CHAPTER 1

CHAPTER 3

Chapter 3 Implementation Plan

3-1 Implementation Plan

3-1-1 Implementation concept

The implementation plan of this project is proposed while taking survey results into account and assuming that the plan is implemented with financing by issuance of national bonds.

1) Establishment of the implementation period

The project content includes, for both bridges, preparatory work, construction road work during the work period, bridge work (substructure, superstructure, bridge appurtenances), approach road work, revetment work, and miscellaneous works. The total work period, which will be about 24 months will commence in September 2001 and be completed and delivered in September 2003. Four months from the middle of April to the middle of June and from October to November of the work period are rainy seasons, during which, as a rule, bridge substructure work will not be done. Only fabrication of superstructure girders can be done even in rainy seasons.

2) Work construction method

The flow of typical work as a whole is shown in Fig.-3.1.1 (common to Gampola Bridge and Muwagama Bridge).

(1) Construction road work

Ordinary vehicles will use the existing bridge while bridge reconstruction is under way. However, a construction road must be provided to enable access to the work site.

(2) Temporary landing bridge construction work

A temporary landing bridge for access is necessary during pier and superstructure erection work. The temporary landing bridge will be made from H-steels, with repair expected about once every four to five months.

(3) Construction of foundation

Based on the result of boring survey, the foundation structures of the bridges concerned will be as follows.

Table－3. 1. 1　Construction of foundation

No.	Bridge name	Foundation	
		Spread foundation	Pile foundation
No.93	Gampola Bridge	･Abutment on the left bank ･Piers	･Abutment on the right bank
No.239	Muwagama Bridge	･Not applicable	･Abutments on left and right banks ･Piers

Based on the result of a boring survey, it was decided that the two bridges covered by this project would employ either piles or spread foundation. In the case of pile foundation, the cast-in-place pile method described below is used as a method appropriate to the strata of Sri Lanka.

①The reverse circulation method, in which excavation is done while applying water pressure caused by head difference to stabilize the bore wall

②The all-round rotation type all-casing method, in which excavation is done while protecting the bore wall with a casing

In both methods, pre-assembled rebars (cage) is immersed and underwater concreting is made in the specified position. In this basic design, the reverse circulation method is assumed as a result of a comparative review because of economic feasibility. The excavation machine and slurry treatment facilities will be procured (or imported) from Japan to be carried into the site.

In the case of both bridges, the existing bridges are secured for traffic until the new bridges are completed. Accordingly, the work is conducted in the proximity of the existing bridges. It is essential to conduct the work while securing necessary distances and paying due attention to the effects on the neighborhood of driving foundation piles.

⑷ Substructure work

For the substructure, an inverted-T type abutment is most advantageous in terms of economy. Basically, the substructure work will be done in the river. The method described below is employed commonly for both bridges.

① Excavation carried out after closure with sheet-piles.

② Use a backhoe for excavation. When the excavation depth is expected to be 5m or deeper, either a clamshell or small backhoe should be used. Provide waling and struts in the specified position, and carefully proceed with excavation with care while avoiding excavation prior to provision of waling and struts.

③ After reaching the specified depth, level the excavation base surface manually, lay broken and crushed stones, and place concrete to the designated height.

④ After pile head treatment, proceed with re-bar assembling, form setup, and concrete placement for footing, columns, and girders in this order, erecting the substructure.

⑤ Remove struts and waling while carrying out filling with specified filler materials to the specified thickness.

⑥ When filling reaches the specified height of ground level, carry out thorough filling of the surrounding ground and remove sheet-piles. Take due care to prevent subsidence when removing sheet-piles.

⑦ Carry out the revetment work (gabions, wire mats, etc.)

As the work in the river is susceptible to natural disasters (high water, etc.), implementation should be avoided during the rainy season. No work should be done during periods of heavy rain.

(5) Construction of the superstructure

The construction procedure for the superstructure is outlined in table 3.1.2 for an expected prestressed concrete connected continuous girder bridge (reinforced concrete connection) and a steel bridge (Trussed Langer).

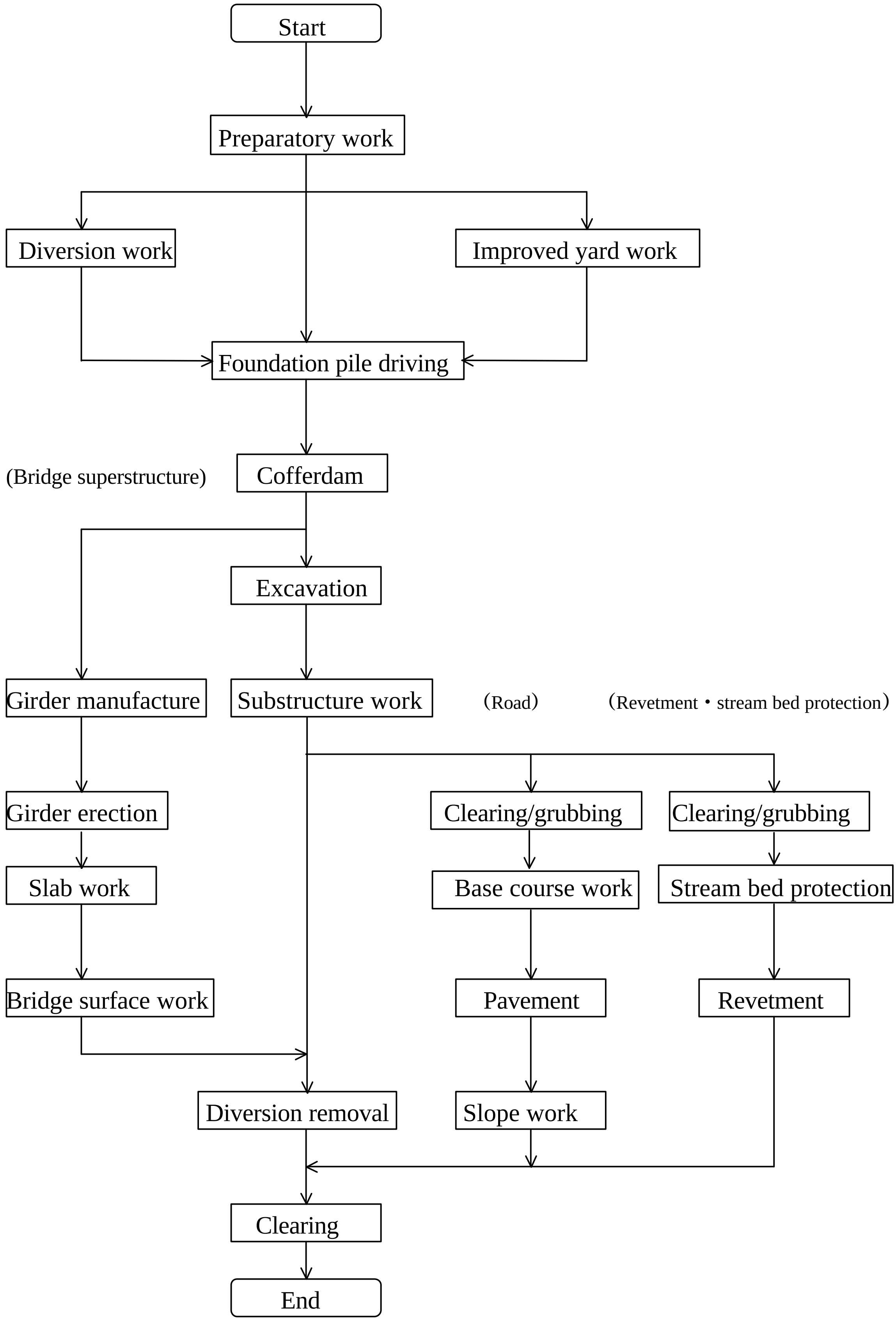

Fig.－3. 1. 1　Work flow chart

Table－3．1．2　Superstructure construction procedure

Gampola Bridge	Muwagama Bridge
Three-span prestressed concrete post-tensioning continuous girder bridge （Reinforced concrete connection type）・erection by erection girder）	Simple through steel bridge （erection using truck crane and bents）
① Fabrication of prestressed concrete precast girders (segments) in the yard ↓ ② Transport of prestressed concrete precast girders (segments) to the erection yard and erection of girders using erection girders ↓ ③ Rebar work of slabs and connections (cast-in-place points) ↓ ④ Placement of intermediate cross beams and filling concrete ↓ ⑤ Placement of concrete in connections (slab, cross beams) ↓ ⑥ Tensioning of PC steels of cross beams and slabs ↓ ⑦ Installation of sidewalk curbs, railings, and necessary equipment under sidewalk ↓ ⑧ Asphalt paving after completion of bridge surface work	① Carry-in of bridge body members that have been temporarily shop-assembled and field assembling with a mobile crane in the yard ↓ ② Installation of the temporary pier (steel bent) at a predetermined position in the river ↓ ③ Installation of a truss girder with a truck crane on the temporary pier (steel bent) set to a specified height ↓ ④ Installation of the lift control device because the bridge middle portion is of a cantilever structure. ↓ ⑤ Cantilever work while lifting girder temporarily and diagonally ↓ ⑥ Tightening of high-tension bolts ↓ ⑦ Coating of spliced portion and installation of accessories ↓ ⑧ Proceed to slab and bridge surface works after completion of erection of the bridge body ↓ ⑨ Installation of sidewalk curbs, railings, and necessary equipment under sidewalk. ↓ ⑩ Asphalt paving after completion of bridge surface work

(6) Approach road work

① Remove existing asphalt.

② Carry out embankment with borrow material to the specified position to make up the filled-up ground.

③ Carry out sufficient rolling compaction of the filled-up ground.

④ Construct drainage, such as drain gutters, crossing drain pipes, etc.

⑤ Place and spread the base course material (crushed stones) to the specified thickness and carry out sufficient rolling compaction with a tire roller.

⑥ Remove loose stones, dust, and other foreign material from the base course surface (spread surface) and apply asphalt manually with an engine sprayer.

⑦ Use an asphalt finisher for leveling to the specified thickness. Carry out initial rolling with a macadam roller and secondary rolling with a tire roller.

⑧ Provide lines such as a center line, marginal strips, etc. Traffic Safety control devices, including signs, etc. must also be provided.

3) Utilization of local engineers and materials/equipment

Excellent engineers are employed by RDA and private enterprises. Considering that semi-government enterprises are capable of performing fabrication up to erection of prestressed concrete girders, the technology level cannot be assumed to be low. However, there is a disparity in terms of quality with advanced countries.

Construction machinery in Sri Lanka has almost no versatility. Heavy machines such as cranes are limited in quantity and leasing becomes difficult depending on convergence of works. Therefore, they are to be brought into Sri Lanka from a third country or Japan. The plan calls for checking and utilizing available equipment as much as possible.

4) Employment of local contractors

Local contractors are not yet sufficiently developed in terms of technical capacity. For types of work that do not require special technology, these contractors will have an opportunity to participate as subcontractors under the supervision and guidance of Japanese contractors, thereby contributing to the development of construction engineering in Sri Lanka.

5) Dispatch of engineers from Japan

Engineers will be dispatched from Japan for the following types of work for supervision and execution of work in the field:

① Prestressed concrete work：Fabrication of prestressed concrete girders, prestressing work of prestressed concrete, girder erection

② Scaffolding work：Erection for steel bridge, special scaffolding

③ Painting：Guidance on painting of steel bridge

④ Operation（plant）

⑤ Operation（cast-in-place piles）

3-1-2 Implementation conditions

The implementation concept assumes that the plan is feasible and takes into account the meteorological conditions (dry and wet seasons) unique to Sri Lanka and materials/equipment procurement situations.

1) Work schedule considers wet and dry seasons

Sri Lanka's dry and wet seasons are clearly identifiable. The type of work whose operating rate significantly declines during the rainy seasons from April to October, such as foundation and bridge substructure works, must be implemented during the dry season as much as possible. It is also necessary to establish an equipment application plan based mainly on implementation during the dry season.

It will be best to start preparatory work and to set up the work base immediately after conclusion of the contract between the Sri Lanka partner and contractor. Since transport of equipment from Japan uses irregular service via Singapore and requires 1.5 to 2.5 months, this project will plan for transport accordingly.

2) Bringing construction material to the site

Construction materials to be carried to the site are transported mainly by land. Materials that are difficult to procure in Sri Lanka are imported from foreign countries and transported to the site via the port of Colombo in the case of import by sea or via Katunayake International Airport in case of import by air.

(1) By land

Nearly all materials procurable in Sri Lanka are found in the Colombo area, and imported materials are collected in the port of Colombo. It is therefore necessary to secure an access route from Colombo to the sites.

① Access to the Gampola Bridge

The main trunk line, Route A5, connects Kandy, the second largest city about 115 km northeast of Colombo with Nuwara Eliya in the central highland. The Gampola Bridge exists at a point where this route crosses the Mahaweli River with the largest drainage area in Sri Lanka at a point about 20 km southward from Kandy toward Nuwara Eliya.

② Access to the Muwagama Bridge

The Muwagama Bridge exists at a point where the route crosses the Kalu River after passing through Ratnapura City about 100 km southeast of Colombo via Route A-4 to enter the B390 road. The bridge is 2 km to the southwest.

(2) By sea

All materials and equipment to be imported by sea from foreign countries are unloaded in Colombo Port to be transported by the inland route described above. In the case of procurement from Japan, it will take about 1.5 to 2 months from shipment in Japan to arrival at the site.

(3) By air

Materials and equipment to be imported by air from foreign countries are unloaded at Katunayake International Airport to be transported into Colombo via Route A-3 and finally to the site via the above route.

(4) Customs clearance

Materials and equipment not procurable in Sri Lanka will be imported from Japan. Though they are not taxable by customs duties, etc. thanks to ODA tax benefits, it is impossible to obtain direct tax exemption in Sri Lanka. Accordingly, RDA, the implementing agency, will budget the amount equivalent to the tax exemption and refund the paid tax to contractors. As the obligation of contractors to bear interest covers the refund period, the list of import materials and equipment and the tax incidence amount must be submitted to RDA to allow RDA to establish beforehand the budget, including the tax amount.

＊ Preparation and submission of the master list of materials and equipment to be imported

＊ Approval of authorities concerned of Sri Lanka on the master list

＊ When imported materials and equipment have entered Sri Lanka, they are transported to the site after customs clearance by paying taxes such as import duties, etc. for taxable materials and equipment. During customs clearance, a National Security Levy (NSL) and Goods and Services Tax (SGT) are levied in addition to the import duties. The GST tax rate is currently 12.5%.

3) Acquisition of land necessary for construction and transfer/removal of obstructions

Securing of the land necessary for the work and transfer/removal of obstructions are included among the obligations of the recipient country. There is a division of the implementing RDA organization in charge of securing the land. This division proceeds with all procedures to secure land related to the RDA project. The same procedure is used to secure land necessary for construction of the bridges. As utilities, such as electricity, telephone, water, etc. require coordination with authorities concerned, it is planned to proceed with removal and transfer, if necessary, through RDA.

① Acquisition of the land and transfer/removal of obstruction facilities, etc.

On the basis of the field survey result, ministries concerned of the Sri Lanka Government will undertake transfer and recovery of public installations that are obstructions to securing the land and construction. Table-3.1.3 and 3.1.4 outlines the land to be secured and facilities to be transferred.

Table－3. 1. 3 Outline of land to be secured

Item		No.93 Gampola Bridge		No.239 Muwagama Bridge	
During implementation ／ bridge construction		During implementation	Bridge construction	During implementation	Bridge construction
Private	Left bank	―	Shop :1	―	Houses :11
	Right bank	―	―	―	Houses :2
Public	Left bank	―	School :4	Local road(Class E)	―
	Right bank	Community hall	―	Local road(Class E)	―

Table－3．1．4　Facilities to be transferred

Item	Authorities concerned	Gampola Bridge	Muwagama Bridge
Electricity	Ceylon Electric Board	High voltage：11kv（before and after implementation） Low voltage：230v（after implementation）	High voltage：33kv（after implementation） Low voltage：230v（after implementation）
Water supply	National Water Supply & Drainage Board	φ 225mm（after implementation） φ 150mm（after implementation）	φ 225mm（after implementation） φ 150mm（after implementation） φ 100mm（after implementation）
Telephone	Sri Lanka Telecom	φ 150mm buried cable（after implementation） overhead line（after implementation）	φ 100mm buried cable（after implementation） φ 75mm buried cable（after implementation）
Others		Poles Telephone switchboard（unit board）	Poles
Transfer cost (Rs.million)		1.0	0.7

② Temporary sites for work

During the work period, temporary sites must be secured for temporary buildings and equipment and for storage of materials and equipment.

Possible candidate sites and uses are shown in Table-3.1.5.

Table－3．1．5　Temporary sites for work

	No.93 Gampola Bridge	No.239 Muwagama Bridge
Candidate sites	Left bank (school yard, public domain) of upstream and downstream sides of the existing bridge, work platform.	Left and right banks (private land) of downstream side of the existing bridge
Use	Approach road, field office, construction material storage yard, machine storage site, various plants.	Detour from the existing road, temporary road, field office, construction materials and machine storage yard, various plants
Item	Temporary yard, Landing bridge and yard	Temporary yard

③　Diversion road

On the Muwagama Bridge side, the existing road for daily activities runs through the site scheduled for construction.　This road will be completely closed during the work, and a diversion road must be provided as shown in Table-3.1.6 because the original functions of the existing one must be restored after the work.

Table－3．1．6　Diversion road

	No.93 Gampola Bridge	No.239 Muwagama Bridge
Location and specifications of diversion road	Not required as the result discussions with RDA	Length：about 30M on the left bank、about 50M on the right bank,
Specifications	NA	Road class：Class E（local road） width (Class E)＝Total width 4M（existing width）、with asphalt pavement

④ Blocking traffic

The basic plan is to leave the existing bridge after construction of the new one, so that there is no need to block the existing traffic. Traffic will be blocked however subject to approval of authorities concerned if required due to deadhead of large vehicles (during girder transport or erection), construction of a temporary approach road, etc.

Traffic will be blocked, if necessary, in the nighttime when the traffic volume is small, with necessary notice boards, protection equipment, and traffic guides provided to ensure thorough safety measures.

⑤ Customs clearance

Materials and equipment procured from Japan will be brought into Sri Lanka mainly via Singapore. It is necessary to obtain understanding of Sri Lanka Government beforehand to ensure smooth customs clearance.

⑥ Safety measures

Both bridges will have a field office and accommodation facilities. Guards will also be assigned to protect equipment and material and to guide the traffic during the work.

Table－3. 1. 7 Safety measures for Construction

No.	Name of bridge	Safety measures	
		Work control	Material/equipment control
No.93	Gampola Bridge	Safety measures are indispensable because transport/erection of heavy materials and structures at elevated places are made near the existing bridge. Piers are constructed using a temporary landing bridge, with large number of work vehicles running on the landing bridge. Therefore, measures to prevent falling are necessary.	It is planned to provide the field office at a bridge location. As the urban area is nearby, communications with telephone sets within the city is possible. As indiscriminate terrorism is possible, the staff will always carry wireless transceivers to ensure the adequate communications. Guards will also be provided for the site and material/equipment control in the nighttime to prevent theft, etc.
No.239	Muwagama Bridge	Market and housing areas exist near the bridge, and traffic is heavy. During transport of materials and equipment and deadhead of heavy machinery, guards will be provided to ensure the safety of pedestrians and the neighborhood. As the work is done in the proximity to the existing bridge, due care will be necessary to prevent contact with the existing bridge and accessories, bridge attachments, etc. during slinging, concrete placement from hopper, etc.	

3-1-3 Scope of Works

The cost of construction of the bridge main body and approach road for the project will be totally borne by the Japanese side.

3-1-4 Consultant supervision

Japanese staff in charge of general affairs, bridges (planning, superstructure, substructure), roads, survey of natural conditions, and bid documents will handle detailed design, preparation of bid documents, and bidding after conclusion of the consultant agreement. During the work period, the consultant will dispatch the Japanese resident supervisor and the staff for supervision and guidance for major work to the site. Principal assignments of the staff are described below.

1) Chief executive

In charge of broad range of duties related to detailed design, bidding, and supervision

2) Bridge (Planning, superstructure、substructure)

In charge of design of superstructure, substructure, foundation, temporary works, and erection accessory works according to individual assignment, as well as drafting and quantity calculation, in the phase of detailed design. During the work, the bridge staff is in charge of supervision, witnessing and inspection of each type of work.

3) Road (road design)・road construction

In charge of design for the access road rehabilitation plan as well as plotting and quantitative calculations according to individual assignments in the phase of detailed design. During the work, the staff is in charge of supervision, witnessing, and inspection of embankments, base courses, and pavement, which exert considerable influence on the quality of completed facilities.

4) Bid documents

The staff prepares bid documents and contracts for bidding and contract duties in the phase of detailed design

5) Resident supervisor

Stationed at the site from commencement to completion of the project and in charge of technical matters such as quality control, process control, safety control, etc. and a series of clerical duties. During construction of the bridge, the supervisor is also in charge of supervision and joint inspections of bridge main body, base courses, pavement, and accessory works.

6) Bridge works (superstructure and substructure)

In charge of technical and clerical duties related to quality, process, and safety controls for each type of bridge work. During construction of the bridge, the consultant staff is also in charge of supervision and joint inspections of bridge main body, base courses, pavement, and appurtenant work.

3－1－5 Procurement plan

1) Labor condition

Though described as a Buddhist country, Sri Lanka contains other religions. Understanding and coordination with local religions and practices in the course of labor control is considered the greatest factor for successful completion of the project.

Understanding of the saying that laborers stick together is essential.

(1) Construction engineers

Among construction technicians, engineer-class technicians are graduates from two universities; Peradenia University and Moratuwa University. Every year, about 1,500 are graduated from these universities, of which about 100 are civil engineers. Apart from these universities, one vocational college and industrial high school exist on average in each district, which send out technicians every year.

(2) Laborers from third countries

In Sri Lanka, third country nationals can rather easily obtain work visas. The Government is also making efforts to introduce excellent technology from overseas. It is said that the advance of enterprises from India, Korea, China, Singapore, USA, and Europe as well as from Japan is increasing yearly. However, ordinary laborers have difficulty entering to work.

(3) Sri Lanka Laws concerning employment

There is an employment law covering enterprises that employ local laborers. Conditions considered important for employment are summarized below.

Table－3．1．8　Sri Lanka law concerning Employment

①	Wage system：	Two systems exist: ENGINEERING TRADE（hereinafter called "ET"） and HOPE&OFFICE EMPLOYEE (hereinafter called "SOE"). ET and SOE include following occupations; ET ··· technical （electric engineer, mechanical engineer, civil engineer, building engineer, service engineer, store keeper）, physical labor (earth worker, driver, carpenter, cleaner, guards SOE···Clerical （clerk, typist, office worker）. Note that the above classification is interpreted differently among enterprises and thus not absolute.
②	Work hours：	48 hours per week
③	Days off and legal holidays：	All workers are allowed to have one day off per week. Workers receiving monthly pay are allowed to have days off equivalent to nine legal holidays. If they work on such a day off, the payment for the day is doubled. In addition, a substitute holiday is allowed later. If they work on a holiday or festival day, the payment is multiplied by 1.5 for initial eight hours and doubled for hours exceeding eight hours.
④	Annual vacation	Absence with leave for 14 days is allowed for workers generally working 288 days a year. For SOE, special absence with leave for seven days is additionally allowed.
⑤	Absence due to sickness	When a medical certificate of a designated medical doctor is submitted within one year of service, absence due to sickness for seven to 14 days is allowed. Payment during this period is guaranteed.
⑥	Absence due to accident	In case of injury due to accident while on duty, absence due to accident is allowed for seven days a year. Absence exceeding the seven-day period is covered by labor insurance.
⑦	Overtime compensation	Overtime compensation is calculated as follows and paid: (A) Hourly overtime rate is calculated as follows for those receiving monthly pay: ・ET·········Overtime payment per hour＝Monthly payment ／200 hours ・SOE······Overtime payment per hour＝Monthly payment／240 hours (B) Hourly rate for overtime compensation is calculated as follows for those receiving daily pay

		・ET・・・・・・・・Overtime pay per hour＝Daily payment／８ hours ・SOE・・・・・Overtime pay per hour＝Daily payment／８ hours (C) Overtime compensation is equivalent to 1.5-fold payment.
⑧	Retirement, disemployment	Retirement and disemployment must always be justified by proper reason. Reasons are classified as follows in terms of law and practices: (A) LAY-OFF : Downsizing because of surplus manpower because the peak time of work is over. (B) RESIGNATION : Retirement due to the worker's own reason. (C)VACATION OF POST : When the worker is absent from the job without approval for a long time (D) TERMINATION : When the worker performance is inadequate or causes an accident For (A), the disemployment list and statement of reason must be submitted to the Labor Standards Office. When the Office issues approval of disemployment, the company submits "One Month Notice" to the staff concerned for disemployment. For (D), the company disemploys the worker immediately and reports it to the Labor Standards Office.
⑨	Pension program	15% of the total compensation is paid to the employee as a pension.

⑷ Number of operating days per month

Table－3. 1. 9 No. of working days per month

Month	Weekday	Sunday	Saturday	Holiday ( )*1	No. of days with precipitation of 10mm or more		Remarks
					Gampola	Muwagama	
1	18	5	5	2(3)	2.0	3.8	＊2 No. of days with average rainfall in dry season： Gampola：6.7 days／month Muwagama ：6.2 days／month
2	19	4	4	1(2)	2.0	2.8	
3	23	4	4	0(0)	3.6	6.6	
4	16	4	4	1(6)	9.2	10.0	＊2 No. of days with average rainfall in rainy season： Gampola ：10.1 days／month Muwagama ：11.3 days／month
5	18	5	4	0(4)	7	12.2	
6	21	4	4	1(1)	11	13.4	
7	20	5	5	1(1)	12.8	9.8	
8	22	4	4	1(1)	10.4	9.4	
9	21	4	4	1(1)	9.2	12.4	
10	20	5	5	1(1)	11	11.8	
11	21	4	4	1(1)	6.8	9.6	
12	21	4	5	1(1)	2.8	7.2	
Total	240 days	52 days	52 days	11(22) days	87.8 days	110.0 days	240+52+11+22=365 days

＊1：( )Sunday overlapping with holiday ＊2：No. of days with rainfall is the average for five years.

＜Calculation of monthly working days＞

① Dry season：Days other than Sunday or holidays are considered to be working days.

(365-52-11)/12 25 days（Operation factor：25/30＝83%）

② Rainy season：Decrease in the operation factor due to the number of days with rainfall (calculation made by assuming days with rainfall as holidays)

[25 days-{(10.1 days+11.3 days)/2-52 days/12 months}]/12 19 days（operation factor：19/30＝63%）

2) Construction materials/equipment procurement condition

（1） Construction materials

① Cement

Due to reasons related to public security at present, cement production in Sri Lanka is limited to two plants only, one in the west and the other in the south.

The supply (production) cannot meet demand and the situation requires import from India, Malaysia, and South Africa. Domestic cement suppliers are Mahaweli Marine Co. Ltd., Ruhunu Cement Co. Ltd., St. Anthony Connoliadated Ltd., Jayan Jaya Traders, Expo Lanaka Commodition Ltd., Mascon Ltd., Lanka Cement Ltd., and L.N.T. Co..

② Ready-mixed concrete

In Sri Lanka, there are ten suppliers that can produce and supply ready-mixed concrete, as shown in Table-3.1.10. These suppliers have limited numbers of plants and concrete mixers. This is makes supply to areas other than the Colombo area extremely difficult.

Therefore, it is planned to bring in a batch plant from Japan for supply.

Table－3. 1. 10 Ready-mixed concrete producers

Name of ready-mixed concrete producers	Retained quantity
SANKEN LANLA (PVT) LTD	Colombo 4 no.、Kandy 1 no.
DEVCO SHOWA (PVT) LTD	Colombo 2 no.、Kandy 1 no.
INFORMAX CONSTRUCTION (PVT) LTD	Colombo 2 no.、Galle 1 no.
TUDAWA SROTHERS	Colombo 2 no.
SUNBEE READY MIXED	Colombo 1 no.
MAGA ENGINEERING	Colombo 2 no.、Ratnapula 1 no.
INTERNATIONAL CONSTRUCTION CONSORTIUM	Colombo 2 no.、Ambalagd 1 no.
KEANGNAM READY MIXED	Colombo 2 no.、Jaela 1 no.
LANKEM LANKA	Colombo 1 no.
LINK ENGINEERS	Colombo 2 no.、Amparo 1 no.

③ Asphalt (bituminous material)

As shown in Table-3.1.11, all of the enterprises that can produce and supply asphalt are located in the Colombo area. If the construction work is to be done outside the Colombo area, the contractor must install its own plant to supply asphalt. To obtain asphalt, the contractor must apply to the state-run enterprise for purchase. Asphalt of special specification is brought in from a third country (Singapore, etc.) , but others are produced domestically. The supply for this project is enough to meet demand.

Table－3. 1. 11 Asphalt producers

Name of asphalt producers	Plant location
1) INTERNATIONAL CONSTRUCTION CONSORTIUM LTD	MADAOATHA (No.291 Modara Street Colombo 15)
2) SHAKEN ENGINEERING (PVT) LTD	PAPPLIYAWELA (401-8-1/1 Gall Road Colombo 4)
3) INDUSTRIAL ASPHALT LTD.	28/7 Nuge Road, Peliyagado
4) INFORMES CONCRETE LTD.	9, Kovil Veediya, Colombo 10
5) LINK ENGINEER	333, T.B. Joyah Mawatha, Colombo 10
6) R.D.&.C.C	Angulana

④ Steels (re-bars, steel members)

Similarly to the case of cement, domestic production of re-bars is not enough to meet demand and the material standard is restricted. BS-based products are imported in large quantity from South Africa and Singapore. Other steel members are available in Sri Lanka, except for special and large steels. Prestressing steels and cover steel plates used in large quantity for bridge construction will all be procured from Japan while other material will be procured locally.

⑤ Concrete aggregate and embankment/base course materials for road

Aggregates for concrete and asphalt pavement are completely procurable in Sri Lanka. Domestic producers have more than 10 large and small aggregate production plants. Candidate quarries that have aggregate plants in the neighborhood of both sites are outlined in the table below. It is also possible to procure aggregate from producers currently engaged in construction and with their plants. Required aggregates are totally procurable.

Table－3. 1. 12　Procurement of Aggregate and Embankment Materials

Mate		Type	NO.93 Gampola Bridge	No.239 Muwagama Bridge
Aggregate (concrete, asphalt paving)		Fine aggregate (sand)	① **Mahaweli River sand** Judging from laboratory test results in the ADB project, this is applicable as fine aggregate for concrete.	① **Kelani and Kalu Rivers sand** Since there is no place near Ratnapura where fine aggregate can be quarried, fine aggregate will be procured from the suburb of Colombo.

		Coarse aggregates (crusher run)	**①Near the Kotmalle dam ～ 20km：** The quarry where coarse aggregates were quarried at a time of Kotmalle dam construction. Two crushers are installed, with production enough for use during construction of this bridge. The rock quality is mainly metamorphic rock (gneiss) showing dark blue while including partially silicic and granitic rocks. Rock mass falls into Soft rock II to medium hard rock classes, but, as aggregate, may be considered to fall approximately in the medium hard rock class. Because of schistosity, the rock shows flat and planular shape when crushed. Judging from the rock type, rock quality, and application result for existing concrete structures and pavement, the material is applicable as aggregate for concrete and asphalt pavement in this project. **② A005 ～ 15km on the NuwaraElya side：** Because the rock quality here is approximately similar to that of the quarry of ①, the material can be applied to the project. However, due to lack of crushers, crushing is manual. As a result, the production is considered insufficient.	**① A4～40km near Balangoda：** Quarries are dotted around the location about 6 km south along the Class B road from Balangoda about 40 km east of Ratnapura. Quarried rocks are transported to the nearby (1 km) RC&DC asphalt plant (with one crusher) that produces crusher run. As rocks are brought in from several quarries, production is considered sufficient. The rock quality falls in Soft rock II to medium hard gneiss, with black dyke of biotite mass and white dyke of feldspar mass observed. The rock is mainly hard and stable, so that it is applicable as crusher run or aggregate. Note that a small amount of granite rock with high white feldspar content exists. This should be avoided during use because it is relatively fragile.

Embankment materials		① **Route B154 ～ 3km near Peradenia：** Cut slope on both sides at a distance of about 3 km from the existing Gampola Bridge. The soil here is sandy silt to silty soil and applicable as embankment material. In certain locations, however, extremely oxidized/weathered silty clay to clayey silty soil in reddish brown color is near the surface layer. This material is not considered appropriate for embankment material. ② **Route B154 ～ 5km near Peradenia：** RDA is currently quarrying the base course material from the cut slope on one side about 5 km from the existing Gampola Bridge. The soil is less weathered than the wall rock and contains a large amount of small quartz gravel, indicating silty sand with mixed sand gravel. Because mixing of gravel and its sandy characteristics, soil compaction is satisfactory, which is advantageous for application as embankment material.	① **Near Ratnapura～5km** The borrowing pit from which RDA is currently quarrying is not located near Ratnapura. Judging from the surrounding ground condition, quarrying of embankment material is possible. Candidate locations will be selected within a 5 km radius. The material is extremely oxidized/weathered silty clay to sandy soil in reddish brown color. Application to embankment material is considered possible. Before selection of the quarrying site, however, it is recommended to refer to the result of tests at the original location and in the laboratory.

⑥ Lumber

Lumber is completely available in Sri Lanka, except that the plywood for special forms and plywood 15 mm or more thick are completely not available. The quality is relatively satisfactory and thus fully applicable for bridge construction.

⑦ Other construction materials and equipment

Bricks and roof tiles are supplied in sufficient quantity in Sri Lanka. All special materials, such as prestressing steel, etc. necessary for bridge construction must be imported. Supply sources of principal materials are shown in Table-3.1.13.

Table－3. 1. 13 Principal construction material supply sources

Name of materials	Local procurement	Procurement from Japan	Reason for procurement	Transport route
Cement	○		Imported from India, SA	
Concrete admixtures		○	Quality maintained	Via Singapore
Re-bars	○		Sri Lanka, Singapore	Via Singapore
Structural steel		○	Not procurable	Via Singapore
Prestressing wire, bar		○	Not procurable	Via Singapore
Bituminous material	○			
Crushed stone, sand	○			
Ordinary wood	○			
Form (plywood, steel made)	○ (plywood)	○ (steel)	Imported from Singapore	Via Singapore
Falsework, scaffold	○		Sri Lanka, Singapore	
Expansion joint (rubber)		○	Quality maintained	Via Singapore
Bearing (rubber)		○	Quality maintained	Via Singapore
Concrete pipe	○			

(2) Construction machinery

Construction machinery available includes that possessed by government agencies and that possessed by private enterprises. Contractors generally undertake work with their own machines, but there are also enterprises specialized in leasing.

However, nearly 80% of these machines are second-hand and may become an obstacle unless carefully maintained.

Each enterprise does not have a sufficient stock of machine parts. Machine failure may interrupt work for a few days or weeks, or a few months in the worst case because parts must be imported from foreign countries.

When implementing the project, it is essential to avoid the worst case of work interruption by thoroughly learning the condition of machines possessed by contractors and leasing companies.

(3) Construction machines and plants possessed by government agencies (Ready-mixed concrete, asphalt)

Construction machinery possessed by Sri Lanka government agencies are shown in Table-3.1.14. These machines cannot be leased to ordinary contractors, but it is said that the agency may lease the machine as an exception when contractors are engaged in the work under its control.

Table－3. 1. 14 Construction machines possessed by government agency

Name of machines	Specification/capacity	Quantity
Bulldozer	50HP – 140HP	48
Scraper	10M3 or less	1
Motor grader	3M - 4M	37
Wheel loader	5M3 - 2.0M3	23
Drilling machine		1
Compressor	350C.F.H	33
Piling machine		3
Vibration roller	10-ton or less	2
Dump truck	10-ton or less	220
Truck crane	10-ton or less	20

*The actual quantity may differ more or less.

(4) Construction machines and plants that can be procured or leased in Sri Lanka

In Sri Lanka, almost all ordinary construction machinery is procurable. But quantity is limited, operation rates are extremely poor, and procurement of replacement parts will take a considerable time. Accordingly, it is necessary to bring in machinery from outside and to prepare replacement parts when there is not enough marginal allowance in the work schedule.

Construction machines that can be procured and leased in Sri Lanka are shown in Table-3.1.15.

Table－3．1．15　List of construction machines procurable in Sri Lanka

Name of construction machines	Specification/capacity	Quantity
Backhoe	0.5m3 or less	6
	0.5m3 - 1.0m3	44
	1.1m3 - 1.5m3	7
	1.5m3 or more	3
Bulldozer	50 H.P - 100 H.P	143
	101 H.P - 139 H.P	88
	140 H.P - 179 H.P	25
	180 H.P - 250 H.P	41
	251 H.P - 350 H.P	32
	350 H.P or more	17
Motor grader	3.0m (blade length)	13
	3.5m (blade length)	67
	4.5m (blade length)	6
Wheel loader	1.5m3 or less	14
	1.5m3 - 2.0m3	70
	2.0m3 - 2.5m3	33
	2.5m3 or more	12
Backhoe with tires	1.0m3 or less	68
Compressor	175 C.F.M	40
	175 – 350 C.F.M	42
	350 C.F.M or more	13
Vibration roller	5ton or less	8
	5ton - 10ton	10
Dump truck	5ton or less	55
	5ton - 7ton	147
	7ton - 10ton	97
	10ton - 16ton	120
	16ton or more	35
Asphalt plant	50ton/h or less	1
	50ton/h or more	3
Distributor	1,000 liters	19
	4,000 liters	4
Truck crane	10ton or less	2
	10ton or more	24
Crawler crane	37ton	15
	80ton	2
Stone crusher	20ton/h or less	1
	20ton/h - 50ton/h	30
	50ton/h - 100ton/h	11
	100ton/h or more	4

3) Construction machines whose procurement must be made outside of Sri Lanka

Special construction machines are extremely difficult to procure in Sri Lanka. Machines necessary for smooth implementation that must be brought in from outside Sri Lank are listed in Table-3.1.16.

Table－3. 1. 16　Machines to be imported

Name of machines	Specification/capacity
Crawler crane Vibro-hammer Generator Compressor Earth auger machine Reverse excavator Grouting machine Crawler drill	50 TON 90 KW, 60 KW 250 KVA 11 M3 1,000 M3 - 1,200 M3 S 320 φ1,000～φ3,000 38 MM, 50 MM 38 MM, 50 MM

4) Maintenance of construction machines

Machine maintenance is an extremely important factors governing the success of a project.

All raw materials (fuels and oils/greases) must be imported in Sri Lanka. Fuels are supplied in sufficient quantity to meet demand. Since certain machines require special oils/greases, they may have to be imported beforehand after selection of the machine. Machine parts must be stocked at the site when using machinery of local contractors if it is to be controlled and used for a long period of time. Even for leased machines, it is necessary to stock parts beforehand after confirmation of machine model.

5) Local contractors

Enterprises to be engaged in bridge construction are either state-owned or private survey/research, design, and contractor companies. Enterprises listed in the table below are excellent ones registered in RDA.

Table－3．1．17　Local contractor in Sri Lanka

Type	Name of enterprises
State-owned	STATE DEVELOPMENT & CONSTRUCTION CORPORATION (No.7 Borupana Road, Ratmalana) STATE ENGINEERING CORPORATION （P.O.Box 194, 130 W.A.D. Ramanayake Mawatha, Colombo 2 ）
Semi-government Road Development Authority（RDA） Exclusive contractors	ROAD CONSTRUCTION & DEVELOPMENT CO. (“Sethsiripaya”, Battaramulla, Sri Lanka)
Private	CML EDWARS CONSTRUCTION CO.,LTD (P.O.Box 1305, No.30, Hanupitiya Road, Colombo 2) SAMUEL SONS & CO.,LTD (P.O.Box 46, 164 Messenger Street, Colombo 12) INTERNATIONAL CONSTRUCTION CONSORTIUM LTD (291, Modera Street Colombo 15) MEGA ENGINEERING (PVT) LTD (200, Nawara Road, Colombo 5) TUDAWE BROTHERS LTD (P.O.Box 26 505/2, Elvitigala Mawatha, Colombo 5) DHARMASENA & COMPANY (106, D.S.Senanayake Road, Colombo 8) DAYA CONSTRUCTION (PVT) LTD (171, Kesbewa Road, Boralesgamuwa) KEANGNAM ENTERPRISES LTD (221/3, Panipitiya Road, Battaramulla) WALKER SONS & CO. ENGINEERS (PVT) LTD (250, Ramanathan Mawatha, Colombo 15)

6）Engineering and consulting companies

Table－3．1．18　Local Engineering and Consulting company in Sri Lanka

Type	Name of enterprise
Private	CHANDRASENA & PARTNERS (22/1, Edomonto Road, Colombo 6) MAHAWELI ENGINEERING & CINSTRUCTION AGENCY (11, Jawatta Road, Colombo 5) W.S. ATKINS INTERNATIONAL LTD (39, St, Michael’s Road, Colombo 3) SCOTT WILSON KIRKPATRICK (Suite 13A, Tower Block, Station Road, Colombo 4) RESOURCES DEVELOPMENT CONSULTANTS LTD (55 2/1, Calle Road, Colombo 3) COST ENGINEERING SERVICES (PVT) LTD (20/2A, Narahenpita Road, Nawala) CENTRAL ENGINEERING CONCULTANCY BUREAU (415, Bouddhaloka Mawatha, Colombo 7) ASPHALTIN (PVT) LTD (32/4, Flower Road, Colombo 3)

7) Foreign contractors (India, Southeast Asian countries, Europe) making advance into Sri Lanka

Table-3.1.19 shows foreign contractors currently active in Sri Lanka.

Table－3. 1. 19　Foreign contractors

Name of contractors	Address
AF CONS (India)	No.50/12 Sir James.Peiris Mawatha Col.2
CHRISTIANI NIELSEN (UK)	No.190 Galle Road Col.3
W.S.ATKINS (UK)	No.39 St.Michale's Road Col.3
LEMMIN KAINEN CONSTRUCTION LTD	No.64 Horton Place Col.7
(Finland)	No.221/3 Pannipitiya Road Battaramulla
KEANGNAM ENTERORISES LTD (Korea)	No.21A Balahenmulla Lane Col.6
SKANSKA INTERNATIONAL (UK)	No.7 Rorlshrue Place Off Col.10
JILIN (China)	No.127/3 Vije Kumaratnuge Mawatha
SHANHAI ENGINEERING CONS.GROUP (India)	Col.6

8) Japanese contractors in Sri Lanka

Table-3.1.20 shows Japanese contractors currently engaged in projects in Sri Lanka.

Table －3. 1. 20　Japanese contractors

Name of contractors	Address
Kajima Corporation	NO.481-C GALLERO. COLOMBO 3
Kumagai Gumi Co., Ltd.	2ND FLOOR NANDA INVESTMENTS BUILDING 25-2/1 C.W.W
	KANNANGARA MWT. COLOMBO 7
Taisei Corporation	C/O COLOMBO HILTON HOTEL SQUARE LOYUS RD.
Hazama-Gumi Ltd.	COLOMBO 1
Mitsui Construction Co.,	7TH FLOOR UNITY PLAZA BAMBALAPITIYA COLOMBO 4
Ltd.	295 MADAMPITIYA RD. COLOMBO 14
Penta-Ocean-Wakachiku	P.O.BOX 383 KOCHCHI-KADE GATE No.4 COLOMBO PORT
joint venture	COLOMBO 13

3－1－6　Implementation Schedule

This plan will be implemented as shown in the schedule below after conclusion of the Exchange of Notes.

1) Implementation design

The detailed design will be conducted and design and bid documents prepared after conclusion of the consulting agreement.

