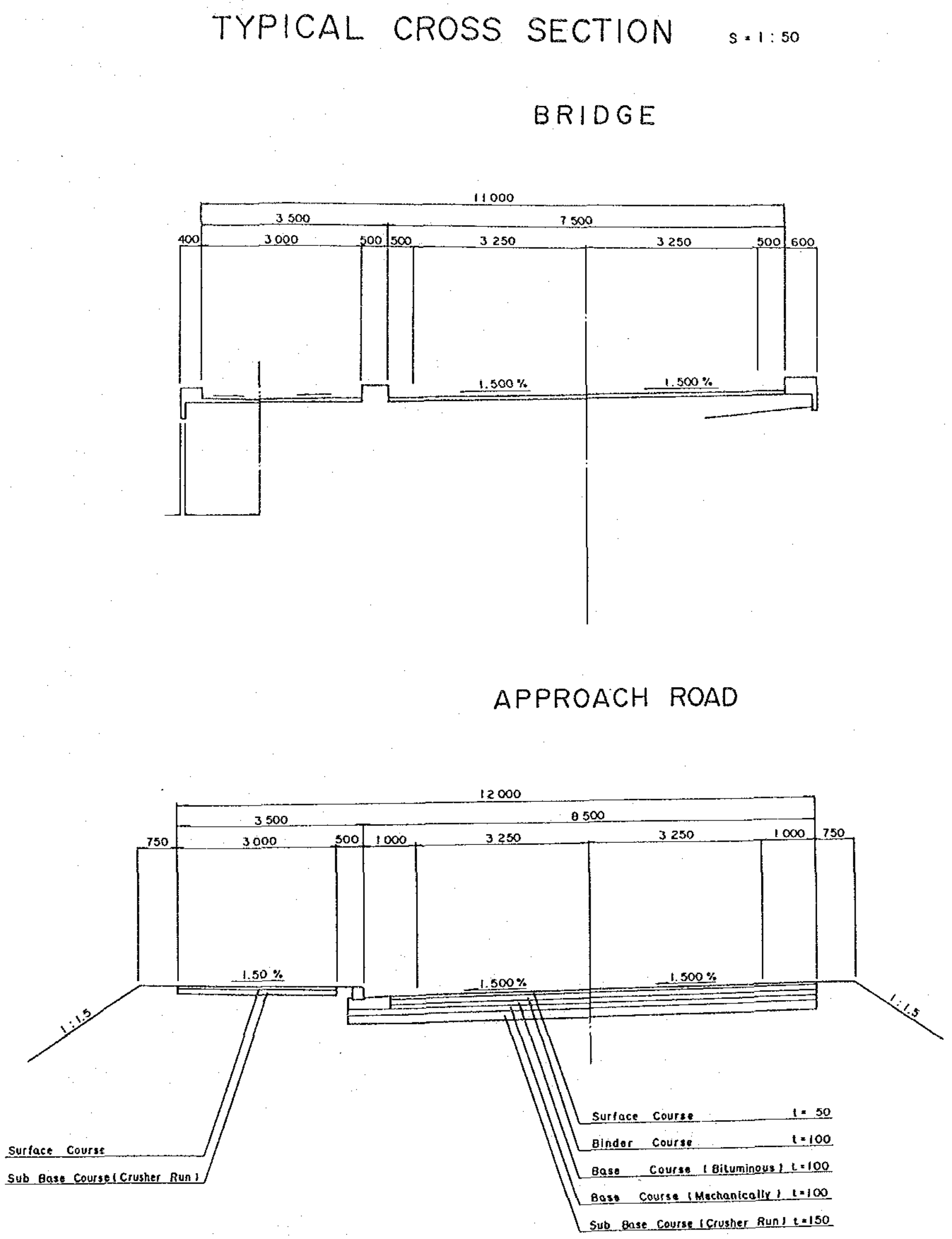
SLOPE: (2.550) — i=0.600% ℓ=100.00 — (3.150) — i=2.200% ℓ=280.00 — (9.310) — i=2.390 ℓ=180.00 — (5.008) — i=1.520% ℓ=40.00 — (4.400)

	NO.-14	NO.-13	NO.-12	NO.-11	NO.-10	NO.-9	NO.-8	NO.-7	NO.-6	NO.-5	NO.-4	NO.-3	NO.-2	NO.-1	NO.0	NO.1
ROAD SURFACE ELEVATION		2.550	2.670	2.790	2.910	3.070	3.310	3.630	4.030	4.470	4.910	5.350	5.790	6.230	6.661	7.035
ORIGINAL GROUND ELEVATION		2.55	2.50	2.15	1.75	0.60	0.60	0.60	0.59	2.90	2.70	3.60	3.10	2.05	1.86	1.47
REDUCED DISTANCE	280.000	260.000	240.000	220.000	200.000	180.000	160.000	140.000	120.000	100.000	80.000	60.000	40.000	20.000	0.000	20.000
DISTANCE	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	0.000	20.000