2) Bidding and contractor agreement

The project agreement will be a direct one between the Sri Lanka Government and the Japanese contractor. Selection of the Japanese contractor will be based on open tendering addressed to Japanese contractors.

Examination items will be discussed beforehand with JICA for approval, then prequalification of Japanese contractors will be made. A consulting company on behalf of the implementing agency of the Sri Lanka Government will handle prequalification.

Bid evaluation and selection of successful bidders will be conducted in the presence of Sri Lanka Governmental staff, consulting company, and bidders, and a witness representing JICA. The construction agreement will be concluded after bid evaluation and determination of successful bidders.

In parallel with conclusion of the construction agreement, the Sri Lanka Government will conclude the banking arrangement as soon as possible with a Japanese authorized foreign exchange bank in order to receive aid funds from the Japanese Government and to make payment to Japanese contractors. The banking arrangement is the basis on which the Sri Lanka Government will issue the Authorization to Pay (A/P) necessary for reception of aid funds from the Japanese Government and advance payment to contractors as well as for application to obtain an export license from MITI. This is also necessary to commence project implementation simultaneously with conclusion of the construction agreement.

Then, approval of the contract is necessary. Approval means that the Japanese Government verifies the appropriateness of the contract as an object of this grant aid. It is also a prerequisite for the contract to go into effect. Specifically, the Ministry of Foreign Affairs receives the contract from the Sri Lanka Government via overseas establishment, determining appropriateness for approval. The Japanese contractor will implement the contract after receiving the approved contract and authorization to pay (A/P).

3) Construction work

The construction work begins with preparation, followed by detouring work, removal of existing bridges, bridge permanent works including substructure, superstructure (girders, bridge surface), approach road, and appurtenant works such as bank protection work, and ends with removal of materials and equipment related to the project. Around the site in Sri Lanka, periods from the middle of April to the middle of June and from October to November are major rainy seasons. During this period, substructure work is limited.

The implementation schedule of this project is shown in Table-3.1.21.

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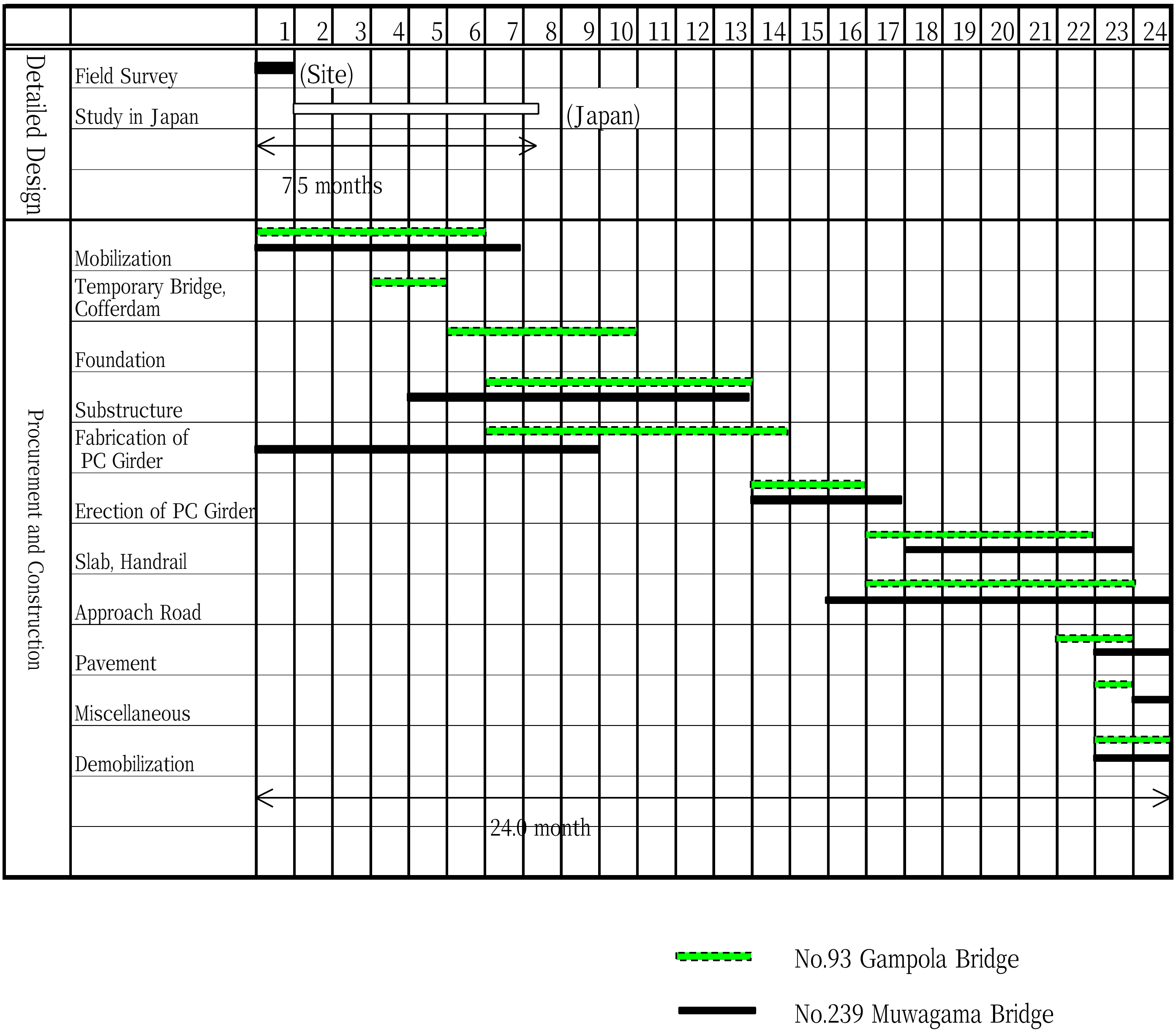
Table－３．１．２１　Implementation Schedule



3－1－7 Obligations of recipient country

During implementation of this plan, the Sri Lanka Government will be responsible for implementing the following matters.

1) Acquisition of land

(1) Securing of the land and transfer/removal of buildings (school, houses, shops) in the land

Table-3.1.3 shows the facility occupation area for replacement of Gampola and Muwagama Bridges. The land within this occupation area is secured for occupation of project facilities, and existing buildings are to be secured and removed at the same time.

(2) Securing of the work yard.（Permanent and temporary facilities）

The proposed yard occupation area in the temporary facility plan for Gampola and Muwagama Bridges is shown in Table-3.1.5. The land within this occupation area is secured for occupation of facilities of this project, and existing buildings are to be secured and removed at the same time.

2) Removal of existing bridges

① Gampola Bridge

a) Time of removal :To secure traffic during implementation period, the existing bridge shall be removed according to the implementation plan after completion of the new bridge. Early removal of the bridge is necessary because of safety concerns due to decrease in the depth of embedment of central piers of the existing bridge.

b) Scope of removal :The superstructure and central piers will be removed. Abutment should not be removed because it will not affect the river flow and function rather as a revetment even after completion of the new bridge.

② Muwagama Bridge

a) Time of removal :To secure the traffic during implementation period, the existing bridge shall be removed according to the implementation plan after completion of the new bridge. Early removal of the bridge is necessary because this is located on the upstream side of the new bridge and because of concern regarding the stability due to decrease in the depth of embedment of central piers of existing bridge.

b) Scope of removal :The superstructure and central piers shall be removed. The abutment should not be removed because it will not affect the river flow and will function as a revetment even after completion of the new bridge.

3) Transfer of utilities

The power transmission line, telephone line, and water pipeline will be transferred at the cost of Sri Lanka counterpart. For transfer items and costs, refer to Table-3.1.4. In particular, the high-voltage 11 kV line provided on the upstream side of Gampola Bridge must be removed before commencement of the project.

4) Tax benefits

All project-related Sri Lanka taxes will be exempted. The legal procedure in Sri Lanka for tax exemption will be made by the Sri Lanka counterpart.

3－2 Operation and Maintenance Method

Upon completion of the project, RAD will operate and maintain the rehabilitated bridge.

1) Maintenance method

For effective utilization of RDA's limited available funds, the maintenance method mainly comprising daily and periodic inspections will be employed to ensure early detection of damage and early countermeasures, thereby preventing major damage to the bridge main body and accessories, such as scouring of abutments by river water, collapse of river embankments, collapse of slopes, etc.

① Daily inspection

Two inspection vehicles will be used for inspections of the route concerned about once a month for visual appearance inspection of the road surface, shoulder, and slope. The condition will be recorded in the form of records to be delivered to the engineer. The inspection crew will consist of three persons per vehicle, including an inspector, recorder, and driver.

② Periodic inspections

When the river water level has lowered after the rainy season, periodic inspection will be made of the river embankment, river bed protection state, and river bed scouring condition. The inspector will survey the damage condition and establish a repair plan.

On the basis of these inspection results, the engineer will judge the necessity of repairs and implement repairs early to prevent worsening.

2) Maintenance and operation method

In order to implement the maintenance method described in 1) above, it is necessary to proceed with planning by the maintenance organization in the RDA.

① A daily inspection group will be established in the RDA. The group members are as follows:

・Engineers	：2	(1 persons×2 shifts)
・Inspector, recorder, driver	：6	(3 persons×2 shifts)
・Inspection vehicles	：2	(1 person ×2 shifts)
・Record maintenance person	：1	

② A repair group will also be established, to rapidly meet the needs for minor repairs indicated by the daily inspections.

③ A maintenance manual will be developed for planned training of inspectors and recorders by the dispatched specialist.

④ The daily inspection records will be entered into a data base to facilitate appropriate estimation of the required maintenance costs.

⑤ Drawings of the project will be stored for future rehabilitation work.

3) Maintenance and operation costs

The content and costs of maintenance estimated for the ten years after completion of the project are as shown in Table-3.2.1.

Table－3. 2. 1 Content and cost of maintenance .

Period	Content	Cost (1000Rs.)
Yearly	① Slope repair	1,212 ㎡ x 5 Rs = 6.1
	② Revetment repair	342 ㎡ x 350 Rs x 5% = 6.0
	③ River bed repair	630 ㎡ x 1,750 Rs x 5% = 55.1
	④ Pavement repair (patching)	2,740 ㎡ x 400 Rs x 5% = 54.8
	Sub total	122(1,000Rs./year)
Every five years	①Bridge surface repair	2,128 ㎡ x 400 Rs = 851.2
	②Medium repair of riverbed	342 ㎡ x 350 Rs x 10% = 12.0
	③Medium repair of embankment	630 ㎡ x 1,750 Rs x 10% = 110.2
	④Pavement overlay	2,740 ㎡ x 400 Rs = 1,096.0
	Sub total	2,069(1,000Rs./year)
Every ten years	①Steel bridge repainting	8,733m2 x 310 Rs = 2,707.2
		2,707 (1,000Rs./year)
Costs for ten-year period		8,605 (1,000Rs./year)

Expenses necessary for maintenance costs are estimated as follows:

8065.0 (1,000 Rs／10 years) 807(0.8 million Rs／1 year)

The percentage of above maintenance costs（0.8 million Rs／year）in the existing maintenance costs （1,416 million Rs／year） is about 0.06%. As a percentage of the existing RDA budget（9,720 millon Rs／year）it is about 0.008%.

Chapter 1 Background of the Project

In Sri Lanka, the development of an inland transportation network for the transport of agricultural products accompanied the growth of plantation farming. In recent years, the preferred means of inland transport means has shifted from railways to roads. By 1995, roads were relied on for about 95% of freight and 85% of passenger transportation. Road traffic is indispensable not only for economic activities, but also for civil life, and the traffic volume is increasing year by year. Nevertheless, development of the roads is lagging behind the increase in traffic volume. In this context, assurance of the safety of road traffic and strengthening traffic capacity are considered to be issues that Sri Lanka must address.

The total length of road networks in Sri Lanka is about 100,000 km, in which the length of trunk national highways (for Classes A and B) remains only about 11,000 km. Though most national highways are paved, various facilities are substantially outdated. The Sri Lanka Government places its priority on measures for rehabilitation and control of existing facilities while relying on grant aid from foreign countries.
It is also proceeding with development of principal road networks through the improvement and expansion of capacity of trunk lines and the construction of new lines.

Bridges in Sri Lanka are heavily deteriorated. Among the more than 4,000 bridges all over the country, 200 to 300 are reported to require rehabilitation. However, due to restrictions in terms of budget and technology, only 20% have been rehabilitated. The remaining bridges continue to be used in spite of the growing danger of collapse caused by substantial damages. In addition, many bridges can not cope with the growing traffic demand because of their narrow width. Since these bridges are used in the daily life of local residents and are thus highly needed as social infrastructure, their rehabilitation is necessary

In the light of the above circumstances, the Sri Lanka Government (competent ministry: Ministry of Transport and Highways, project implementing agency: Road Development Authority, RDA) requested in 1990 that the Japanese Government develop M/P related to the National Bridge Rehabilitation Plan. In response, the Japanese Government conducted a Project Formation Study on roads and bridges from February to March 1993 and carried out a

Development Study, the National Bridge Rehabilitation Plan, from March 1995 to July 1996. Subsequently, in May 1997, on the basis of these study results, the Sri Lanka Government requested the Japanese Government to provide assistance for rehabilitation, through grant-aid, for 13 bridges among 35 top-priority bridges (requiring rehabilitation by the year 2000) selected from 100 bridges covered by the above development study. The Japanese Government dispatched a preliminary study team to Sri Lanka in November 1997, which selected five bridges to be surveyed. In March 1998, a full-scale study was implemented. Rehabilitation was completed on three of the five bridges concerned, and will be completed for the two remaining bridges in March 2001.

The Sri Lanka Government, which intends to promote rehabilitation of other bridges, sent a request to the Japanese Government in August 1998, concerning implementation of rehabilitation of 19 bridges under the secondary grant aid project. In response to the request, the Japanese Government, dispatched the Basic Design study team to the site (the first field survey) in June 2000, conducting survey of requested bridges, discussions with the Sri Lanka Government, and analysis of data and coordination with authorities concerned in Japan. In consequence, two bridges of Gampola and Muwagama were selected to be covered by this project in view of their urgent need of rehabilitation and socio-economic contributions. In July 2000, a study (the second field survey) was started.

This Project consists of reconstruction of the Gampola Bridge to eliminate a bottleneck on Route A5, a critical route in Sri Lanka, assuring a safe and smooth traffic flow while contributing to the development of the economy of Sri Lanka as well as regional societies around the bridge. The Project also includes reconstruction of the Muwagama Bridge, which has been an obstacle to traffic in the rapidly developing Ratnapura City and suburban Muwagama area. This work will assure safe and smooth traffic flow while contributing to the development of economy of Sri Lanka as well as regional societies in the area around the bridge.

CHAPTER 2

Chapter 2 Contents of the Project

2－1 Objectives of the Project

In Sri Lanka, the preferred means of inland transport has shifted from railways to roads in recent years. Roads are relied on for about 95% of freight and 85% of passenger transportation. In the face of a rapid increase in traffic volume, road traffic has become indispensable for economic activities and for civil life. Assurance of the safety of road traffic and strengthening traffic capacity are considered to be issues that Sri Lanka must address.

Though most national highways are paved, various facilities are substantially outdated. The Sri Lanka Government places a priority on measures for rehabilitation and management of existing facilities while relying on grant aid from foreign countries. It is also proceeding with development of principal road networks through the improvement and expansion of capacity of trunk lines and the construction of new lines.

Bridges in Sri Lanka are badly deteriorated. Among the more than 4,000 bridges all over the country, 200 to 300 are reported to require rehabilitation. However, due to restrictions in terms of budget and technology, only 20% have been rehabilitated. In addition, many bridges cannot cope with the growing traffic demand because of their narrow width. Since these bridges are used in the daily life of local residents and are thus highly needed as social infrastructure, their rehabilitation is necessary.

The Japanese Government conducted a Project Formation Study on roads and bridges in 1993 and carried out a Development Study, the National Bridge Rehabilitation Plan, from March 1995 to July 1996. In the course of the development study, a list of bridges that were deteriorated and required to be rehabilitated to ensure the safety while coping with increase in the traffic demand was established. Subsequently, on the basis of the study results, the Sri Lanka Government requested the Japanese Government to provide assistance for rehabilitation, through grant-aid, for 13 bridges among 35 top-priority bridges (requiring rehabilitation by the year 2000) selected from 100 bridges covered by the above development study. After selection of five bridges to be surveyed, in March 1998, a full-scale study was implemented. Rehabilitation of three of the five bridges concerned was completed in March 2000, and rehabilitation of the two remaining bridges will be completed in March 2001.

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2－2 Basic Concept of the Project

2－2－1 Selection of bridges to be surveyed

1) Basic policy for selection

In this plan, the 19 bridges shown in Table–2.2.1 were included in the request from the Sri Lanka Government.

Table-2.2.1 List of 19 bridges to be surveyed

No.	RDA Sr No.	Route	Bridge site	Bridge type
1	No.7	B425	Gampaha, Western Province	L=139.2, W=6.85, PSC
2	No.22	B431	Kandy, Central Province	L=162.3, W=4.17, Bailey
3	No.42	B464	Hambantota, Southern Province	L= 59.2, W=4.29, RSJ/RCS
4	No.59	B157	Kalutara, Western Province	L= 51.0, W=3.82, RSJ/RCS
5	No.66	B111	Gampaha, Western Province	L= 36.8, W=6.40, ST.TR.H
6	No.67	B157	Kalutara, Western Province	L= 19.1, W=3.50, RSJ/RCS
7	No.93	AA005	Kandy, Central Province	L= 98.3, W=4.85, ST.TR
8	No.122	B045	Chilaw, North Western Province	L= 18.5, W=5.00, RSJ
9	No.130	B127	Kegalle, Sabaragamuwa Province	L= 24.7, W=4.54, ST.TR
10	No.154	B445	Kegalle, Sabaragamuwa Province	L= 10.4, W=4.60, RSJ/BUC
11	No.157	B461	Matale, Central Province	L= 24.8, W=3.20, RSJ/BUC
12	No.158	B473	Chilaw North Western Province	L= 19.7, W=5.20, ST.TR
13	No.181	B312	Matale, Central Province	L= 18.9, W=3.80, RSJ/RCS
14	No.197	B288	Gampaha, North Western Province	L= 52.8, W=5.48, ST.TR.
15	No.200	B478	Kurunegala, North Western Province	L= 78.6, W=4.25, ST.TR/H
16	No.239	B390	Ratnapura, Sabaragamuwa Province	L=107.0, W=4.30, ST.TR/H
17	No.267	B458	Kalutara, Western Province	L= 18.7, W=5.27, ST.TR/H
18	No.272	B216	Kalutara, Western Province	L= 19.4, W=5.20, RCC
19	No.273	B458	Kalutara, Western Province	L= 26.4, W=4.25, ST.TR/H

Selection was made in the first field study according to the procedure shown in Fig.2.2.1. Criteria for selection were as follows:

① Existence of any project

Bridges for which a project is already under way or for which a project plan is established were excluded.

② Ensuring safety during implementation of the project

Bridges for which there exist problems in terms of public order, survey, and project implementation were excluded.

③ Technical capacity of the counterpart to implement the project

Since it was confirmed that the Sri Lankan counterpart can implement independently work for bridges up to a length of about 20 m, bridges with a length of 20 m or less were excluded.

④ Traffic volume

Because of common recognition with the Sri Lankan counterpart that the traffic volume is the most appropriate method to quantitatively judge the socioeconomic situation, grouping was made on the basis of traffic volume. As the field survey indicated that congestion occurs most frequently when the traffic volume exceeds 5000 vehicles/day, bridges to be rehabilitated were selected on the basis of whether or not the traffic volume there was 5000 vehicles/day. (See Fig.-2.2.1)

Bridges that were excluded from the final consideration because their length was 20 m or less were also considered during selection if the traffic volume there is large.

⑤ Overall evaluation

Agreement with the Sri Lankan counterpart was reached as follows. Namely, concerning bridges selected as described above, effects related to (a) consistency with the development plan, (b) present condition of bridges including the damage situation, (c) socioeconomic positioning, (d) traffic volume, and (e) technology transfer are rearranged and analyzed according to the statistical method to objectively determine priority for final selection of bridges to be rehabilitated.

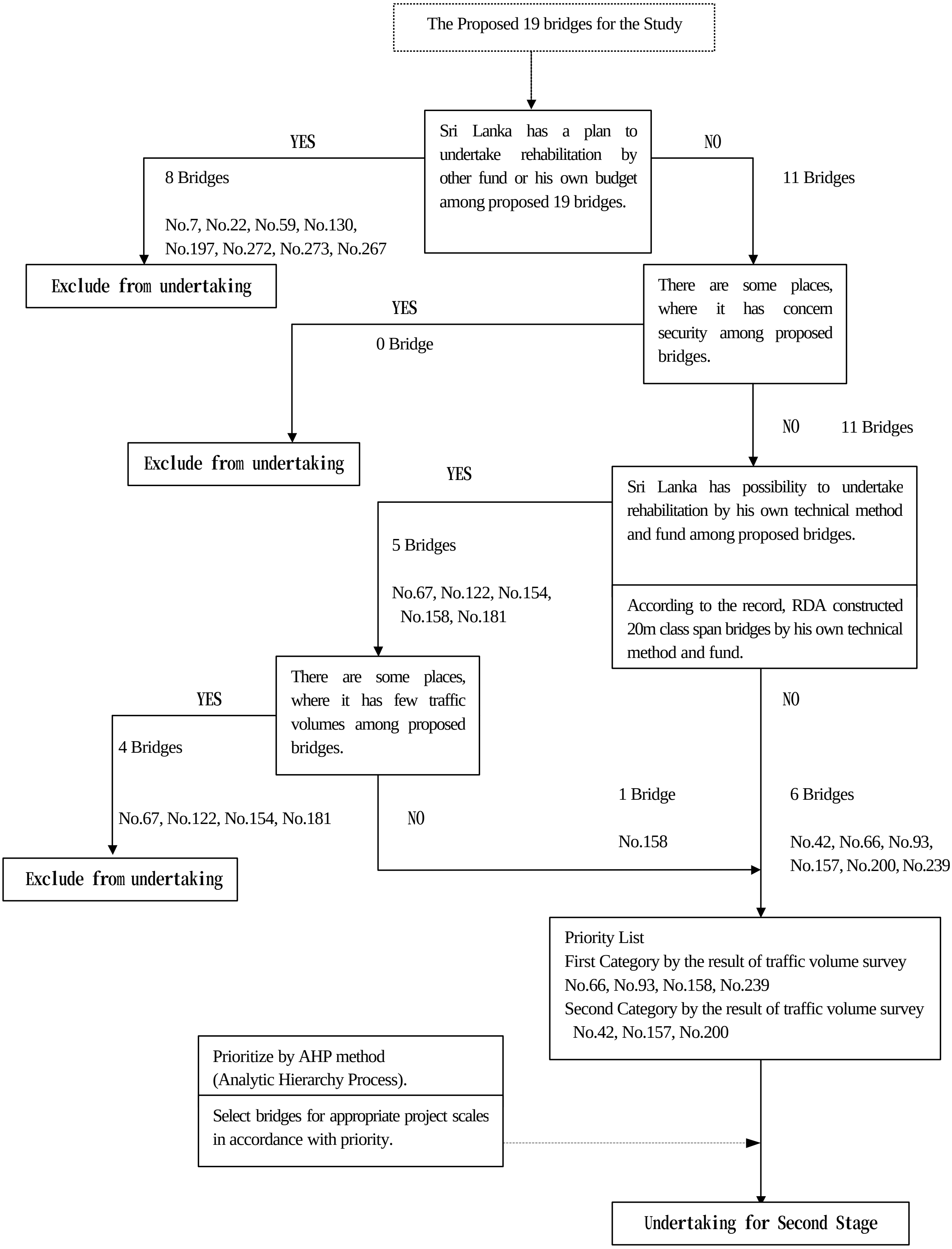


Figure:- 2.2.1 Flowchart of the Selection of the Proposed Bridges

2) Determination of priority among bridges under survey

Bridge selection for the grant-aid project must be made not only on the basis of traffic volume, but also on the basis of the degree of damage of existing bridges, and effects on the development plan and socio-economic condition.

Since these evaluation criteria cannot directly ensure quantitative evaluation, prioritization of bridges is not objective and remains vague. Therefore, this chapter includes a study made according to the Analytic Hierarchy Process (AHP) of seven bridges selected to determine priority among them.

(1) Outline of the Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) features hierarchical structurization of a multi-purpose decision-making problem in terms of overall objective – evaluation criteria (comparative item or element) – alternative relationship. Even when decision-making must rely on experience and instinct, image, etc., this method can select an alternative through conversion into the qualitatively meaningful numerical values by weighing based on a pair comparison between evaluation criteria. Namely, this method is effective as a method to convert various concepts based on different ways of thinking and criteria, into one mass weight. Basically, AHP consists of the following three stages.

① First stage :Hierarchical structurization of a problem

A problem under complicated circumstances is decomposed into hierarchical structures. The top layer of the hierarchy consists of one element that is an overall objective (goal). For lower levels, several elements are determined from the relationship with the level immediately above in compliance with the subjective judgment of the decision-maker. The alternative comes at the bottom of this hierarchy.

② Second stage :Pair comparison of elements

Weighing is made among elements of each level. Namely, pair comparison between elements on one level is made with reference to a relationship element of a level immediately above. When n is assumed to be a prime number for comparison, the decision-maker will perform pair comparison of $n(n-1)/2$ pieces. Besides, using a scale of importance, values used in pair comparison are determined to be

1/9,1/8,•••••,1/2,1,2,•••••,8,9. The content of individual numerical figures is shown in the table below.

Scale of importance	Definition
1	Equal importance
3	Weak importance
5	Strong importance
7	Very strong importance
9	Absolute importance

(2,4,6, and 8 are to be used for respective intermediate levels.
A fraction is used when the level of importance is low.)

③ Third stage : Calculation of the priority

From the pair comparison matrix (known) obtained above, the weight (unknown) between elements in each level is calculated. A geometric average is used for calculation of the weight between elements.

Using the result of the weighing calculation between elements of each level, weighing of the layer as a whole is calculated. In this way, the priority of each alternative relative to the target is determined.

(2) Bridges concerned and evaluation items

① Bridges covered by hierarchical analysis

Hierarchical analysis is made for seven bridges (shown below) of Categories 1 and 2 determined in Table-2.2.2, Selection of Bridges Under Survey.

Table- 2. 2. 2 Bridges covered by hierarchical analysis

Serial No.	Name of route	Name of area	Bridge type	Bridge length and width	Traffic volume determined in this survey ( ) : Pedestrians
42	B-464	Hambantota , Southern Province	Three-span steel truss girder structure	L=59.2 W=4.29	3,374 (288)

66	B-111	Gampaha, Western Province	Two-span steel truss girder structure	L=36.8 W=6.40	8,165 (987)
93	AA-005	Kandy, Central Province	Two-span steel truss girder structure	L=98.3 W=4.85	6,555 (6,434)
157	B-461	Matale, Central Province	Three-span steel I-girder section structure	L=24.8 W=3.20	471 (215)
158	B-473	Chilaw, North Western Province	Simple girder steel truss girder structure	L=19.7 W=5.20	6,081 (105)
200	B-478	Kurunegala, North Western Province	Three-span steel truss girder structure	L=78.6 W=4.25	972 (66)
239	B-390	Ratnapura, Sabaragamuwa Province	Three-span steel truss girder structure	L=107.0 W=4.30	8,209 (4,645)

② Evaluation items in the hierarchical analysis (Evaluation criteria)

The evaluation criteria for hierarchical analysis of bridges concerned are described below:

(a) Consistency with the development plan (Development plan)

Bridge selection must be made after study of the relationship between the development plan of Sri Lanka and bridges concerned while considering the importance of the development plan and the effect on the development plan.

(b) Resent condition of bridges including the damage situation (Existing bridge condition)

Bridge selection must be made while considering results of the bridge damage survey, structural standard (width, etc.), and the year of construction.

(c) Socioeconomic effects on Sri Lanka (Socioeconomic effects)

Evaluation must be made while considering the importance of the route, geological conditions, effects on the development plan, and industries.

(d) Socioeconomic effects on the area surrounding the bridge (Regional socioeconomic effects)

Evaluation must be made of the effects on activation or infrastructure development of the regional society, such as schools, markets, hospitals, and police offices.

(e) Traffic volume （Traffic volume）

Evaluation must be made on the traffic volume (up/down total) in this study.

(f) Technology transfer effects （Technology transfer）

Considering the present condition of construction technology of Sri Lanka, the effects when bridge rehabilitation is to be covered by grant aid must be evaluated.

⑶ Study of the priority order among bridges covered by the hierarchical analysis

① First stage：Hierarchical structurization of a problem

Comparison items (elements) for selection of bridges to be covered by grant aid are the working expenses, workability, environmental impact, and investment effects.

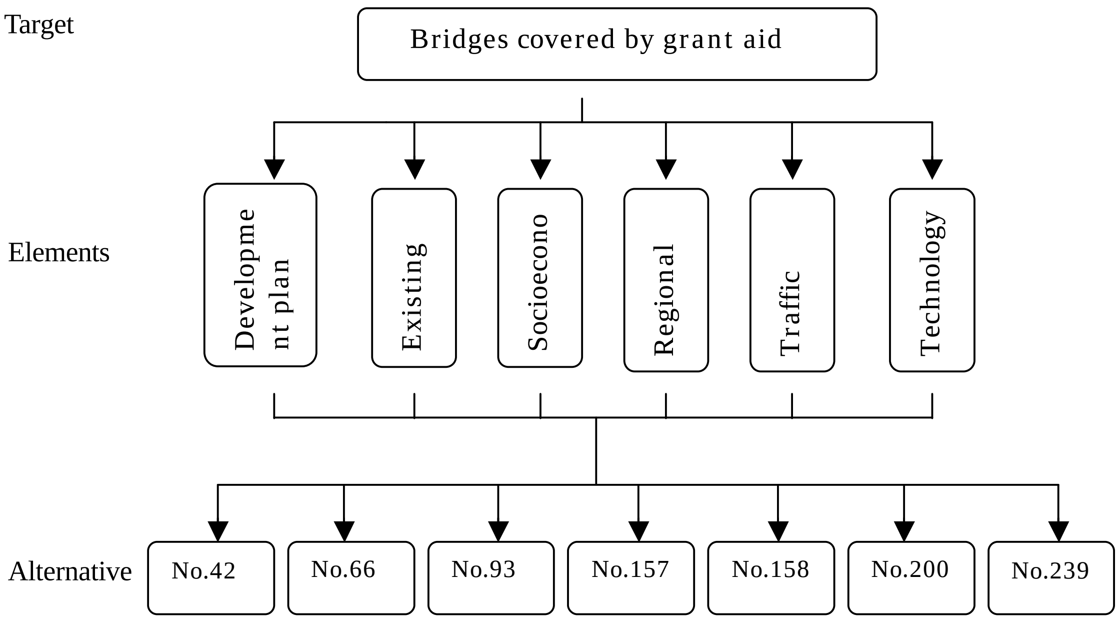


Fig.- 2. 2. 2 Comparative elements for hierarchical analysis

② Second stage：Pair comparison of elements

In this stage, a pair comparison is made for each comparison item (element). The comparison results are shown in the table below. For weighing of pair comparison between elements, implementation and averaging of comment hearing through questionnaire, etc. will enable reflection of various concepts differing ways of thinking, standards, and thought. In this stage, it was decided to collect comments through questionnaires from Sri Lanka side and member of study team and to use the result of the questionnaire. Table –3.2.3 shows the weight of pair comparison.

Table- 2. 2. 3 Weight of pair comparison

	Development plan	Existing bridge condition	Socioeconomic effects	Regional socioeconomic effects	Traffic volume	Technology transfer
Development plan	1	1/7	1/3	1/2	1/5	3
Existing bridge condition	7	1	6	4	4	7
Socioeconomic effects	3	1/6	1	1/2	1/3	4
Regional socioeconomic effects	2	1/4	2	1	1/3	4
Traffic volume	5	1/4	3	3	1	7
Technology transfer	1/3	1/7	1/4	1/4	1/7	1

③ Third stage :Calculation of the priority

The priority is calculated by taking the geometric average of pair comparison results between elements. The calculation result is shown in Table-2.2.4.

Table－2. 2. 4 Priority of elements (1)

	Calculation of geometric average		Priority of elements
Development plan	(1 ×1/7×1/3×1/2×1/5× 3) ^ (1/6)	0.493	0.493/8.812=0.056
Existing bridge condition	(7 × 1 × 6 × 4 × 4 × 7) ^ (1/6)	4.093	4.093/8.812=0.465
Socioeconomic effects	(3 ×1/6× 1 ×1/2×1/5× 4) ^ (1/6)	0.833	0.833/8.812=0.094
Regional socioeconomic results	(2 ×1/4× 2 × 1 ×1/3× 4) ^ (1/6)	1.049	1.049/8.812=0.119
Traffic volume	(5 ×1/4× 3 × 3 × 1 × 7) ^ (1/6)	2.070	2.070/8.812=0.235
Technology transfer	(1/3×1/7×1/4×1/4×1/7× 1) ^ (1/6)	0.274	0.274/8.812=0.031
	Total	8.812	1.000

Then, the score (any score classification will be acceptable) is determined for each element of each alternative. The score is multiplied by the weight of each element for overall evaluation of each route. The score of each element is shown in Table-2.2.5 for each alternative. Score allocation is as shown in the table below.

Table－2. 2. 5 Priority of elements (2)

Element	Classification	Score
Development plan	Related development plan exists and is either completed or in progress	5
	Related development scheduled for the near future	4
	Development plan in progress near the bridge site	3
	Development plan scheduled for completed in the near future near the site	2
	The plan exists near the bridge site, but not clear.	1
Existing bridge condition	Repair or replacement needed immediately	5
	Old bridge, which must be replaced in the near future and whose width is small.	4
	Though narrow in width, the bridge shows no remarkable damage but must be watched with care.	3
	Wide bridge that requires simple touch-up of paint, etc.	2
	No problem in terms of the width, state, etc.	1
Socioeconomic effects	With definite grounds for selection, bridge rehabilitation will bring about the effect within a short period.	5
	Though definite grounds exist for selection, bridge rehabilitation will require a certain time period to demonstrate its effectiveness.	3
	Possibly effective in the future	1
Regional socioeconomic effects	With definite ground for selection, the bridge rehabilitation will bring about the effect within a short period.	5
	Though definite ground exists for selection, the bridge rehabilitation requires a certain time period to demonstrate its effectiveness.	3
	Possibly effective in the future	1
Traffic volume	7000 vehicles／day or more	5
	5000 vehicles／day or more to 7000 vehicles／day	4
	3000 vehicles/day or more to 5000 vehicles／day	3
	1000 vehicles／day ～3000 vehicles／day less than 1000 vehicles／day	2
		1
Technology transfer	This type of work is rather rare in Sri Lanka and will prove highly effective.	5
	A few examples of this type of work exist in Sri Lanka and will prove effective.	3
	Sri Lanka has its own experience in this type of work will prove less effective.	1

Table－2. 2. 6 Ranking of alternatives

	Development plan	Existing bridge condition	Socioeconomic effects	Regional socioeconomic effects	Traffic volume	Technology transfer
No.42	**3**	**4**	**1**	**1**	**3**	**3**
No.66	**2**	**4**	**3**	**5**	**5**	**1**
No.93	**5**	**4**	**5**	**5**	**4**	**5**
No.157	**1**	**3**	**1**	**2**	**1**	**1**
No.158	**1**	**4**	**1**	**4**	**4**	**1**
No.200	**1**	**3**	**1**	**3**	**1**	**3**
No.239	**3**	**4**	**4**	**5**	**5**	**3**

The score is multiplied by the weight of each element for overall evaluation of each route. It may be judged that the alternative route with the largest total sum has the highest priority. The result is shown in Table-2.2.7.

Table－２．２．７　Calculation of the priority order

No.	Calculation of the priority order	Priority order
No.42	**3** ×0.056＋ **4** ×0.465＋ **1** ×0.094＋ **1** ×0.119＋ **3** ×0.235＋ **3** ×0.031＝3.04	**5**
No.66	**2** ×0.056＋ **4** ×0.465＋ **3** ×0.094＋ **5** ×0.119＋ **5** ×0.235＋ **1** ×0.031＝4.05	**3**
No.93	**5** ×0.056＋ **4** ×0.465＋ **5** ×0.094＋ **5** ×0.119＋ **4** ×0.235＋ **5** ×0.031＝4.30	**1**
No.157	**1** ×0.056＋ **3** ×0.465＋ **1** ×0.094＋ **2** ×0.119＋ **1** ×0.235＋ **1** ×0.031＝2.05	**7**
No.158	**1** ×0.056＋ **4** ×0.465＋ **1** ×0.094＋ **4** ×0.119＋ **4** ×0.235＋ **1** ×0.031＝3.46	**4**
No.200	**1** ×0.056＋ **3** ×0.465＋ **1** ×0.094＋ **3** ×0.119＋ **1** ×0.235＋ **3** ×0.031＝2.23	**6**
No.239	**3** ×0.056＋ **4** ×0.465＋ **4** ×0.094＋ **5** ×0.119＋ **5** ×0.235＋ **3** ×0.031＝4.27	**2**

As a result the priority order of the bridge is as follows’
First：No. 93,　Second：No. 239,　Third：No. 66,　Fourth：No. 158,　Fifth：No. 42

3) Selection of bridges to be rehabilitated

This project is expected to be of a scale nearly equivalent to the First Medium and Small Bridge Rehabilitation Project (Phase 1) (Sri Lanka Five-bridge Reconstruction Project). The expected bridge area of the first (No.93) and the second (No.239) bridges are beyond the scale of Phase 1, so that implementation of the project for two bridges of No.93 and No.239 on the basis of grant-aid is considered appropriate.

Table－２．２．８　Comparison of the First Medium to Small Bridge Rehabilitation Project (Phase 1) and this project in terms of bridge size

Serial NO.	Bridge length (m)	Width (m) （Roadway）	Total (m2)	Serial NO.	Existing bridge length (m)	Estimated width (m2) （Roadway）	Total (m2)
NO.31	14.0	7.4	103.6	NO.93	98.3	7.4	727.4
NO.32	14.0	7.4	103.6	NO.239	107.0	7.4	791.8
NO.33	75.0	7.4	555.0	—	—	—	—
NO.38	25.0	3.7	92.5	—	—	—	—
NO.70	42.0	7.4	310.8	—	—	—	—
Total	170.0	—	1165.5	計	205.3	—	1519.2

As the total of expected bridge area of the first（No.93）and the second (No.239) bridges is beyond the scale of Phase 1, implementation of No.93 and No.239 was recommended as appropriate for implementation of the project.

The result of analysis conducted in Japan as described above was explained to the Sri Lankan counterpart before start of the second field survey.　Agreement with the Sri Lankan counterpart was reached to the effect that the project will be implemented on two bridges only, namely, the first No. 93 (Gampola Bridge) and second No. 239 (Muwagama Bridge). Agreement was also reached among persons concerned that bridges ranked third and lower will not be brought forward.

2- 2- 2 Rehabilitation plan policy

1) Outline of the bridge to be surveyed

(1) Site condition of bridges to be surveyed

① Gampola Bridge

This is located along the critical route A5 connecting Kandy, the second largest city in Sri Lanka, and Nuwara Eliya, a famous tourist resort, crossing Mahaweli River, the longest river of Sri Lanka, at Gampola. On the Kandy side of the bridge, the route passes through Gampola City, and B132 branches from this route toward Nawalapitiya. For the Kandy-Gampola section where the traffic volume is the largest in Route A5, improvement is under way under ADB aid. The improvement project is also scheduled for the mountainous road between Gampola and Nuwara Eliya under JBIC aid.

This bridge is the only one that connects Gampola City and the area on the opposite bank where there are public facilities such as a teacher training center, offices of the provincial government, and theaters. This is not only a bridge on a Class A national highway, but also plays an important role in the economy and social life of areas in the neighborhood of Gampola City.

The existing bridge was completed in 1926 and is 74 years old. Rehabilitation is required urgently because of functional degradation and problems related to traffic safety due to damage caused by wear and tear and increased traffic.

② Muwagama Bridge

This is a bridge located at an intersection of Route B369 branching from the national highway Route A4 in the middle of Ratnapura with the Kalu River, connecting Ratnapura City with the Muwagama area on the opposite side of the Kalu River. Ratnapura City is a famous jewel production site in Sri Lanka, has achieved rapid development in these years. In line with Ratnapura City, the Muwagama area is increasingly urbanized with a large number of houses and governmental buildings and schools located along Route B369. In the area about 10 km along Route B369, there are expanding tea and coconut plantations. In this situation, the bridge serves not only as a spine of traffic within the city, but also as a transport road for agricultural products.

For the national highway Route A4, the improvement project under Korean aid has been completed for the 100 km section from Colombo to Ratnapura. Improvement is about to be started also for the section from Ratnapura toBalangoda.

The existing bridge was completed in 1920 and is 80 years old. Rehabilitation is urgently required because of functional degradation and problems related to traffic safety due to damage caused by wear and tear and increased traffic.

（2） Outline and damage condition of bridges to be surveyed

Table-2.2.9 shows an outline and damage condition of bridges to be surveyed.
For both bridges, the soundness confirmation based on numerical analysis was not done because of lack of design calculation. As overall drawings and a general view of the substructure were stored, the soundness was evaluated visually using these drawings.

Table－２－２－９　Outline and damage condition of bridges to be surveyed

<table>
<tr><td colspan="2">Bridge name</td><td>Gampola Bridge（No.93）</td><td>Muwagama Bridge（No.239）</td></tr>
<tr><td colspan="2">Bridge type</td><td>Double simple-steel truss bridge</td><td>Triple simple-steel truss bridge</td></tr>
<tr><td colspan="2">Bridge length</td><td>49.10m+48.90m=98.3m</td><td>20.00m＋55.70m＋20.00m=95.7m</td></tr>
<tr><td rowspan="2">Width</td><td>Roadway</td><td>4.85m</td><td>4.25m</td></tr>
<tr><td>Sidewalk</td><td>2@1.20m</td><td>2@1.20m</td></tr>
<tr><td colspan="2">Skew angle</td><td>９０°</td><td>９０°</td></tr>
<tr><td rowspan="2">Abutment</td><td>Body</td><td>Stone masonry block structure（H=10m）</td><td>Stone masonry block structure（H=10m）</td></tr>
<tr><td>Foundation</td><td>Caisson foundation（H=10m）</td><td>Caisson foundation（H=10m）</td></tr>
<tr><td rowspan="2">Piers</td><td>Body</td><td>Stone masonry block structure（H=14m）</td><td>Stone masonry block structure（H=10m）</td></tr>
<tr><td>Foundation</td><td>Caisson foundation（H=10m）</td><td>Caisson foundation（H=10m）</td></tr>
<tr><td colspan="2" rowspan="2">Traffic volume（pedestrians）</td><td>1990：2，279 vehicles／day</td><td>5，709 vehicles／day（1997）</td></tr>
<tr><td>2000：6，555 vehicles／day(6,434persons／day)</td><td>8，209 vehicles／day(4,645 persons／day)（2000）</td></tr>
<tr><td colspan="2">Year of construction</td><td>１９２６</td><td>１９２０</td></tr>
<tr><td rowspan="4">Damage condition</td><td>Superstructure</td><td>・Corrosion in progress
・Lower chord with loss of section due to corrosion</td><td>・Corrosion in progress
・Lower chord with loss of section due to corrosion</td></tr>
<tr><td>Substructure</td><td>・Cracks in abutment concrete on the Ratnapura side(t=7mm)
・Weathered stone surface, with filler lost partially</td><td>・Weathered stone surface, with filler lost partially</td></tr>
<tr><td>Foundation</td><td>・Caisson's embedded depth is as small as 2 m due to lowering of river bed caused by scouring (Caisson projecting from the water surface)</td><td>・River bed in front of pier caisson is lowered by more than 3m due to scouring</td></tr>
<tr><td>Others</td><td>・Partial damage to pavement (stone pitching)
・Newel post inclined due to settlement on the backside of abutment</td><td>・Heavy damage to the sidewalk on the downstream side, and closed.</td></tr>
<tr><td colspan="2">Functionality</td><td>・Narrow width, making passing of large vehicles difficult, resulting in congestion at the approach road.
・Sidewalk too narrow for number of pedestrians</td><td>・Narrow width, making passing of large vehicles difficult, resulting in congestion at the approach road.
・Sidewalk too narrow for the number of pedestrians. Besides, the sidewalk on one side is damaged and closed.</td></tr>
</table>

2) Rehabilitation plan policy

(1) Review of the rehabilitation method

For rehabilitation of bridges, the following methods may be considered depending on the structural type, degree of damage, and availability of data for design:

Plan 1: Reinforcement and widening of existing bridges

Plan 2: Erection of a new bridge with a roadway while using the existing one only as a sidewalk

Plan 3: Reinforcement of existing bridges to use as road bridges with one lane (sidewalk on one side) while constructing a new structure for one lane with a sidewalk on one side

Plan 4: Erection of a new bridge with two lanes and a sidewalk on each side

Concerning the above four plans, problems and feasibility were reviewed for the Gampola and Muwagama Bridges. The result is shown in Table–2.2.10.