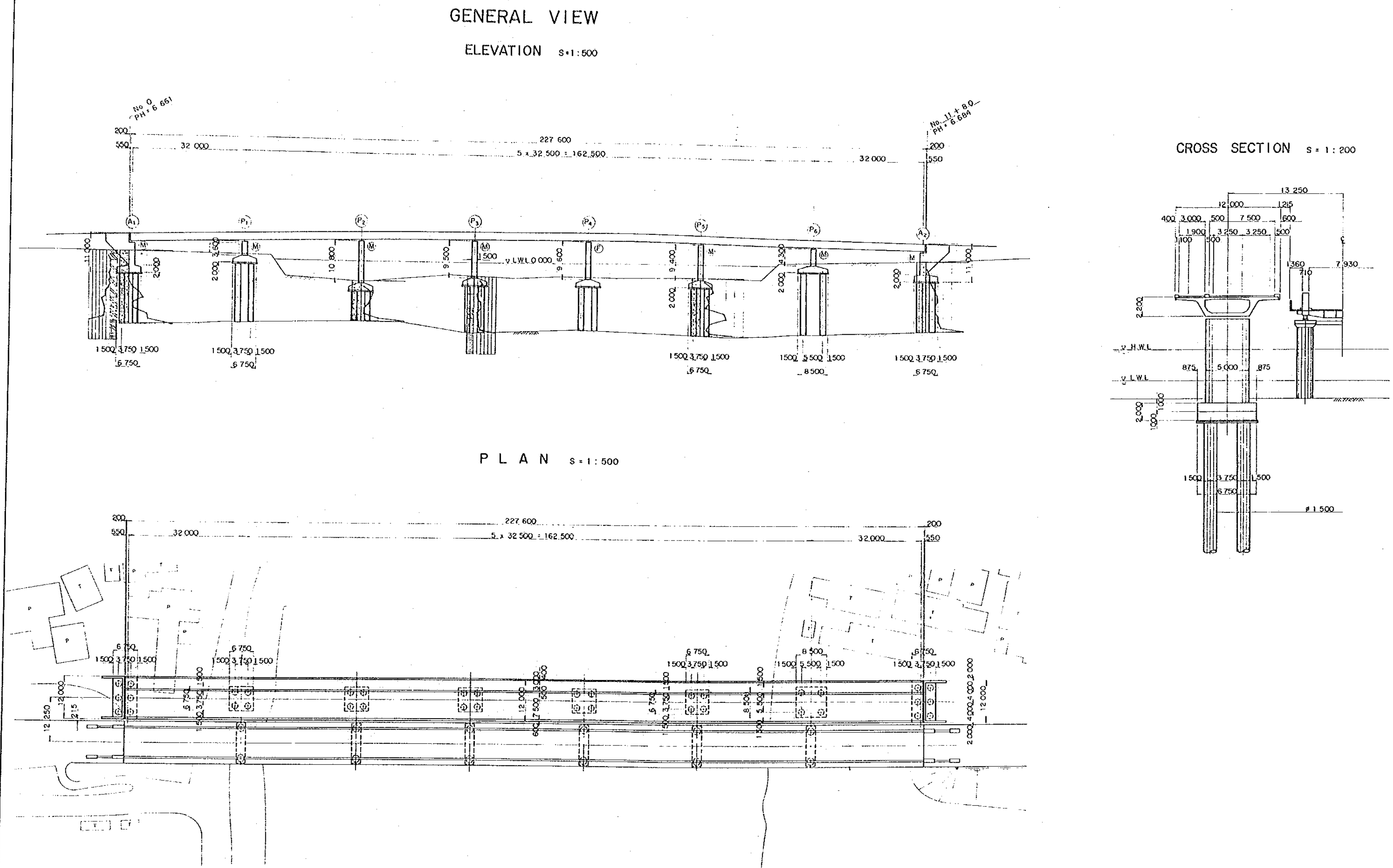
	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7	NO.8	NO.9	NO.10	NO.11	NO.12	NO.13	NO.14	NO.15	NO.16	NO.17	NO.18
ROAD SURFACE ELEVATION	7.329	7.557	7.715	7.802	7.818	7.764	7.639	7.443	7.177	6.841	6.433	5.964	5.508	5.095	4.726	4.400	
ORIGINAL GROUND ELEVATION	1.40	-5.15	-4.25	-3.80	-3.65	-4.15	-3.90	-4.00	0.92	1.35	2.05	3.10	4.20	5.00	4.76	4.40	
REDUCED DISTANCE	40.000	60.000	80.000	100.000	120.000	140.000	160.000	180.000	200.000	220.000	240.000	260.000	280.000	300.000	320.000	340.000	360.000
DISTANCE	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000