Table－2－2－10　Problems and issues of rehabilitation plans

	Gampola Bridge	Muwagama Bridge
Plan 1	●Steel truss through bridge with the main steel distance of ?? . Widening of existing bridge is impossible. ●The bridge is old and there is no design chart and calculations. Selection of an appropriate reinforcement method is impossible. ●The substructure is stone masonry and rehabilitation is difficult. ●Pier foundation is heavily eroded, making rehabilitation difficult	●Steel truss through bridge with the main steel distance of 5.1m. Widening of existing bridge is impossible. ●The bridge is old and there are no design calculations. Selection of an appropriate reinforcement method is impossible. ●The substructure is stone masonry and rehabilitation is difficult. ●Pier foundation is heavily eroded; protection is necessary.
Plan 2	●Sidewalk is provided on one side; pedestrians have to cross the road on both sides of the bridge, causing problem related to the safety. ●Congestion due to crossing pedestrians occur on both sides of bridge, which is less convenient. ●Gampola has grown rapidly in recent years and pedestrians using the bridge are expected to increase. Accordingly, securing of pedestrian safety is an important issue.	●Sidewalk is provided on one side; pedestrians have to cross road on both sides of the bridge, causing safety problems. ●Congestion due to crossing pedestrians on both sides of bridge; less convenient. ●Ratnapura is a city growing rapidly in these years and pedestrians using the bridge is expected to increase. Accordingly, securing pedestrian safety is an important issue.
Plan 3	●The bridge is old and there are no design chart or calculations, making selection of an appropriate reinforcement method difficult. ●The substructure is stone masonry, and reinforcement is difficult. ●Pier foundation is heavily eroded, making reinforcement difficult	●There is no design calculation; detailed survey is necessary to select appropriate reinforcement method. ●The substructure is stone masonry, and reinforcement is difficult. ●Piers are heavily eroded, making protection necessary.

Plan 4	●Poor alignment of approach road ●Delay in removal of an existing bridge may make it more susceptible to erosion. ●A temporary bridge necessary in case of replacement at existing location.	●Delay in removal of existing bridge may make it more susceptible to erosion. ●Securing of land necessary ●Embankment for the approach road necessary

(2) Rehabilitation policy

For the following reasons, both Gampola and Muwagama Bridges are to be reconstructed by bridges with two lanes (sidewalk on both sides).

①Gampola Bridge (No.93)

a) Excessive lowering of the river bed due to scouring, resulting in a dangerous conditions with the embedded depth of pier caisson foundation reduced to only about 2m.
b) Considerable progress of corrosion, with sectional loss due to corrosion of lower chord that is a principal member of truss.
c) Old bridge without design chart and calculations, making selection of appropriate reinforcement method difficult.
d) When the existing bridge is used as a pedestrian bridge, pedestrians have to cross the road on both sides of the bridge, causing disadvantages in terms of safety and convenience.
e) The bridge is already 74 years old. Even if the existing bridge can be used, it will be necessary to build a new one in ten or twenty years, when the life of bridge is in consideration.
f) Issues if any for construction of a new bridge can be solved by the bridge plan.

②Muwagama Bridge (No.239)

a) Progress in corrosion of truss lower chord. The sidewalk is closed for traffic because of damage.
b) Excessive lowering of the river bed due to scouring; the pier foundation is not exposed.
c) Old bridge without design calculations, making selection of an appropriate reinforcement method difficult.
d) If the existing bridge is used as a pedestrian bridge, pedestrians will have to cross the road on both sides of the bridge, causing disadvantages in terms of safety and convenience.
e) The bridge is already 80 years old. If it is used as a single-lane bridge, a new bridge would have to be constructed in ten or twenty years.
f) Issues if any for construction of a new bridge can be solved by the bridge plan.

2－3 Basic design

2－3－1 Design concept

1）Basic design considerations

This survey for the basic design is made with the content considered most appropriate according to our grant-aid scheme while paying due consideration to socio-economics, natural conditions, environment, laws, and other construction circumstances. Basic considerations are as follows.

① Dry and wet seasons

The wet season differs among areas concerned, but the period from April to November is the rainy season and the period from December to March is the dry season for both the Mahaweli River (Gampola Bridge) and the Kalu River (Muwagama Bridge). During the wet season, rainfall ranges from 300 to 600 mm and the number of days with rain exceeds 20 days. The peak of rainfall throughout the year is in June and October. Rainfall varies heavily from year to year, with the difference between monthly maximum and minimum values being 700 mm or more for June in the Mahaweli River. It is essential that implementation plans and schedules are established with due consideration for dry and wet seasons. In addition, due care must be taken during the work. During the wet season, deterioration of the operation factor or delay of the work may be expected, so that due consideration must be made for the delay of the work. During the wet season, any work in the river must be done while always paying close attention to the rain factor.

② Establishment of road and bridge standards with due consideration for existing and future road utilization

Gampola Bridge is located along the Class A national highway while Muwagama Bridge is located along the Class B national highway. Both bridges are within the Gampola metropolitan and Ratnapura metropolitan areas, which face remarkable increases in traffic volume. Existing bridges were constructed in the 1920s and are suffering increased damage due to increased traffic volume, vehicle weight and scouring of rivers. Considering future road development in Sri Lanka, the vehicle weight will tend to increase. For Route A5 where the Gampola Bridge is located, in particular, the ADB and the JBIC have already decided to support rehabilitation of the road. Therefore, road and bridge standards must be set for planning of the bridges concerned while paying due consideration for future developments.

③ Effective utilization of local materials and equipment

Very few construction materials and machines in Sri Lanka are versatile, and the quantity of cranes and other heavy machines is limited. Depending on project back-logs, they may become difficult to lease and may have to be brought in from a third country or Japan. The study will be conducted so that available materials and equipment will be utilized to a maximum extent.

④ Consideration of the technical level of local engineers

There is a state-owned prestressed girder manufacturing company in Sri Lanka, whose platen girders are erected in the country. Excellent local engineers are available in large numbers, mainly from RDA, who are experienced and high in technical level. They are also mastering steel bridge construction technology in the course of grant-aid for the Narthupana Bridge project currently under way. It appears however that there exists a gap in terms of not only quality control, but also design and construction when compared with advanced countries. Accordingly, training of engineers will be conducted while undertaking sufficient technology transfer not only in design and construction, but also in quality control, in the course of the project. For these projects, qualified Japanese staff will be dispatched to Sri Lanka.

⑤ Easy to maintain structure and type

RDA earmarks sums in the budget for maintenance of roads and bridges in Sri Lanka. But the budget for roads and bridges, including maintenance costs, account for about 2% of the national budget. Accordingly, this project will involve a study of methods, structures, materials, and types, which will enable reduction of maintenance costs in the future, so that national highways ranked at A and B can be maintained without fail.

⑥ Reduction of work costs and work periods

A study will be made of work content to determine how costs and work periods can be reduced as much as possible to comply with the intent of Japanese grant aid.

2) Applicable standards

(1) Applicable standards

Sri Lanka prepared the Bridge Design Manual based on BS5400 in November 1997, and planning and design of bridges have been made in compliance with this Manual and BS5400. In this Manual, the HB live load is assumed to be 30 units. When this HB30 live load is compared with the B live load currently applied in Japan, the degree of effects varies depending on the bridge type and span length. There is a tendency for the HB30 live load to become more severe for concrete bridges with a span length of up to 40 m, while the Japanese B live load becomes more severe for steel bridges and concrete bridge with a span length of 50 m or more (Figs.-2.3.1 to 2.3.4).

Since there is not much difference, however, it was agreed upon with RDA, after discussions, that the Japanese B live load will be applied in this project.

Basically, the Japanese specification is applied. Considering the situation in Sri Lanka, it was agreed to employ the standards shown in Table-2.3.1.

Table－2. 3. 1 Applicable standards

Approach road	Geometric design	・Road design standard (GDSR) 1998（**RDA**） ・Final report of ADB Ⅲ road improvement project（**RDA**）
	Pavement	・Expressway road design manual （**RDA**） ・Final report of ADB Ⅲ road improvement project （**RDA**） ・Asphalt Pavement Requirements （Japan Road Association）
	Small structures	Same as above
Bridges	Superstructure Substructure Foundation	・Specification for Highway Bridges and Explanation, December 1996 (Japan Road Association) ・Standard Specification for Concrete （Japan Society of Civil Engineers） ・Bridge Design Manual(BDM) 1997（**RDA**）
Rivers		・Revised Explanation and Cabinet Order Concerning Structural Standards for River Management Facilities（Japan Institute of Construction Engineering）

Note）Though the Bridge Design Manual (BDM) 1997（RDA）is in accordance with BS5400, partial modification is made in consideration of the natural conditions and special circumstances of Sri Lanka.

Comparison Study on Converted Bending Moment by Span between B Live Load in JP and BS(HA+HB30)

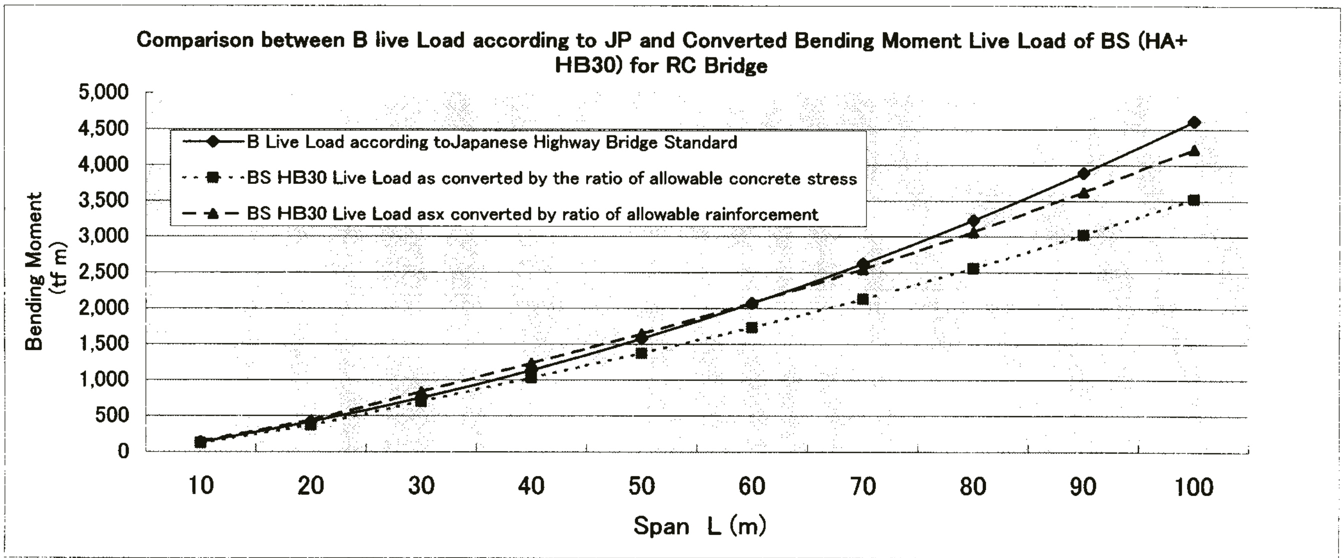
1)Servicavility Limit State

i) RC Single Girder Bridge(Figure-2.3.1)

Comparison between B live Load according to JP and Converted Bending Moment Live Load of BS (HA+HB30) for RC Bridge

Carriageway width = 7.4m

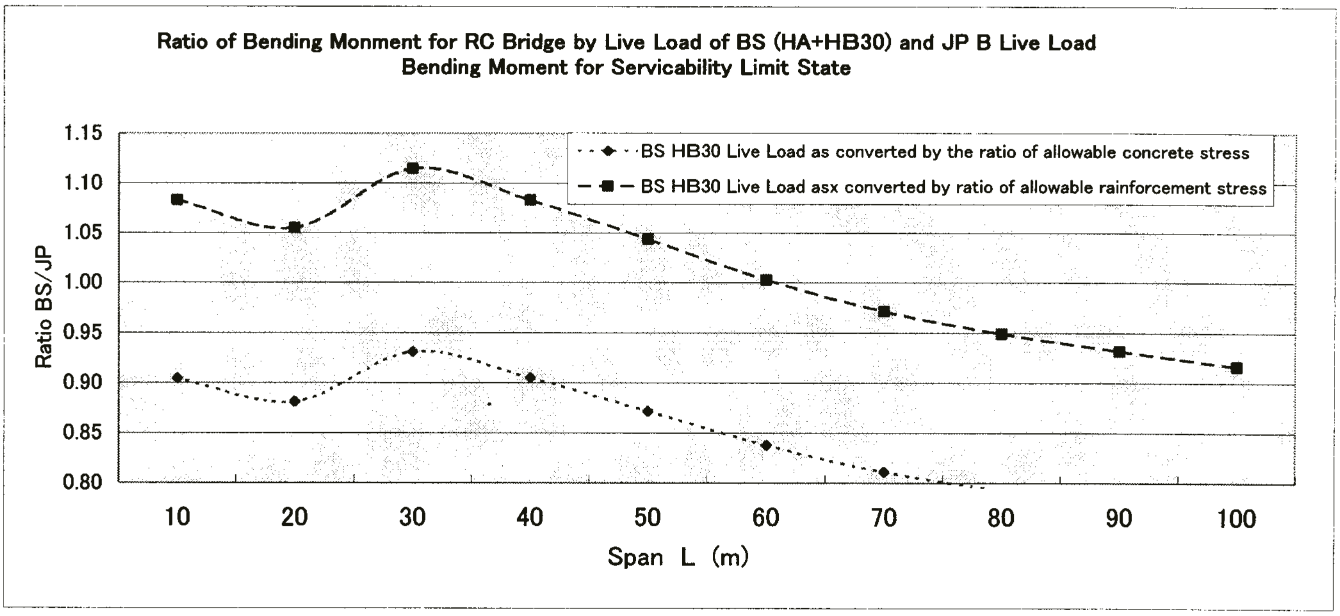
Span Length L (m)	10	20	30	40	50	60	70	80	90	100
B Live Load according toJapanese Highway Bridge Standa	134	417	749	1,134	1,574	2,069	2,620	3,226	3,889	4,608
BS HB30 Live Load as converted by the ratio of allowable	121	367	697	1,026	1,372	1,733	2,125	2,558	3,026	3,526
BS HB30 Live Load asx converted by ratio of allowable ra	145	440	835	1,229	1,643	2,075	2,544	3,062	3,623	4,222



Ratio of Bending Moment for RC Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Carriageway width = 7.4m

Span L (m)	10	20	30	40	50	60	70	80	90	100
BS HB30 Live Load as converted by the ratio of allowable concrete stress	0.90	0.88	0.93	0.90	0.87	0.84	0.81	0.79	0.78	0.77
BS HB30 Live Load asx converted by ratio of allowable rainforcement stress	1.08	1.05	1.11	1.08	1.04	1.00	0.97	0.95	0.93	0.92

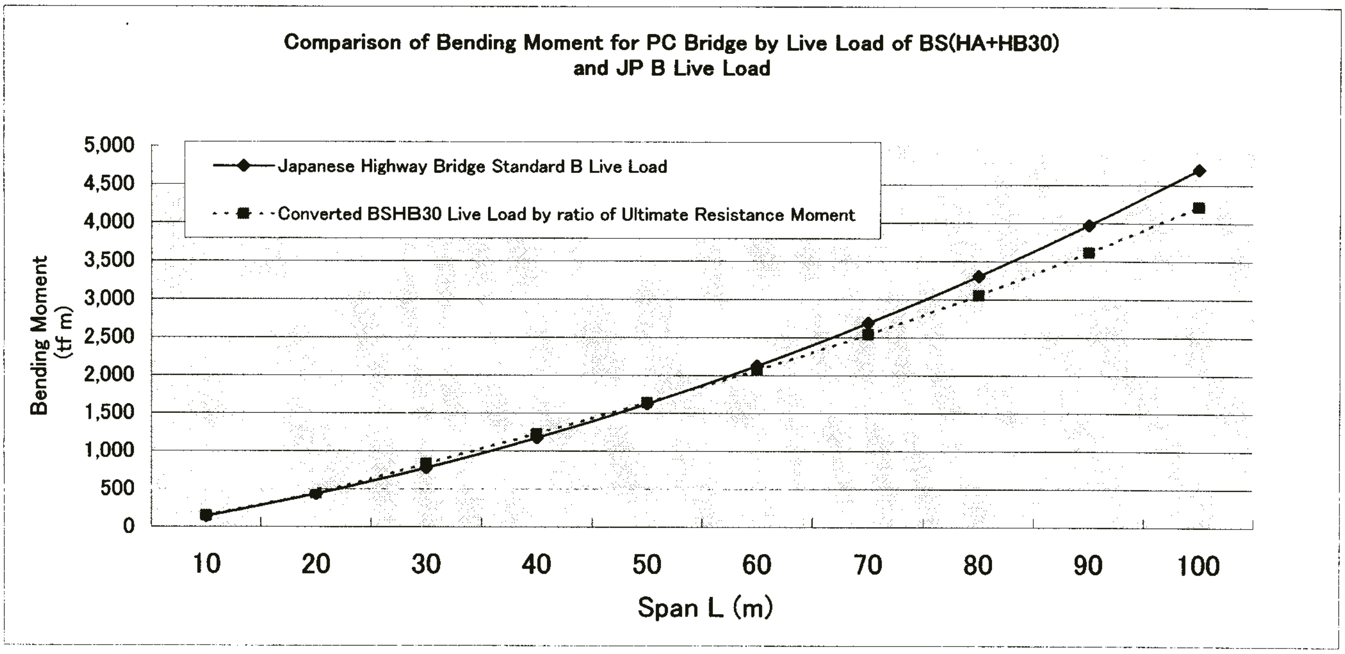


ii) PC Single Girder Bridge (Figure—2.3.2)

Ratio of Bending Moment for PC Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Carriageway = 7.4m

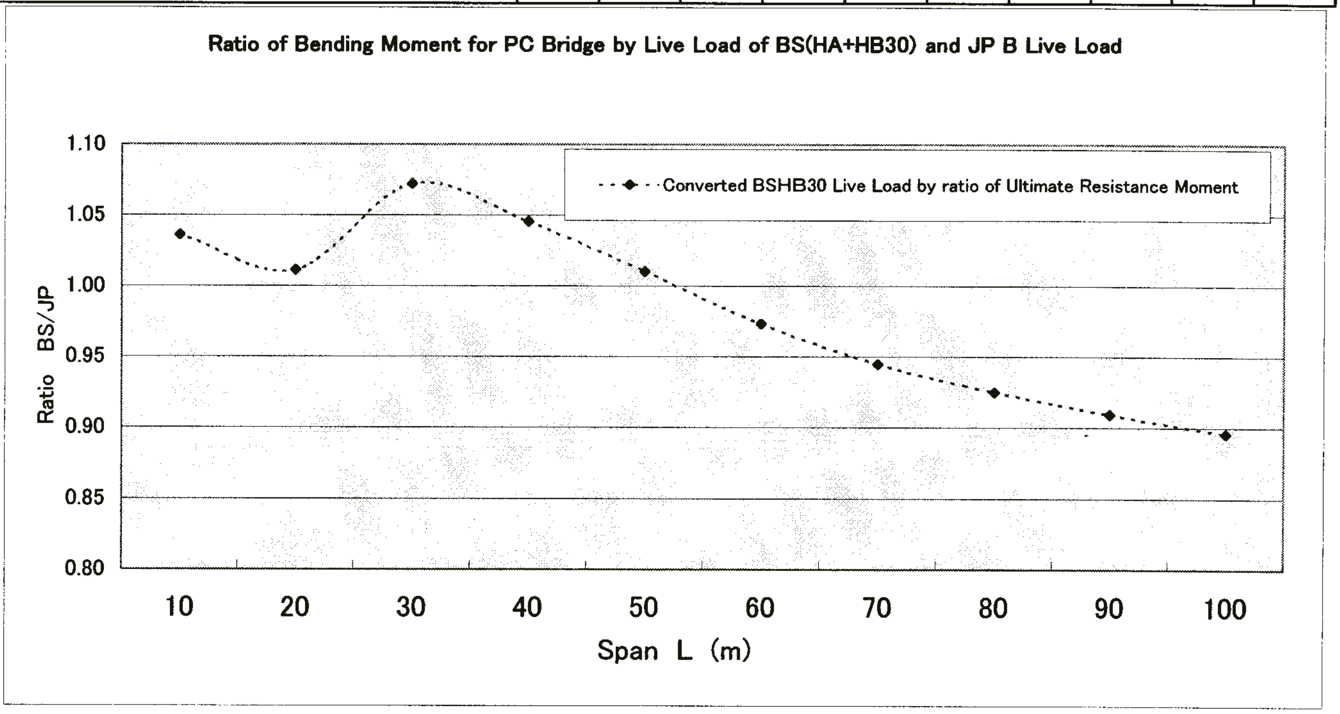
Span L (m)	10	20	30	40	50	60	70	80	90	100
Japanese Highway Bridge Standard B Live Load	140	434	777	1,172	1,622	2,127	2,687	3,303	3,974	4,702
Converted BSHB30 Live Load by ratio of Ultimate Resistance Moment	145	438	833	1,225	1,638	2,069	2,537	3,054	3,613	4,210



Comparison between B live Load according to JP and Converted Bending Moment Live Load of BS (HA+HB30) for PC Bridge

Carriageway = 7.4m

Span L (m)	10	20	30	40	50	60	70	80	90	100
Converted BSHB30 Live Load by ratio of Ultimate Resistance Moment	1.04	1.01	1.07	1.05	1.01	0.97	0.94	0.92	0.91	0.90

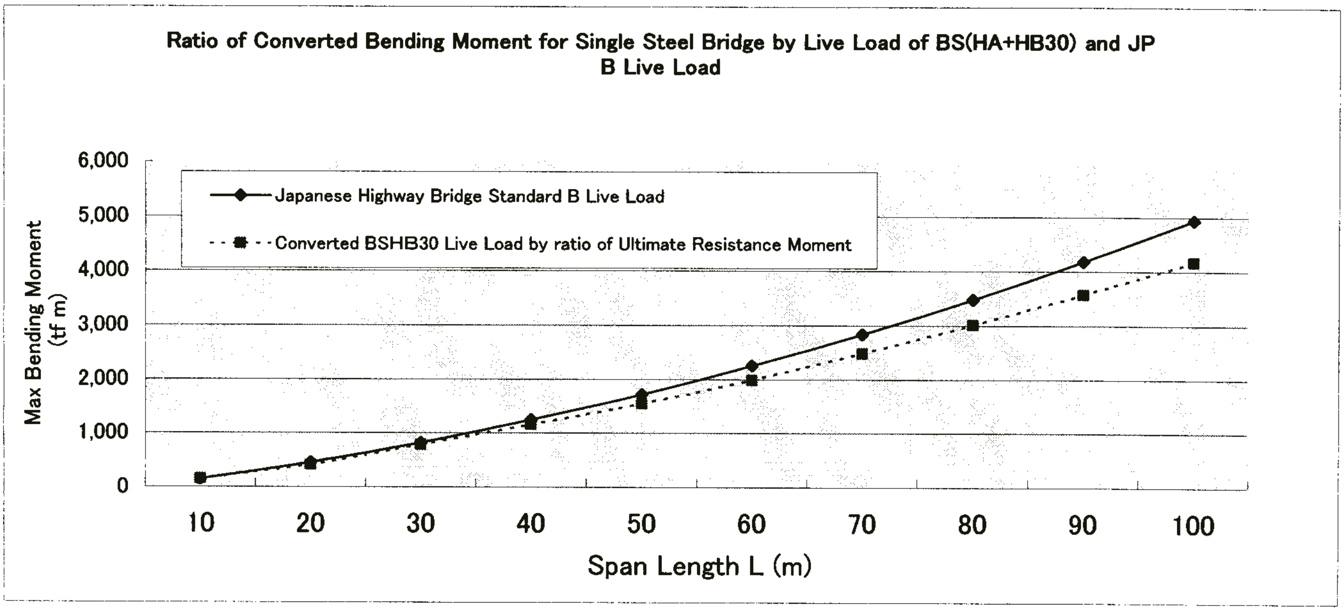


iii) Steel Single Girder Bridge (Figure-2.3.3)

Comparison between B live Load according to JP and Converted Bending Moment Live Load of BS (HA+HB30) for Steel Girder Bridge

Carriageway = 7.4m

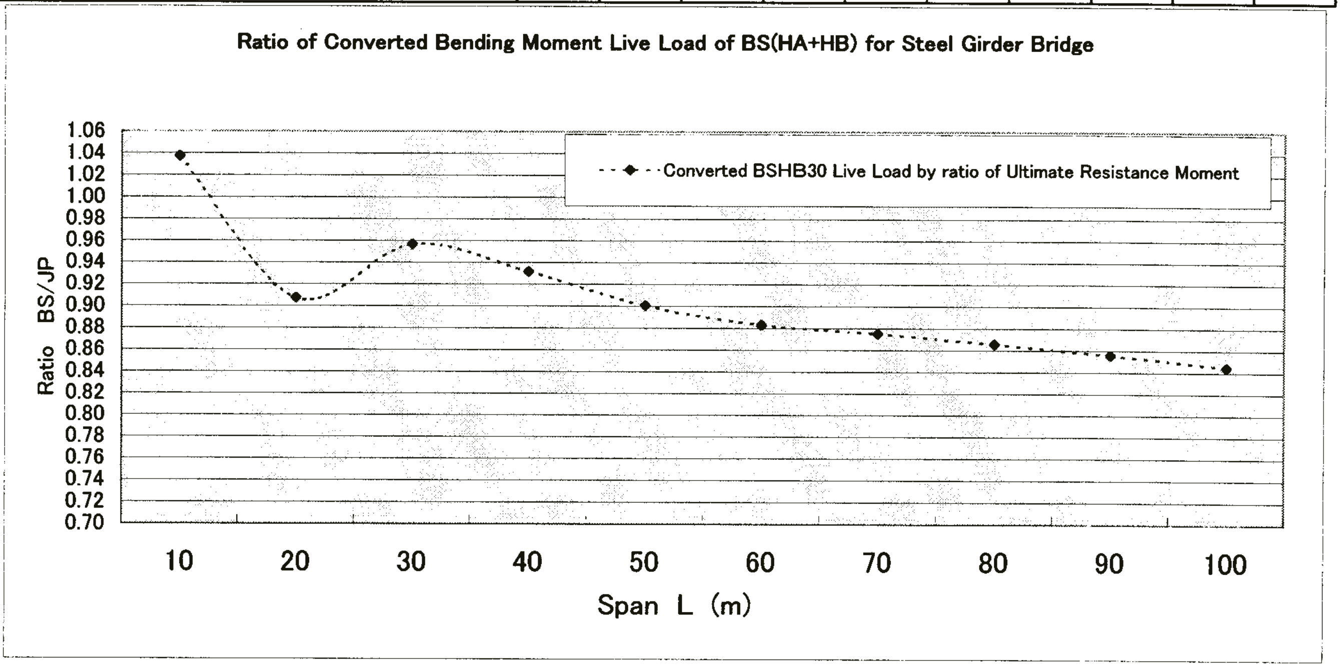
Span L (m)	10	20	30	40	50	60	70	80	90	100
Japanese Highway Bridge Standard B Live Load	145	456	821	1,242	1,717	2,249	2,836	3,479	4,179	4,934
Converted BSHB30 Live Load by ratio of Ultimate Resistance Moment	150	414	786	1,156	1,546	1,985	2,481	3,012	3,575	4,168



Ratio of Converted Bending Moment Live Load of BS (HA+HB30) for Steel Girder Bridge

Carriageway = 7.4m

Span L (m)	10	20	30	40	50	60	70	80	90	100
Converted BSHB30 Live Load by ratio of Ultimate Resistance Moment	1.04	0.91	0.96	0.93	0.90	0.88	0.87	0.87	0.86	0.84



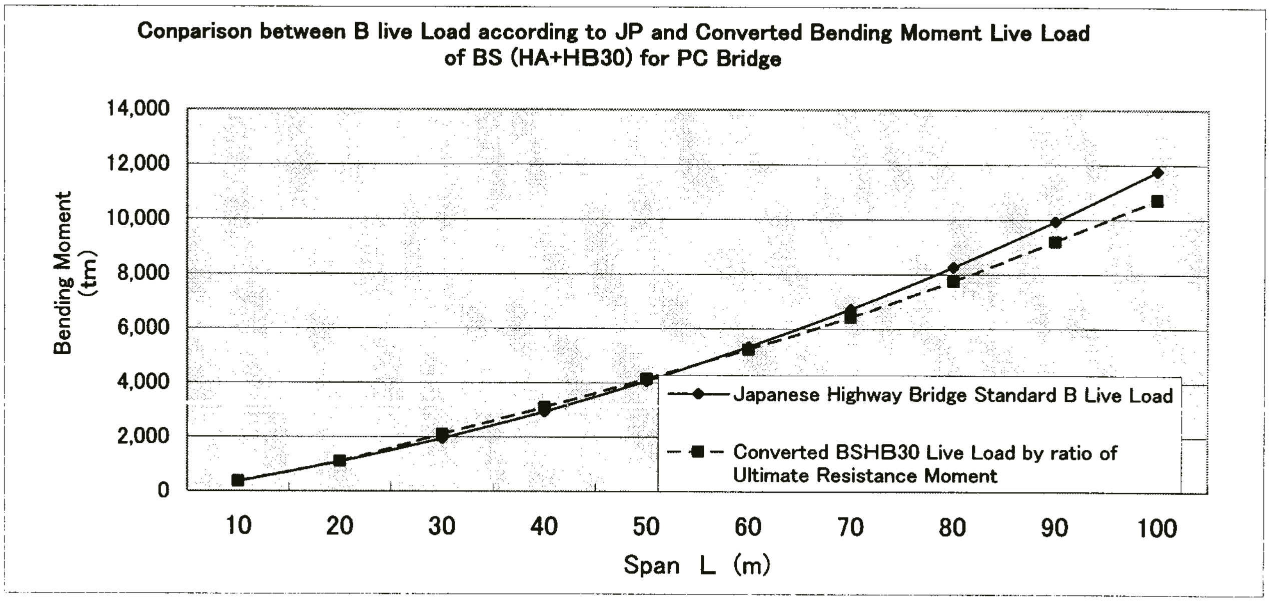
2) **Ultimate Limite State**

i) **PC Single Span Bridge (Figure-2.3.4)**

Conparison between B live Load according to JP and Converted Bending Moment Live Load of BS (HA+HB30) for PC Bridge

Carriageway = 7.4m

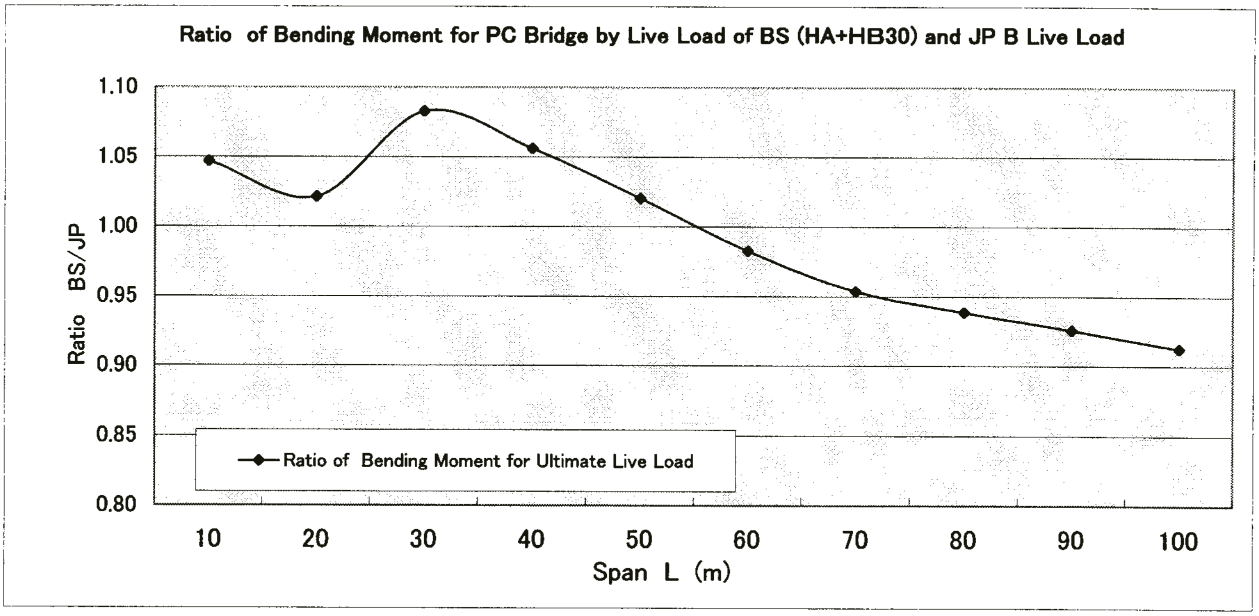
Span Length L (m)	10	20	30	40	50	60	70	80	90	100
Japanese Highway Bridge Standard B Live Loa	350	1,084	1,941	2,930	4,055	5,317	6,717	8,256	9,936	11,755
Converted BSHB30 Live Load by ratio of Ultimate Resistance Moment	366	1,107	2,102	3,094	4,136	5,224	6,405	7,747	9,196	10,723



Ratio of Bending Moment for PC Bridge by Live Load of BS (HA+HB30) and JP B Live Load Bending Moment for Ultimate Limt State

Carriageway = 7.4m

Span Length L (m)	10	20	30	40	50	60	70	80	90	100
Ratio of Bending Moment for Ultimate Live Lo	1.05	1.02	1.08	1.06	1.02	0.98	0.95	0.94	0.93	0.91



3) Design Standard

⑴ Geometric design of road

For roads to be rehabilitated according to this basic design, the geometric design values in Table-2.3.3 will be employed according to the Road Design Standard of Sri Lanka shown in Table-2.3.2.

Table－2. 3. 2 Road design standard

Bridge	Road class	Traffic volume (units/day)	Road standard	Topographic conditions	Design speed classification	Design speed(km/h)	Remarks
Gampola Bridge (No.93)	A	300 ～ 18,000	R3 (improved)	Mountainous	Urban	50	Compliance with ADBIII
Muwagama Bridge (No.239)	B	300 ～ 18,000	R3 (improved)	Mountainous	Urban	50	—

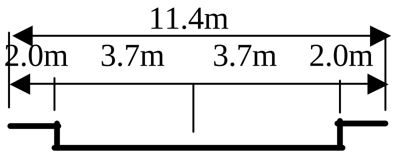
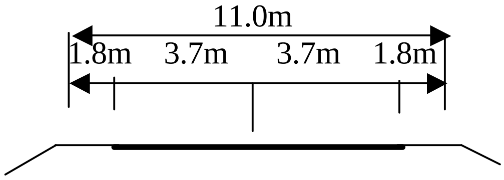
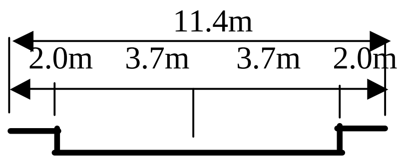
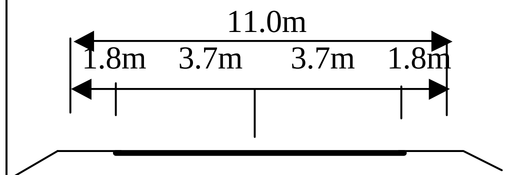
Table－2. 3. 3 Values employed in the road geometric design

Item		Unit	Design value	
			Gampola Bridge R3(shape changed)	Muwagama Bridge R3 (shape changed)
Design speed		km/h	50	
Roadway width (including shoulder)		m	7.4 (2 lanes ; 3.7+3.7)	
Crossfall (asphalt concrete pavement)	Roadway	%	Earth work section : 2.5 Bridge section : 1.5	
	Shoulder		3.0	
Horizontal alignment	Minimum curve radius	m	85 (72)	
	Maximum crossfall	%	6	
Vertical alignment	Minimum grade	%	0.3	
	Maximum grade	%	4	5

（2）Road width composition

The width composition of the bridge and approach road is shown in Table-2.3.4.

Table－2. 3. 4　Width composition of bridge and approach road

Bridges	Road class and standard	Component elements	Components of cross section
Gampola Bridge (No. 93)	Road class：A Road standard：R3 (improved)	Roadway width：3.7m x 2 = 7.4 m Shoulder　：1.8 m （Provided on both sides of earth work only） Sidewalk width：2.0 m （Provided on both sides on bridge only） Curb and railings：Included in width of sidewalk Gutters： 0.9 m (Provided on both sides of earth work only) Crossfall： Earth work； 2.5% (Asphalt pavement) Bridge； 1/60 (1.5%) Railings and mount-up of sidewalk： Handrail　：h= 1.1m Mount-up：h≧225mm	 Bridge  Approach road
Muwagama Bridge (No. 239)	Road class：B Road standard：R3 (improved)	Roadway width：3.7m x 2= 7.4 m Shoulder　：1.8m （Provided on both sides of earth work only） Sidewalk width：2.0m （Provided on both sides of bridge only） Curb and railings：Included in width of sidewalk Gutters：0.9m （Provided on both sides of earth work only） Crossfall： Earth work； 2.5% (asphalt pavement) Bridge； 1/60 (1.5%) Handrail and sidewalk mount-up： Handrail　：h= 1.1m Mount-up：h≧225mm	 Bridge  Approach road

（3）Pavement design

For the pavement design, the Sri Lanka Bridge Design manual (BDM) 1997 (RDA) will be applied. For pavement of bridge, the Asphalt Pavement Requirement of the Japan Road Association will be applied.　The pavement composition shown in the final report of ADB III road improvement project will be employed only for the existing run-off section to the approach road. The general pavement composition is as shown in Table-2.3.5.

Table－2.3.5 Road pavement composition

Location of road	Classification of design traffic volume	CBR	Surface course	Binder course	Base course	Subbase course	Total thickness
			Dense grade	Coarse grade	Crushed stone for mechanical stabilization	Crusher run	
Bridge	—	—	5cm	—	—	—	5cm
①Approach road to Gampola Bridge (No.93)	B	8	5cm	5cm	15cm	15cm	40cm
②Approach road to Muwagama Bridge (No.239)	B	**8** (embankment)	5cm	5cm	15cm	15cm	40cm
③Diverging of daily road to Muwagama Bridge (No.239)	L	8	5cm (coarse grade)		10cm	10cm	25cm

(4) Bridge design

① Design method

Design of the bridge concerned is made according to the Specification for Highway Bridges and its Explanation, December, 1996 (Japan Road Association) by means of the allowable stress method.

② Loads

a) Principal load

I) Dead load

The dead load is the total weight of the bridge itself and the attachments. It is calculated on the basis of the unit volume weights shown in Table-2.3.6.

Table－2. 3. 6 Unit volume weight of materials

Material	Unit volume weight (kN/mm²)	Material	Unit volume weight (kN/mm²)
Iron、steel	77	Plain concrete	22.5-23.0
Cast iron	71	Cement mortar	21.0
Aluminum	27.5	Wood	8
Reinforced concrete	24.0-24.5	Bituminous material	11
Prestressed concrete	24.5	Asphalt concrete	22.5

II）Attachments and attached weight

Table-2.3.7 shows the type and weight of attachments.

III）Live load

B live load to be applied

Table－2. 3. 7 Type and weight of attachments

Bridges	Attachments	Type	Quantity (pieces)	Weight (kN/m)
Gampola Bridge (No.93)	Water supply	Steel pipe (galvanized) φ225	**1**	0.93
		Steel pipe (galvanized) φ150	**2**	0.4
	Telephone	Steel pipe (galvanized) φ150	**5**	1.23
Muwagama Bridge (No.239)	Water supply	Steel pipe (galvanized) φ300	**1**	1.34
		Steel pipe (galvanized) φ225	**1**	0.93
	Telephone	Steel pipe (galvanized) φ100	**1**	0.6
		Steel pipe (galvanized) φ75	**1**	0.4

IV） Impact of live load

Impact of live load is taken into account. The impact is calculated using the impact coefficient – i calculated from live load shown in Table-2.3.8.

Table－２.３.８ Calculation of impact coefficient *i*

Bridge type	Impact coefficient *I*	Remarks
Steel bridge	T= $\frac{20}{50 + \text{span length}}$	Regardless of whether T load or L load is used
Reinforced concrete bridge	T= $\frac{20}{50 + \text{span length}}$	When T load is used
	T= $\frac{7}{20 + \text{span length}}$	When L load is used
Prestressed concrete bridge	T= $\frac{20}{50 + \text{span length}}$	When T load is used
	T= $\frac{10}{25 + \text{span length}}$	When L load is used

V） Prestressing force

VI） Effect of concrete creep

VII） Effect of concrete drying shrinkage

VIII） Ground pressure

IX） Water pressure (static, running water)

X） Buoyancy or uplift

b) Secondary load

Loads to be considered for combination of loads are shown below:

I） Wind load

The wind load specified in the Specification for Highway Bridge will be applied.

II） Effect of temperature change

Considering temperature fluctuations in Sri Lanka, the following will be applied:

Concrete： ± 15℃ （average 35℃、maximum 50℃、minimum 20℃）

Note that 0.1 of the dead load or equivalent will be considered as a shoe horizontal component due to temperature change.

III) Effect of earthquakes

The bridge design manual sets forth that the effect of earthquakes need not be taken into account because there is almost no record of earthquakes in Sri Lanka. Accordingly, the effect of earthquakes is not taken into account in this design.

c) Particular load

Particular loads are those to be taken into account depending on the bridge structural type, construction method, and bridge point condition. The following loads are considered:

I) Load during construction

II) Effect of movement of the fulcrum

III) Braking force

IV) Collision load

d) Increased allowable stress due to combinations of loads

Increase in the allowable stress due to combination of loads is shown in Table-2.3.9.

Table－2. 3. 9 Increased allowable stress due to combinations of loads

Load combination	Incremental coefficient
Principal load	1.0
Principal load+ Temperature change	1.15
Principal load+ Braking load	1.25
Principal load+ collision load	1.5
Load during construction	1.5

③ Strength of materials to be used

a) Concrete

The design standard strength and Young's modulus for concrete are shown below:

Ⅰ) Design standard strength (28-day strength)

Prestressed concrete girder : σck=35N/mm^2, 40N/mm^2

Reinforced concrete slab, reinforced concrete girder : σck=24N/mm^2

Reinforced concrete sidewalk, railing : σck=24N/mm^2

Substructure (abutment・pier) : σck=21N/mm^2, 24N/mm^2

Foundation (cast-in-place pile) : σck=24N/mm^2

Ⅱ) Young modulus

The Young coefficient calculated as shown in Table-2.3.10 is used.

Table-2.3.10 Young modulus value

Design standard strength (N/mm^2)	21	24	35	40
Young modulus (kN/ mm^2)	23	24	29	31

b) Re-bar

Re-bars are based on SD345 in accordance with the Specification for Highway Bridge.

c) Prestressing steel

Prestressing steel twisted wire and prestressing rod are in accordance with the Specification for Highway Bridge.

d) Steels

SS and SM steels in accordance with the Specification for Highway Bridge.

④ River conditions

Ⅰ) Design rainfall

Gampola Bridge : Q=2,650m^3/sec

Muwagama Bridge : Q=4,550m^3/sec

Ⅱ) Design high-water level

Gampola Bridge : Q=MSL 474.60m

Muwagama Bridge : Q=MSL 103.73m

III) Clearance under girder

In accordance with the Cabinet Order of Japan to ensure the value shown in Table-2.3.11.

Table－2. 3. 11　Clearance under girder

Design rainfall (m^3／sec)	200＜	200≦ ＜500	500≦ ＜2000	2000≦ ＜5000	5000≦ ＜10000	≦10000
Standard value (m)	0.6	0.8	1.0	1.2	1.5	2.0

IV) Pier 's flow detrimental ratio

6% or less according to the Cabinet Order of Japan

⑤ Soil constant

As a result of field survey, the soil constant was set as shown in Appendix, Soil Constant.

2－3－2 Basic Design

1) Selection of bridge points

(1) Bridge locations

Reconstruction was determined to be necessary after a damage survey of the condition of the bridges concerned. On the basis of the results of a field survey, selection of new bridge points was reviewed for three cases: the current position, the upstream side and the downstream side of the existing bridges in terms of the possibility of acquiring needed land, the geology, environmental conditions, and traffic through temporary roads. Agreement was reached on the following points:

① Gampola Bridge

The new bridge will be constructed on the upstream side of the existing one for the following reasons:

- There would be no substitute road in the suburb if a new bridge were to be constructed at the current location.
- Provision of a temporary bridge and temporary road during the work period would be geologically difficult if the plan designates the existing bridge position.
- A temple and lime trees are on the left of downstream side, which make transfer of the bridge difficult.
- If the new bridge were constructed on the downstream side, adverse effects such as scouring, etc. might occur until the existing bridge is removed.
- It was confirmed that part of an elementary school on the right bank of the upstream side can be used.
- A temporary bridge becomes necessary when the plan designates the existing bridge position. This is disadvantageous in terms of both work period and cost.

② Muwagama Bridge

The new bridge was planned for the downstream side of the existing one for the reasons given below. Before planning the bridge for the downstream side where it is susceptible to effects of scouring caused by the existing one, thorough discussions were held with authorities concerned.

- There would be no substitute road in the suburb if a new bridge were to be constructed in the current location.
- Provision of a temporary bridge and temporary road during the work period would be geologically difficult if the plan designates the existing bridge position.
- A Ratnapura vegetable market on the right bank of the upstream side makes land

acquisition difficult.

- A temporary bridge would have to be erected if the existing bridge position were used. Because the approach road on the right bank runs on the 8 m embankment, the scale of the temporary road would be large.
- When the new bridge is constructed on the downstream side, adverse effects such as scouring may occur. If necessary, scouring and other adverse effects can be avoided by proposing a structure without piers, such as a single span bridge.

(2) Distances from existing bridges

The distances between existing and new bridges were determined in view of the points outlined below. As a result, a distance of 16.5 m between road centers will be secured between the existing and new bridges.

① The location should be where construction work in the proximity does not affect existing bridge piers

The existing bridges are 70 years or more old and heavily damaged. When new piers are to be provided for the new bridge, the distance (where no measure is taken) must be secured to prevent adverse effect of the construction work in the neighborhood of the existing piers.

② Alignment of approach roads

The alignment of existing approach roads will not be changed substantially.

③ Avoidance of effects on the wing of existing bridge abutments

The location of new bridge abutments must be such that foundation piles do not interfere with the caisson foundation built for the existing bridge abutment wing.

④ Sufficient distance must be secured for superstructure, substructure, and foundation work.

A distance of 1.0 m or more must be secured between the temporary bent, landing bridge, cofferdam, and scaffold and the existing bridge.

2) Topological and geological conditions

(1) Gampola Bridge

① Outline of the geology

The location planned for the Gampola Bridge is about 500 m above sea level in a central highland surrounded by precipitous mountains. The bridge is planned in a narrow plain portion of this terrain. The right bank is relatively flat and the left bank is a low hill having outcrops of soft to hard rock mass.

Around the bridge point, the topography shows a V-shaped valley due to erosion and locations where bedrock (schist, gneiss) is exposed in the form of hard rocks in the river bottom. It is therefore thought that the Mahaweli River is an eroding river. The existing bridge is heavily eroded at the foundation of existing piers and the river bed is considered to have lowered considerably. In the past, moreover, the river channel moved toward the relatively flat right-bank side, which is presumed to have caused significant gouging of bedrock toward the right bank side.

② Geological and ground composition

Boring was conducted at six points upstream and downstream of the existing bridge. The result is shown below. (See Fig.-2.3.5)

The granitic gneiss (hard rock class) that is bedrock dips from the left bank to the right bank side and is at a depth of 5 m on the left bank and about 20 m on the right bank. Heavily weathered granitic gneiss (clayey soil: N value of about 7) has built up a depth of 2 m on top of the bedrock. Loose sandy layers and soft clayey soil layers have accumulated from the top of the weathered rock to the ground surface. On the left bank, distribution of rolling stones and cobbles is observed in a relatively shallow position. However, the middle portion of the river is heavily eroded, with only river deposit of about 1 m present on top of the heavily weathered soil.

On the right bank, a loose sandy soil layer that may have originated from backfilling during construction of the existing bridge is distributed at a thickness of about 11 m below the ground surface. Moreover, a cobble layer of about 20 cm exists on the bedrock.

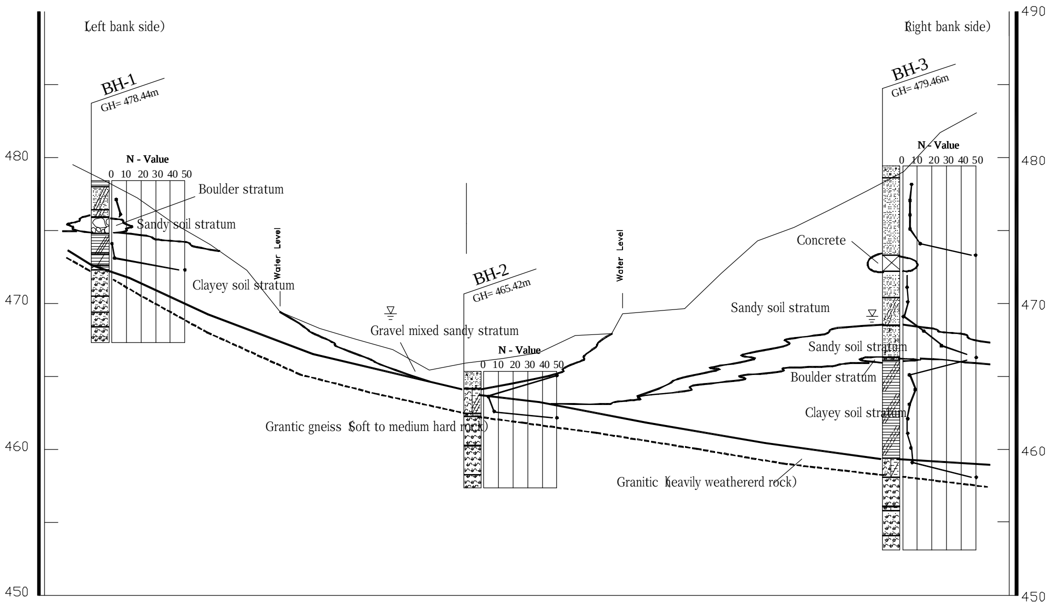


Fig. －2. 3. 5 Ground and geological map of Gampola Bridge planned point

③ Bearing stratum and type

The N values for the sediment and weathered soils are approximately less than 30 and are not expected to provide bearing capacity as a bearing stratum. Accordingly, only the rock mass (soft to hard) of granitic gneiss is considered capable of becoming the bearing stratum for this new bridge site.

At the abutment on the left bank side, the thickness of the weathered soil layer is as much as 12 m on the downstream side, resulting in dipping of the bearing stratum (rock mass line) downward by about 20 degrees from upstream to downstream direction. Contrary to the case of the left bank, at the abutment on the right bank side, the bearing stratum (rock mass line) dips downward by about 15 to 20 degrees from downstream to upstream direction. Considering such geological conditions as the depth to the bearing stratum and dipping of the bedrock, the pile foundation or spread foundation is considered appropriate for the abutment and the spread foundation for piers.

④ Design and construction considerations

- Distribution of cobble and rolling stones is observed. This may hinder earth retaining work and foundation pile driving.
- Dipping of the bearing layer (rock mass line) at about 20 degrees may exist in the bridge crossing direction
- The rock mass of the bearing stratum is classified roughly as soft rock II. This hardness must be taken into account for selection of machinery used during excavation for embedment.

(2) Muwagama Bridge

① Outline of geology

The Muwagama Bridge site is about 100 m above sea level and near the boundary between the central highland and southwestern areas. The surrounding mountains are relatively gentle, with a ridge line running from northwest to southeast, which indicates the direction of tectonic activity. Mountains in the neighborhood are relatively weathered. Non-weathered rocks or blocks several meters in diameter are frequently left in weathered soil of the ground or talus material in the form of rolling stones.

The planned bridge site is located in a narrow plain portion where rivers running through this terrain join. There is a small hill with exposed soft to hard rocks on the left bank and a lowland is spreading on the right bank. This appears to be the reason why the bedrock on the right bank is gouged to a great extent and there are many points with thick soil sedimentation transported during flood. Though the river bed shows signs of scouring, it is not as heavy as the case of the Gampola Bridge

② Geological and ground composition

In order to grasp the ground and geological conditions at the Muwagama Bridge site, four boring surveys were conducted on the downstream side of the existing bridge. The results were evaluated through comparison with the existing data. This is described below. (See Fig.-2.3.6)

- Left Bank: For the bedrock, the charnockite gneiss rock with a hardness equivalent to the medium hard rock is distributed at a depth of 15 – 20 m. Clayey soil layers are deposited on top of this, with intervening loose sandy or clayey soil layers, a total of 8 m thickness, including one with a maximum thickness of 4 m, which contain rolling stones and cobble layers.

- Right bank：The bedrock is granitic gneiss (medium hard to soft II class) present at the depth of 20 – 25 m below the surface. On top of this bedrock, heavily weathered soil (N value of about 20) of granitic gneiss is deposited with the thickness of 1 – 7 m. There are alternate layers of clayey and sandy soil on top of heavily weathered soil. In the deeper position, there are sandy layers (gravel mixed sand to sand) and sand mixed clay layers with N values of 40 or more.

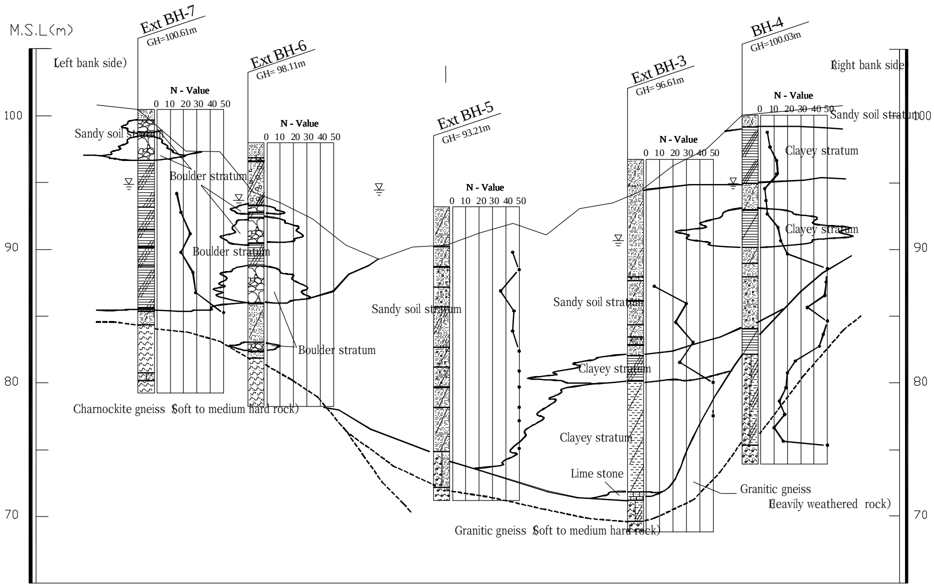


Fig.－2. 3. 6　Ground and geological map of planned site for Muwagama Bridge

③ Bearing stratum and type

・Left bank

As N values exceeding 30 are not observed consecutively for 5 m or more in the sediments and the weathered soil layer, it is considered appropriate to use the bedrock, that is the charnockite gneiss, and granitic gneiss, as a bearing stratum. It is highly possible that the rock mass line at the left bank abutment dips steeply from the downstream side by 70 – 80 degrees to the upstream side. It is considered appropriate to use a pile foundation.

・Right bank

It was confirmed that the layer with an N value of 30 or more continues for 7 – 8 m from a point 11 m below the ground surface. Considering that its continuity could not be confirmed horizontally and that a heavily weathered soil layer with an N value of 20 or less is distributed with a thickness of about 5 m, it may be appropriate to use the bedrock of granitic gneiss (soft I to soft II) as a bearing stratum.

It is possible that the rock mass line at the abutment dips steeply at about 60 degrees from the upstream to downstream side. Considering the depth to the bearing stratum and the dip of bedrock, a pile foundation is appropriate for an abutment and pier.

④ Design and implementation conditions

・Distribution of cobble and rolling stones is expected to be remarkable on the left bank, which may hinder earth retaining and foundation pile driving.

• It is highly possible that the bearing stratum (rock mass line) dips steeply at about 60 – 80 degrees. A detailed review is necessary before designing the foundation work.

• It is possible that intermediate layers with an N value of 30 – 50 may exist and that cobble and rolling stones are distributed in large quantity. These facts must be taken into account when selecting the foundation pile driving method.

3) Hydraulic and hydrologic conditions

(1) Outline of the river basin at bridge locations

① Outline of rivers

This section describes the result of river and hydrologic surveys of Gampola and Ratnapura. Gampola Bridge No. 93 is planned upstream of the Mahaweli River. This river has the largest basin area in Sri Lanka and also the largest runoff. The Muwagama Bridge No. 239 crosses the Kalu River, which has the fifth largest runoff. The basins of these rivers are outlined below.

(a) Mahaweli River

Kotmale dam is about 16.5 km upstream of the planned bridge location. The basin area upstream of the planned bridge is about 888km^2. The highest altitude of the headwater is 2,100 m, and the riverbed around Gampola Bridge site is 460m above sea level. The area is mostly steep forest land, with villages and tea fields located in various parts of the land. The basin of Kotmale dam has a governing area substantially affecting the Gampola Bridge location. Data on this dam is shown in the table below.

Table－2. 3. 12 Data of Kotmale dam

Name	Kotmale dam
Completion	1985
Type	Rock fill dam
Crest length (m)	600
Dam height (m)	87 (EL 706.5 m)
Flood operating level	704.3 m
Flood storage capacity	181,100,000 m^3
Design high water level	703 m

Reservoir capacity	174,000,000 m^3
Lowest operating level	665 m
Objectives	Power generation 200 MW, irrigation, municipal water, flood control
Administrator	Mahaweli Authority

Kotmale Dam effectively controls floods for this basin. Since operation of this dam started, the maximum inflow has not been directly related to the maximum outflow in many cases. Namely, the maximum outflow was not observed on days when maximum inflow occurred, indicating that the storage effect of the dam is high.

An inflow of 27.1 x 10^6 m^3(hereinafter, x 10^6 m^3 should be read as million m^3) on October 7, 1995 caused a maximum outflow of 12.3 million m^3 on October 9. This can be considered outflow related to a flood. The storage volume in this case is as follows.

Table－2. 3. 13 Kotmale dam level － Storage capacity

Reservoir level	Year/month/day of occurrence	Storage capacity (Million m^3)
698.2	1995-10-7	144.3
702.4	1995-10-8	168.8
703.0	1995-10-9	172.0

In this case, the dam that received an inflow of 27.1 million m^3 on October 7 stored a flood of 27.7 million m^3 to reach the design high water level until October 9, that is, two days later. The average rainfall was 123 mm and more at the Ramboda precipitation station and 128 mm at the Hatton precipitation station, indicating approximate similar readings. Data on the rivers and river courses are shown in Table-2.3.14.

(b) Kalu River

The basin area of this river upstream from the Muwagama Bridge location is about 614 km^2. The maximum altitude of the headwater is 1523m, and the river reaches the planned bridge location after running for about 58 km. The river bed is 90.7 m above sea level. The mean annual rainfall within the basin is 157 mm, which is larger than that of the Mahaweli River. Other data is shown in Table 2.3.14. At the bridge location, on the left bank, a tributary, the Ei Oya River with a basin area of about 3 km^2, merges, but its contribution to flood discharge as a whole is not much.

② River data

River data is shown in the table below.

Table－2. 3. 14 River and river channel data

Name of river	Mahaweli River	Kalu River
Total basin area of main river (km^2)	10,448	2,719
Basin area concerned (km^2)	888	614
Dam basin area (km^2)	544	---
Tributary basin area (km^2)	344	---
Max river bed altitude (m)	2,100	1,523
Max river bed altitude of tributary (m)	1,150	---
Min river bed altitude (m)	460	90.7
Total length of main river (km)	335	129
Length of channel concerned (km)	75.4	58
Length of channel downstream of Dam (km)	16.5	---
Length of tributaries (km)	43.0	---
Coefficient of river regime*	1,000 or more	1,000 or more
Typical grain size of river bed (dr)	0.1cm	0.04cm
Average water depth in low channel (H1)	3.5m	5.5m
River width/depth ratio (B/H1)	64.3	5.9
Depth/grain size ratio (H1 /dr)	5690	22700

*Coefficient of river regime= Largest record flood / Recorded lowest water level

③ Determination of the roughness coefficient of river

The roughness coefficient of the low channel in each river was determined as indicated below, while referring to Strickler's equation, the Guidebook for Planning River Channels of the River Bureau of the Ministry of Construction, hydraulic formulas of the JSCE, past water levels known from interviews, and results of analysis of grain size of river bed materials.

(a) Mahaweli River

Local flood levels known from interviews vary greatly. At a point 600 m downstream of the Gampola bridge with the water level of 8 m, the roughness coefficient is considered to be less than 0.0285 with a flow rate of 6.3 m/s and a flow of 2770 m^3/s. The conservative roughness coefficient of low channel is set at 0.03.

(b) Kalu River

At a point 600 m downstream of the bridge, the roughness coefficient at around 7.5 m flood level known from interviews is 0.025, but the flow was 2550 m^3/s or less. Considering data obtained from local interviews, the roughness coefficient of the low channel was estimated conservatively at 0.03.

n = 0.030

For the roughness coefficient from the grain analysis result of river bed materials, Figure 3.2.5 of the Guidebook for Planning River Channels (draft) (P42. the Flood Control Division, River Bureau of the Ministry of Construction, April 1996) shows n1=0.028 for a dr of 20 mm or less.

Strickler's equation n2 = 0.015 dr1/5

Natural rivers of Hydraulic formulas of the JSCE n3 = 0.025〜0.05 Average 0.038

The result of calculation by introducing the above river values into the above formula is summarized in the table below.

Table－2. 3. 15 Roughness coefficient of rivers concerned

Name of river	dr(mm)	n1	n2	n3	Average n
Mahaweli River	1	0.028	0.015	0.038	0.027
Kalu River	0.4	0.028	0.012	0.038	0.026

The calculation result is slightly smaller than the above estimate. Considering overgrowth of tropical vegetation and 100-year probability flow, however, this project will employ n=0.03.

(2) Calculation of design flood discharge and design flood levels at bridge locations

A representative basin precipitation station is selected for each river. Probability processing of maximum daily rainfall was made for each year, and the probability flood volume was calculated by using a rational formula. Probability processing was also made on observation records of water levels and flows. The flood level was calculated by applying the above roughness coefficient to each probable flood volume. The analysis flow is shown below.

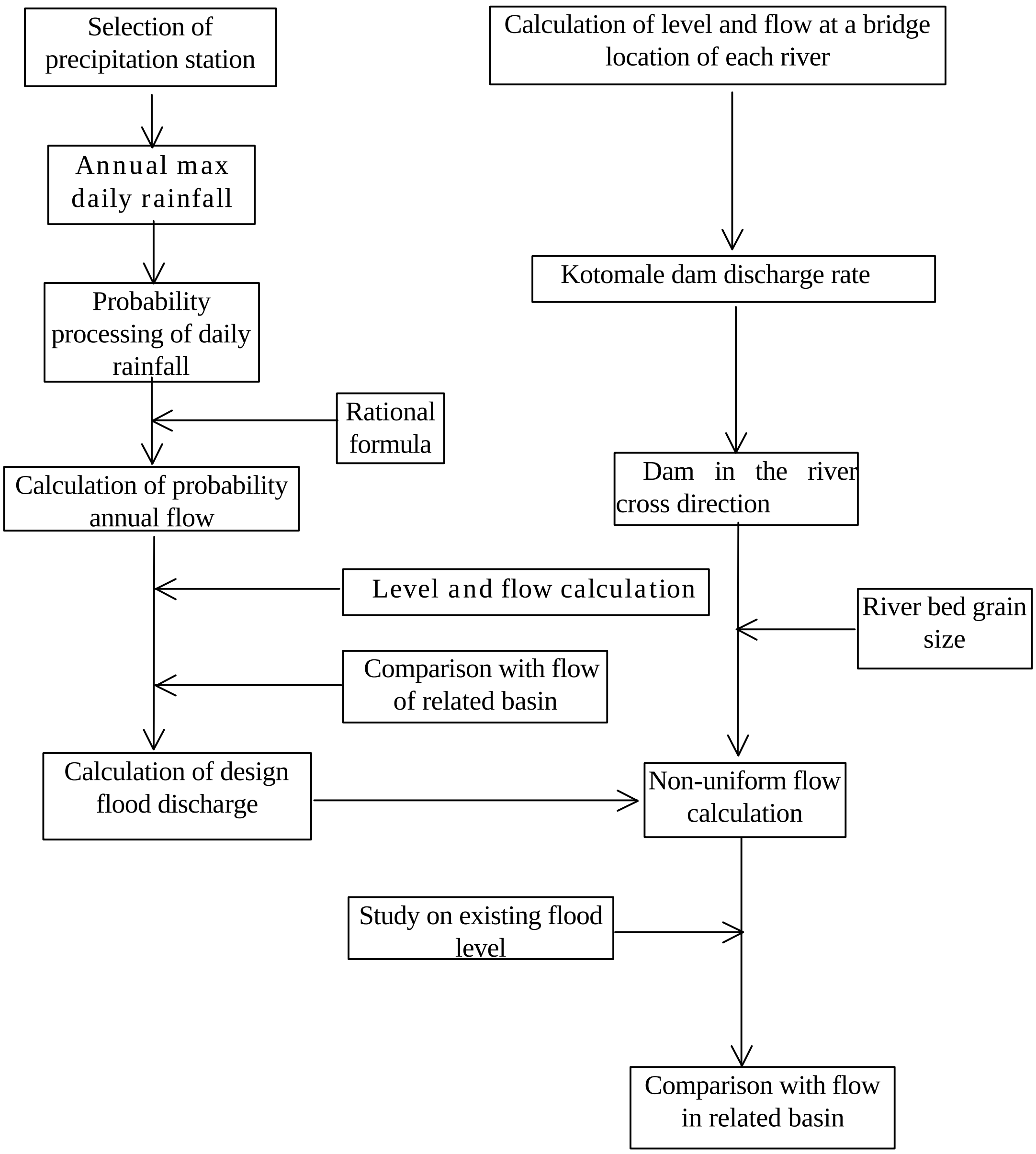


Fig －2. 3. 7 Analysis flow

① Basin mean daily rainfall in each probable year

On the basis of maximum daily rainfall data at each station, the probable daily rainfall was calculated as follows according to the Thomas Plot Method.

Table－2. 3. 16 Probable daily rainfall at each station (mm)

Probability year	Ramboda	Hatton	Yellaben	Ratnapura
	(1)	(2)	(3)	(4)
1/100	252	226	252	394
1/50	217	204	216	345
1/10	138	148	134	239
1/2	55	95	50	147

The basin average daily rainfall for each river was calculated as follows:

Mahaweli River (in dam basin) $R_{24} = [(1) + (2)] / 2$

Mahaweli River (remaining basins) $R_{24} = (3)$

Kalu River Ratnapula $R_{24} = (4)$

The calculation result of probable basin mean daily rainfall of each river is shown in Table-2.3.17.

Table－2. 3. 17 Basin mean rainfall

Probability year	Mahaweli River Dam basin	Mahaweli River Other basins	Kalu River
1/100	239	252	394
1/50	211	216	345
1/10	143	134	239
1/2	75	50	147

② Calculation of flood runoff

The basin area of the Mahaweli River includes 544km^2 for the Kotmale Dam basin and 344 km^2 for other basins. In the case of the Kalu River, the basin area is 614 km^2. The Flow of each basin is calculated using a rational formula.

There are no level and flow stations near the planned site of the Muwagama Bridge. For the Kalu River, the top ranked level record of EL103.73 was on August 15, 1947, and a second highest level record of EL103.58 has been recorded. RDA has independently calculated the design flood level for the bridge concerned by using the top ranked flood level record. Using this as a reference, comparison is made with the flow calculated from the rational formula (Rational formula).

③ Calculation of flood concentration time

As calculation equations, Kraven's equation, equation of Public Works Research Institute, etc. are available. In this project, Rziha's equation that produces intermediate values is employed:

Rziha's equation $T = L/V$、$V = 20(h/L)^{0.6}$

where T：Flood concentration time（h）;V：Concentration speed（m/ s）;and **h**：Head（**m**）L：Channel length（**m**）are used.

Table－2. 3. 18 Flood concentration time for each river

River condition	Dam discharge to Mahaweli River	Other basins of Mahaweli River	Kalu River
h(m)	703-460=243	710	1,432
L(m)	16,500	43,000	58,000
V(m/s)	1.6	1.7	2.2
T(h)	2.9	7	7.3

④ Calculation of rainfall within the flood concentration time

The rainfall within the flood concentration time is calculated from the basin mean daily rainfall as follows:

$Rt = R24(t/24)^{k}$

where, R24：Daily rainfall **t**：Flood concentration time; and K：Constant (0.3) are used.

Table－2. 3. 19 Daily max rainfall and rainfall within the flood concentration time (Rt) for each river （Unit mm）

Probability year	Dam discharge to Mahaweli River	Other basins of Mahaweli River	Kalu River
R24			
1/100	239	252	394
1/50	211	216	345
1/10	143	134	239
1/2	75	50	147
t (h)	2.9	7	7.3
Rt(mm/t)			
1/100	127	174	276
1/50	112	149	241
1/10	76	93	167
1/2	40	35	103

(Rational formula) Calculation of $Q = 1/3.6\, f\, r\, A$

where Q：Peak runoff rate（m3/ s） f ：Runoff coefficient = 0.7 （Mountain and tea field）

r ：Rainfall within flood concentration time（mm/h）; and A：Basin concerned (km2) are used.

Table－2. 3. 20 Probable rainfall and flow for each basin

Probability year	Dam discharge to Mahaweli River	Other basins of Mahaweli River	Kalu River
A(Km^2)	544	344	614
R(mm/h)			
1/100	43	25	38
1/50	39	21	33
1/10	26	13	23
1/2	13	5	14
Q(m^3/s)			
1/100	4548	1672	4537
1/50	4125	1405	3940
1/10	2750	870	2746
1/2	1375	334	1671

Table－2. 3. 21 Flow at Gampola on Mahaweli River when flood discharge of Kotmale Dam is taken into account

Probability year	Rainfall (mm)	Basin area (Km^2)	Runoff	Dam inflow (M m^3)	Flood storage capacity (M m^3)	Discharge (M m^3)	Discharge rate (m^3/s)	Merge rate (m^3/s)
1/100	239	544	0.7	91.01	7.1	83.91	971	2643
1/50	211	544	0.7	80.35	7.1	73.25	848	2253
1/10						14.68	170	1040
1/2						7.78	90	424

Note that the runoff for 1/10 and 1/2 was so small that the actual discharge was processed on the basis of probability and added.

⑤ Assumed flood effects on the downstream area

It is assumed that the rainfall with a 100-year flood level flows into the Kotmale dam while it maintains the maximum past storage record level of 703 m. Such an inflow is calculated as follows.

239mm×544km²×0.7＝91.01million m^3.

The dam flood storage capacity is 181.1－174＝7.1million m^3,

so that it is necessary to discharge 91.01－7.1=83.91million m^3.

This results in a discharge of 971 m^3/sec.

This discharge volume is the maximum flow that may affect the bridge location concerned, which is the flow with a 100-year flood level to be calculated as 1672＋971＝2643 m^3/s.

Similarly, the flow with a 50-year flood level is 1405＋848＝2253 m^3/s.

⑥ Results of calculation to determine design flood discharge

The design flood discharge is calculated as shown in Table-2.3.22.

Table－2. 3. 22 Results of calculation to determine design flood discharge(m^3/s)

Probability year	Mahaweli River	Kalu River
1/100	2650	4550
1/50	2300	3950
1/10	1050	2759
1/2	450	1700

⑦ Calculation of the river channel discharge capacity

This is calculated using the Manning's formula:

Flow velocity＝1／n × R $^{(2/3)}$ × I$^{(1/2)}$ (m/s)

Flow rate Q＝A×V (m³/s)

A：Discharge area（m2） V：Flow velocity (m/s) R：Hydraulic radius（A/P）

n：Roughness coefficient I：River bed gradient P：Wetted perimeter (m)

Table－2. 3. 23 Discharge capacities of Mahaweli and Kalu Rivers

Constant	Mahaweli River	Kalu River
Nn Roughness coefficient	0.03	0.03
P Wetted perimeter（m）	89	106
R R=A/P	5.60	8.32
I River bed gradient	1/375	1/700
V Flow velocity（m/s）	5.43	5.18
A Discharge area（m²）	498	879
Q Flow rate (m³/s)	2650	4550

⑧ Discussion of analytical results

a) Mahaweli River

For the Gampola point, the discharge capacity was found to handle the flood with a 100-year flood level satisfactorily through the dam discharge rate and runoff from the remaining basins (2650 m³/s).

Trust may be placed on the fact known from local interviews that no flood passing over bridge girders has been experienced after completion of the dam. The dam has conducted flood control operation only once for two days from October 7, 1995. The maximum level in this case was up to the design high-water level, and the dam can maintain capacity for flood level operation. The area is a world famous site of quality tea production, and the many artificial reservoirs found in this area are thought to substantially reduce the primary outflow of the flood.

6) Kalu River

For the Muwagama, Ratnapura point, the calculation of flood with a 50-year flood level produced a value lower than the recorded highest water level (103.73 m), indicating that there is no particular problem. The calculation result with a 100-year flood level is higher than this level. In upstream landside areas protected by the bank, there is a wide area of lowland whose altitude is lower than 100 m. The flood will deluge this lowland, geologically making it impossible for the water level to rise above this level.

(3) Channel and river bed fluctuation of each river

On the basis of the results of a field survey this time and by referring to the map, changes of channels and river bed fluctuation are described for each river.

① Mahaweli River

In the case of this channel, mountain rivers reach the planned bridge location concerned. Since the geological map shows almost no change, the river channel is expected to be free from change in the future.

Not many houses, but many tea fields are on the basin upstream of the bridge location. The population shows a slight downward trend. Concerning the river bed fluctuation, transport of sediments has decreased since construction of the Kotmale Dam on the upstream side. The river bed lowering is promoted further by quarrying of river bed materials upstream and downstream of the bridge. Since construction of the dam, the river bed has lowered by about 4m.

Quarrying of river bed material upstream and downstream of the planned bridge location must be considered together with local scouring and future measures to prevent lowering of the river bed.

The friction velocity U_*^2 (cm^2/s^2) and typical grain size dr (cm), which are shown in Fig.-3.15 on page 22 of the Guidebook (draft), were plotted to verify the river channel characteristics. The result showed that the channel of the Mahaweli River tends to increase in width. As the rock mass exists about 2 m and below the existing river bed, scouring will be to this rock mass at most. Accordingly, embedment of piers and surrounding countermeasure works are considered sufficient to cope with scouring.

② Kalu River

In upstream landside areas of this river channel, the ground height is low on both the right and left banks. At the bridge point, the existing clearance under girder is enough for the design flood level.

The wide floodplain with 100 m or less ground altitude in upstream landside areas will allow the flood to deluge the plain, preventing the flood from threatening the existing clearance under girder. Similarly to the case of the Mahaweli River, quarrying of river bed material is done here, promoting lowering of the river bed.

Table－2. 3. 24 Survey on flood mark of rivers concerned

Year/month/day of occurrence	Mahaweli River (EL m)	Kalu River (EL m)
1947-8-5	484.96	
1941-5-13	481.95	
1978-11-23	481.34	
1974-7-27	481.08	
1933-5-24	480.84	
1913-12-6	480.69	
1940-5-18	480.38	
1957-12-23	479.96	
1913-10-5	479.96	
1906-10-27	479.67	
1956-6-23	479.45	
1968-5-5	479.42	
1942-7-15		103.73
1996-6-8		103.58

The bridge surface altitude of Gampola Bridge over the Mahaweli River is EL483.5 m. The past flood record shows overflowing over the bridge surface, but since completion of the Kotmale Dam in 1985, no such flood has been recorded.

The flood mark of the Mahaweli River was found at the Gampola Station building located 0.7 km upstream of the left bank.

⑷ Result of calculation of water level

As a rule, the existing cross section view was used for the river cross section during calculation of various hydraulic data at each bridge point. As a result of calculation, design flood discharge and flood level for the design probability year (100-year) are shown below.

Table-2.3.25 Design flood discharge and design high water level at bridge points

Name of river	Mahaweli River	Kalu River
Design flood discharge (m^3/s)	2650	4550
Design high water level (m)	474.60	104.40
Flow velocity (m/s)	5.43	5.18
Recorded highest water level (value employed by RDA)	No level rise record since construction of Kotmale dam	103.73
High-water level employed for this project (m)	474.60	103.73

※ The design high-water level of the Kalu River was calculated to be 104.40 m, but is assumed to be 103.73 m in consideration of geological conditions and existing maximum observed levels. The wide floodplain with 100 m or less ground altitude in upstream landside areas spreads, which will allow floods to deluge the plain, preventing floods from threatening the existing clearance under girder.

⑸ Bridge size

In consequence, the bridge length required in terms of river hydrology and hydraulics is considered to be as follows.

a) Gampola Bridge

The Mahaweli River channel is considered to be stable, and there will be no problem if the existing river channel is secured. As the new bridge will be designed at a height nearly the same as the existing bridge, a sufficient allowance will exist from the design flood level to clearance under girder.

② Muwagama Bridge

The Kalu River channel is also stable. Considering the river sectional shape on both the upstream and downstream sides, there is no need to increase the bridge length further. It is considered rational to set the new bridge length at the existing length.

4) Road design

(1) Road horizontal alignment

①Alighment design

The Gampola Bridge will be built approximately parallel to the existing road, with the bridge section shifted toward the upstream side. At the Nuwara Eliya side of approach road, the alignment is designed not to interfere with the main building of Teachers College. An alignment ensuring continuation of the existing intersection function for the Gampola side has been selected. The Muwaguma Bridge will be built approximately parallel to the existing road, with the bridge shifted to the downstream side. The approach road is planned as run-off to the existing alignment.

②Scope of implementation

The scope of implementation is shown in Table-2.3.26.

Table－2. 3. 26 Scope of construction of approach road

Site	Start point	End point
No.93 Gampola Bridge	・Gampola side ADB road improvement project Route A5 Measurement point BC No.133 (about 40 m up to box culvert end)	・Nuwara Eliya side JBIC road improvement project Route A5 Measurement point EC No.134 ・Nawarapitiya side Route A013
No.239 Muwagama Bridge	・Ratnapura side Route B390	・Ratnapura side Route B390

③Width composition

The width composition is shown in Table-2.3.4.

For the road composition, a total width of 2.0 m and an effective width of 1.5 m have been secured for the bridge section. The reasons are as follows:

a) A width of 2.0 m is planned for sidewalks in the urban area on the RDA side.

b) In the bridge plan, based on aid from other donors, a total width of 2.0 m and an effective width of 1.5 m have been secured.

c) The route covered by this project corresponds to Type 4, Class 2 of the Japanese Road Structure Ordinance, so that the effective width of 1.5 m must be secured.

The width for the sidewalk has been secured within a range sufficient to ensure the safety of pedestrians.

(2) Road vertical alignment

The vertical alignment was determined in view of the following conditions:

① Gampola Bridge

The elevation is aligned to the existing bridge elevation at the abutment. The approach road will have the alignment already planned in the road improvement supported by the JBIC and the ADB.

② Muwagama Bridge

The elevation determined by adding the free board and girder height to the design high-water level becomes higher than the existing bridge height. Accordingly, a grade of about 3% is provided to the bridge so that the bridge connects to the existing road through the approach road.

(3) Road drainage

Road drainage is provided by restoring the existing drainage device. Basically, U-gutters are arranged along the road, with cross culvert and catch basin provided as required.

(4) Road structures

Where the toe of the embankment slope of road earthwork interferes with the boundary with private land to a great extent, retaining walls, etc. are to be provided as required to reduce the scope of land acquisition. The basic wall structure will be wet masonry, which is employed most frequently in Sri Lanka.

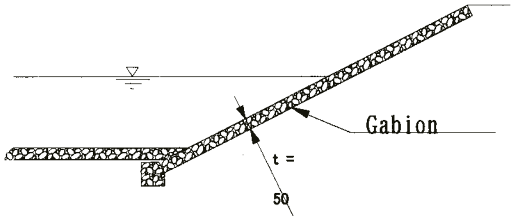
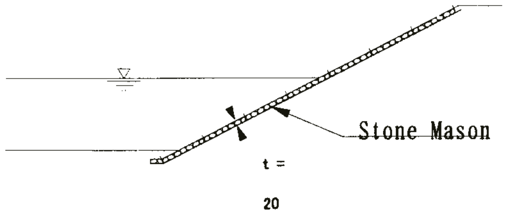
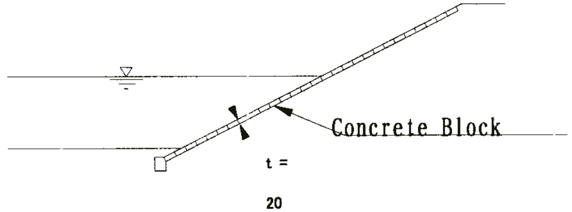
(5) Revetment and bed protection works

The channel varies greatly depending on revetment and bed protection works. In this project, these protection works are provided to ensure a stable channel and bridge safety, etc.

The approach embankment on both sides of the bridge may suffer erosion because the river is meandering greatly before and after the bridge and increase in water volume during the wet season may cause the flow directly against the river slope.

Accordingly, the slope in the river that may affect structures is protected with wet masonry. The bed protection work is provided around abutments and piers. Table-2.3.27 shows a comparison of the revetment types.

Table—2. 3. 27 Comparison of revetment types

	Wire mat work	Masonry work	Concrete block work
Illustration			
Structure	• Gabions and wire mats are available. • Flexible structure, enabling application to any topographical condition • Tends to be easily sucked out in sandy soil ×	• Stones must be arranged in a regular pattern. • Easy to match to topographical condition • Structurally most stable ○	• Installation of prefabricated concrete blocks in a regular pattern. • Leveling stones needed under concrete blocks to ensure flatness. • Not applicable to the complicated topographical condition △
Constructibility	• Easy to do because it is sufficient to load stones into the wire mesh. • No local experience in this kind of work ○	• Lay stones after leveling the ground • Filling to be made with concrete or mortar • Same construction as the existing embankment ○	• Lay concrete blocks after leveling of the ground • Filling to be made with concrete or mortar • Curing of fillers necessary △
Maintenance	• Only loading of stones to points where stones are lost necessary • Maintenance necessary for broken wire mesh ×	• Easy to maintain and repair because only filling at points where stones are lost is necessary. ○	• Repair of lost portion is difficult. ×
Economy	1.10 ×	1.00 ○	1.30 ×
Evaluation	×	○	×

5) Bridge design

(1) Abutment location

The Mahaweli and Kau Rivers where the bridges are located are among the largest rivers in Sri Lanka. The basin width is 50 m or more even during the normal season. There is no levee near the planned site for bridge and the river is flowing in a natural condition. It is necessary to select an abutment location that does not hinder flood control and to conside the river and topographical conditions and the existing bridge location. The abutment location of each bridge is shown below.

① Gampola Bridge

This bridge is already over 70 years old and has suffered flooding several times. It was submerged only once during a great flood in 1947. The bridge has allowed flood waters to flow through the section between the existing abutments during floods occurring almost every year, and the field survey showed no mark of substantial erosion. Therefore, the new bridge is planned with abutment locations aligned to the existing bridge while maintaining the same flow through section as the existing bridge.

② Muwagama Bridge

The topograpy at the bridge point is a relatively flat lowland on the Ratnapura side, with an embankment approach road (H=8). There is a steep slope on the opposite bank. An abutment is erected on the slope. According to the hearing, inundation occurs several times a year around the planned site, and houses in the neighborhood of the bridge are flooded. Being located in a relatively elevated position, this bridge has never been flooded in the 80 years since it was built. The field survey found no signs of large-scale erosion either. Accordingly, the new bridge abutment position is aligned to the existing one while maintaining the same flow-down section as the existing bridge.

(2) Bridge length

To maintain the existing flow-down section, the bridge length was determined as shown in Table-2.3.28. It is designed to prevent the front wall of the abutment from protruding toward the river side beyond the existing abutment.

(3) Pier location (span arrangement)

The pier location must be determined while considering the effects of blockage of flow by bridge piers and blockage with drift wood. Therefore, the pier location is to be determined according to the Cabinet Order Concerning Structural Standards for River Management Facilities while referring to the following standards：

Standard span length：More than the value calculated in Fig-2.3.7. For the existing piers, the standard span length was set to 15 m because it will be removed after completion of the new bridge.

Pier`s flow detrimental ratio：６％ or less

The existing and standard span lengths of both bridges are shown in Table-2.3.29. As the existing span length is approximately equivalent to the standard span length, piers will be provided basically in alignment with the existing pier locations. Therefore, the expected span arrangements are as indicated below. These arrangements for the two bridges are also compared.