CURVE: A=100 L=50.00 — R=200 L=200.00 — A=100 L=50.00 — R=∞ L=193.50 — R=1000 L=100.00 — A=80 L=53.33 — R=120

5-5-2 Typical Cross Section

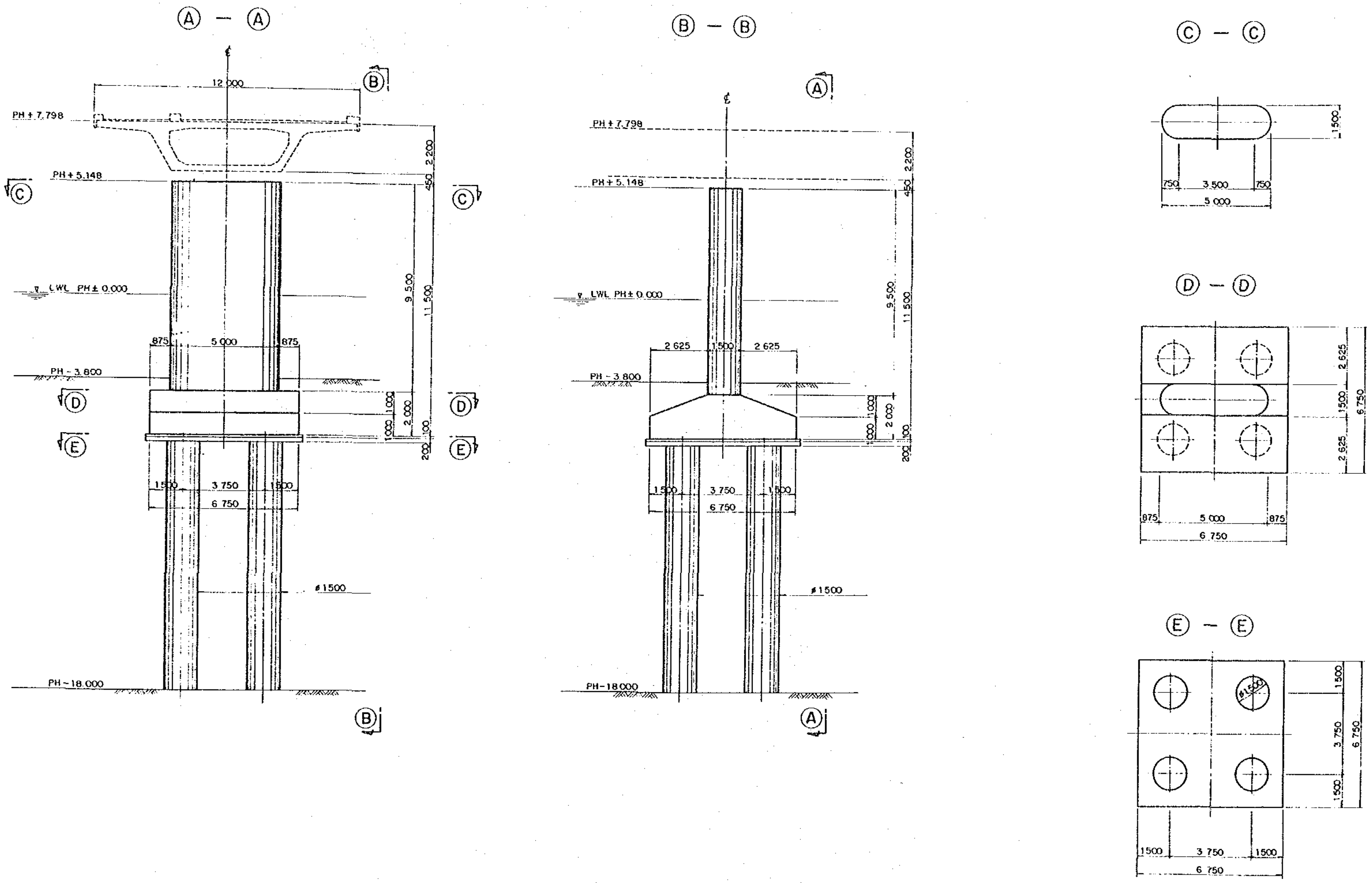


5-5-3 General View



5-5-4 Pier

P_3 PIER S = 1 : 100



CHAPTER 6

PROJECT IMPLEMENTATION PLAN

CHAPTER 6 PROJECT IMPLEMENTATION PLAN

Fig. 6.1 shows the organization whereby the project will be executed.

6-1 Project Implementation Organization

1) Project execution organization -
   The government body that executes this project on behalf of the Democratic Socialist Republic of Sri Lanka is the RDA (Road Development Authority) whose responsibility is to manage, supervise and maintain the project. The Department of External Resources of the Ministry of Finance and Planning, as the agency to receive aid and cooperations, will engage in the adjustment, management, etc. of the matters agreed between the two countries and the budget.

2) Consultant -
   The consultant must perform the following works.
   a. Detailed designing
   b. Assistance pertaining to bid and contracts on behalf of the Sri Lankan government.
   c. Construction supervision

3) Contractors -
   Japanese contractor selected by open tender according to the grant aid system of the Japanese government must undertake the construction of facilities.

   Contractor must fully understand the grant aid system and pay special attention to complete the work within the prescribed construction period.

6-2 Construction Plan

6-2-1 Construction policies

(1) Basic Policy -

1) Social and economical conditions of Sri Lanka shall be taken into consideration, and working conditions that allow schedule control shall be assured for smooth progress in the work.
2) Good communications shall be maintained among the authorities of the Sri Lankan

government, the consultant and contractor through adequate discussions so that the work will be carried forward smoothly.