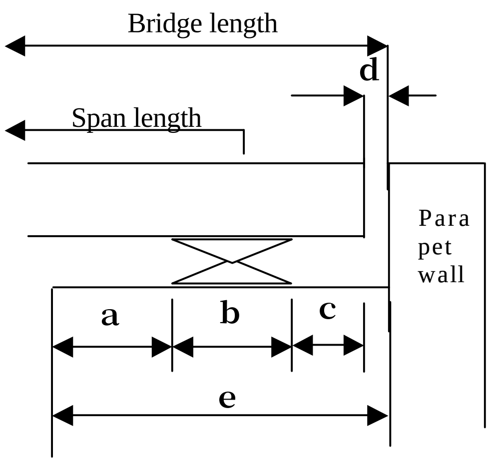
① Gampola Bridge：Single span（Bridge length＝100m span length 98.2ｍ）
Two spans（Bridge length ＝99m span length 48.7ｍ×２）
Three spans（Bridge length＝99m span length 32.6ｍ×３）

② Muwagama Bridge：Single span（Bridge length ＝99m span length 97.2ｍ）
Two spans（Bridge length＝98ｍ span length 48.2ｍ×２）
Three spans（Bridge length＝22＋55＋22=99）

Table－2. 3. 28　Determination of bridge length

		Gampola Bridge			Muwagama Bridge		
Pier distance of existing bridge (Distance between abutment front)	Feet inch	311'6"			308'00"		
	m	94.95			93.88		
Span arrangement		Single span	Two spans	Three spans	Single span	Two spans	Three spans
Bearing support end distance（a）	mm	700	450	400	700	450	300
Bearing support width（b）	mm	1000	800	600	1000	800	500
Bearing support end - girder end distance（c）	mm	300	300	200	300	300	200
Girder expansion gap（d）	mm	100	100	100	100	100	100
Shoe width（e = a + b + c + d）	mm	2100	1650	1300	2100	1650	1100
Bridge length	m	100.0	99.0	99.0	99.0	98.0	99.0
Span length	m	98.2	48.7	32.6	97.2	48.2	55.0
New bridge abutment distance	m	95.7	95.8	96.4	94.8	94.7	96.8

1 feet＝0.3048 m＝12inchs
1 inch＝2.54cm



Table－2．3．29　Existing and standard span lengths

Bridge	Span arrangement of existing bridge	Design rainfall	Standard span length(m)	Remarks
Gampola Bridge	47.95＋47.95 ＝95.9 (m)	2,650 (m^3/sec)	20	There is a dam on the upstream side; no large flood has occurred in recent years. No substantial problem is expected in terms of river control.
Muwagama Bridge	19.51+54.86+19.51 =93.88 (m)	4,550 (m^3/sec)	20	Existing minimum span length is 19.51m, and no deformation (scouring) has occurred. The existing bridge scale will not present any substantial hindrance.

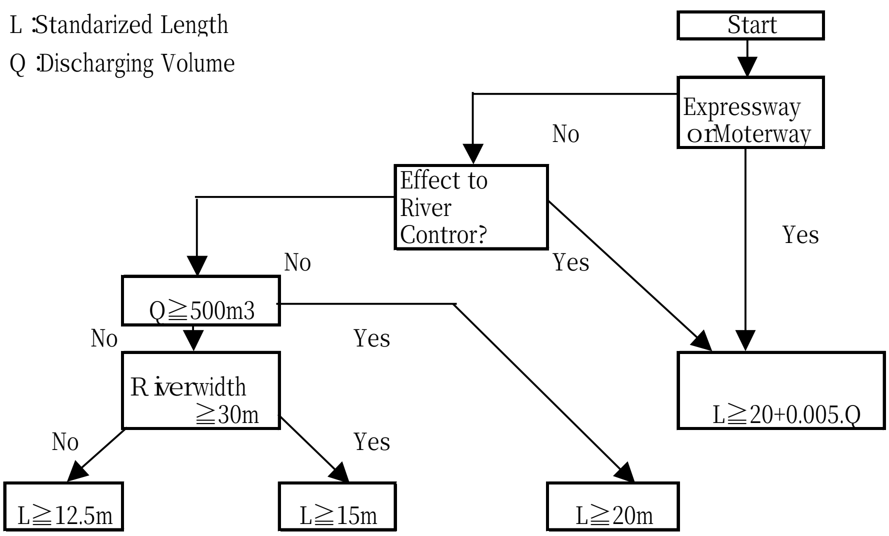


Fig.－2．3．8　Calculation of span length

6) Selection of bridge type

(1) Basic requirements for bridge type

The following basic requirements are taken into account to select the bridge type:

① Economically superior type with low construction cost

Generally, the steel bridge tends to be higher in unit price than the concrete bridge. The bridge covered by this basic design has a length of 100 m, for which the steel bridge will be advantageous in certain cases depending on construction and local conditions. Accordingly, review will be made for concrete and steel bridges to ensure selection of an economically feasible type.

② Ease of maintenance

Concrete bridges are advantageous in terms of maintenance, and a review will be made of selection of a concrete bridge type. Certain steel bridges may use uncoated steels, but this basic design basically uses the coating specification.

③ Type allowing the use of materials and construction machinery procurable in Sri Lanka.

Materials and construction machinery procurable in Sri Lanka are easier to obtain. The type selected should allow easy procurement of materials and machinery in Sri Lanka.

④ Type with less special equipment to ensure effective technology transfer

The type should not involve a great deal of special technology because employment of a large number of local workers is desired to contribute to reduction of unemployment and bring other economic effects. The type to be selected will also take into account transfer of Japanese technology to local engineers to train engineers to be able to work independently.

⑵ Superstructure type

Considerations include: (1) Fundamentals for Selection of Bridge Types The four plans shown below are selected for the superstructure of this project on the basis of standard applicable spans of Table-2.3.30 and compared.

Table－2. 3. 30 Proposed Design for Superstructure

Bridges	Gampola Bridge	Muwagama Bridge
Plans for comparison	①Single-span Langer bridge ②Two-span continuous steel plate girder bridge ③Two-span continuous prestressed concrete box girder bridge ④ Three-span post-tensioned connection girder	①Single-span Trussed Langer bridge ②Two-span continuous steel plate girder bridge ③Three-span simple prstressed concrete girder bridge ＋simple truss ④ Three-span continuous prestressed concrete rigid frame bridge

Table－２．３．31 List of standard applicable span

Type		Span (50m / 100m / 150m)	Girder height/ span ratio
Steel bridge	Simple composite girder		1/18
	Simple girder		1/17
	Continuous girder		1/18
	Simple box girder		1/22
	Continuous box girder		1/23
	Simple truss		1/9
	Continuous truss		1/10
	Deck Langer girder		1/6.5
	Deck Lohse girder		1/6.5
	Arch		1/6.5
Prestressed concrete bridge	Simple pre-tension girder		1/15
	Simple hollow slab		1/22
	Simple T girder		1/17.5
	Simple composite girder		1/15
	Continuous composite girder		1/15
	Continuous non-composite girder		1/16
	Simple box girder		1/20
	Continuous box girder(cantilever)		1/18
	Continuous box girder(support)		1/18
	π type rigid frame		1/32
concrete	HHollow slab		1/20
	CContinuous spandrel-filled arch		1/2

3) Substructure types

The following points are to be taken into account for selection of the substructure type, particularly, the abutment.

—An abutment front wall is provided so that the bridge axis becomes normal to the river channel, and the structural plan must ensure that the front wall does not protrude over the river beyond the existing abutment. Due attention must also be paid to provide protection against scouring around the abutment.

—The abutment and pier must of a structure safe against water flow at the high-water level. The appropriate embedded depth must be secured according to the flow velocity and bed soil, with the footing top end embedded to a minimum 2.0 m depth from the river bed.

—Basic abutment type is to be an inverted T type that is most economical.

—Piers must be of the economical type sufficiently safe against scouring.

a) Foundation type

In this study, a boring survey was made at six points for Gampola Bridge and at 12 points for Muwagama Bridge (of which eight are for the existing survey data). In consequence, the following foundation types were selected.

Table—2.3.32 Foundation Type

	Gampola Bridge	Muwagama Bridge
A 1 abutment	Spread foundation	Pile foundation
P 1 abutment	Spread foundation	Pile foundation
P 2 abutment	Spread foundation	Pile foundation
A 2 abutment	Pile foundation	Pile foundation

For pile types, reinforced concrete piles, prestressed concrete piles, H-steel piles, steel pipe piles, and cast-in-place piles as shown in Table-2.3.33 are considered. The cast-in-place was selected for the following reasons:

- Piles made in Sri Lanka are difficult to use because of the large bridge size
- Relatively long piles are advantageous in terms of workability and economy.
- Easy to work with in the field
- Reliable construction

A comparison of cast-in-place piles φ800, φ1000, and φ1200 available for this project was made. Piles φ1000 in size, as shown in shown in Fig.-2.3.9 were found to be most economical.

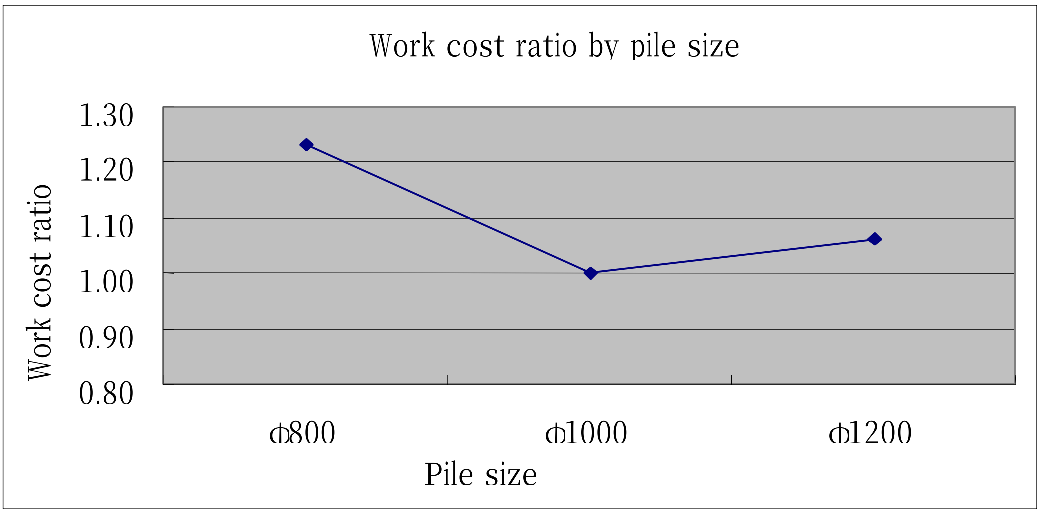


Fig.－2. 3. 9 Work cost ratio by pile size

Table－2. 3. 33 Features of available pile types

Pile type	Pile length application range	Supplier	Features
Reinforced concrete piles	5m to about 10m	Manufacture possible in Sri Lanka	• As a driving method is to be employed, these piles are generally used in cases with a soft upper stratum and a bearing layer to a depth of about 10 m. • Used for foundation of small bridges where vertical and horizontal loads are small. • Attention necessary for damage such as cracks, etc. during driving • Difficulty in joint treatment • Economically advantageous
Prestressed concrete piles	About 30m	Import (Thailand, Singapore, Japan)	• As a driving method is considered to be employed, these piles are generally used in cases with a soft upper stratum and a bearing layer to a depth of about 30 m. • Used for foundation of small bridges where vertical and horizontal loads are small. • Fewer cracks and less damage during driving because concrete strength is higher than that of reinforced concrete piles. • Slightly economically advantageous
H steel piles	About 30m	Import (Thailand, Singapore, Japan)	• Applicable when piles are long because there is no problem in terms of welding joints. • Normally applied to foundation of temporary structures. • Prevention of corrosion necessary • Slightly economically advantageous

Steel pipe piles	15～60m	Import (Thailand, Singapore, Japan)	• Applicable when the piles are long because there is no problem in terms of welding joints. • Used for bridge foundation where vertical and horizontal loads are large. • Slightly economically disadvantageous
Cast-in-place piles	15～60m	Procurable in Sri Lanka (Possible if the excavation machine is available)	• Applicable when the piles are long because there is no problem in terms of welding joints. Applicable when vertical and horizontal loads are large. • Used for bridge foundation where vertical and horizontal loads are large. • Slightly economically inferior

Table－2. 3. 34　Foundation type selection table

Conditions \ Type of Foudaton				Spread Foundation	Driving Pile Foundation			Pile Foundation by Inner Excavation						Cast-in-place Pile Foundation				Caisson Foundation		Steel Pipe Sheet Pile Foundation	Diaphragm Foundation
								PHC Pile			Steel Pipe Pile										
					RC Pile	PHC Pile	Steel Pipe Pile	Final Impact Method	Jet String Method	Concrete Placing Method	Final Impact Method	Jet String Method	Concrete Placing Method	All Casing	Reverse Circulation Drill	Earth Drill	Caisson Type	Pneumatic Caisson	Open Caisson		
Ground Conditions	Conditions above Bearing Layer	Extremely Soft Layer in Intermediate Stratum		△	○	○	○	○	○	○	○	○	○	○	○	×	×	○	○	○	○
		Extremely Hard Layer in Intermediate Stratum		○	×	△	○	○	○	○	○	○	○	△	○	△	○	○	△	△	○
		Gravel in the Intermediate Stratum	Gravel Size 5cm or less	○	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			Gravel Size 5cm～10cm	○	×	△	△	△	△	△	△	△	△	○	○	△	○	○	○	△	○
			Gravel Size 10cm～50cm	○	×	×	△	×	×	×	×	×	×	△	×	×	○	○	△	×	△
		Ground that would Liquefy Exists		△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Conditions of the Bearing Layer	Depth of Bearing Layer	Less than 5m	○	×	×	×	×	×	×	×	×	×	×	×	×	○	×	×	×	×
			5～15m	△	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	△	△
			15～25m	×	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			25～40m	×	×	○	○	○	○	○	○	○	○	○	○	△	△	○	○	○	○
			40～60m	×	×	△	○	△	△	△	○	○	○	△	○	×	×	△	○	○	○
			More than 60m	×	×	×	△	×	×	×	×	×	×	×	△	×	×	×	△	△	△
		Nature of Bearing Layer Soil	Clayey Soil (20≦N)	○	○	○	○	○	×	△	○	×	△	○	○	○	○	○	○	○	○
			Sand, Gravel (30≦N)	○	○	○	○	○	○	×	○	○	×	○	○	○	○	○	○	○	○
		Large Dip (More than 30 degree)		○	×	△	○	△	△	△	○	○	○	○	△	△	○	○	△	△	△
		Excessive Irregularities of Bearing Layer Surface		○	△	△	○	△	△	△	○	△	△	○	○	○	○	○	△	△	○
	Groundwater Condition	Groundwater Levels near surface		△	○	○	○	○	○	○	○	○	○	○	○	△	△	○	○	○	○
		Extremely Large Amount of Inflow Water		△	○	○	○	○	○	○	○	○	○	○	○	△	×	○	○	○	△
		Confined Groundwater at 2 m or more from surface		×	○	○	○	×	×	×	×	×	×	×	×	×	×	△	△	○	×
		Groundwater flow of 3m/min or more		×	○	○	○	○	×	×	○	×	×	×	×	×	×	○	△	○	×
Structural Characteristics	Load Size	Small Vertical Load (Span 20m or Less)		○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	△	×	×
		Normal Vertical Load (Span 20m～50m)		○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Large Vertical Load (Span 50m or more)		○	×	△	○	△	△	△	○	○	○	○	○	△	○	○	○	○	○
		Horizontal Load Comparatively Smaller than Vertical		○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△
		Horizontal Load Comparatively Larger than Vertical		○	×	△	○	△	△	△	○	○	○	○	○	○	○	○	○	○	○
	Type of Support	Bearing Pile		/	○	○	○	○	○	○	○	○	○	○	○	○	○	/	/	/	/
		Friction Pile		/	○	○	○	/	/	/	/	/	/	○	○	○	/	/	/	/	/
Work Conditions	Work Above Water	Water Depth less than 5m		○	○	○	○	△	△	△	△	△	△	×	○	△	×	△	△	○	×
		Water Depth 5m or more		×	△	△	○	△	△	△	△	△	△	×	△	×	×	△	△	○	×
	Narrow Working Space			○	△	△	△	△	△	△	△	△	△	△	△	△	○	△	△	×	△
	Batter Pile			/	△	○	○	×	×	×	△	△	△	△	×	×	×	/	/	/	/
	Effects of Harmful Gas			△	○	○	○	○	○	○	○	○	○	○	○	○	×	×	○	○	○
	Environment	Anti-vibration / Anti-noise Measures		○	×	×	×	△	○	○	△	○	○	△	○	○	○	○	○	△	○
		Effects on Neighboring Structures		○	×	×	△	△	○	○	△	○	○	○	○	○	△	△	△	△	○

○：Highly Applicable　△：Applicable　×：Less Applicable

(4) Selection of the bridge type

The comparison table of bridge tables is shown in subsequent pages. In consequence, the following bridge types were selected:

①Gampola Bridge：Three-span post-tensioned connection girder bridge
Reason：Economically superior. Easy to maintain

②Muwagama Bridge：Single-span Trussed Langer bridge
Reason：No economical difference, but the shortest in work period.
Not susceptible to effects of wet season
Not susceptible to scouring of river bed

Table−2. 3. 35(1) Comparison Study on Bridge Type Selection for No.93 Gampola Bridge

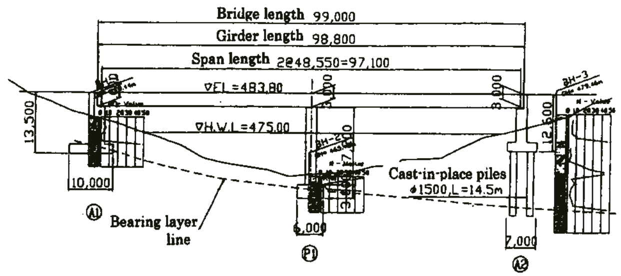
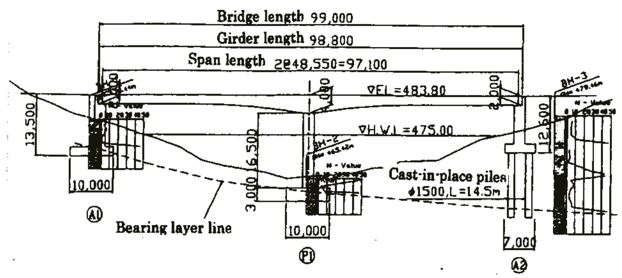
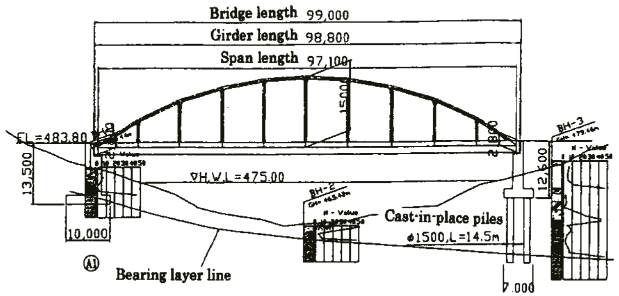
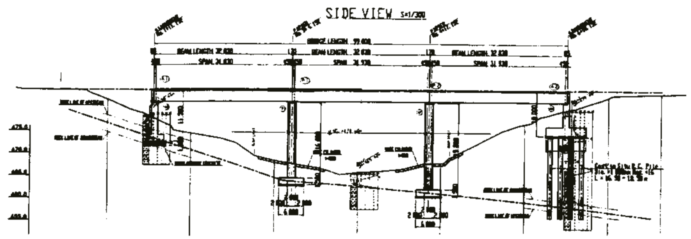
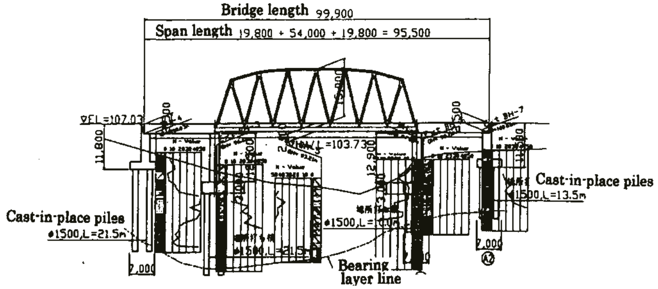
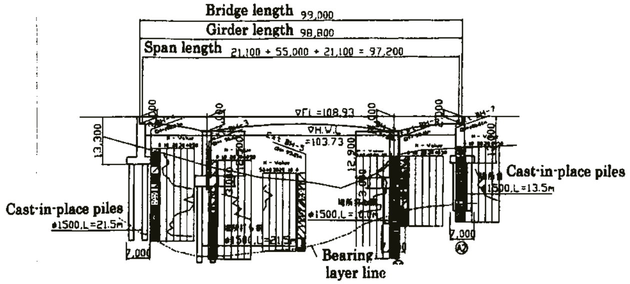
	Plan 1 : Two-spaned Continuous Steel I Girder Bridge	Plan 2 : PCT type Rigid-Frame Bridge
Illustration		
Structural outline	･Section with equal girder heights. About 3.0 m girder height necessary ･Main girder structure based on five steel I girders. ･Weather resistant non-coated girder used to facilitate maintenance ･Cast-in-place concrete slabs	･Ordinary prestressed concrete rigid-frame bridge ･The girder height at fulcrum is about 4.0 m. ･Main girder is of a box girder structure. Prestressed concrete structure employed in the transverse direction if necessary. ･Large load carried by the intermediate piers. The pier size need not be increased because of absence of earthquake.
Work outline	･Superstructure to be erected through launching method using temporary bent and erection nose ･Right-of-way on the right bank used for superstructure work yard ･Before construction of piers, temporary closure with double cofferdam is made. ･Landing bridge for access is provided from the right bank side. ･Temporary platform necessary on the left bank for construction of abutment on the left bank	･Main girder to be erected according to a cantilever method. ･Connection between abutment and cantilever (side span section) to be erected using the support on the ground ･Landing bridge to be provided from the right bank ･For construction of piers, temporary closure is made with a double cofferdam. ･Temporary platform necessary on the left bank for construction of abutment on the left bank
Structural merits/demerits	○No design problem ○As the required girder height can be secured, there is no need to change the existing road height.	○Ordinary T rigid-frame strcuture without any design problem ○As the required girder height can be secured, there is no need to change the existing road height
Work merits/demerits	○No substantial problem in terms of construction work ●Temporary bent necessary in the river during superstructure construction ●Cofferdom (18 x 18 m) for pier construction and temporary landing bridge are necessary.	○Cantilever erection for which there is abundant overseas experience ●Concrete and other materials are to be supplied from intermediate piers. Landing bridge necessary till the superstructure is completed. ●Cofferdom (18 x 18 m) for pier construction and temporary landing bridge necessary
Effects on river	･Standard span length is met. ･Pier's flow detrimental ratio is about 5%. ･Temporary blockage may occur during construction of piers.	･Standard span length is met ･Pier's flow detrimental ratio is about 6% ･Temporary blockage may occur during construction of piers
Cost Comparison	1.15	1.06
Work periods	22 months	26 months
Maintenance	○The use of weather-resistant steels can eliminate the necessity of maintenance, such as painting, etc.	○Concrete structure, which requires less maintenance than the steel bridge.
Overall evaluation	･Most advantageous in terms of process, but inferior in terms of economy ･Technology guidance necessary for maintenance in the future ･Use of weather-resistant steel may present aesthetic problem (girder color). ○	･Less future maintenance required ･Concrete bridge, with high technology transfer effect ○

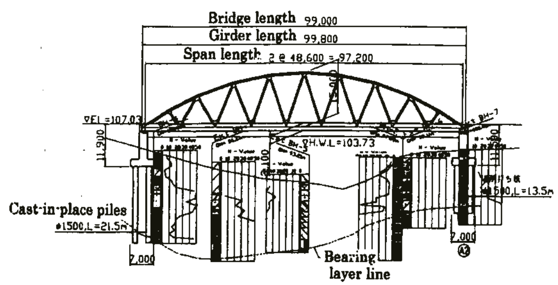
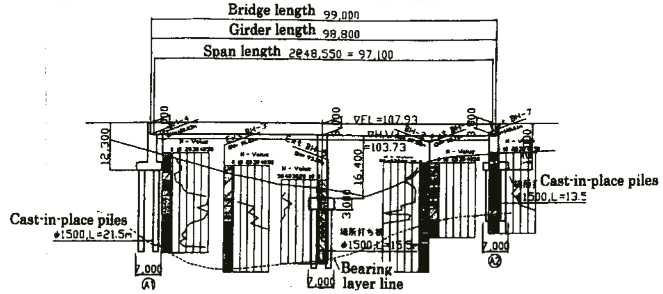
Table-2. 3. 35(2) Comparison Study on Bridge Type Selection for No.93 Gampola Bridge

	Plan 3 : Steel Langer Bridge	Plan 4 : Three-Span Continous Post-tension Composite Girder Bridge
Illustration		
Structural outline	・Single-span steel through Langer bridge	・Three-span PC post-tension connection composite girder bridge, without need of expansion ・Single girder at a time of girder erection. Under live load, this carries the load as continuous girder. ・Four main girders with height of 1.3m ・Cast-in-place reinforced concrete slabs using precast plates
Work outline	・Launching method with erection nose and temporary bent while construction is underway on the right bank. ・Right-of-way on the right bank used for the work yard ・Temporary platform necessary on the left bank for construction of the left-bank abutment	・Precast girders fabricated in the fabrication yard and erected through launching ・Labor saving possible by the use of precast members ・Temporary platform necessary on the left bank for construction of left-bank abutment ・Landing bridge for access to be provided from the right bank side ・For pier construction, temporary closure made with a double cofferdam
Structural merits/demerits	○No design problem ○Aesthetically satisfactory ●Large abutment size	○No design problem ○Though the number of piers increases, the size is reduced.
Work merits/demerits	●Temporary bent necessary in the river ●Less workability because of limited yard availability on the right bank ●Complicated control during launching, such as deflection control, etc.	○Improved quality control because main girders are fabricated in the yard ○Ordinary method, without issues related to construction works ○Not exposed to effects of flood during erection of superstructure ●Girder fabrication yard must be newly secured because the construction yard is limited.
Effects on river	○Almost no effects on the river	○No effects on the river once the existing bridge is removed. ●Effects on the river may occur when the existing bridge is not removed
Cost Comparison	1.27	1.00
Work periods	23カ月	24カ月
Maintenance	○Use of weather-resistant steels can eliminate the necessity of maintenance	○Concrete structure, which is easy to maintain
Overall evaluation	・Less effects on the river, but inferior in economy ・Aesthetically satisfactory △	・Economically superior and easy maintenance in the future ・Concrete bridge with high technology transfer effect ・Effects on river may occur when the existing bridge is not removed. ◎

Table—2. 3. 35(3) Comparison Study on Bridge Type Selection for No.239 Muwagama Bridge

	Plan 1 : Steel Truss (Main span) +Prestressed Concrete Simple T girder Bridge (Side span)	Plan 2 : Three-span Continuous Prestressed Concrete Box Girder Bridge
Illustration		
Structural outline	・Prestressed concrete post-tensioning girder between side spans and truss structure for center span ・Combination of simple girders comprising steel and concrete bridges ・Pile foundation for abutments and piers because the bearing stratum is deep ・Coating of truss girders	・Ordinary prestressed concrete rigid-frame bridge ・Girder height at fulcrum is about 1.0m. ・Main girder to be of a box structure. If necessary, prestressed concrete structure in a horizontal direction
Work outline	・Center span truss erected through launching after completion of side spans ・Piers can be constructed from the land. Considering the soft ground and high water during rainy season, a work platform is provided. ・Cast-in-place concrete piles for the foundation	・Support provided for side spans in advance, followed by cantilever from piers ・Piers can be constructed from the land. Considering the soft ground and high water during the rainy season, a work platform is provided ・Cast-in-place concrete piles for the foundation
Structural merits/demerits	○Combination of simple bridges, without any particular problem ●The girder height is, at the lowest point,1.2m, and the approach road height increases by about 50 cm.	●At its highest, girder height is 4m, and the approach road becomes elevated by about 3 m from the existing level. ●Unbalanced span arrangement, resulting in uneconomical section
Work merits/demerits	●Deflection control necessary during launching of truss. ●Work yard on the left bank narrow, poor workability. ●Because of boulders, construction of piers and abutment foundations is not easy. ●High water during wet season restricts the pier construction period, making process control difficult.	●Form travellers may be submerged due to high water during wet season ●The foundation is necessary for the support of the side span. ●Narrow work yard on the left bank, with poor workability ●Because of boulders, construction of piers and abutment foundations is not easy ●High water during rainy season restricts the pier construction period, making process control difficult
Effects on the river	○Standard span length is met and there is no problem. ○Pier's flow detrimental ratio about 6% ●Exposed to effects of existing bridge till it is removed ●Temporary blockage of flow during construciton of piers	○The standard span length is met and there is no problem. ○Pier's flow detrimental ratio is about 6%. ●Exposed to the effects of existing bridge till it is removed ●Temporary blockage of flow during construciton of piers
Cost Comparison	1.01	1.02
Work periods	24 months	28 months
Maintenance	●Periodical maintenance of coating, etc.	○Concrete structure requires less maintenance than a steel bridge
Overall evaluation	・Susceptible to effects of rainy season. Due to large number of boulders, foundation piles is difficult to construct. ・Slightly inferior in terms of economy and work periods ○	・Economically superior, but with longer work periods and susceptibility to effects of rainy season ・Because of boulders, foundation piles is difficult to construct. Substantial change in the vertical alignment ・Concrete bridge with high technology transfer effect △

Table—2. 3. 35(4) Comparison Study on Bridge Type Selection for No.239 M[illegible]wagama Bridge

	Plan 3 : Steel Trussed Langer Bridge	Plan 4 : Two-span Continuous Steel I Girder Bridge
Illustration	 	
Structural outline	・Single-span steel through Langer bridge ・Trussed Langer because cantilever is provided partially ・Cast-in-place concrete slabs ・Coating	・Section with equal girder heights, About 3.0 m girder height necessary ・Main girder structure based on five steel main I girders ・Weather resistant non-coated girder used to facilitate maintenance ・Cast-in-place concrete slabs
Work outline	・Temporary bent is provided. Construction with support for on-land work while cantilever method used for the section over the river ・Right-of-way on the right ban used for the work yard. A yard is also provided on the right bank. ・Cast-in-place concrete piles for the foundation.	・Superstructure erected through launching with temporary bent and erection nose ・Right-of-way on the right bank used for superstructure work yard ・For pier construction, temporary clousure made with double cofferdam ・Landing bridge for access to be provided from the right bank ・Temporary platform necessary on the left bank for construction of the left-bank abutment ・Cast-in-place concrete piles for the foundation
Structural merits/demerits	○No design problem ○Intermediate pier not necessary ●The girder height is about 2m, and the approach road height increases by 1 m. ●Increased abutment size	○No design problem ○The required girder height can be secured. There is no need to substantially change the existing road
Work merits/demerits	○Less susceptible to effects of high water during wet season ●Temporary bent (pile foundation) necessary in the river ●Foundation piles necessary for the bent ●Less yard on the right bank, with poor workability ●Because of boulders, abut foundation is difficult to construct	○No substantial problem in terms of work ●Temporary bent (pile foundation necessary in the work during erection of superstructure) ●Copfferdam (18 x 18 m) and temporary landing bridge necessary for pier construction ●Because of boulders, pier and abutment foundations are difficult to construct ●High water during rainy season restricts the pier construction period, making process control difficult
Effects on the river	○No blockage of flow because there is no structure in the river ○No substantial effect even when the existing bridge is left.	●New pier to be provided in the middle of river, causing substantial effects on the river ●When detrimental effects on the river are confirmed, the standard span length (45 m) is to be increased. This is not acceptable when considering the existing piers. ●Pier's flow detrimental ratio is about 5%. As three piers will exist in the river until the bridge is removed, this detrimental ratio is high ●Temoirary blockage of flow during construction of piers.
Cost Comparison	1.00	1.02
Work perid	21 months	22 months
Maintenance	●Periodical maintenance of coating, etc.	○Use of weather resistant steel to eliminate need for maintenance of coating., etc.
Overall evaluation	・Less susceptible to effects of high water during rainy season and scouring of existing bridge piers ・Short work period and superior economy ◎	・Pier to be provided in the middle of river newly, causing substantial effects on the river ・Most advantageous in terms of process, but inferior in economy ・Use of weather resistant steel causes aesthetic problem (girder color) △

CHAPTER 4

Chapter 4 Project Evaluation and Recommendation

4－1 Project Effects

This project aims at economic development and improvement of people’s livelihoods in regional society along the road including bridges. The project also involves reconstruction of heavily damaged bridges to prevent physical damage and injury to personnel due to the bridge falling and to avoid stagnation of regional social activities and administrative functions incurred by associated traffic shutdowns.

The area covered by this project has facilities necessary for daily life. Considering the current bridge conditions, such as deterioration and blockage of traffic by oncoming traffic, etc., however, urgent rehabilitation is necessary. There is a great expectation of grant-aid for development of social infrastructures. Concerning both bridges, it is either impossible or extremely difficult to use another route.

Effects of this project are listed in the table below.

Table- 4. 1. 1 Effects of this project

Present state and problems	Countermeasures	Effects and degree of improvement
① Danger of bridge falling due to scouring of piers and deterioration of the bridge	① Replacement with a new bridge with a structure highly resistant to floods by raising the road and embedment of abutment/piers for protection of approach slope.	①Assurance of traffic throughout the year around and improvement of traveling quality, which is expected to contribute to stabilization of people's livelihoods, such as securing medical service and public order in case of emergency
② Bridges covered by project are not durable under heavy traffic and not wide enough to allow smooth running of large industrial trucks.	② Rehabilitation to assure traffic of heavy vehicles including large trucks.	②The road will fully function as a national road to contribute to economic development of the region and the country.
③ The bridge width and number of lanes not complying with the Sri Lank standard make travel in opposite directions impossible on the bridge, causing traffic bottlenecks.	③ Rehabilitation to create bridge width and number of lanes complying with the Sri Lanka standard to cope with current conditions.	③Appropriate bridge width and number of lanes for current conditions will enable smooth traffic flow.
④ The sidewalk is narrow and heavily damaged, causing mixed traffic of pedestrians, bicycles, and vehicles, resulting in safety problems.	④ Separation of the sidewalk and roadway according to traffic volume to secure traffic safety.	④ Enhanced safety through separation of sidewalk and roadway.
⑤ The river water level rises in the rainy season. Some bridges cannot ensure clearance for maximum water level.	⑤ Create appropriate clearance to eliminate possibility of flooding.	⑤Securing of sufficient flow capacity of the river to prevent traffic failure caused by road flooded with river water, thereby contributing to stabilization of the society and economy.

The population to benefit from the project is about 4 million, including the Central Province (about 2.3 million) where the Gampola Bridge is located and the Sabaragamuwa Province (about 1.7 million) where the Muwagama Bridge is located Projects of other donors do not interfere with this project, and project implementation based on grant-aid is judged to be appropriate. After consideration of the Sri Lanka's capacity for maintenance and operation of this project, implementation based on grant-aid is considered appropriate.

4－2　Technical cooperation and tie-ups with other donors

The World Bank, ADB、 and JBIC will provide the following aid for the road sector.

Table－4．2．1　Aid condition of other agencies

Donors	Project name	Year of implementation
ADB	Road rehabilitation　(First)	Completed in 1992
ADB	Rehabilitation of road and seven bridges (Second)	Completed in 1996
WB	Rehabilitation of road and 26 bridges（First）	Completed in 1989
WB	Rehabilitation of road and 22 bridges　（Second）	Completed in 1997
WB	Rehabilitation of road and 19 bridges (Third)	Completed in 1998
ADB	Rehabilitation of road and 25 bridges　（Third）	Completed in 1999
Kuwait Fund	Reconstruction of 27 bridges	1997～under way
EDCF	Ratnapura - Bandarawela road rehabilitation	Completed in 1999
EDCF	Ratnapura - Balangoda road rehabilitation	2000～2002 under way
ADB/JBIC	Rehabilitation of road and 47 bridges (Fourth)	2000～2002 under way
ADB/JBIC	Construction of Southern Expressway	Detail design under way
EDCF	Hatton - Nuwara Eliya road rehabilitation	
EDCF	Katunayake～Padeniya road rehabilitation	
Saudi Fund	Rehabilitation of seven bridges	

This project does not overlap with other donors' projects and its implementation on the basis of grant-aid is considered appropriate.

Tie-ups with other donors in the course of this project are possible for the following matters.　This is expected to further enhance its effects.

① Gampola Bridge

The national road AA005 connecting the second largest city of Sri Lanka, Kandy, with Nuwara Eliya, the tea production site and a leading tourist sites, is now under improvement because of its importance.　For the Kandy – Gampola section where traffic volume is the largest, improvement work is under way with the ADB fund support.　Road improvement work is also planned under assistance from JBIC for the mountainous area between Gampola and Nuwara Eliya.　This project, which involves reconstruction of the narrow Gampola Bridge that causes bottlenecks, lends itself to tie-ups with road improvement projects respectively of ADB and JBIC before and after this bridge.　These in turn will alleviate traffic hindrances over the entire route of AA005.

② Muwagama Bridge

The B390 road branches from A4 in the approximate center of Ratnapura, passes through the Muwagama area divided by the Kalu River, and connects to Palawela, Karawita.

Because of the short distance to the center of Ratnapura, Muwagama and areas on opposite banks of the Kalu River are now commutable areas and serve more and more as commuter towns along with the development of the central area of Ratnapura.

In line with this situation, the traffic through the Muwagawa Bridge has increased substantially due to the increase in commuters in addition to the conventional traffic for tea transport.

This project involves reconstruction of the Muwagama Bridge that now is a hindrance to traffic to and from the Muwagama area and the central area of Ratnapura because of its narrowness. The project will eliminate congestion along B390 while supporting the Ratnapura City Development project through tie-ups. Moreover, tie-up with the ADB's road network improvement project for development and improvement of the A4 section between Colombo and Ratnapura and with an EDCF project (supported by Korean loan) for development and improvement of the section from Ratnapura toward Balangoda, Central Province will facilitate communication between cities. This will effectively contribute to networking for smooth exchanges of personnel and goods.

4－3 Recommendation

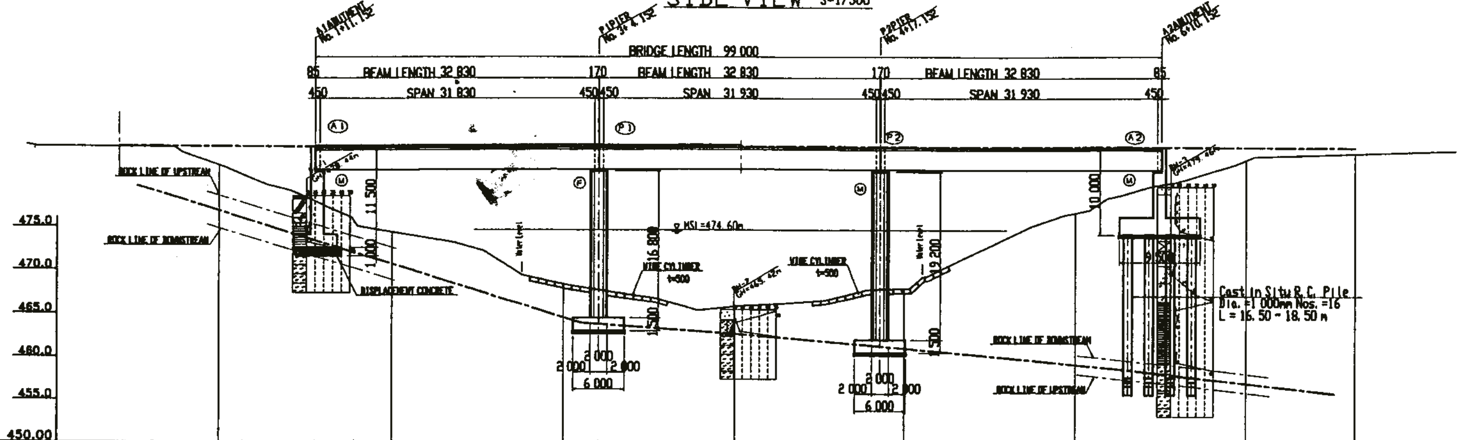
As described above, implementation of this project will offer considerable effects and contribute greatly to social and economic development in the surrounding areas. Therefore, the appropriateness of implementing this project on the basis of grant-aid can be confirmed. In addition, the Sri Lanka capacity in terms of personnel and funds is considered sufficient and without any problem for operation and administration of this project. Note however that re-coating every 10 years must be made without fail for the Muwagama Bridge.

Review of the budgetary measures of RDA, an implementing agency of the Sri Lanka Government, and the technical and operational capability of divisions in charge showed that implementation on the basis of grant-aid is appropriate.