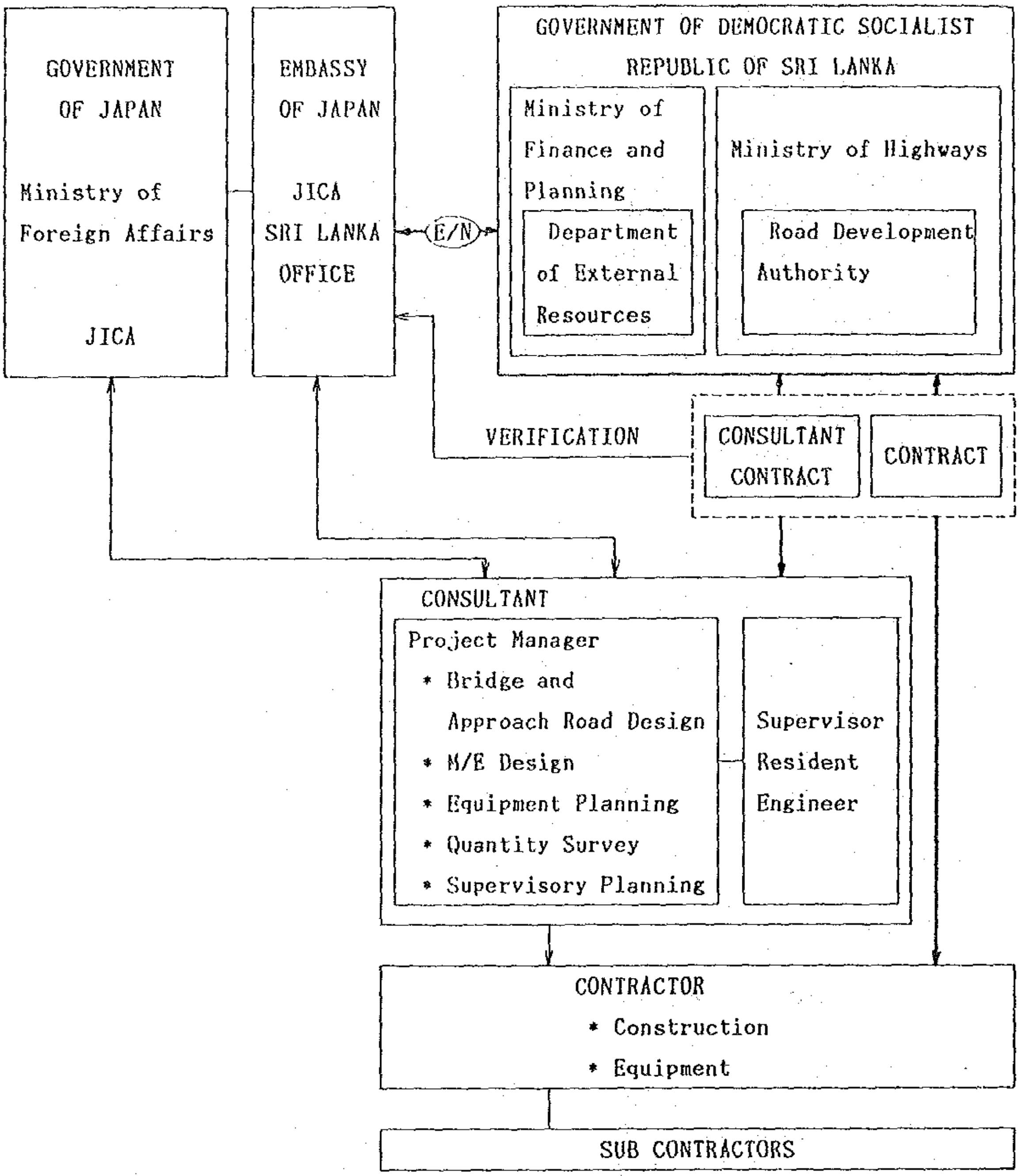


Fig. 6.1 Project Executing Organization

3) Construction materials and equipment, machines and workers shall be procured as much as possible from Sri Lanka not only to contribute in the stimulation of the Sri Lankan economy, but alsoto encourage technical transfer. That which cannot be procured locally shall be supplied from Japan.

(2) Considerations for construction -

The following are considerations to be taken during construction.

1) The Labor Standards Act -
In Sri Lanka, no such codes as Japan's Labor Safety and Sanitary codes exists. There is, however, a well-organized labor standards act, and workers are strongly aware of their rights. Personnel management during the work shall be carried out observing this act.

2) Conditions of the construction industry in Sri Lanka -
In Sri Lanka, the Road Development Authority under the Ministry of Highways, is directly responsible for maintaining or improving roads. It will be possible to receive assistance from this office for the paving of roads.

3) Material procurement conditions -
It is possible for the contractor to procure construction materials and equipment without obtaining the approval of Sri Lankan authorities or without being restricted by allotments. Oil and fuel will be purchased directly from the Ceylon Fuel Corporation, and other materials will be procured from general markets.

While gravel, sand, crushed stone, ready-mixed concrete, filling materials, etc. can be easily procured, lumber must be imported since it is in an urgent need and furthermore is very expensive in Sri Lanka.

Reinforcements produced in Sri Lanka are poor in quality and cannot be used in essential structures. Therefore, they are to be imported. Thus, most of the construction materials and equipment except gravel, sand, crushed stone, cement and ready-mixed concrete will be procured in Japan.

4) Procurement of construction machinery -
Construction machinery owned by Sri Lanka is small in number. Paving machines, on the other hand, can be borrowed from the Road Development Authority. All of the other machinery will be procured in Japan and sent back to Japan after the completion of the work.