DRAWINGS

No. 93 GAMPORA BRIDGE GENERAL VIEW

SIDE VIEW S=1/300

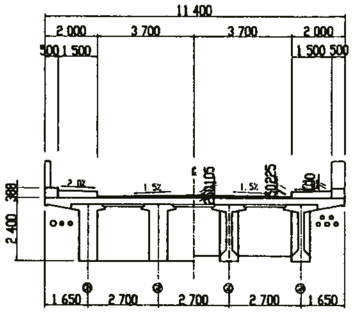


PROPOSAL EL	484.034	484.042	484.068	484.081	484.093	484.134	484.139	484.149	484.149	484.139	484.136	484.097	484.081	484.068	484.060	484.047	484.047	484.067
GROUND EL	482.450		478.330		474.200	468.100	467.700	466.100	466.180	467.780	470.900	477.700		479.550		483.210		483.280
DISTANCE	20.000	22.760	31.152	35.652	40.000	60.000	64.152	80.000	80.652	97.152	100.000	120.000	125.652	130.152	132.682	140.000	140.730	152.682
SPAN	20.000	2.760	8.392	4.500	4.348	20.000	4.152	15.848	0.652	16.500	3.500	20.000	5.652	4.500	2.530	7.348	0.730	11.952
STATION	No. 1	+2.760	+11.152	+15.652	No. 2	No. 3	+4.152	No. 4	+0.652	+17.152	No. 5	No. 6	+5.652	+10.152	+12.682	No. 7	+0.730	+12.682

GRADE: i = 0.300% L = 80.652m; 484.216; i = 0.300% L = 72.030m; 484.000; i = 1.043% L = 102.582m

CURVE: IP No. 1 IA=52° 9' 43" R= 25 TL=12.237 CL=22.760; R = ∞; IP No. 2 IA=4° 53' 42" R= 200 TL=8.549 CL=17.087

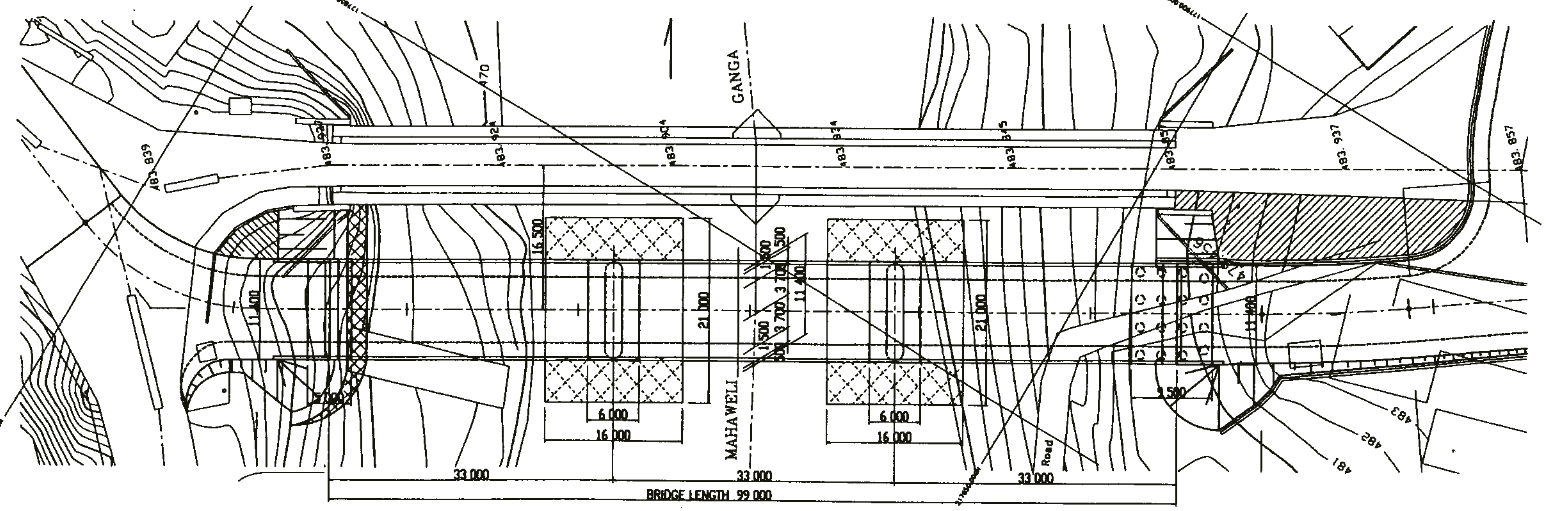
SUPERSTRUCTURE S=1/100



DESIGN CRITERIA

ROAD CLASSIFICATION		A
TIPE		3 SPAN COMBINED PC COMPOSITE GIRDER
BRIDGE LENGTH		99. 000m
SPAN LENGTH		3 @ 32. 000m
ROAD VIDTH		CARRIAGEVAY 7.400m, SIDE VALK 2@1.500m
PAVEMENT		ASPHALT CONCRETE t=50mm
LONGITUDINAL GRADIENT		AS SHOWN
CROSS SECTIONAL GRADIENT		AS SHOWN
DESIGN LIVE LOAD		TYPE B LIVE LOAD
SKEWED ANGLE		90° 00' 00"
DESIGN HORIZONTAL SEIEMIC INTENSITY		N. A
TIPE OF SUB STRUCTURE		A1, A2 : INVERTED T TYPE P1, P2 : WALL TYPE
TIPE OF SUB FOUNDATION		A1, P1, P2 : DIRECT A2 : BORED PILE
GEOLOGICAL CONDITION OF SUPPORT		GRANITE(SOFT~MEDIUM HARD ROCK)
SUPER STRUCTURE	CONCRETE	σck=30 N/mm²
	R-BAR	SD345
SUB STRUCTURE	CONCRETE	σck=24 N/mm²
	R-BAR	SD345
APPLIED STANDARD		「SPECIFICATION OF HIGHWAY SRIDGE」
		JAPAN ROAD ASSOCIATION (DEC.1996)

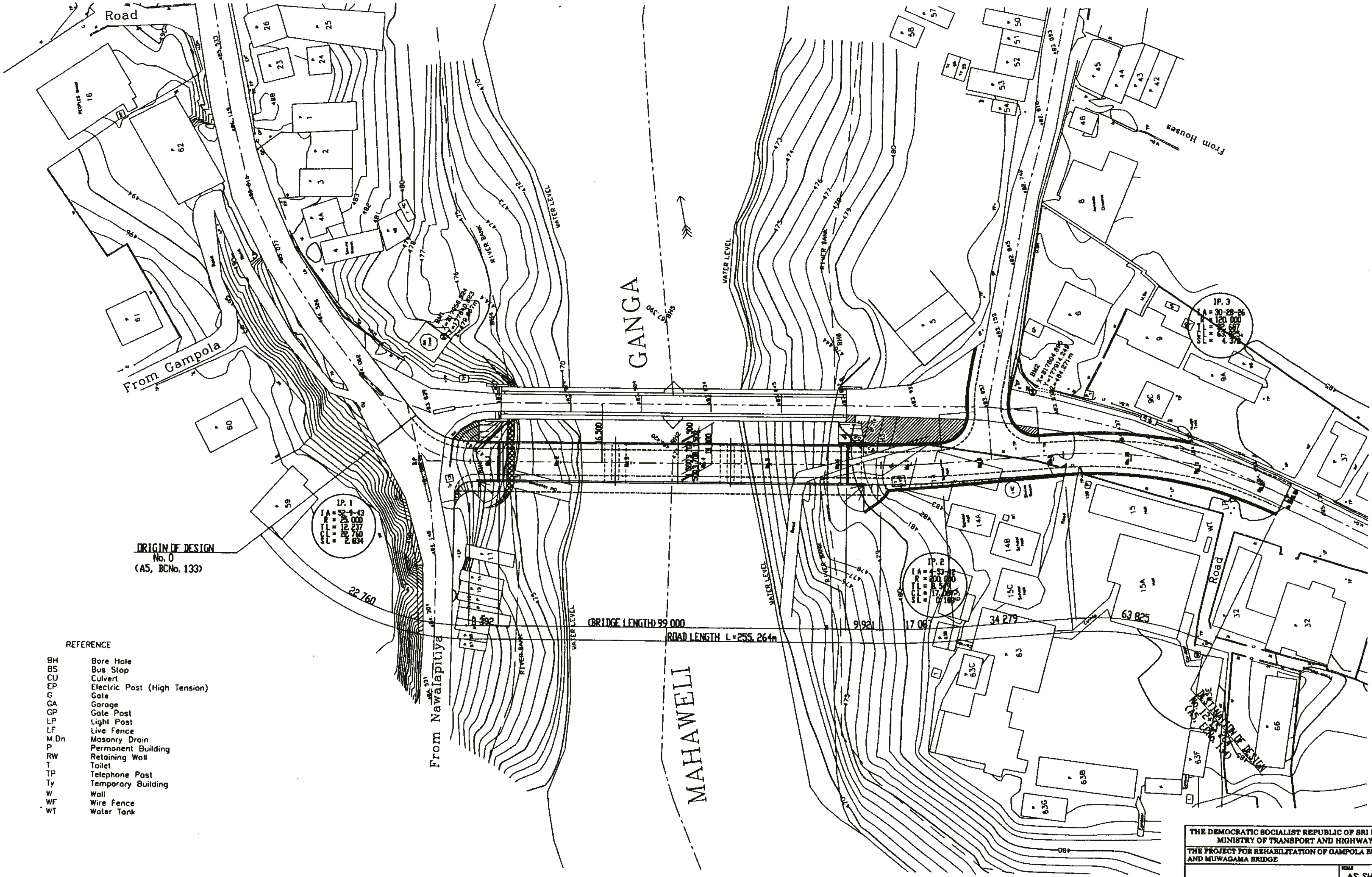
PLAN S=1/300



D-1

THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA MINISTRY OF TRANSPORT AND HIGHWAYS	
THE PROJECT FOR REHABILITATION OF GAMPOLA BRIDGE AND MUWAGAMA BRIDGE	
No. 93 GAMPOLA BRIDGE GENERAL VIEW	AS SHOWN 1
ORIENTAL CONSULTANTS COMPANY LIMITED	

No. 93 GAMPOLA ROAD PLAN S=1/500



REFERENCE

BH	Bore Hole
BS	Bus Stop
CU	Culvert
EP	Electric Post (High Tension)
G	Gate
GA	Garage
GP	Gate Post
LP	Light Post
LF	Live Fence
M.Dn	Masonry Drain
P	Permonent Building
RW	Retaining Wall
T	Toilet
TP	Telephone Post
Ty	Temporary Building
W	Wall
WF	Wire Fence
WT	Water Tank

THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF TRANSPORT AND HIGHWAYS

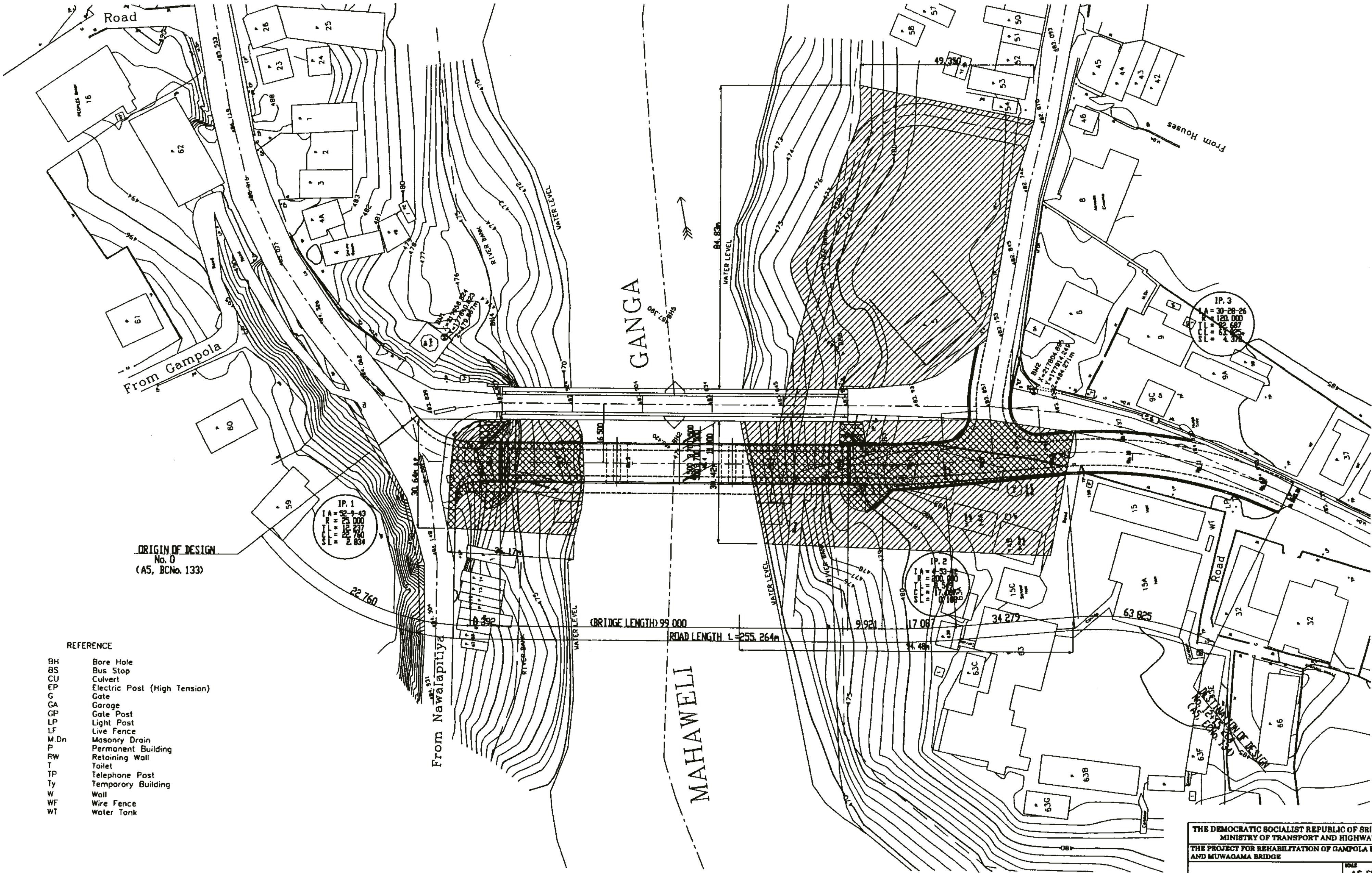
THE PROJECT FOR REHABILITATION OF GAMPOLA BRIDGE AND MUWAGAMA BRIDGE

No. 93 GAMPOLA ROAD PLAN — SCALE: AS SHOWN — DRAWING No. 1

ORIENTAL CONSULTANTS COMPANY LIMITED

DRAWN BY | DESIGNED BY | PROJECT MANAGER | APPROVED BY

No. 93 GAMPOLA LAYOUT OF CONSTRUCTION YARD S=1/500



REFERENCE

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THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF TRANSPORT AND HIGHWAYS

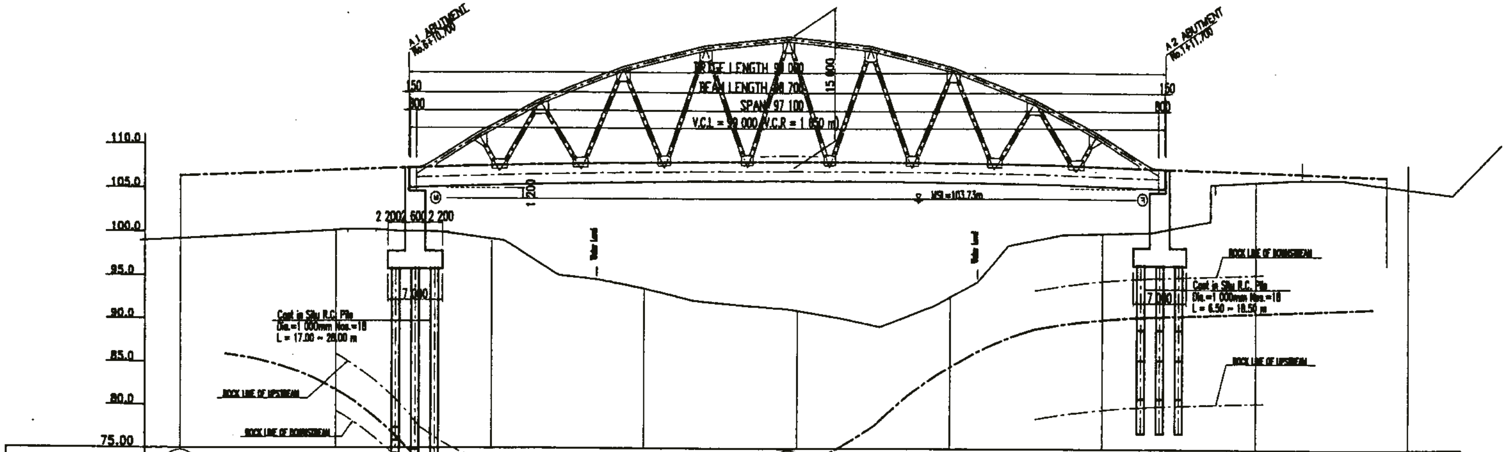
THE PROJECT FOR REHABILITATION OF GAMPOLA BRIDGE AND MUWAGAMA BRIDGE

No. 93 GAMPOLA LAYOUT OF CONSTRUCTION YARD	SCALE: AS SHOWN; DRAWING No. 1

ORIENTAL CONSULTANTS COMPANY LIMITED

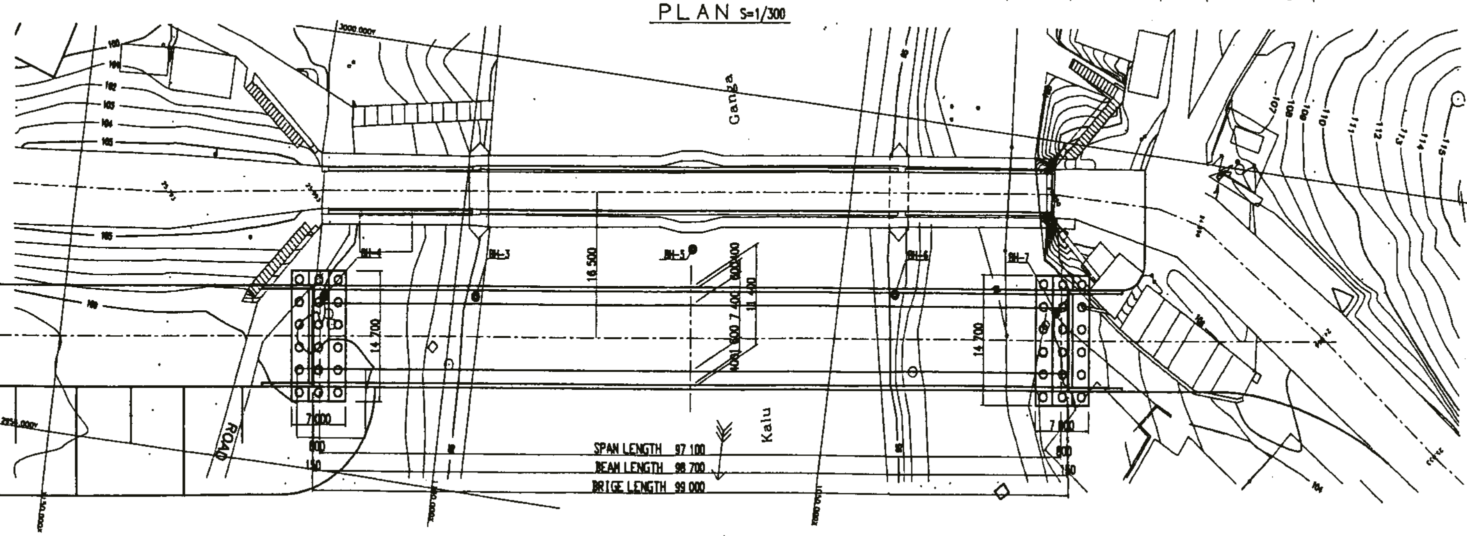
No.239 MUWAGAMA BRIDGE GENERAL VIEW

SIDE VIEW S=1/300

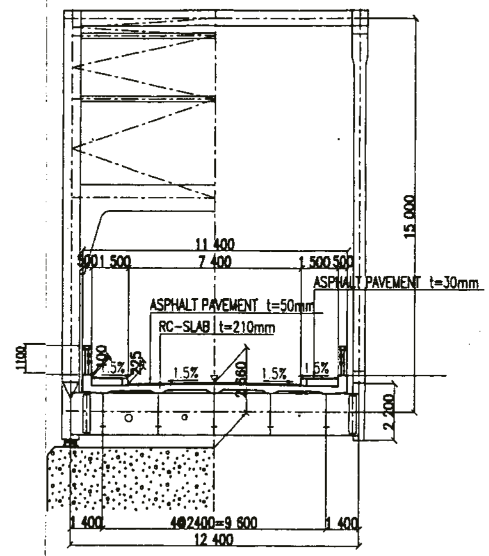


	No.8	No.7	No.6 +10.700	No.6	No.5	+1.200 No.4	No.3	No.2	No.1 +11.700	No.1	No.0 +13.840	No.0
GRADE	106.336	i = 3.000% L = 78.800m				108.700	i = 3.000% L = 67.360m				106.679	
PROPOSAL EL	106.336	106.936	107.215	107.501	107.880	107.957 107.957	107.821	107.443	107.215	106.864	106.679	105.000
GROUND EL	99.220	100.120	100.000	99.180	93.490	90.920	92.580	99.840	100.330	105.740	106.000	105.000
DISTANCE	160.000	140.000	130.700	120.000	100.000	81.200 80.000	60.000	40.000	31.700	20.000	13.840	0.000
SPAN	20.000	9.300	10.700	20.000	18.800	1.200 20.000	20.000	8.300	11.700	6.160	13.840	0.000
STATION	No.8	No.7	No.6 +10.700	No.6	No.5	+1.200 No.4	No.3	No.2	No.1 +11.700	No.1	No.0 +13.840	No.0
CURVE	R = ∞											

PLAN S=1/300



SUPER STRUCTURE S=1/100

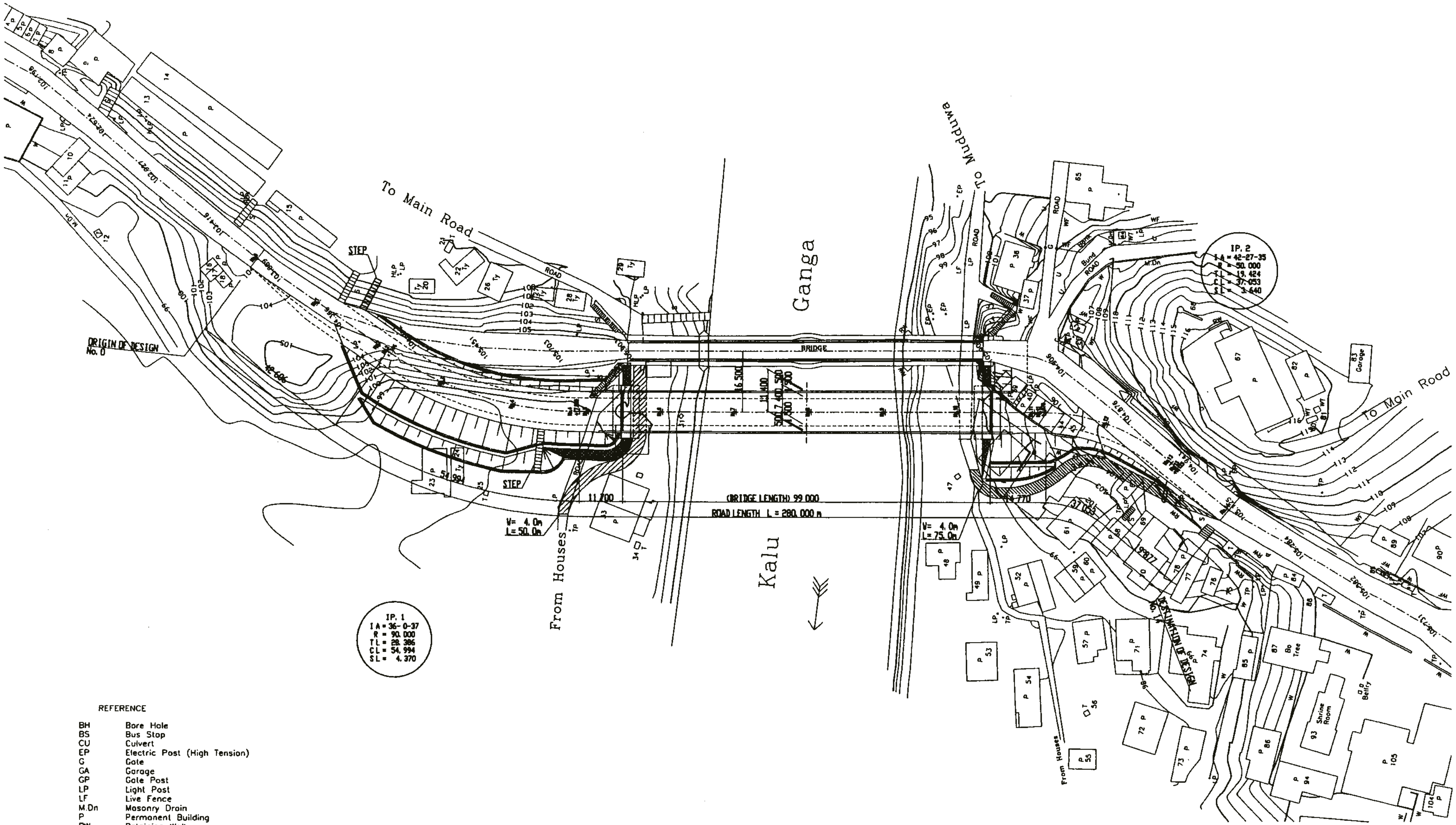


DESIGN CRITERIA

ROAD CLASSIFICATION		B
TYPE		TRUSSED LANGER
BRIDGE LENGTH		99.000m
SPAN LENGTH		97.1000m
ROAD WIDTH		CARRIAGEWAY 7.400m, SIDE WALK 2@1.500m
PAVEMENT		ASPHALT CONCRETE t=50mm
SLAB		RC-SLAB t=210mm
LONGITUDINAL GRADIENT		AS SHOWN
CROSS SECTIONAL GRADIENT		AS SHOWN
DESIGN LIVE LOAD		TYPE B LIVE LOAD
SKEWED ANGLE		90° 00' 00"
DESIGN HORIZONTAL SEISMIC INTENSITY		N. A
TYPE OF SUB STRUCTURE		A1, A2 ; INVERTED T TYPE
TYPE OF SUB FOUNDATION		A1, A2 ; BORED PILE
GEOLOGICAL CONDITION OF SUPPORT		GNEISS(SOFT~MEDIUM HARD ROCK)
SUPER STRUCTURE	CONCRETE	σck=24 N/mm²
	STEEL	SM400, SM490Y
	R-BAR	SD345
SUB STRUCTURE	CONCRETE	σck=24 N/mm²
	R-BAR	SD345
APPLIED STANDARD		「SPECIFICATION OF HIGHWAY BRIDGE」
		JAPAN ROAD ASSOCIATION (DEC.1996)

THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA MINISTRY OF TRANSPORT AND HIGHWAYS		
THE PROJECT FOR REHABILITATION OF GAMPOLA BRIDGE AND MUWAGAMA BRIDGE		
NO.239 MUWAGAMA BRIDGE GENERAL VIEW	SCALE AS SHOWN	DRAWING No. 1
ORIENTAL CONSULTANTS COMPANY LIMITED		
DRAWN BY	DESIGNED BY	PROJECT MANAGER	APPROVED BY

No. 239 MUWAGAMA ROAD PLAN S=1/500



REFERENCE

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RW	Retaining Wall
T	Toilet
TP	Telephone Post
Ty	Temporary Building
W	Wall
WF	Wire Fence
WT	Water Tank

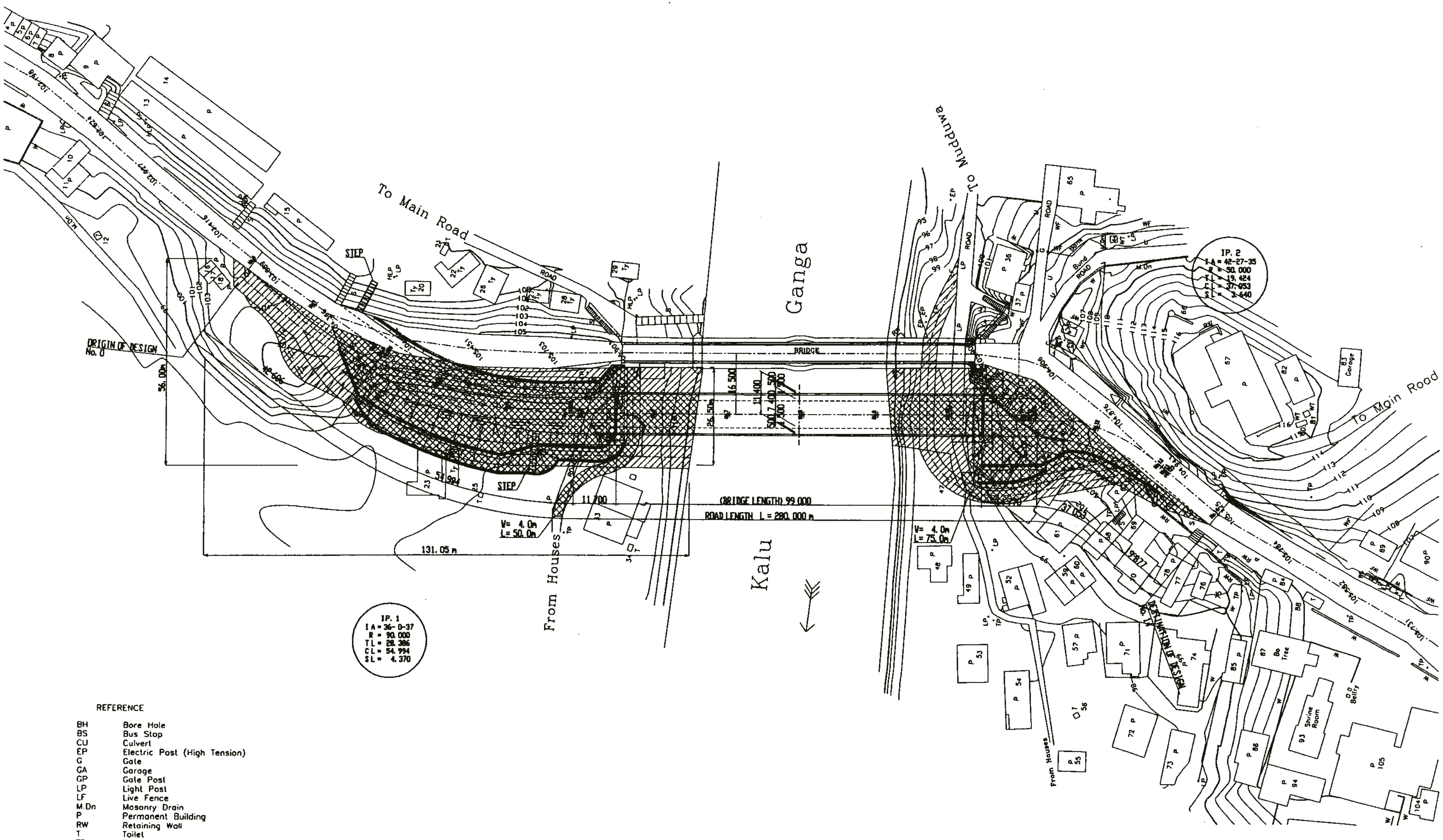
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF TRANSPORT AND HIGHWAYS

THE PROJECT FOR REHABILITATION OF GAMPOLA BRIDGE AND MUWAGAMA BRIDGE

No. 239 MUWAGAMA ROAD PLAN — SCALE 1 / 500 — DRAWING No. 1

ORIENTAL CONSULTANTS COMPANY LIMITED

No. 239 MUWAGAMA LAYOUT OF CONSTRUCTION YARD S=1/500



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P	Permanent Building
RW	Retaining Wall
T	Toilet
TP	Telephone Post
Ty	Temporary Building
W	Wall
WF	Wire Fence
WT	Water Tank

Permanent

Temporary

THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF TRANSPORT AND HIGHWAYS

THE PROJECT FOR REHABILITATION OF GAMPOLA BRIDGE AND MUWAGAMA BRIDGE

No. 239 MUWAGAMA LAYOUT OF CONSTRUCTION YARD

SCALE 1 / 500

DRAWING No. 1

ORIENTAL CONSULTANTS COMPANY LIMITED

Appendices

Appendices

1. Member List of the Survey Team
2. Survey Schedule
3. List of Party Concerned in the Recipient Country

Appendices :

1. Member List of the Survey Team

1-1. For the First study

Mr. Masafumi NAGAISHI	Leader	Sri Lanka Office, JICA Assistant Resident Representative
Mr. Kazuo YANAGIDA	Chief Consultant / Road Traffic Planner	Oriental Consultants Co., Ltd.
Mr. Mamoru OKUBO	Bridge Designer Ⅰ	Oriental Consultants Co., Ltd.
Mr. Jiro KOJIMA	Bridge Designer Ⅱ	Oriental Consultants Co., Ltd.

1-2. For the Second study

Mr. Kenji KIYOMIZU	Leader	Institute for International Cooperation, JICA Senior Advisor
Mr. Kazuo YANAGIDA	Chief Consultant / Road Traffic Planner	Oriental Consultants Co., Ltd.
Mr. Mamoru OKUBO	Bridge Designer Ⅰ	Oriental Consultants Co., Ltd.
Mr. Jiro KOJIMA	Bridge Designer Ⅱ	Oriental Consultants Co., Ltd.
Mr. Yoshimitsu YAMADA	Natural Conditions Surveyor Ⅰ	Oriental Consultants Co., Ltd.
Mr. Hitoshi SHIMADA	Natural Conditions Surveyor Ⅱ	Oriental Consultants Co., Ltd.
Mr. Masataka FUJIKUMA	Construction Planner / Cost Estimator	Oriental Consultants Co., Ltd.

1-3. For Explanation Draft Final Report

Mr. Seiji KAIHO	Leader	Sri Lanka Office, JICA Resident Representative
Mr. Kazuo YANAGIDA	Chief Consultant / Road Traffic Planner	Oriental Consultants Co., Ltd.
Mr. Mamoru OKUBO	Bridge Designer Ⅰ	Oriental Consultants Co., Ltd.
Mr. Jiro KOJIMA	Bridge Designer Ⅱ	Oriental Consultants Co., Ltd.

Appendices :

2. Survey Schedule

2-1. Schedule for the First Site Survey

No	Date	Day	Stay	1	2	Remark
1	6/22	Thr.	Colombo		1200 Narita—1750 Singapore (SNG) (SQ997) 2240 SNG—0005 Colombo (SQ402)	
2	23	Fri.	Colombo	Courtesy Call to JICA Office, Embassy of Japan, Min. of Transport &Highways, Dept. of External Resources, Dept. of National Planning and Road Development Authority		
3	24	Sat.	Colombo		Site survey (Bridges No.66 & 154)	
4	25	Sun	Colombo		Site Survey (Bridges No.122 & 158)	
5	26	Mon.	Colombo	Discussion of I/C Report with RDA Officials		
6	27	Tue.	Colombo	Discussion of I/C Report with RDA Officials		
7	28	Wed.	Nuwara Eliya	Site survey (Bridges No.239)		
8	29	Thr.	Kandy	Site survey (Bridges No.93)		
9	30	Fri.	Colombo		Site survey (Bridges No.157 & 181& 200)	
10	7/1	Sat.	Hambantota		Site survey (Bridges No.67)	
11	2	Sun	Colombo		Site survey (Bridges No.42)	
12	3	Mon.	Colombo		Report of site survey to RDA Officials	
13	4	Tue,	Colombo		Review of Site survey	
14	5	Wed.	Colombo		Review of Site survey Discussion of answering of Questionnaire with RDA Officials	
15	6	Thr.	Colombo		Review of Site survey	
16	7	Fri.	Colombo		Review of Site survey	
17	8	Sat.	Colombo		Team meeting	
18	9	Sun	Colombo		Team meeting	
19	10	Mon.	Colombo	Discussion of the Minutes with RDA Officials		
20	11	Tue,	Colombo	Signing of the Minutes, Report to JICA Office and Embassy of Japan		
21	12	Wed.			0120 Colombo—0710 SNG (SQ401) 0950 SNG—1735Narita (SQ12)	

1. Mr. Masafumi NAGAISHI	Leader	Sri Lanka Office, JICA Assistant Resident Representative
2. Mr. Kazuo YANAGIDA	Chief Consultant / Road Traffic Planner	Oriental Consultants Co., Ltd.
Mr. Mamoru OKUBO	Bridge Designer I	Oriental Consultants Co., Ltd.
Mr. Jiro KOJIMA	Bridge Designer II	Oriental Consultants Co., Ltd.

2-2. Schedule for the Second Site Survey

No	Date	Day	Stay	1	2	3,4&7	5,6
1	7/31	Mon.	Colombo		1200 Narita—1750 Singapore (SNG) (SQ997) (2,3,4& 7) 1200 Kansai—1715 SNG (SQ985)(5& 6) 2240 SNG—0005 Colombo (SQ402)		
2	8/1	Tue.	Colombo		Courtesy Call to JICA Office, and Road Development Authority (RDA) (unofficial)		
3	2	Wed.	Colombo	1200 Narita—1750 SNG(SQ997) 2240 SNG－0005 Colombo(SQ402)	Team Meeting, Confirmations Method of Geo-logical Survey and Topographic-Survey		
4	3	Thru.	Colombo	Courtesy Call to JICA Office, Embassy of Japan, Min. of Transport &Highways, Dept. of External Resources, Dept. of National Planning and Road Development Authority (official)			
5	4	Fri.	Colombo	Discussion with RDA Officials			
6	5	Sat.	Colombo	Site survey (Bridges No.93)			
7	6	Sun	Colombo	Site survey (Bridges No.239)			
8	7	Mon.	Colombo	Discussion of the Minutes with RDA Officials			Site survey
9	8	Tue.	Colombo	Signing of the Minutes, Report to JICA Office and Embassy of Japan			Ditto
10	9	Wed.	Colombo	0120 Colombo—0710 SNG (SQ401) 0950 SNG—1735Narita (SQ12) *1	Site survey		
11 -20	10 -19	Thru.	Colombo		Ditto		
21	20	Fri.	Colombo		Ditto		
22	21	Mon.	Colombo		Ditto		
23	22	Tue.	Colombo		Report of site survey to RDA Officials Report to JICA Office and Embassy of Japan		
24	23	Wed.	Colombo		=*1	Team meeting, Review of Site survey	
25	24	Thru.	Colombo			Ditto	
26	25	Fri.	Colombo			Ditto	
27	26	Sat.	Colombo			Review of Site survey	
28	27	Sun	Colombo			Ditto	
29	28	Mon.	Colombo			Report of Survey to RDA Officials Report to JICA Office and Embassy of Japan	
30	29	Tue.				=*1	

1.Mr. Kenji KIYOMIZU	Leader	Institute for International Cooperation, JICA Senior Advisor
2.Mr. Kazuo YANAGIDA	Chief Consultant / Road Traffic Planner	Oriental Consultants Co., Ltd.
3.Mr. Mamoru OKUBO	Bridge Designer Ⅰ	Oriental Consultants Co., Ltd.
4.Mr. Jiro KOJIMA	Bridge Designer Ⅱ	Oriental Consultants Co., Ltd.
5.Mr. Yoshimitsu YAMADA	Natural Conditions Surveyor Ⅰ	Oriental Consultants Co., Ltd.
6.Mr. Hitoshi SHIMADA	Natural Conditions Surveyor Ⅱ	Oriental Consultants Co., Ltd.
7.Mr. Masataka FUJIKUMA	Construction Planner / Cost Estimator	Oriental Consultants Co., Ltd.

2-3. Schedule for Explanation Draft Basic Design Report

No	Date	Day	Stay	1	2
1	10/23	Mon.	Colombo		1200Narita—1750 SNG (SQ997) 2240 SNG—0005 Colombo (SQ402)
2	24	Tue,	Colombo	Courtesy Call to JICA Office, Embassy of Japan, Dept. of External Resources, Dept. of National Planning, Min. of Highways, and Road Development Authority	
3	25	Wed.	Colombo		Explanation of Draft Report at RDA
4	26	Thru.	Colombo		Explanation of Draft Report at RDA Minutes of Discussion
5	27	Fri.	Colombo		Site survey (Bridges No.239)
6	28	Sat.	Kandy		Site survey (Bridges No.93)
7	29	Sun.	Colombo		Site survey (Bridges No.93)
8	30	Mon.	Colombo	Discussion of the Minutes with RDA Officials Signing of Minutes of Discussion Courtesy Call to Embassy of Japan	
9	31	Tue,			0120 Colombo—0710 SNG (SQ401) 0950 SNG—1735Narita (SQ12)

1. Mr. Seiji KAIHO	Leader	Sri Lanka Office, JICA Resident Representative
2. Mr. Kazuo YANAGIDA	Chief Consultant / Road Traffic Planner	Oriental Consultants Co., Ltd.
Mr. Mamoru OKUBO	Bridge Designer I	Oriental Consultants Co., Ltd.
Mr. Jiro KOJIMA	Bridge Designer II	Oriental Consultants Co., Ltd.

Appendices :

3. List of Party Concerned in the Recipient Country

◆ Ministry of Finance & Planning

1. Mr. J. H. J. Jayamaha	Director, Japan Division, Department of External Resources

◆ Ministry of Transport & Highways

2. Mr. G. Hewagama	Secretary

◆ Ministry of Highways

3. Mr. S. L. Senevirante	Secretary
4. Mr. W.A. Karunasena	Additional Secretary

◆ Road Development Authority

5. Mr. W. A. Jayasinghe	Chairman
6. Dr. G. L. Asoka J. de Silva	Director, Engineering Services Division (ESD)
7. Mr. H. M. K. G. C. Bandara	Chief Engineer (Planning), Traffic & Planning Office, ESD
8. Mr. D. K. Rphitha Swarna	Senior Engineer, BDO, ESD
9. Mr. Gunasena Imaduwa	Colombo Additional District S secretary , Acquiring Officer & Director LAND
10. Mr. A.M. Jawzi	Provincial Director, RDA Central Province
11. Mr. I. K. Baddegawa	Executive Engineer, RDA Kandy, Gampola office
12. Mrs. N. Samerasinghe	Executive Engineer, RDA Matale office
13. Mr. A. N. Abegsuviya	Executive Engineer, RDA Ratunpura office

◆ Peradenia University

14. Dr. J.B.Weerakoon	Professor, Pasadena University

Appendices

4.Minutes of Discussion

For the First Survey	**11th July 2000**
For the Second study	**8th August 2000**
For Explanation Draft Final Report	**10th October 2000**

MINUTES OF DISCUSSIONS
ON THE BASIC DESIGN STUDY
ON THE PROJECT FOR REHABILITATION OF NARROW AND WEAK BRIDGES
ON NATIONAL HIGHWAYS (PHASE 2)
IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
(FIRST FIELD STUDY)

In response to the request from the Government of Democratic Socialist Republic of Sri Lanka (hereinafter referred to as "Sri Lanka"), the Government of Japan has decided to conduct a basic design study on the Project for Rehabilitation of Narrow and Weak Bridges on National Highways (Phase 2) (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to Sri Lanka a basic study team (hereinafter referred to as "the Team"), which is headed by Mr. Masafumi Nagaishi, Assistant Resident Representative of JICA Sri Lank Office, and is scheduled to stay in the country from June 23 to July 11, 2000.

The Team held discussions with the concerned officials of the Government of Sri Lanka, and conducted a field survey at the project site.

In the course of the discussions and field survey, both parties have confirmed the main items of the Project as described on the attached sheets. The Team will proceed further and prepare the Interim Report.

Colombo, July 11,2000

Mr. Masafumi Nagaishi
Leader, Basic Design Study Team
Japan International Cooperation Agency

Mr. G. HEWAGAMA
Secretary
Ministry of Transport & Highways

Mr.W.A.Jayasinghe
Chairman
Road Development Authority

Mr. J.H.J. Jayamaha
Director, Japan Division
Department of External Resources

ATTACHMENT

1. OBJECTIVE

The objective of the Project is to construct permanent bridges to ensure safe and smooth flow of traffic in the Project area. And in the long-term view, socio-economic activities will be encouraged hence to contribute the development of the Project area.

2. PROPOSED SITES

The proposed sites, which are subjected to the first field survey of the Project, are shown in ANNEX-1.

3. RESPONSIBLE ORGANIZATION AND IMPLEMENTING AGENCY

(1) Responsible Organization: Ministry of Transport & Highways

(2) Implementing Agency: Road Development Authority

The organization chart is shown in ANNEX-2.

4. BRIDGES REQUESTED BY THE GOVERNMENT OF SRI LANKA

As a result of the discussions, Government of Sri Lanka has declined the application for 8 bridges, which have already been constructed and funded by his own fund or another donors among 19 requested bridges. The 11bridges listed in ANNEX-3 (a) are requested for the first field survey by the Sri Lankan side. However, the final selection of bridges and their detail design will be decided after further studies.

5. CRITERIA FOR THE SELECTION AND PRIORITIZATION OF BRIDGES

The criteria for the selection and prioritization of the bridges subjected to the second filed survey are shown in ANNEX-3 (b). The criteria are agreed between the Sri Lankan side and the study team. The selection of bridges will be considered based on the result of the first field survey in Sri Lanka, and first analysis and study in Japan.

6. JAPAN'S GRANT AID SYSTEM

The Sri Lankan side understands the Japan's Grant Aid Scheme and the necessary measures to be taken by the Government of Sri Lanka described in ANNEX-4 and ANNEX-5 for the smooth implementation of the Project, as a condition for the Japanese Grand Aid to be implemented.

7. SCHEDULE OF THE STUDY

(1) The consultants will proceed to first analysis and study in Japan until end of July.

(2) JICA will prepare an Interim Report and dispatch a mission in the early August in order to explain and confirm the contents of the Interim Report, then proceeds the second field survey.

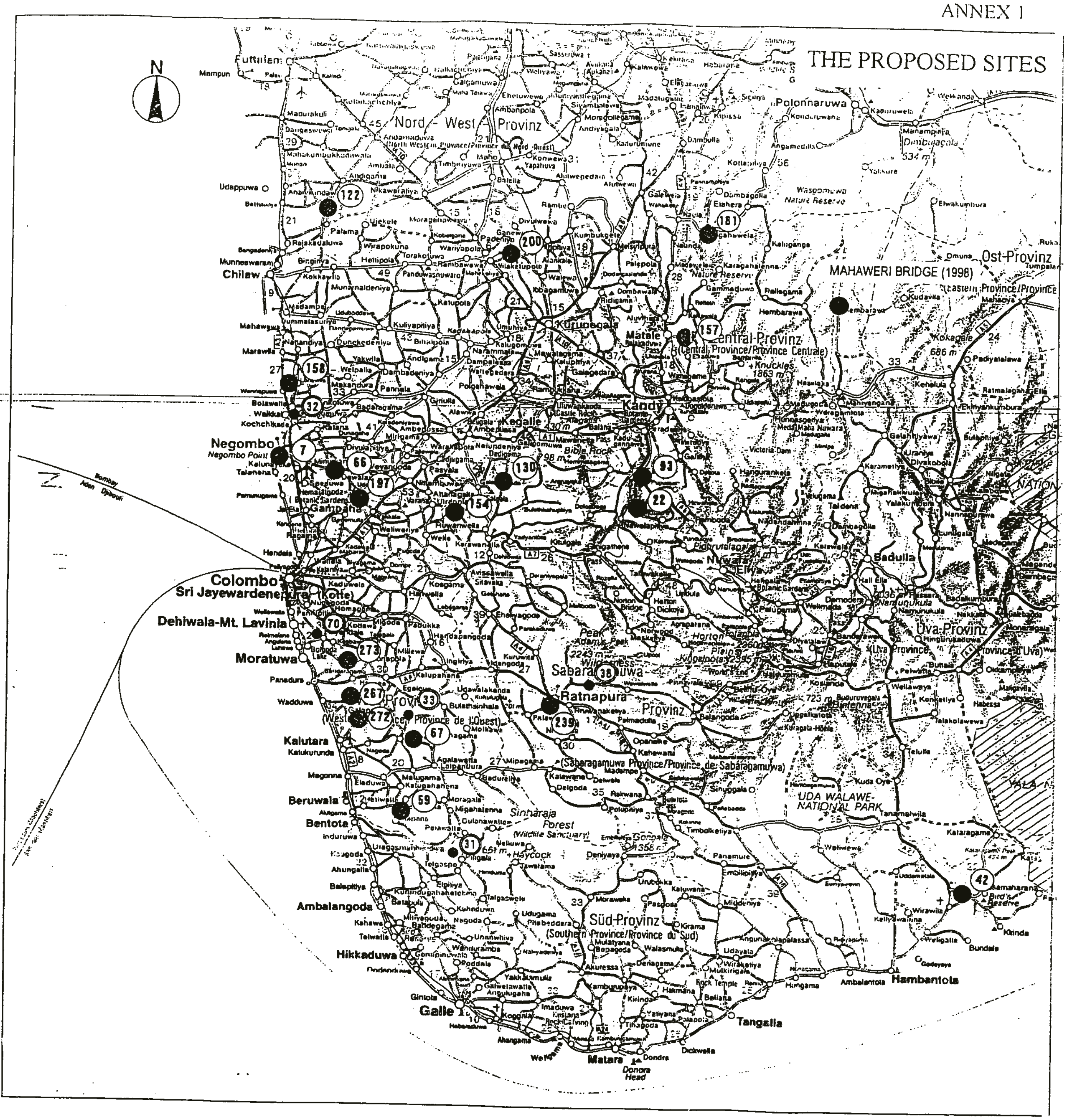
(3) In case that contents of the Report are accepted by the Sri Lankan side in principle, JICA will prepare and explain the Draft Final Report in the end of October 2000, and complete the final report and sent it to Sri Lankan side by February 2001.

8. OTHER RELEVANT ISSUES

(1) The Sri Lankan side shall prepare the full time counterpart and assign the officer in charge of land acquisition for the team in the second field survey.

(2) The procedure of land acquisition on the Project for Rehabilitation of Narrow and Weak Bridges on National Highways (Phase 1) had been delayed. The Sri Lankan side shall take necessary measures for the land acquisition on the Project (Phase 2) without delay to secure smooth implementation of the Project.

(3) An environment impact assessment confirmed not to be included as the requirement for the area around the requested bridges. If it shall occur necessity for environment impact assessment, the Sri Lankan side shall fulfill procedure of the assessment within the schedule.



LGEND

The Proposed Sites on the Project for Rehabilitation of Narrow and Weak Bridges

The Proposed Sites for This Study:

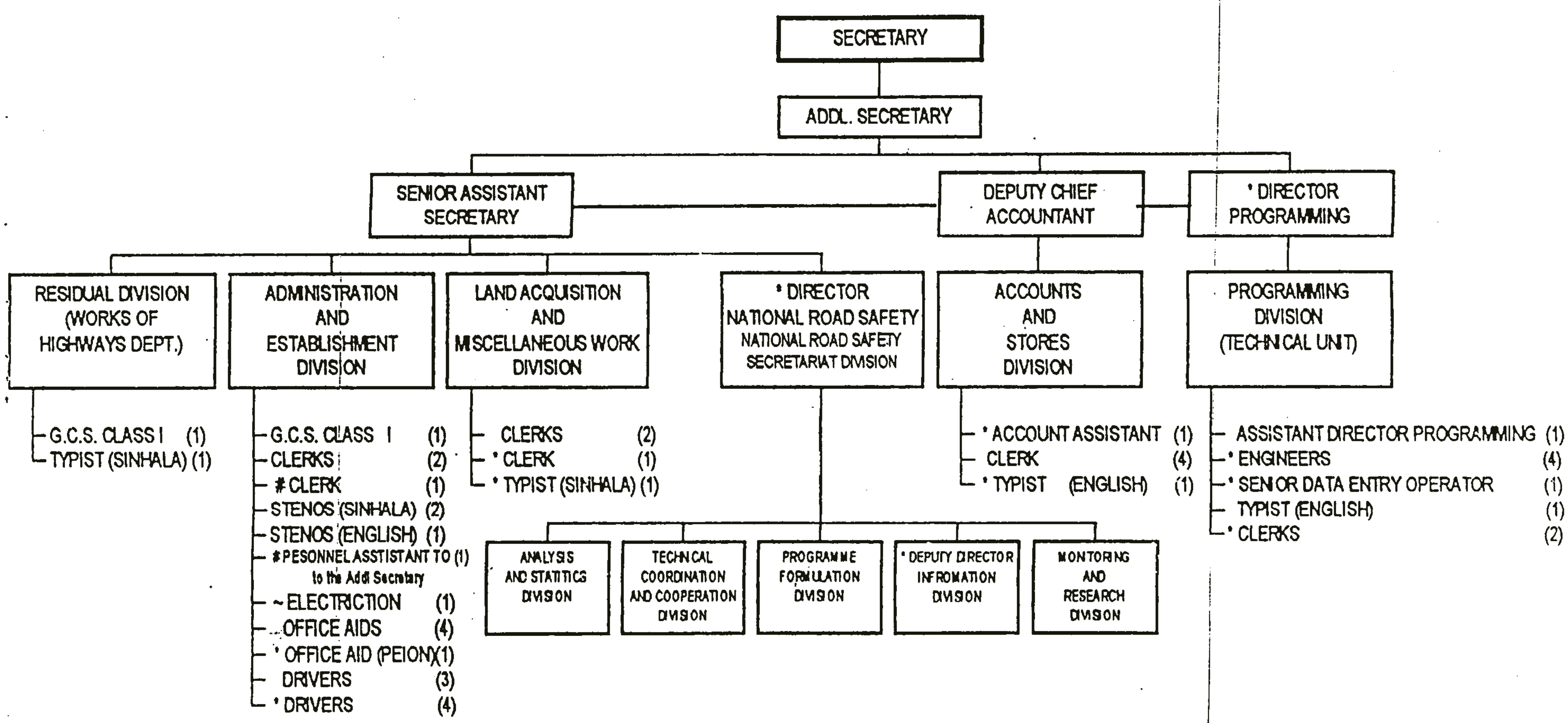
No.7, No.22, No.42, No.59, No.66, No.67, No.93, No.122, No.130, No.154,

No.157, No.158, No.181, No.197, No.200, No.239, No.267, No.272, No.273

The Project for Reconstruction of Five Bridges (Phase1)

(Under Construction): No.31, No.32, No.33, No.38, No.70

ORGANISATION CHART FOR HIGHWAYS DIVISION
MINISTRY OF TRANSPORT AND HIGHWAYS



OFFICE AIDES (4) - Attending to collection and delivery of letters, Roneo, Photocopy Machine, Book binding and Cleaning of office etc.

ELECTRICTION (1) - Overall incharge for day to day maintenance of Air-Conditioners, Telephone System, Libbrery etc.

NATIONAL ROAD SAFETY SECRETARIAT STAFF

* ENGINEERS	(4)
* CLERK	(1)
* DATA ENTRY OPERATOR	(1)
* OFFICE AID (PEON)	(1)

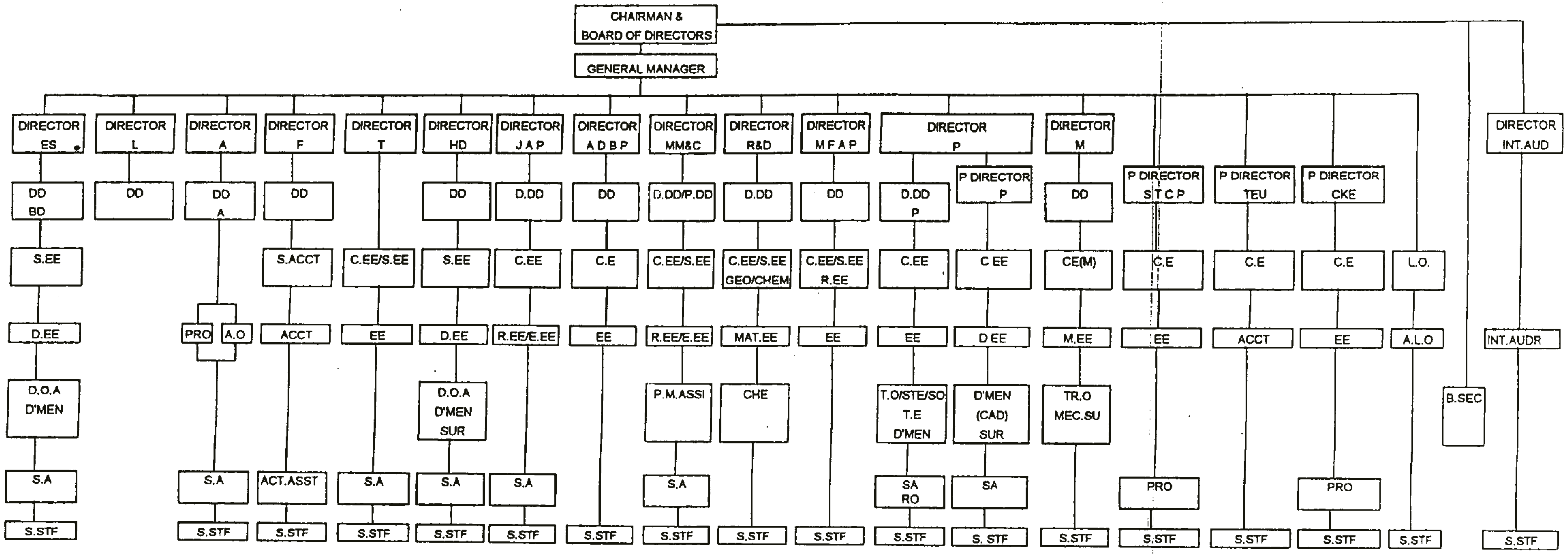
[* - All staff release from RDA]

[# - All staff release from RC & DC]

A-4-5

ANNEX-2

ORGANIZATION CHART -RDA



ABBREVIATION

DIRECTORS

A	ADMINISTRATION
P	PLANNING
ES	ENGINEERING SERVICES
F	FINANCE
T	TRAINING
MM&C	MAITENANCE MANAGEMENT & CONTRUCTION
M	MECHANICAL
HD	HIGHWAY DESIGN
INT.AUD	INTERNAL AUDIT
R&D	RESEACH & DEVELOPMENT
L	LANDS
J A P	JAPAN AIDED PROJECTS
A D B P	ASIAN DEVELOPMENT BANK PROJECTS
M F A P	MISCELLANEOUS FORIGN AIDED PROJECTS

PROJECT DIRECTORS

TEU	TENDER EVALUTION
CKE	COLOMBO-KATUNAYAKA EXPRESS WAY
S T C P	SOUTHERN TRANSPORT CORRIDOR PROJECTS

DEPUTY DIRECTORS

D.D	DEPUTY DIRECTOR
D.DD	DEPUTY DIRECTORS
BD	BRIDGES DESIGN
HD	HIGHWAY DESIGN
P	PLANNING
P.DD	PROVINCIAL DIRECTORS
C.EE	CHIEF ENGINEERS
S.EE	SENIOR ENGINEERS
C.E(M)	CHIEF ENGINEER MECHANICAL
D.EE	DESIGN ENGINEERS
GEO	GEOLOGIST
R.EE	RESIDENT ENGINEERS
L.O	LEGAL OFFICER
MAT.EE	MATERIAL ENGINEERS
E.EE	EXECUTIVE ENGINEERS
EE	ENGINEERS
A.L.O	ASSISTANT LEGAL OFFICER

DOA	DRAWING OFFICE ASSISTANT
T.O	TECHNICAL OFFICER
S.O	STATISTICAL OFFICER
TR.O	TRANSPORT OFFICER
MEC.SU	MECHANICAL SUPERINTENDENT
PRO	PUBLIC RELATION OFFICER
AO	ADMINISTRATIVE OFFICER
S.ACCT	SENIOR ACCOUNTANT
ACCT	ACCOUNTANT
SUR	SURVEYORS
P.M.ASSI	PROGRESS MONITORING ASSISTANT
S.A	STAFF ASSISTANT
B.SEC	BOARD SECRETARY
CHE	CHMIST
ACT.ASI	ACCOUNT ASSISTANT
INT.AUDR	INTERNAL AUDITOR
S.T.E	SENIOR TRAFFIC ENUMERATOR
T.E	TRAFFIC ENUMERATOR
R.O	RECORD OFFICER
S.STF	SUPPORT STAFF

BRIDGE REQUESTED BY THE GOVERNMENT OF SRI LANKA

No.	RDA Inventory No.	Location	Present Situation	Fund
—	No. 7	Gampaha	Under Construction	Sri Lanka
—	No. 22	Kandy	Under Construction	Sri Lanka
1	No. 42	Hambantota		
—	No. 59	Kulutara	Under Construction	Sri Lanka
2	No. 66	Gampaha		
3	No. 67	Kulutara		
4	No. 93	Kandy		
5	No. 122	Chilaw		
—	No. 130	Kegalle	Under Construction	Sri Lanka
6	No. 154	Kegalle		
7	No. 157	Matare		
8	No. 158	Chilaw		
9	No. 181	Matare		
—	No. 197	Gampaha	Commencemnt by end of 2000	Sri Lanka
10	No. 200	Kurunegala		
11	No. 239	Ratnapura		
—	No. 267	Kulutara	On the tender	Sri Lanka
—	No. 272	Kulutara	On the tender	Sri Lanka
—	No. 273	Kulutara	On the tender	Kuwait fund

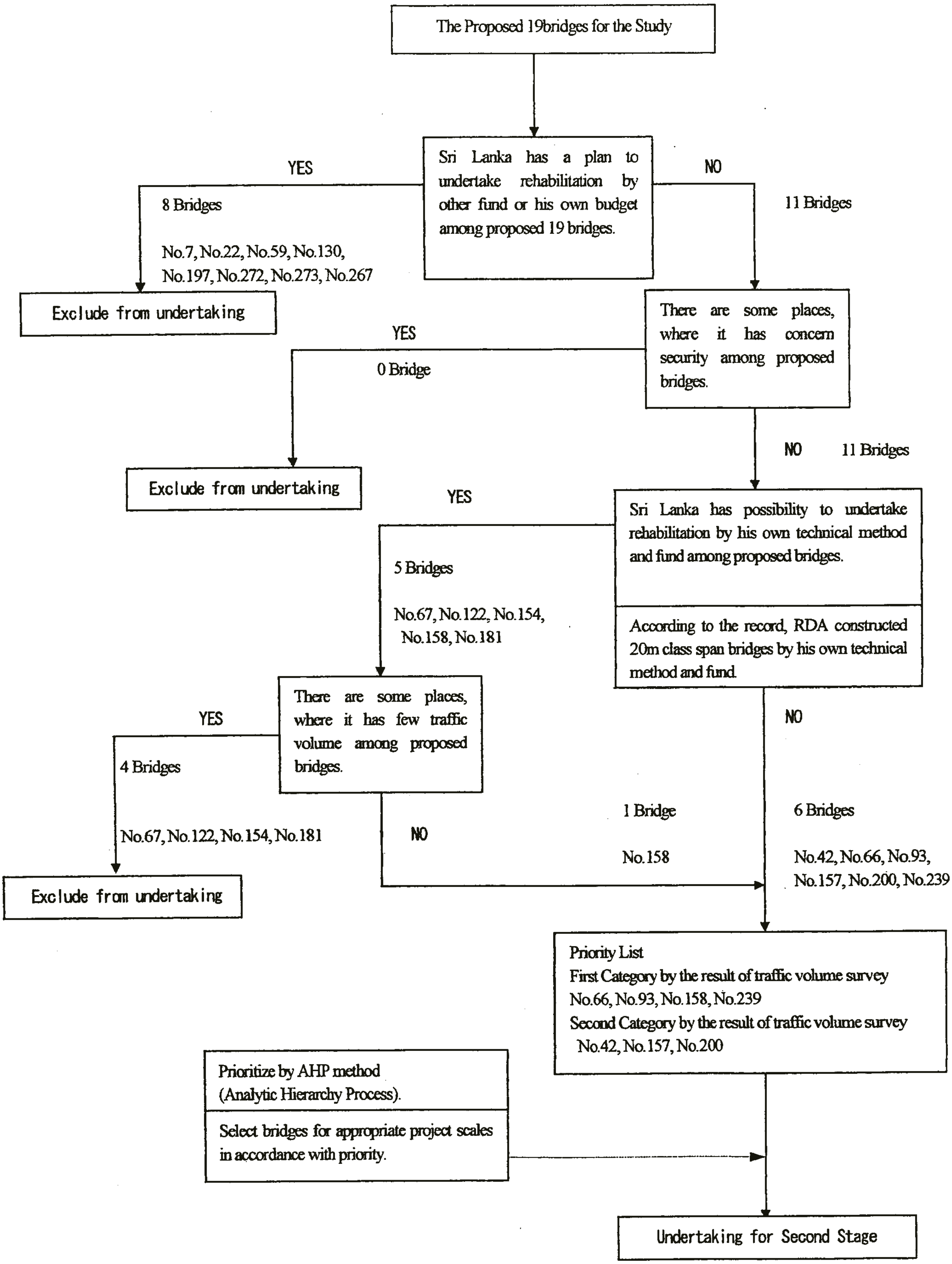
Note:

The Government of Sri Lanka declines 8 bridges among 19bridges, which was applied to Grant Aid. The scope of first site survey is the investigation for the remaindering 11 bridges.

No	SER No.	Route No Bridge No	Name of Road	Type of Bridge Length / Width (m)	Existing Defects	Traffic Volume [/day] (Y)	Remark
1	42	B-464 5/1 km	Weerawila-Tissa-Kataragama (Southern/Hambantota)	RSJ/RCS L=59.20 W=4.29	Narrow/ Poor slab·deck	[1,140] ('90) [1,320] ('96)	
2	66	B-111 7/1km	Ekala-Kotadeniyawa (Western / Gampaha)	ST.TRH L=36.80 W=6.40	Poor alignment/ Narrow/ Poor pier	[6,125] ('94) [10,753] ('99)	
3	67	B-157 23/2 km	Horana-Anguruwatota-Aluthgama (Western / Kalutara)	RSJ/RCS L=19.10 W=3.50	Narrow	[750] ('91) [846] ('99)	
4	93	AA- 005 21/4km	Peradeniya-Badulla-Chenkaladi (Central / Kandy)	ST.TR L=98.30 W=4.85	Narrow Corrosion	[4,699] ('94) [4,910] ('96)	
5	122	B-045 19/1 km	Bangadeniya-Andigama-Anamaduwa (North Western/Chilaw)	RSJ L=18.50 W=5.00	Weak/ Narrow	[470] ('93) [665] ('95)	
6	154	B-445 14/1 km	Veyangoda-Ruwanwella (Sabaragamuwa/kegalle)	RSJ/BUC L=10.35 W=4.60	Weak	[3,192] ('94) [1,024] ('98)	
7	157	B-461 28/2 km	Wattegama-Kandenuwara-Wariyapola (Central / Matale)	RSJ/BUC L=24.80 W=3.20	Weak Corrosion	[50] ('91)	
8	158	B-473 3/2 km	Vennappuwa-Kirimetiyana (North Western / Chilaw)	ST.TR L=19.70 W=5.20	Weak/ Narrow	[3,560] ('95)	
9	181	B-312 11/5 km	Naula-Elahera-Kaluganga (Central / Matale)	RSJ/RCS L=18.90 W=3.80	Narrow	[310] ('91) [363] ('96)	
10	200	B-478 10/1 km	Wilakatupotha-Ganewattha-Kubukgete (NorthWestern/ Kurunegala)	ST.TR/H L=78.60 W=4.25	Narrow Poor slab	[240] ('93)	
11	239	B-390 1/3 km	Ratnapura-Palawela-Karawita (Sabaragamuwa/Ratnapura)	ST.TR/H L=107.00 W=4.30	Weak truss Poor deck Narrow	[5,709] ('97)	

CRITERIA FOR THE SELECTION AND PRIORITIZATION OF BRIDGES

1) The encouragement for Relative Development Plan
2) The Present Situation of Bridges (e.g. damage, traffic flow and so forth)
3) The encouragement for Social and Economic growth
4) The Traffic volume
5) The Availability of Land acquisition
6) The Others



Flowchart of the Selection of the Proposed Bridges

JAPAN'S GRAND AID SCHEME

1. GRAND AID PROCEDURES

1) Japan's Grand Aid Program is executed through the following procedures.

- Application (Request made by the recipient country)
- Study (Basic Design Study conducted by Japan International Cooperation Agency (JICA))
- Appraisal & Approval (Appraisal by the Government of Japan and Approval by the Cabinet)
- Determination of the Implementation (The Note exchanged between the Governments of Japan and Recipient country)

2) Firstly, the application or request for a Grand Aid project submitted by the recipient county is examined by the Government of Japan (Ministry of Foreign Affairs) to determine whether or not it is eligible for Grand Aid. If the request is deemed appropriate, the Government of Japan assigns JICA to conduct a study on the request.

Secondly, JICA conducts the study (Basic Design Study) using (a) Japanese consulting firm(s).

Thirdly, the Government of Japan appraises the project to see whether or not it is suitable for Japan's Grand Aid Program, based on the Basic Design Study report prepared by JICA, and the results are then submitted to the Cabinet for approval.

Fourthly, the Project, once approved by the Cabinet, becomes official with the Exchange of Notes signed by the Governments of Japan and the recipient country.

Finally, for the implementation of the Project, JICA assists the recipient country in such matters as preparing tenders, contracts and so on.

2. BASIC DESIGN STUDY

1) Contents of the Study

The aim of the Basic Design Study (hereinafter referred to as "the Study") conducted by JICA on a requested project (hereinafter referred to as "the Project") is to provide a basic document necessary for the appraisal of the Project by the Government of Japan.

The contents of the Study are as follows:

a) Confirmation of the background, objectives and benefits of the Project and also institutional capacity of agencies concerned of the recipient country necessary for the Project's implementation.

b) Evaluation of the appropriateness of the Project to be implemented under the Grand Aid Scheme from a technical, social and economic point of view.

c) Confirmation of items agreed on by both parties concerning the basic concept of the Project.

d) Preparation of a basic design of the Project.

e) Estimation of costs of the Project.

The contents of the original request are not necessarily approved in their initial form as the contents of the Grand Aid project. The Basic Design of the Project is confirmed considering the guidelines of the Japan's Grand Aid Scheme.

The Government of Japan requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

2) Selection of Consultants

For smooth implementation of the Study, JICA uses (a) registered consultant firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms. The selected firm(s) carry(ies) out a Basic Study and write(s) a report, based upon terms of reference set by JICA. The consultant firm(s) used for the Study is(are) recommended by JICA to the recipient country to also work on the Project's implementation after the Exchange of Notes, in order to maintain technical consistency.

3. JAPAN'S GRAND AID SCHEME

1) Japan 's Grant Aid

The Grant Aid Program provides a recipient country with non-reimbursable funds to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with the relevant laws and regulations of Japan. Grant Aid is not supplied through the donation of materials as such.

2) Exchange of Notes (E/N)

Japan's Grant Aid is extended in accordance with the Notes exchanged by the two

Governments concerned, in which the objectives of the Project, period of execution conditions and amount of the Grant Aid, etc., are confirmed.

3) "The period of the Grant Aid"

"The period of the Grant Aid" means the one fiscal year which the Cabinet approves the Project for. Within the fiscal year, all procedures such as exchanging of the Notes, concluding contracts with (a) consultant firm(s) and (a) contractor(s) and final payment to them must be completed. However, in case of delays in delivery, installation or construction due to unforeseen factors such as weather, the period of the Grant Aid can be further extended for a maximum of one fiscal year at most by mutual agreement between the two Governments.

4) Under the Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased.

When the two Governments deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country.

However, the prime contractors, namely, consulting, constructing and procurement firms, are limited to "Japanese national." (The term "Japanese nationals" means persons of Japanese nationality of Japanese corporations controlled by persons of Japanese nationality.)

5) Necessity of "Verification"

The Government of recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by the Government of Japan. This "Verification" is deemed necessary to secure accountability to Japanese taxpayers.

6) Undertakings required of the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as the following:

(1) To secure land necessary for the sites of the Project and to clear, level and reclaim the land prior to commencement of the construction.

(2) To provide facilities for the distribution of electricity, water supply and drainage and other incidental facilities in and around the sites.

(3) To secure buildings prior to the procurement in case the installation of the equipment.

(4) To ensure all the expenses and prompt excursion for unloading, customs clearance at

the port of disembarkation and internal transportation of the products purchased under the Grant Aid.

(5) To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the products and services under the Verified Contracts.

7) "Proper Use"

The recipient country is required to maintain and use the facilities constructed and the equipment purchased under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

8) "Re-export"

The products purchased under the Grant Aid should not be re-exported from the recipient country.

9) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account in the name of the Government of the recipient county in a bank in Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an authorization to pay issued by the Government of the recipient country or its designated authority.

MAJOR UNDERSTANDINGS TO BE TAKEN BY EACH GOVERNMENT

NO	Items	To be covered by Grant Aid	To be covered by Recipient side
1	To secure land		●
2	To clear, level and reclaim the site when needed		●
3	To construct gates and fences in and around the site		●
4	To bear the following commissions to a bank of Japan for the banking services based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment commission		●
5	To ensure prompt unloading and customs clearance at the port of disembarkation in recipient country		
	1) Marine (Air) transportation of the products from Japan to the recipient country	●	
	2) Tax exemption and customs clearance of the products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project site	(●)	(●)
6	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 recipient country and stay therein for the performance of their work		●
7	To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contract		●
8	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid		●
9	To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities		●

Minutes of Discussions
on the Basic Design Study
on the Project for Rehabilitation of Narrow and Weak Bridges
on National Highways (Phase 2)
in the Democratic Socialist Republic of Sri Lanka
(Second Field Study)

In response to the request from the Government of Democratic Socialist Republic of Sri Lanka (hereinafter referred to as "Sri Lanka"), the Government of Japan has decided to conduct a basic design study on the Project for Rehabilitation of Narrow and Weak Bridges on National Highways (Phase 2) (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to Sri Lanka a basic design study team (hereinafter referred to as "the Team"), which is headed by Mr. Kenji Kiyomizu, Development Specialist, JICA, and is scheduled to stay in the country from August 1 to August 29, 2000.

The Team held discussions with the concerned officials of the Government of Sri Lanka, and conducted a field survey at the project site.

In the course of the discussions and field survey, both parties have confirmed the main items of the Project as described on the attached sheets. The Team will proceed on project works further and prepare the Draft Basic Design Report.

Colombo, August 8, 2000

清水建二

Mr. Kenji Kiyomizu
Leader
Basic Design Study Team
Japan International Cooperation Agency

Mr.G.Hewagama
Secretary
Ministry of Transport and Highways

Mr.J.H.J.Jayamaha
Director, Japan Division
Department of External Resources

Mr.W.A.Jayasinghe
Chairman
Road Development Authority
Ministry of Transport and Highways

ATTACHMENT

1. OBJECTIVE

The objective of the Project is to construct permanent bridges to secure safe and smooth traffic movement in the Project area. And in the long-term view, socio-economic activities will be encouraged to contribute to the Project area.

2. PROPOSED SITES

The proposed sites which are subjected to the second field survey of the Project are shown in **Annex-1**.

3. ITEMS SELECTED FOR THE PROJECT

After discussions with the Team, Serial No.239 Muwagama Bridge and No.93 Gampola Bridge were finally agreed upon as the items selected for the Project by the Sri Lankan side. JICA will assess the appropriateness of the selection and will recommend to the Government of Japan for approval.

4. RESPONSIBLE ORGANIZATION AND IMPLEMENTING AGENCY

(1) Responsible Organization: Ministry of Transport and Highways

(2) Implementing Agency: Road Development Authority

The organization charts are shown in **Annex-2**.

5. JAPAN'S GRANT AID SCHEME

The Sri Lankan side understands the Japan's Grant Aid Scheme and the necessary measures to be taken by the Government of Sri Lanka as explained by the Team and described in Annex-4 and Annex-5 of the Minutes of Discussions signed by both parties on July 11, 2000.

6.SCHEDULE OF THE STUDY

(1) The consultants will proceed on further studies in Sri Lanka until August 29, 2000 as the second field survey.

(2) The Sri Lankan side was accepted the content of the Interim Report, so that JICA will prepare the Draft Basic Design Report and dispatch a mission in order to explain and confirm the contents in the end of the October, 2000.

(3) In case that the content of the Draft Basic Design Report is accepted by the Sri Lankan side, JICA will finalize the report and send it to the Sri Lankan side by February, 2001.

7. OTHER RELEVANT ISSUES

(1) There has been certain delay in the procedure of land acquisition on the Project for Rehabilitation of Narrow and Weak Bridges on National Highways (Phase 1). As such the Sri Lankan side will take necessary measures for the land acquisition on the Project (Phase 2) to avoid delay to secure smooth implementation of the Project. The Sri Lankan side should define the procedure and the time schedule on the land acquisition during the second field survey. Also, if the land acquisition is concerned with other officials, the Sri lankan side shall obtain the written confirmation from the officials during the second field survey.

(2) It is confirmed that Environment Impact Assessment is not required for the area around the selected bridges as described in **Annex-3**.

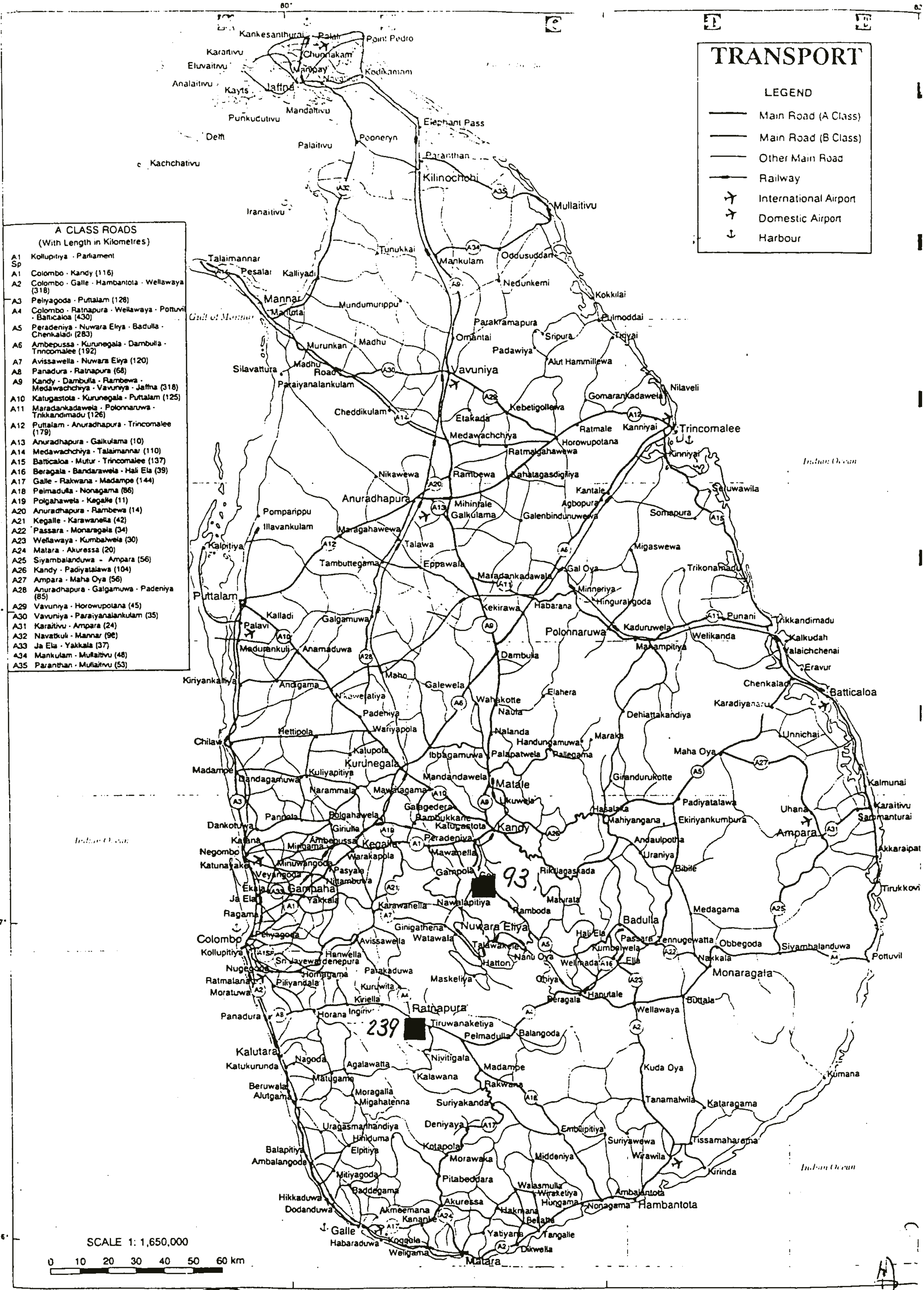
(3) The Sri Lankan side shall allocate the budget for the tax exemption in accordance with the Draft Basic Design Report. Also, the procedure of the tax exemption, particularly, the time schedule should be clarified during the second field survey.

(4) The Sri Lankan side shall be responsible for the removal of the existing bridges, if it is necessary to do so.

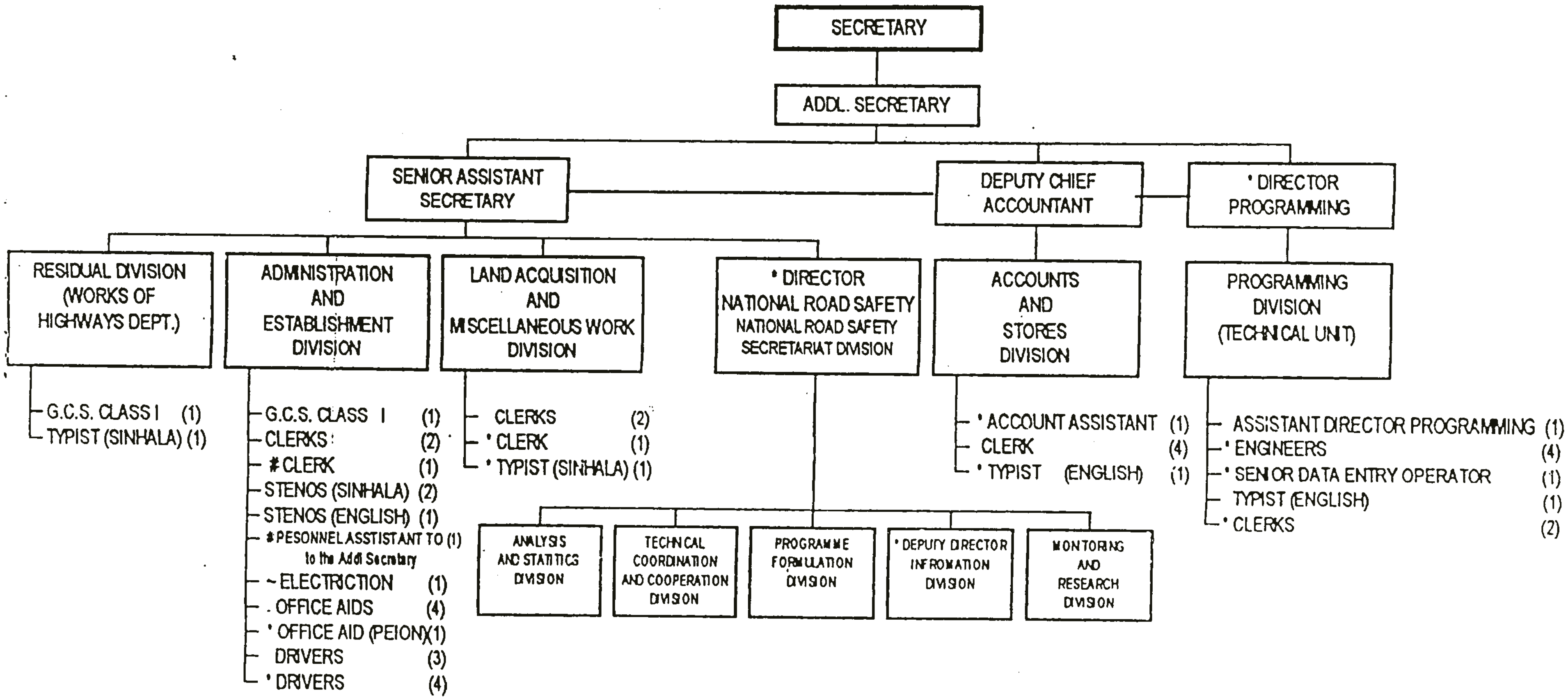
(5) The Sri Lankan side shall be responsible for the relocation of the utilities and also provide the sufficient data to the basic design study team for newly installation.

(6) The name of the Project has been agreed between the Sri Lankan side and the JICA to change as follows:

" The Project for the Rehabilitation of Gampola and Muwagama Bridges"


TRANSPORT
LEGEND
Main Road (A Class)
Main Road (B Class)
Other Main Road
Railway
International Airport
Domestic Airport
Harbour
A CLASS ROADS
(With Length in Kilometres)
A1 Sp Kollupitiya - Parliament
A1 Colombo - Kandy (116)
A2 Colombo - Galle - Hambantota - Wellawaya (318)
A3 Peliyagoda - Puttalam (126)
A4 Colombo - Ratnapura - Wellawaya - Pottuvil - Batticaloa (430)
A5 Peradeniya - Nuwara Eliya - Badulla - Chenkaladi (283)
A6 Ambepussa - Kurunegala - Dambulla - Trincomalee (192)
A7 Avissawella - Nuwara Eliya (120)
A8 Panadura - Ratnapura (68)
A9 Kandy - Dambulla - Rambewa - Medawachchiya - Vavuniya - Jaffna (318)
A10 Katugastota - Kurunegala - Puttalam (125)
A11 Maradankadawela - Polonnaruwa - Trikkandimadu (126)
A12 Puttalam - Anuradhapura - Trincomalee (179)
A13 Anuradhapura - Galkulama (10)
A14 Medawachchiya - Talaimannar (110)
A15 Batticaloa - Mutur - Trincomalee (137)
A16 Beragala - Bandarawela - Hali Ela (39)
A17 Galle - Rakwana - Madampe (144)
A18 Pelmadulla - Nonagama (86)
A19 Polgahawela - Kegalle (11)
A20 Anuradhapura - Rambewa (14)
A21 Kegalle - Karawanella (42)
A22 Passara - Monaragala (34)
A23 Wellawaya - Kumbalwela (30)
A24 Matara - Akuressa (20)
A25 Siyambalanduwa - Ampara (56)
A26 Kandy - Padiyatalawa (104)
A27 Ampara - Maha Oya (56)
A28 Anuradhapura - Galgamuwa - Padeniya (85)
A29 Vavuniya - Horowupotana (45)
A30 Vavuniya - Paraiyanalankulam (35)
A31 Karaitivu - Ampara (24)
A32 Navatkuli - Mannar (96)
A33 Ja Ela - Yakkala (37)
A34 Mankulam - Mullaitivu (48)
A35 Paranthan - Mullaitivu (53)
SCALE 1: 1,650,000
0 10 20 30 40 50 60 km
93
239
Jaffna
Point Pedro
Elephant Pass
Kilinochchi
Mullaitivu
Mannar
Vavuniya
Trincomalee
Anuradhapura
Puttalam
Polonnaruwa
Batticaloa
Kurunegala
Kandy
Matale
Negombo
Colombo
Nuwara Eliya
Badulla
Ampara
Ratnapura
Monaragala
Kalutara
Galle
Matara
Hambantota
Indian Ocean
Gulf of Mannar

ORGANISATION CHART FOR HIGHWAYS DIVISION
MINISTRY OF TRANSPORT AND HIGHWAYS



OFFICE AIDES (4) - Attending to collection and delivery of letters, Roneo, Photocopy Machine, Book binding and Cleaning of office etc.

ELECTRICTION (1) - Overall incharge for day to day maintenance of Air Conditioners Telephone System Libbrery etc.

NATIONAL ROAD SAFETY SECRETARIAT STAFF

- * ENGINEERS (4)
- * CLERK (1)
- * DATA ENTRY OPERATOR (1)
- * OFFICE AID (PEON) (1)

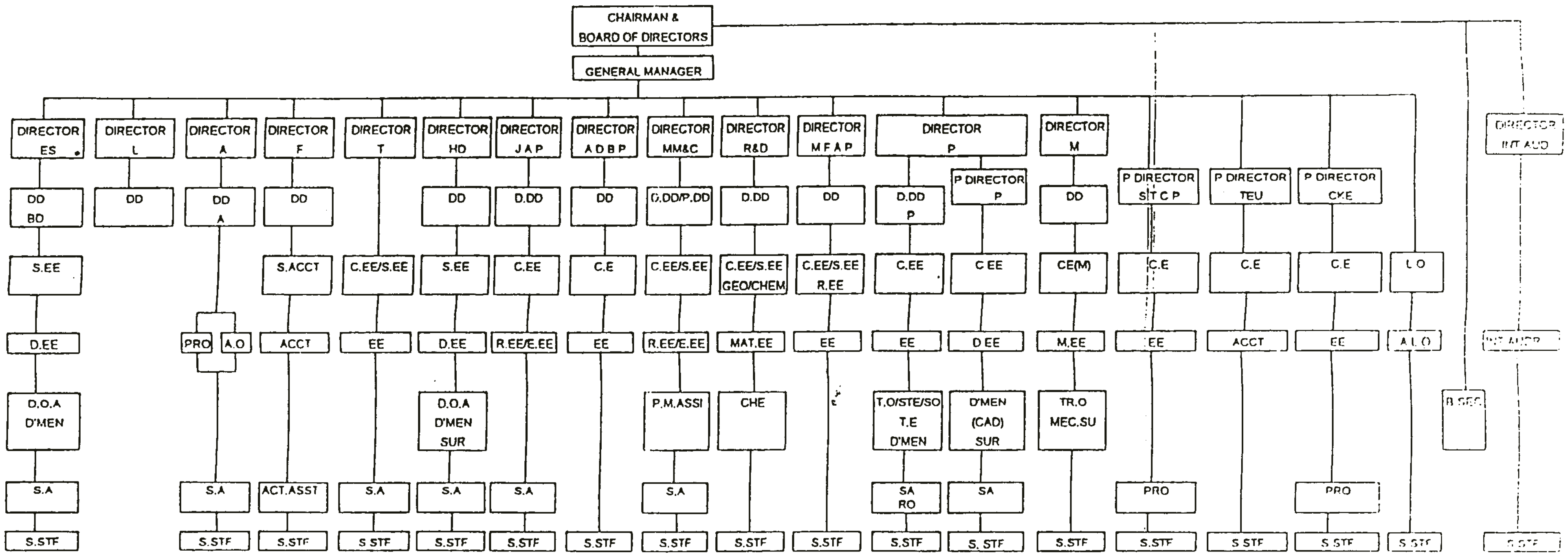
[* - All staff release from RDA]

[# - All staff release from RC & DC]

A - 4 - 20

ANNEX-2

ORGANIZATION CHART -RDA



ABBREVIATION

DIRECTORS

A	ADMINISTRATION
P	PLANNING
ES	ENGINEERING SERVICES
F	FINANCE
T	TRAINING
MM&C	MAITENANCE MANAGEMENT & CONTRUCTION
M	MECHANICAL
HD	HIGHWAY DESIGN
INT.AUD	INTERNAL AUDIT
R&D	RESEACH & DEVELOPMENT
L	LANDS
J A P	JAPAN AIDED PROJECTS
A D B P	ASIAN DEVELOPMENT BANK PROJECTS
M F A P	MISCELLANEOUS FORIGN AIDED PROJECTS

PROJECT DIRECTORS

TEU	TENDER EVALUTION
CKE	COLOMBO-KATUNAYAKA EXPRESS WAY
S T C P	SOUTHERN TRANSPORT CORRIDOR PROJECTS

DEPUTY DIRECTORS

D.D	DEPUTY DIRECTOR
D.DD	DEPUTY DIRECTORS
BD	BRIDGES DESIGN
HD	HIGHWAY DESIGN
P	PLANNING
P.DD	PROVINCIAL DIRECTORS
C.EE	CHIEF ENGINEERS
S.EE	SENIOR ENGINEERS
C.E(M)	CHIEF ENGINEER MECHANICAL
D.EE	DESIGN ENGINEERS
GEO	GEOLOGIST
R.EE	RESIDENT ENGINEERS
L.O	LEGAL OFFICER
MAT.EE	MATERIAL ENGINEERS
E.EE	EXECUTIVE ENGINEERS
EE	ENGINEERS
A.L.O	ASSISTANT LEGAL OFFICER

DOA	DRAWING OFFICE ASSISTANT
T.O	TECHNICAL OFFICER
S.O	STATISTICAL OFFICER
TR.O	TRANSPORT OFFICER
MEC.SU	MECHANICAL SUPERINTENDENT
PRO	PUBLIC RELATION OFFICER
AO	ADMINISTRATIVE OFFICER
S.ACCT	SENIOR ACCOUNTANT
ACCT	ACCOUNTANT
SUR	SURVEYORS
P.M.ASSI	PROGRESS MONITORING ASSISTANT
S.A	STAFF ASSISTANT
B.SEC	BOARD SECRETARY
CHE	CHMIST
ACT.ASI	ACCOUNT ASSISTANT
INT.AUDR	INTERNAL AUDITOR
S.T.E	SENIOR TRAFFIC ENUMERATOR
T.E	TRAFFIC ENUMERATOR
R.O	RECORD OFFICER
S.STF	SUPPORT STAFF

මාර්ග සංවර්ධන අධිකාරිය
வீதி அபிவிருத்தி அதிகாரசபை
Road Development Authority

"සෙත්සිරිපාය", බත්තරමුල්ල.
"செத்சிறிபாய", பத்தரமுல்லை.
"Sethsiripaya", Battaramulla,
Sri Lanka.