5) Changes in the construction cost -
Sri Lanka has also received an impact from worldwide inflation, and workers' wages, the price of cement and ready-mixed concrete is expected to rise. Consideration especially needs to be given to wages since they are rising steadily each year.

6) Construction period -
Sri Lanka has two rainy seasons a year (April to June, September to November) during which working hours will be greatly shortened. During these rainy seasons, flood caused by heavy rain often occur, and an appropriate construction schedule considering these conditions is necessary.

7) Conditions of transport and custom clearance -
Concerning machines and materials supplied from Japan, a minimum of two months will be necessary to have them packed, transported, cleared although customs and brought to the site. The assistance of Sri Lanka authorities is indispensable particularly for cargo works and customs clearance.

6-2-2 Distribution of works

The range of works for which the Japanese government and the Sri Lankan government will be responsible for is as follows.

(1) Works and facilities to be provided by the Japanese government

-1 Construction of the bridge and access roads
-2 Bridge and access road accessories
  1) Lighting
  2) Drainage system
  3) Shoes expansion joints, guard rails
  4) Newel post, plazas at the ends of the bridge
  5) Monument plaque
-3 Facilities to be used during the work
  1) Roads to be used during the work
  2) Provisional landing stage to be used dring the work
-4 Others
  1) Transportation of construction materials and equipment from Japan to Sri Lanka
  2) Consulting services

(2) Works and facilities to be provided by the Sri Lankan government

(1) Acquisition and reclamation of land
(2) Power distribution lines for the work
(3) Main water pipe leading to the site
(4) Rewiring of telephone lines
(5) Traffic safety signs, marks, etc.

6-2-3 Detailed design and construction supervision plan

When the said Project is to be undertaken, design and construction supervision contracts will be concluded between the RDA and the Japanese consultant who will then provide the following services within the limits of the grant aid.

(1) Preparation of construction design documents -
Immediately after signing the exchange note (E/N) pertaining to engineering services, design and construction supervision contracts are to be concluded between the Japanese consultant and the RDA. The consultant will prepare the detailed design documents and tender documents based on these contracts and obtain the approval of the Sri Lankan government.

(2) Construction supervision -
The consultant shall come to the site as soon as he has permitted the contractors to commence the work and carry out construction supervision services.

6-2-4 Construction implementation plan

(1) Temporary work

1) Provisional yard -
A provisional yard of approximately 16,000 m^2 will be assured on the downstream left bank of the bridge construction site. A site office, warehouses, various process sheds, material and equipment storage houses will be built in the yard to serve as a work base, and the yard will be surrounded by a barbed wire fence to protected it against burglars.

2) Power distribution to the work site -
Power used in the work is 150 kva, which is received at the site at the high voltage of 3,300V, and then distributed to the construction site through wires after being transformed into a low voltage of 400V. Many of the machines brought from Japan use a 200V three-phase configuration, so such machines will be transformed into 200V before use. It will be necessary to procure one 300kva diesel generator for the

operation of vibro hammers and for emergency use.

3) Water distribution to the work site -
Water taps of 50mm in diameter will be installed in the provisional yard, thereby drinking water and water used in the work will be distributed to where necessary. Tap water will rarely be used in the work except in chemical injection work. For curing concrete or mixing bentonite stabilizers, irrigated water from the river will be used.

(2) Construction of substructure

1) Provisional landing stage -
Provisional landing stage made of large H-shaped steel and lining plate will be erected on the downstream side of the bridging point. The construction of the substructure will be carried out on these landing stages, which will be removed immediately after the completion of the substructure. 50t crawler cranes and 90kw vibro hammers will be used to erect the landing stages. Shaped steel used for the provisional erection will be brought from Japan and sent back immediately after completion of the work. After careful study of the technology level of the workers on the Sri Lankan side, it was decided to assign Japanese workers to the key jobs (crawler crane drivers, scaffolding men and welding operators) for such works as piling by means of vibro hammers and scaffold erecting operations. Local workers will be assigned to the auxiliary works.

2) Coffering with steel sheet piles -
A single coffering will be administered out at A1, P1, P6 and A2 using steel sheet piles (L=12m). At P2, P3, P4 and P5, however, construction cannot be carried out only with a single cofferdam because a substantial volume of water leaks from steel sheet piles when unwatering due to the river's low water level and the depth of the excavation floor. Therefore, inside steel sheet piles (L=20m) and outside steel sheet piles (FSP4 type, L=12m) will be used for a double-coffering. Steel sheet piles will be placed using 50t crawler cranes and 90kw vibro hammers. Steel sheet piles will be brought from Japan and sent back immediately after completion of the work. Japanese workers will be assigned to the above operations.

3) Water stopping work for the improvement of ground -
The water level of the river and the excavation floor around the in-river working spots, P2, P3, P4, P5 and P6 are deep at about 8m. Moreover, the river-bed is made up of sand layers with a high permeability coefficient. For that reason, if unwatering is carried out without taking any measures, piping or boiling phenomena may occur at the bottom of the excavation and wash away the setting part of the steel sheet piles

in these spot. All these may eventually force the said steel sheet pillers to fall down. To prevent this from happening, underground of 5m to 8m below the excavation floor will be improved by injecting into it LW chemicals that will create unpermeable layers of 3m in thickness. Since there are no specialists in chemical injection work in Sri Lanka, so specialists will be dispatched from Japan, and local workers will be hired for the auxiliary works.

4) Piling of cast-in-place concrete piles -
Cast-in-place concrete piles will be piled by means of the reverse circulation drilling method, because the Benoto or earth drilling method require high machine transporting costs and thus proves to be very uneconomical. The construction will be carried out on the provisional scaffolds using 50t crawler cranes and reverse sets of 90kw vibro hammers. Since the ground subject to drilling is formed by sand layers, destruction of the holed walls must be prevented by maintaining the height of the stabilizer within the stand pipe at more than 2.0m above the water level of the river. Deteriorated stablizers will be disposed of into the river, and the remaining earth will be used to fill the access roads.

Immediately after the construction of the scaffolds is completed, all the reverse piles will be piled. Crane operators, reverse operators and reverse workers will play the main roles in the work, and it is the personnel dispatched from Japan who will undertake these assignments. Local workers will be hired for the auxiliary works including reinforcement work and stabilizer mixing work.

5) Pile cap and column work -
While works relating to formworks, reinforcement and concrete are to be carried out primarily by local worker, experienced workers will be responsible for the training of carpenters and reinforcing-bar-placers.

Formworks will be made of wood, and lumber will be supplied from Japan. Reinforcements made in Japan will be used. Ready-mixed concrete will be procured from the concrete plant in Sri Lanka.

(3) Construction of superstructure

1) Superstructure construction method -
The superstructure will be constructed by the incremental launching method. 22 segment of 11\m in size will be erected. Since normal cement will be used, thirteen days will be required for one cycle when taking into account the influence of the rainy season.

2) Girder fabrication platform and reaction frame -
The girder fabrication platform and reaction frame will stand nearer to the provisional yard if they are placed between the A1 to P1 on Colombo side. As a consequence, material transportation will become easier. However, the use of service roads within the riverbed cannot be assured, and therefore, a stage that can replace the above platform or frame by piling H-shaped steel piles between the A2 to P6 on the opposite bank will be erected. A pushing reaction girder will be fixed at the P6 so that it will support against a reaction of approximately 200 tons.

3) Launching girders -
Launching girders will be assembled immediately after the 1st segment has has been built. This girder shall be ajointed to cross section of this bridge. They will be dismantled soon after extrusion and erection have been completed and sent back to Japan.

4) Works on the bridge surface -
After girder erection has been completed, wheel guards and handrails will be completed using a wheel guard wagon. At the same time, electric wire will be laid for lighting facilities. Lighting poles will be erected after concrete is placed to form wheel guards. Roads will be paved, and marks will be drawn upon consultation with the engineers from the RDA.

5) Works on the access roads -
Fill for covering the roads will be brought from a place within 30km of the site. Crush stones for the ground base will also be purchased from the suburbs. Asphalt pavement is to be laid upon consultation with engineers from the RDA.

The construction of access roads does not require much work, therefore, the necessary machines will not be brought from Japan but borrowed from the RDA.

6.3 Materials and Equipment Procurement Plan

Major material and machinery required in the present construction work shall be procured in Sri Lanka as much as possible if no problem is deemed to arise in view of quality, supply charges and delivery period. For general civil engineering works including road construction, construction machinery available in Sri Lanka shall be used, while large-scale machinery for construction of the bridge itself or temporary landing bridges shall be brought in from Japan and brought back to Japan after the work. Major material and machinery to be procured in Sri Lanka and Japan are as follows:

Table 6.1 Construction Schedule

Description	UNIT	QUANTITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27			
Preliminary work																																
Provisional scaffolds																																
Sub structure A_2 Abutment																																
P_6 Bent																																
P_5																																
P_4																																
P_3																																
P_2																																
P_1																																
A_1 Abutment																																
Superstructure																																
Assembly of bents and landing girders																																
Erection of extruded girders																																
Works on the bridge surface																																
Access roads																																
Clearance																																

(1) Major materials and machines procured in Sri Lanka)

1) List of materials

- Ready-mixed concrete
- Regular cement
- Gravel
- Sand
- Oil and fuel

2) List of machines

- Asphalt finishers, Bulldozers, Tire rollers, Macadam rollers
- Shovel loaders
- Dump trucks, etc.

(2) Major materials and machines procured in Japan

1) List of materials

- PC steel
- Reinforcement
- Steel formworks
- Lumber for formworks
- Steel sheet piles
- Bridge accessories
- Ground improvement chemicals
- Bentonite, etc.

2) List of machines

- Crawler crane
- Vibro hammers
- Reverse circulations
- Submarine pumps
- Reinforcement processors
- PC steel processors
- PC steel jacks
- Manual launching girder
- Extrusion jacks
- Boring machine
- Grout pumps
- Grout mixers, pump
- Concrete breakers
- Unic Vehicles, etc.

6-4 Implementation Schedule

This project shall be scheduled as follows. First of all, an exchange note (E/N) pertaining to engineering services will be signed. Contractor will selected after the E/N on the construction work has been signed, and the tender has been concluded. The construction work will proceed after that.

Table 6-2 shows the schedule of works after the E/N on engineering is signed by the governments of the two countries. In order to save time in the overall process, operations shall be carried out in parallel as often as possible.

After the E/N on engineering is signed, the design and construction management contract will be concluded between the Japanese consultant and the RDA. Thereafter, the design and tender documents will be prepared for the approval of the Sri Lankan government.

6.5 months will be needed to complete the consultant contract, detailed design and formalities to obtain the approval of the Sri Lankan government.

- Signing of the E/N on the construction work to the selection of a contractor (3.0 months)
  Upon receiving the approval of the Sri Lankan government on the detailed design, the E/N pertaining to the construction work will be signed by the two countries. Following that, a series of bidding procedures such as invitation to bid, explanation of bid, bid opening, evaluation of bid and the selection of a contractor etc. will be carried out. Three months will be needed for these procedures.

- Construction work (27 months)
  About 27 months will be necessary from the conclusion of the construction contract to the completion of the work.

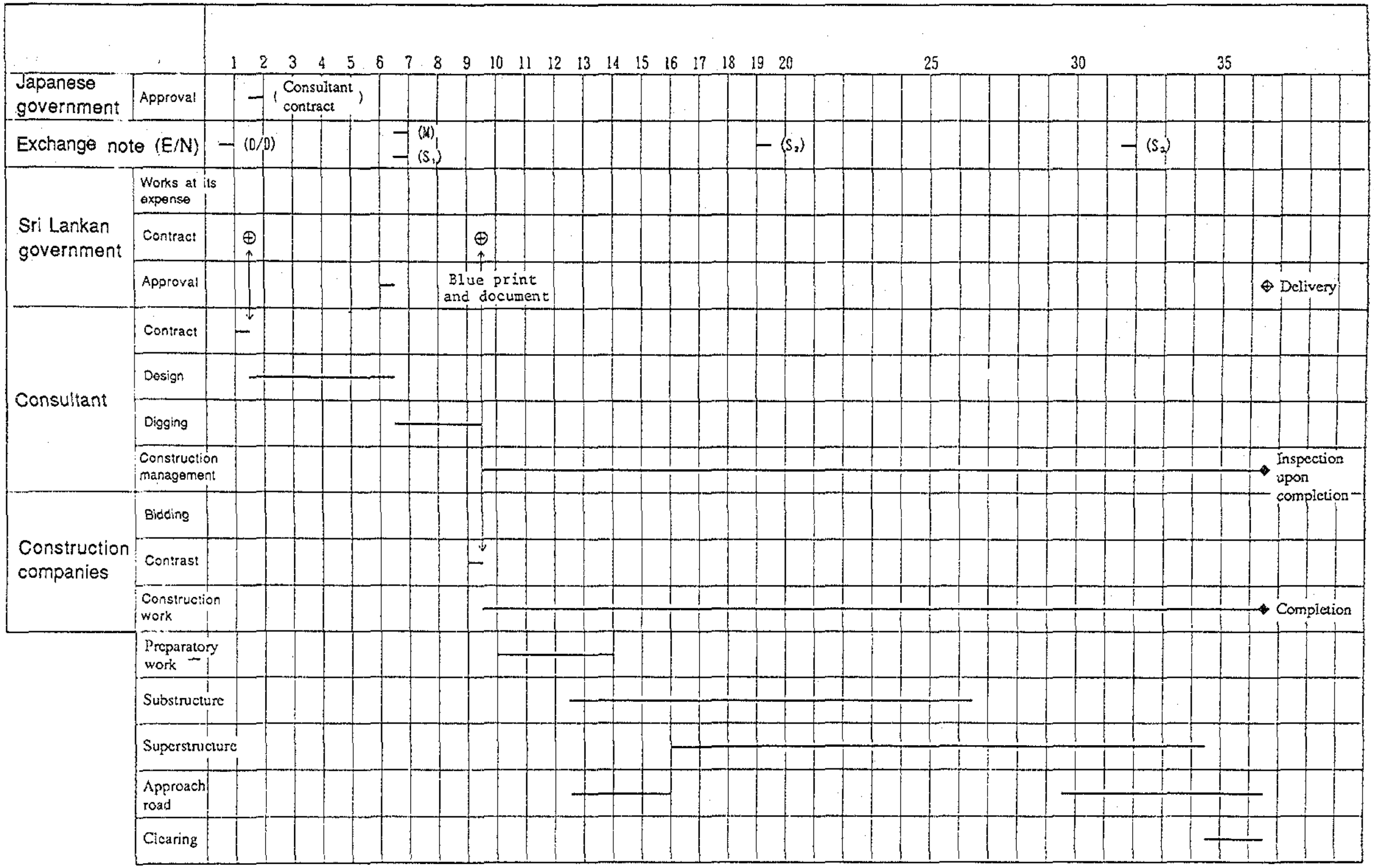
6-5 Approximate Working Expenses

The working expenses required for executing this Project are estimated as follows:

6-5-1 Working Expenses to Be Borne by the Democratic Socialist Republic of Sri Lanka

The working expenses to be borne by the Democratic Socialist Republic of Sri Lanka, except for the land expenses (including the land rent for the manufacturing yard) and

Table 6.2 Implementation Schedule



Note) D/D : E/N for detailed design
M : Master E/N
S1 ~ S3 : E/N concluded at the beginning of every fiscal year

compensation expenses, are estimated at R.750,000 (about ¥3,230,000) and its breakdown is as follows:

(1) Electrical and water-supply construction cost for bridge construction	546,000
(2) Existing facility dismantling cost	62,000
(3) Temporary land cost (rented land)	143,000
Total :	751,000

CHAPTER 7

MAINTENANCE AND MANAGEMENT PLAN

CHAPTER 7 MAINTENANCE AND MANAGEMENT PLAN

7-1 Maintenance and Management Organization

Maintenance and management system of bridges will be established based on the technical aid granted by the ADB. It will be established within the RDA as part of the measures for a more sound system, and its objective is to establish an organization to manage pavements, bridges and roads. It is scheduled to commence the formation of bridge maintenance and management system. A chief engineer and an executive engineer from Colombo will be responsible for the regular inspections, maintenance, management and repair work of the new bridge other than repair work that is too complicated to be handled by them. If such a serious repair is called for in the future, it will be the responsibility of the director of the Colombo Municipality Council to carry it out. The Bridge Assessement Office of the Engineering Services Department is responsible for the periodical detailed and specialized inspections, maintenance plan and repair work.

7-2 Maintenance Plan

This is a presstressed concrete bridge that will require minimum maintenance once completed. Concrete protection is designed so as to resist the eroding effects of sodium, taking into account the fact that the erection site is quite close to the sea. Moreover, rust-prevention measures will also be taken on shoes and expansion joints. Consequently, this bridge will not necessitate maintenance and management costs that would be required by steel bridges primarily in the form of rustproof painting. The areas that will require maintenance and management are listed below. Expenses for these services will be as little as maintenance cost for a normal paved road.

(1) Cleaning of catch basin
(2) Cleaning of road surfaces and re-marking
(3) Maintenance and inspection of lighting facilities
(4) Maintenance and inspection of expansion joints
(5) Mowing around the access roads

7-3 Maintenance Cost

The major expenses of the above-mentioned maintenance and management services are as follows.

	Annual expenses (Rs)
(1) Cleaning	12,200
(2) Inspections	26,500
(3) Lighting	53,700
	Total RS 92,400

CHAPTER 8

PROJECT EVALUATION

CHAPTER 8 PROJECT EVALUATION

8-1 Impact of Project Implementation

Since about 90 years have passed since the Victoria Bridge was constructed, it has become superannuated, and traffic on it has been restricted since 1986. If a new bridge is constructed to restore the bridge's functions we could expect the following effects.

(1) Impact on traffic through restoration of the bridge's function -
Since traffic restrictions will be eliminated by constructing the new bridge, heavy vehicle traffic which is now concentrated on the New Kelani Bridge will be reduced, and traffic snarls during rush hours will be resolved. In addition, since the traffic flow between Colombo and northern Sri Lanka will be diversified, the traffic inside Colombo will become smoother and such benefits as a reduction in the number of traffic accidents will be obtained.

(2) Impact on the New Kelani Bridge -
As a result of an investigation conducted earlier this year (1988 Jan.), a structural defect was discovered in the New Kelani Bridge. The details of this situation are now under examination, but it is clear that the defect needs to be repaired. However, since at present heavy vehicle traffic is allowed only on the New Kelani Bridge, it is impossible to conduct such full-scale repairs there because restricted traffic control is needed on the Victoria Bridge until its own function are restored.

Accordingly, the restoration of the Victoria Bridge's functions will contribute to making the New Kelani Bridge a sound bridge, and also prolong the life of the bridge.

(3) Impact on local economy and technology transfer resulting from construction the new bridge -
If a concrete bridge is constructed rather than a steel bridge, such resources as local workers and materials can be used effectively, resulting in a stimulation of the local economy. In addition, small concrete bridges have been constructed before in Sri Lanka with local technology, so the technical basis for the design and the construction of concrete bridges has been established. Consequently, the technology (such as the design and construction of a box girder using the incremental launching method and cast-in-place concrete piles with a temporary cofferdam) employed in this new bridge, which is new to Sri Lanka, will be effectively transferred and contribute to the future development of bridge building technology.

(4) Contribution to the economy of Sri Lanka -

In order to develop the economy of Sri Lanka, it will be necessary to provide a sound infrastructure, especially an improved traffic network. The Government of Sri Lanka has a five-year road improvement plan and is going ahead aggressively with the improvement of its road traffic network.

By restoration of the functions of the Victoria Bridge, the road traffic between Colombo and northern Sri Lanka will become smooth and the economy of this area will benefit. In addition, it will be effective in accomodating the expanding future traffic volume accompanying the development of the economy.

8-2 Validity of the Project Implementation

Considering the current and in future traffic conditions around the Victoria Bridge and the entire country, this project is very urgent, and therefore the Sri Lankan government has given it a high priority.

Also, the implementation of this Project will contribute to the development of the traffic system, the economy and the bridge construction technology of Sri Lanka in the present and in the future.

In addition, Sri Lanka is structurally prepared to implement this project, and the project expenditures and maintenance costs which Sri Lanka will be after implementation will not be heavy. So the burden on Sri Lanka will be small.

As indicated above, in light of the Project's urgency, the Project's effectiveness, the basic preparedness of Sri Lanka and the relatively small expenditures to be borne by Sri Lanka, it can be concluded that this Project is valid for grant-aid assistance from Japan.