මගේ අංකය / எனது இல. / My No. RDA/ES/B/G-46

ඔබේ අංකය / உமது இல. / Your No.

දිනය / திகதி / Date 07th Aug., 2000.

The Team Leader,
Basic Design Study Team,
Japan International Cooperation Agency.

Dear Sir,

GRANT AID ASSISTANCE FOR THE REHABILITATION OF GAMPOLA & MUWAGAMA BRIDGES
ENVIRONMENT IMPACT ASSESSMENT CLEARANCE

With reference to your inquiry regarding the need for Environment Impact Assessment for the above bridges, this is to confirm that an Environment Impact Assessment is not necessary for the area around the above two selected bridges.

Yours faithfully,

GENERAL MANAGER
ROAD DEVELOPMENT AUTHORITY

DKRS/n.

දුරකථන / தொலைபேசி / Telephone 862721, 862722, 863101-3 | ටෙලෙක්ස් / ரெலெக்ஸ் / Telex 22412 "ROADEV" CE | ෆැක්ස් / பெக்ஸ் / Fax 864801 | විදුලි පණිවුඩ / தந்தி / Telegram "RC

MINUTES OF DISCUSSIONS

BASIC DESIGN STUDY ON THE PROJECT FOR
REHABILITATION OF GAMPOLA BRIDGE AND MUWAGAMA BRIDGE
IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
(Explanation on Draft Report)

In July 2000, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a Basic Design Study Team on the Project for Rehabilitation of Gampola Bridge and Muwagama Bridge (hereinafter referred to as "the Project") to the Democratic Socialist Republic of Sri Lanka (hereinafter referred to as "Sri Lanka"), and through discussion, field survey, and technical examination of the results in Japan, JICA prepared a draft report of the study.

In order to explain and to consult on the components of the draft report, JICA sent to Sri Lanka the Draft Report Explanation Team (hereinafter referred to as "the Team"), which is headed by Mr. Seiji Kaiho, Resident Representative, JICA Sri Lanka Office, from October 23 to October 31, 2000.

As results of discussions, both parties confirmed the main items described on the attached sheets.

Colombo, October 30, 2000

Seiji Kaiho
Leader,
Draft Report Explanation Team
Resident Representative JICA

S.L.Seneviratne
Secretary
Ministry of Highways

J.H.J. Jayamaha
Director, Japan Division
Department of External Resources

W.A.Jayasinghe
Chairman
Road Development Authority
Ministry of Highways

ATTACHMENT

1. Component of the Draft Report

The Sri Lankan side agreed and accepted in principle the components of the draft report explained by the Team.

2. Japan's Grant Aid Scheme

The Sri Lankan side understands the Japan's Grant Aid Scheme and necessary measures to be taken by the Sri Lankan side as explained by the Team and described in Annex-4 and Annex-5 of the Minutes of Discussions signed by both parties on July 11,2000,and this adds some additional measures to be taken by the Government of Sri Lanka.

3. Schedule of the study

JICA will complete the final report in accordance with the confirmed items and send it to the Sri Lankan side by the end of February 2001.

4. Other relevant issues

(1) Ministry of Highways shall be responsible to secure smooth implementation of the Project, as the responsible organization of the Project on behalf of the Government of Sri Lanka.

(2) The Sri Lankan side shall allocate the budget for the taxes in accordance with details of the recommended Project, indicated the Draft Basic Design Report for the smooth implementation of the Project.

(3) The Sri Lankan side will take necessary measures for the safety and security of the Project in order to ensure smooth implementation of the Project.

(4) The Team confirmed that Sri Lankan side would execute the demolition of existing Gampola Bridge and Muwagama Bridge at their own expenses, after completion of the new bridges construction.

(5) Sri Lankan side shall have responsibility for maintenance of new bridges.

(6) Sri Lankan side shall have regulation to prevent sand harvesting around bridge area to maintain riverbed condition and prevent scour.

(7) Sri Lankan side shall have the sites cleared of all the utilities, such as high-tension cables, telephone cables and water pipes etc., which would obstruct the construction works before the implementation of the Project.

(8) Sri Lankan side shall be responsible to complete the acquisition of land required to secure smooth implementation of the Project to avoid delays.

(9) The name of the Project has been agreed between the Sri Lankan side and the JICA to change as follows:
"The Project for Rehabilitation of Gampola Bridge and Muwagama Bridge"

Appendices

5. Other Relevant Data

Technical Memorandum
(Second Site Survey 22nd August 2000)

Technical Memorandum
on the Basic Design Study
on the Project for Rehabilitation of Narrow and Weak Bridges
on National Highways (Phase2)
in the Democratic Socialist Republic of Sri Lanka
(Second Field Survey)

As the result of discussion between Basic Design Study Team of the mentioned project (hereinafter referred to as "the Team") and Road Development Authority (hereinafter referred to as "RDA"), both parties have confirmed the Design Criteria of the Project as described on the attached sheets. However, the final decision will be effective upon the concurrence by JICA. The Team will proceed on project works further and prepare the Draft Basic Design Report.

Colombo, August 22,2000

Mr.Kazuro YANAGIDA
Project Manager
Basic Design Study Team

Dr. G. L. Asoka J. de Silva
Director, Engineering Services
Road Development Authority

ATTACHMENT

1. EXTENT OF THE PROJECT

According to the decision of the extent of Project as shown in the table, RDA agreed to coordinate the incorporation of the Project with the ADB project while the Study Team will proceed further design works and prepare the Draft Basic Design Report. (See **ANNEX 1**)

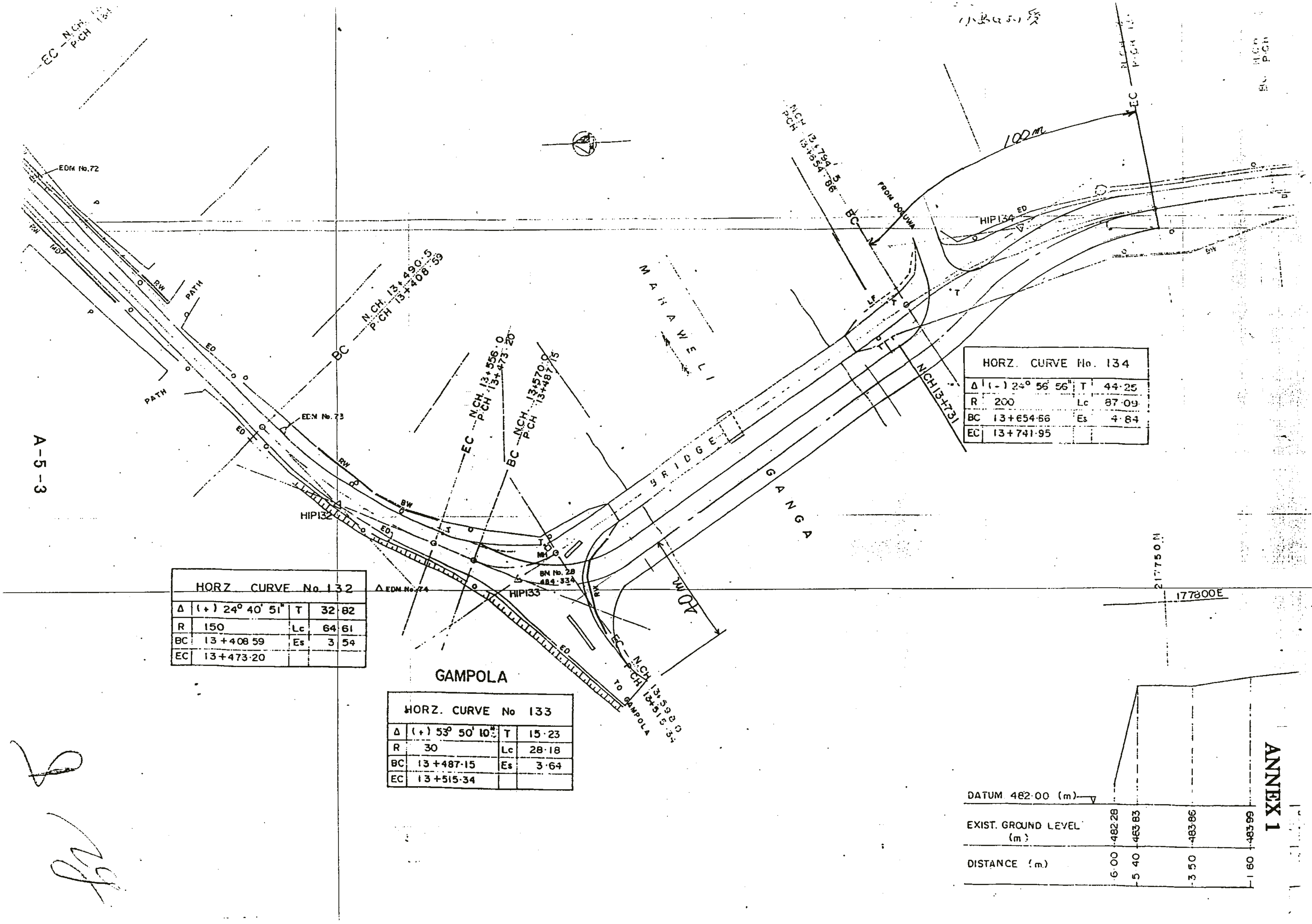
Project Site	Start	End
No. 93 Gampola Bridge	*Route AA005 BC No. 133 (where at the edge of the box-Culvert)	*Route AA005 EC No. 134 (where the new approach road incorporates to the existing road AA005) *Route AB013 Appx. 40 meters of the distance from the end of the Bridge. (where the new approach road incorporates to the existing road ~~B390)~~ AB013
No. 239 Muwagama Bridge	Appx. 200 meters of the distance from the beginning of the Bridge. (where the new approach road incorporates to the existing road B390)	Appx. 100 meters of the distance from the end of the Bridge End. (where the new approach road incorporates to the existing road B390)

2. BASIC DESIGN CRITERIA

After discussions with the Study Team, the Basic Design Criteria, attached herewith, are agreed by RDA to apply for the basic design for the Project. (See **ANNEX 2**)

3. COMPENSATION OF EXISTING ROADS

RDA accepts the proposal of the new diversion for the existing roads, which will be affected by the implementation of Project at Muwagama bridge. (See **ANNEX 3**)



HORZ. CURVE No. 132

Δ	(+) 24° 40' 51"	T	32.82
R	150	Lc	64.61
BC	13+408.59	Es	3.54
EC	13+473.20		

HORZ. CURVE No. 133

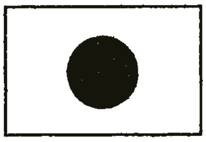
Δ	(+) 53° 50' 10"	T	15.23
R	30	Lc	28.18
BC	13+487.15	Es	3.64
EC	13+515.34		

HORZ. CURVE No. 134

Δ	(-) 24° 56' 56"	T	44.25
R	200	Lc	87.09
BC	13+654.66	Es	4.84
EC	13+741.95		

DATUM 482.00 (m)

EXIST. GROUND LEVEL (m)	482.28	483.83	483.86	483.99
DISTANCE (m)	6.00	5.40	3.50	1.60



BASIC DESIGN STUDY

ON

THE PROJECT FOR REHABILITATION OF GAMPOLA AND MUWAGAMA BRIDGES

IN

THE DEMOCRATIC SOCIALIST REPUBLIC OF SLI LANKA

BASIC DESIGN CRITERIA

August 2000

ORICONSUL

Oriental Consultants Company Limited

Basic Design Criteria of the Project for Rehabilitation of Gampola and Muwagama Bridges

1. Design Standards

As the result of the discussion with RDA, it was agreed to apply following standards. Table 1.1 shows the summary.

Table 1.1 Applicable Standards and References

Road	Geometric	• Geometric Design Standards of Roads in RDA 1998(GDSR) • Final Report for ADB Funded Third Road Improvement Project
	Pavement	• A Guide to The Structural Design of Roads under Sri Lankan Condition in RDA April 1999 • Final Report for ADB Funded Third Road Improvement Project • Manual for Asphalt Concrete Pavement, Japan Road Association（アスファルト舗装要綱　日本道路協会）
	Road Structure	• Ditto
Bridge	Superstructure Substructure	• Specification for Highway Bridges in 1996 (SHB) in Japan Road Association（道路橋示方書・同解説　平成８年１２月　日本道路協会） • Standard Specification for Concrete in 1996 in Japan Civil Engineering Association.（コンクリート標準示方書　土木学会） • Bridge Design Manual in RDA 1997(BDM)
River Control		• Cabinet Order concerning Structural Standards for River Control Facilities, etc., Sankaido, March 1978 in Japan（改定　解説・河川管理施設等構造令　国土開発技術研究センター）

Note: Bridge Design Manual in RDA 1998 was provided based on BS5400 with certain modification to suit Sri Lankan local conditions.

2. Design Values

(1) Geometric Design

Table.2.1: Design speed and Road Classification

The Bridge	Road Class	Design volume	Type of Road	Terrain	Design Speed Category	Design Speed	Remark
Gampola (No.93)	A	300 - 18,000	Modified R3	M	Urban	50	Adopt ADB AA005
Muwagama (No.239)	B	300 - 18,000	Modified R3	M	Urban	50	N/A

Table 2.2 Values employed in the Road Geometric Design

Item		Unit	Design value	
			Gampola Modified R3	Muwagama Modified R3
Design speed		Km/h	50	
Traffic Lane width including margin		M	7.4	
Cross fall(Asphalt Concrete Surface)		%	Road: 2.5%(Shoulder: 3.0-4.0) Bridge: 1.5%	
Horizontal Alignment	Min. Radius of Curve	M	85 (72)	
	Max. Superelevation	%	6	
Vertical Alignment	Min. Gradient	%	0.3	
	Max. Gradient	%	4	5

Note: The geometric design criteria employed herein are principally adapted based on GDSR. The design values may change in accordance with further design works.

(2) Road Cross Section

The cross section of the approach roads and the bridges have been adopted based on the GDSR as shown in the ***Attachment-1***.

(3) Pavement Design

Highway Design Manual in RDA 1998 and Manual for Asphalt Concrete Pavement, Japan Road Association will be applied to the pavement design for the approach roads, however, the pavement structure provided in the Final Report for ADB Funded Third Road Improvement Project shall be considered for the linking access to the proposed road.

(4) Bridge Design

(a) Analysis Methods of Structure

Allowable Stress Design Methods based on SHB is to be applied with the structure analysis.

(b) Loads

a) Principal Loads

① Dead Loads

The dead load is a total weight of the self-weight of the bridge and the other facilities, which are calculated based on the unit weights shown in Table 2.3

Table 2.3 Unit Weight of Materials

Material	Unit volume weight (kN/m³)	Material	Unit volume weight (kN/m³)
Iron, cast steel	77	Concrete	22.5-23.0
Cast iron	71	Cement mortar	21.0
Aluminum	27.5	Wood	8
Reinforced concrete	24.0-24.5	Bitumen	11
Prestressed concrete	24.5	Asphalt concrete	22.5

Note: The various utilities, which are installed onto the bridges, shall be taken into account as the design load.

② Live loads

According to the comparison study as attached in ***Attachment-2***, B live load (Load equivalent to 25 tons, which is applied to the principal trunk roads in Japan) will be applied to the bridge design loads.

③ Impact Effect by Live loads

The impact effect caused by the live loads shall be considered. The impact coefficient "i" is to be calculated by the following equation quoted from SHB shown in Table 2.4.

Table 2.4 Calculation of the Impact Coefficient

Type	Impact coefficient i	Remarks
Steel bridge	$T=\dfrac{20}{50+\text{span length}}$	Not affected by whether the T load or L load is used.
Reinforced concrete bridge	$T=\dfrac{20}{50+\text{span length}}$	In case T load used
	$T=\dfrac{7}{20+\text{span length}}$	In case L load used
Prestressed concrete bridge	$T=\dfrac{20}{50+\text{span length}}$	In case T load used
	$T=\dfrac{10}{25+\text{span length}}$	In case L load used

④ Pre-stress force: shall be considered according to the SHB, in case that PC concrete girder is applied.

⑤ Creep and Shrinkage: shall be considered in accordance with the SHB.

⑥ Ground pressure: shall be calculated in accordance with the SHB.

⑦ Water pressure: shall be calculated in accordance with the SHB.

⑧ Buoyancy or Uplift force: shall be considered in accordance with the SHB.

b) Secondary loads

This load shall be taken into account for the combination of loads:

① Wind loads

According to the Bridge Design Manual in RDA 1998, the Mean Hourly Wind Speed Value of v in m/s for the location of the bridges are given in the wind loading zone map shown in ***Attachment-3***. The wind loads for both bridge sites shall be calculated based on the SHB.

② Effect of temperature change (According to the air temperature fluctuation of Sri Lanka)

Concrete: ± 15℃ (average 35℃, maximum 50℃, and minimum 20℃)

Note that 0.1 of the dead load or equivalent will be considered as a shoe horizontal component due to temperature change.

③ Effect of the earthquake

There is almost no observation record of the earthquake in Sri Lanka. Accordingly, the effect of earthquake is not taken into account.

c) Particular load

Particular loads are those to be taken into account depending on the bridge type, construction type, and bridge point condition of this project:

① Load during construction

② Effect of movement of the fulcrum

③ Braking and Traction force

④ Collision load

d) Increase in the allowable stress due to combination of loads

Increase in the allowable stress due to combination of loads is shown in Table 2.5.

Table 2.5 Increase in the allowable stress due to combination of loads

Load combination	Increase coefficient
Principal load	1.0
Principal load + temperature load	1.15
Principal load + braking force	1.25
Principal load + collision load	1.5
During construction	1.5

(c) Strength of Materials

Standard strength of materials, which is specified in Japan Industrial Standards (hereinafter refereed to as " JIS"), will be adapted as the design strength.

a) Concrete

The design strength and Young's modulus of concrete are shown below:

① Design Strength (28-days strength)

PC girder: $\sigma ck=35N/mm^2$, $40N/mm^2$

RC slab, Cross beam, RC girder: $\sigma ck=24N/mm^2$

RC sidewalk, railing: $\sigma ck=24N/mm^2$

Substructure (Abutment, Pier): $\sigma ck=21N/mm^2$, $24N/mm^2$

Piles (Cast in-situ) : $\sigma ck=24N/mm^2$

② Young Modulus

Design standard strength (N/mm^2)	21	24	35	40
Young modulus (kN/mm^2)	23	24	29	31

b) Steels (PC steel, Reinforcing Bar, Steel Plate)

The design strength of steels shall conform to that specified in JIS.

(d) Overhead Clearance

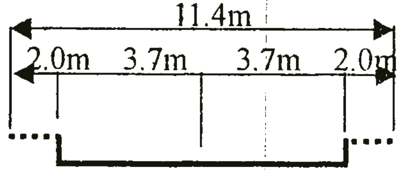
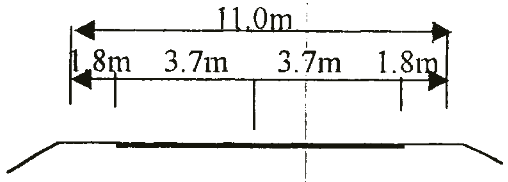
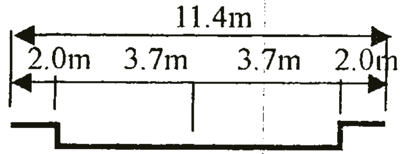
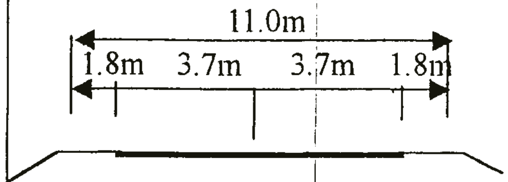
Accordingly, the clearance under girder in compliance with the standard established on the basis of the Cabinet Order of Japan will be employed. Relationship between the design flood discharge and clearance under girder must be more than the values specified in Table 2.6.

Table 2.6 Relationship between Design Flood Discharge and Overhead Clearance under Girder

Design flood discharge Q (m3 /s)	Q＜200	200≦Q ＜500	500≦Q ＜2000	2000≦Q ＜5000	5000≦Q ＜10000	10000＜ Q
Clearance under girder (m)	0.6	0.8	1.0	1.2	1.5	2.0

Road Cross Section

Attachment-1

Bridge	Road Cross Elements	Bridge Length	Typical Cross Section	Remarks
No. 93 Gampola Bridge	• Class:A • R.O.W: Modified R3 (Width to be decided by RDA) • Carriageway: 3.7m x 2 • Shoulder (Bridge Sidewalk width):1.8m(1.8m)x2 • Side Drain: 0.9m x 2 • Cross falls: Carriageways 2.5% (Asphalt concrete pavement) Bridge: 1/60 (1.5%) • The fence and kerbs: Fence (Hand rails) :h= 1.1m Kerb :h≧225mm	Bridge Length: 105m	 Bridge  Approach Road	
No. 239 Muwagama Bridge	• Class: B • R.O.W: Modified R3 (Width to be decided by RDA) • Carriageway: 3.7m x 2 • Shoulder (Bridge Sidewalk width): 1.8m (1.8m) x2 • Side Drain: 0.9m x 2 • Cross falls: Carriageways 2.5% (Asphalt concrete pavement) Bridge: 1/60 (1.5%) • The fence and kerbs: Fence (Hand rails) :h= 1.1m Kerb :h≧225mm	Bridge Length: 102m	 Bridge  Approach Road	

Comparison for Live load between BS and JP
(for HB 30Unit Loading)

1. Condition

(1) Subject of Structure : RC Simple Span Bridge
PC Simple Span Bridge
~~Steel Simple Span Bridge~~

(2) Compare with Bending moment at center of span of simple beam

(3) Effective width is assumed 7.4 m. (With 2 lane: 2@ 3.7)

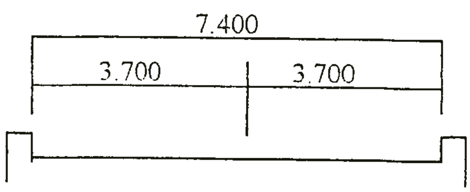
(4) Units will be used t-f, tf-m.

(5) Design with BS is based on limit state method and Japanese Standard is base allowable stress method. Comparison Bending Moment for live load will be carried as follows.

	Japanese Standard	British Standard
Maximum Bending Moment	M_{JS}	M_{BS}
Partial Load Factor γ_{fL}	1.0	γ_{fL}
Allowable Stress factor (Stress Limitation factor)	F_{JP}	F_{BC}
Characteristic Concrete Cube Strength	f'cu by Cylinder test f'cu = 0.85 fcu	fcu by Cubic test
Compare Moment	M_{JS}	M'_{BS} $= M_{BS} \times \gamma_{fL} \times f'cu / fcu$

(6) Design Span L = 10m to 100m

Cross-section of bridge



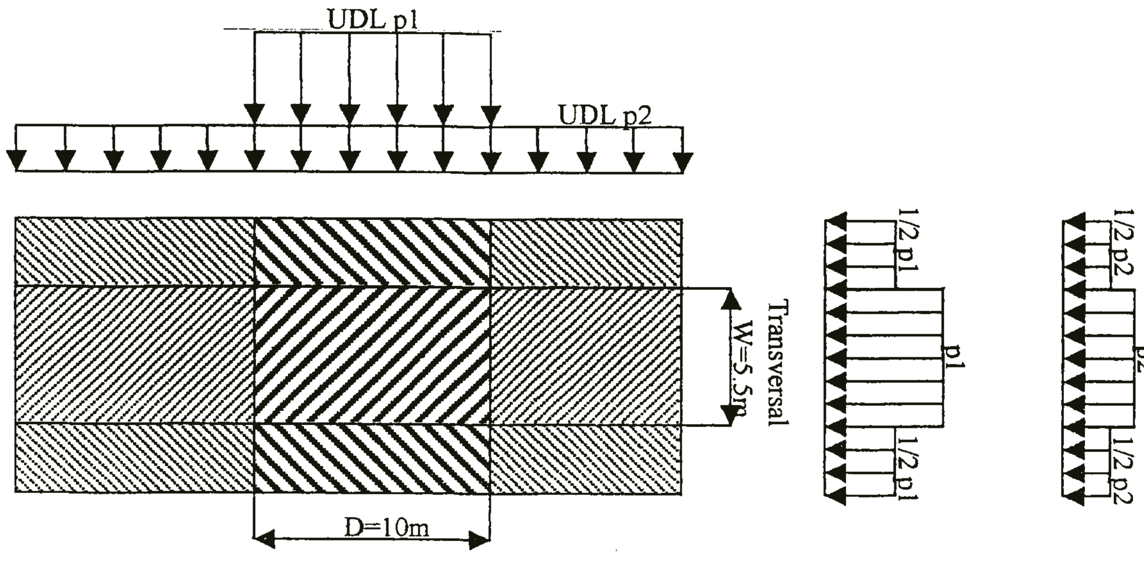
2 Lane Carriageway

2. Live Load

1) Japanese Live Load

i) L Live Load

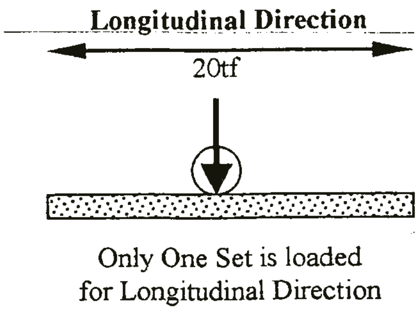
B Live Load shall be applied for main road

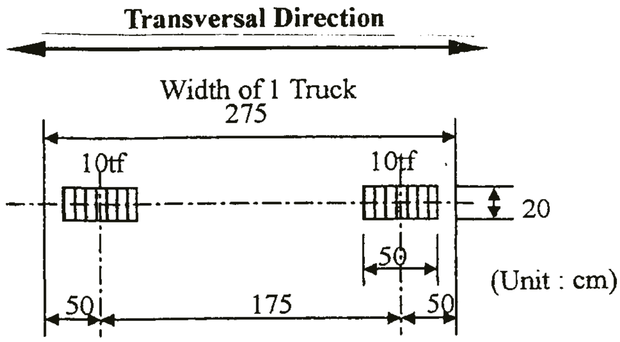


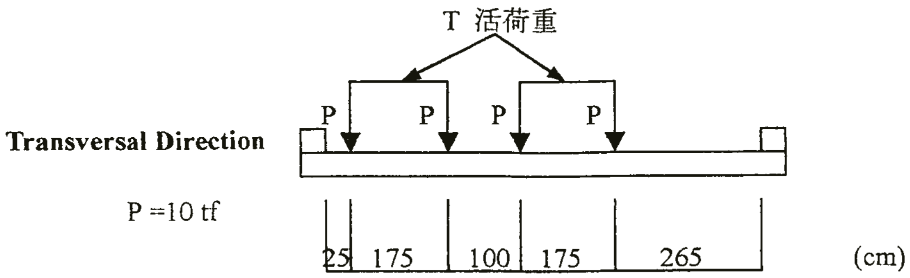
Main Loading Width (B = 5.500 m)					Sub-Loading
Loading Length D (m)	Uniformly Distributed Load p1 Load (kgf/m2) for Bending Moment	Uniformly Distributed Load p2			
		L<=80	80<L<=130	L>130	
10	1,000	350	430-L	300	50 % of Main Load

ii) T Live Load

This T Live Load is mainly used for the transversal direction of bridge slab design. But for short span bridge with less than 15m long span this T live Load is also used for longitudinal direction design.







No limited Set of T Load for Transversal Direction

iii) Impact

Coefficients of Impact **i** shall be calculated as follow

For L Load

Bridge Type	Coefficient of Impact **i**
Steel Bridge	i = 20 / (50 +L)
Reinforced Concrete Bridge	i = 7 / (20 +L)
Prestressed Concrete Bridge	i = 10 / (25 +L)

For T Load

Span Length	L > 4m
Coefficiect for T Load	L/32 + 7/8

2) **British Standard**

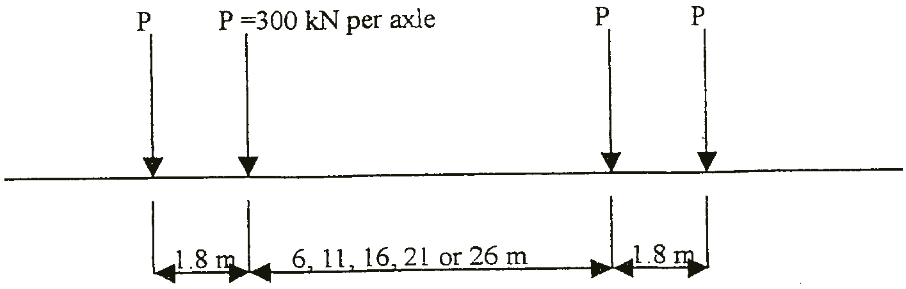
HA and HB Loading shall be applied for highway

i) **HA Loading**

HA Loading	Uniformly Distributed Load (UDL)			Knife Edge Load (KEL)
Loaded Length (m)	L<30	30<=L<380	380<=L	
Load per meter of lane W (kN)	30	$151 \times (1 / L)^{0.475}$	9	kN

ii) **B. HB Loading**

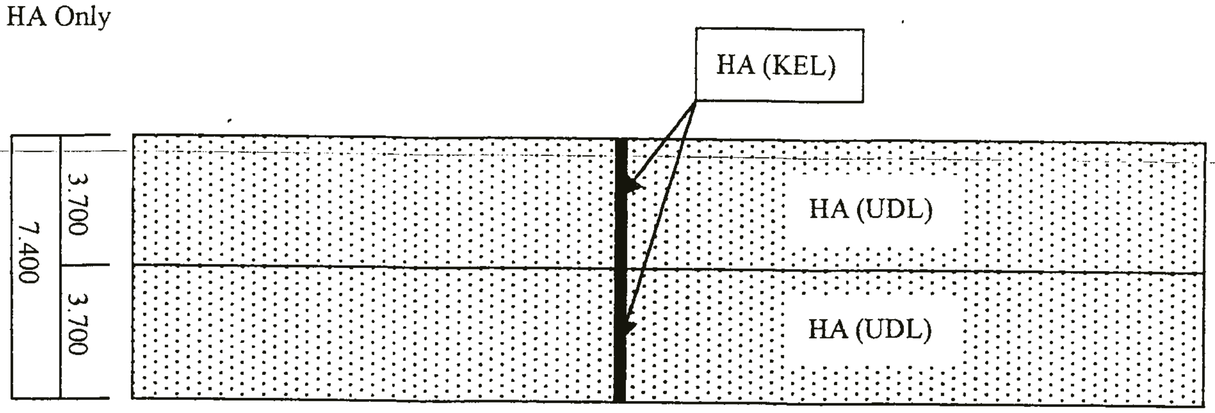
For 30 Unit P = 300 kN per axle (10kN per one Unit)



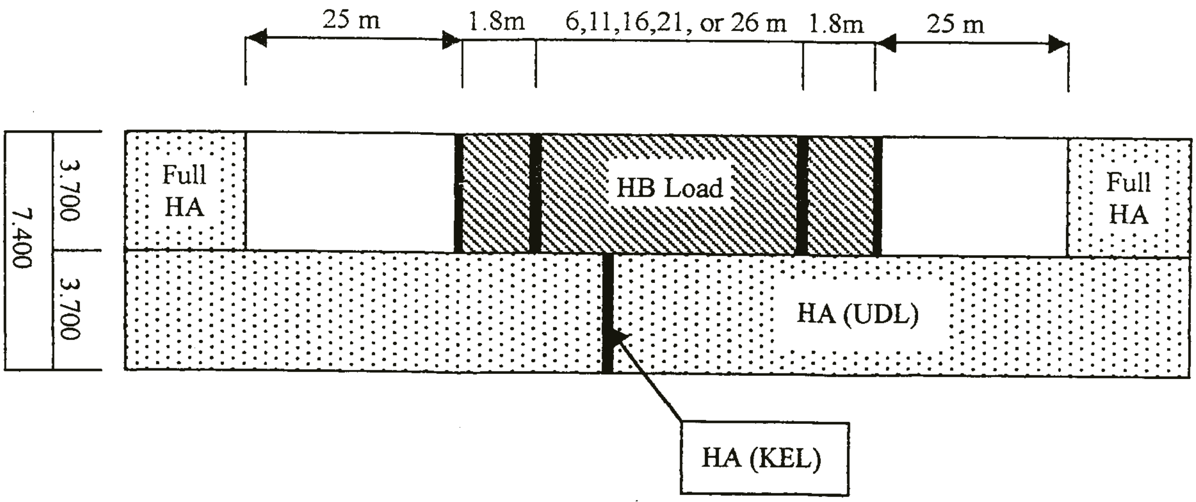
iii) Combination of HA and HB Loading

For Bridge with 2 lane (2 × 3.70 m carriageway width)

① HA Only



② HA and HB Loading



iv) Partial Load Factor on BS

On BS Partial Load Factor γ_{fL} is taken in each combination as below.

Load		Limit State	γ_{fL} to be taken in combination Combination 1 Permanent loads primary live load
Highway bridge live loading	HA alone	ULS	1.50
		SLS	1.20
	HA with HB or HB alone	ULS	1.30
		SLS	1.10

3. Stress Limitations for serviceability Limit State

3.1 Japanese Standard

Material	Type of stress under design loading	Type of construction	
		Reinforced concrete	Prestressed concrete
Concrete	Compressive stress distribution due to bending	1/3 f' cu	0.35 f'cu
	compressive stress distribution due to axial loading	0.85/3 f'cu	0.28 f'cu
Reinforcement	Tension (for SD345 : fy = 35 kgf/mm^2)	0.51 fy (1,800 kgf/cm^2)	Not applicable

3.2 BS for serviceability Limit State

For reinforced and Prestressed concrete, the compressive and tensile stress limitations are in the below table.

Material	Type of stress under design loading	Type of construction	
		Reinforced concrete	Prestressed concrete
Concrete	Triangular or near triangular compressive stress distribution (e.g. due to bending)	0.50 f cu	0.40 fcu
	Uniform or near uniform compressive stress distribution (e.g. due to axial loading)	0.38 fcu	0.30 fcu
Reinforcement	Compression Tension (Grade 460)	0.75 fy (325 N/mm^2)	Not applicable

4. Ratio of stress limit

1) Concrete

i) RC

Krc = (0.50 fcu) / (1/3 f'cu) = 1.5 (fcu / f'cu)

f'cu = 0.85 fcu due to the ratio of strength by Cubic test and Cylinder test

Kc = 1.5 (fcu / (0.85 fcu)) = 1.76

ii) PC

Kpc== (0.40 fcu) / (0.35 f'cu) = 1.18 (fcu / f'cu)

f'cu = 0.85 fcu due to the ratio of strength by Cubic test and Cylinder test

Kc = 1.18 (fcu / (0.85 fcu)) = 1.34

2) Reinforcement

Kr = (0.75 fy) / (0.51 fy) = 1.47

3) Steel Bridge

Ks= (1.7 σ sy) / (1.2 σ sy) =1.42

5. Bending Moment for each Span Length and Ratio of Bending Moment by Live Load of BS(HA+HB30) and JP B Live Load

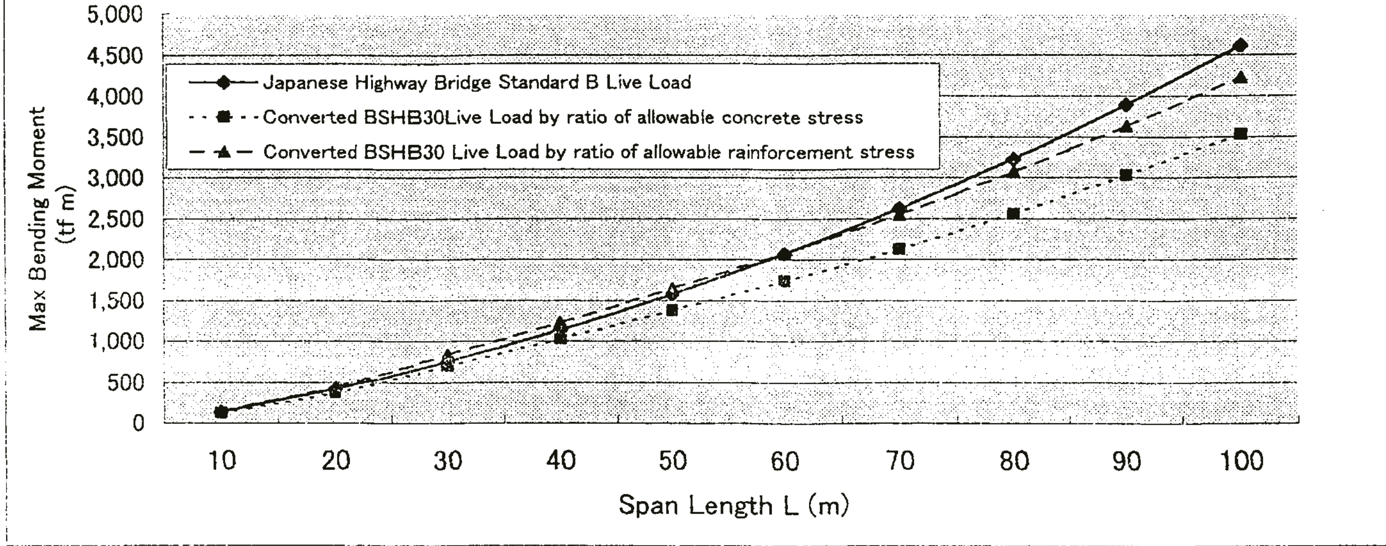
1)Serviceability limit states

i) RC Single Span Bridge

Conparison of Bending Moment for RC Single Span Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Carriadgeway Width = 7.4m

Span Length L (m)	10	20	30	40	50	60	70	80	90	100
Japanese Highway Bridge Standard B Live Load	134	417	749	1,134	1,574	2,069	2,620	3,226	3,889	4,608
Converted BSHB30Live Load by ratio of allowable concrete stress	121	367	697	1,026	1,372	1,733	2,125	2,558	3,026	3,526
Converted BSHB30 Live Load by ratio of allowable rainforcement stress	145	440	835	1,229	1,643	2,075	2,544	3,062	3,623	4,222

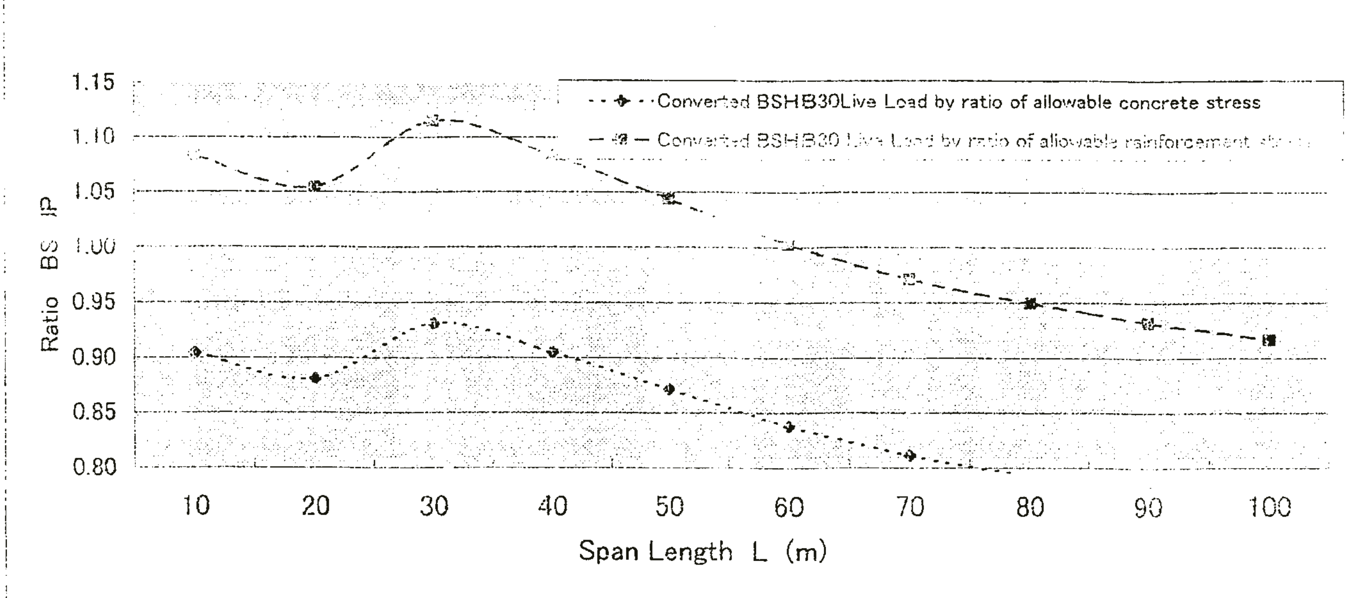


Conparison of Bending Moment for RC Single Span Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Ratio of Bending Moment for RC Sinple Span Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Carriadgeway Width = 7.4m

Span Length L (m)	10	20	30	40	50	60	70	80	90	100
Converted BSHB30Live Load by ratio of allowable concrete stress	0.90	0.88	0.93	0.90	0.87	0.84	0.81	0.79	0.78	0.77
Converted BSHB30 Live Load by ratio of allowable rainforcement stress	1.08	1.05	1.11	1.08	1.04	1.00	0.97	0.95	0.93	0.92



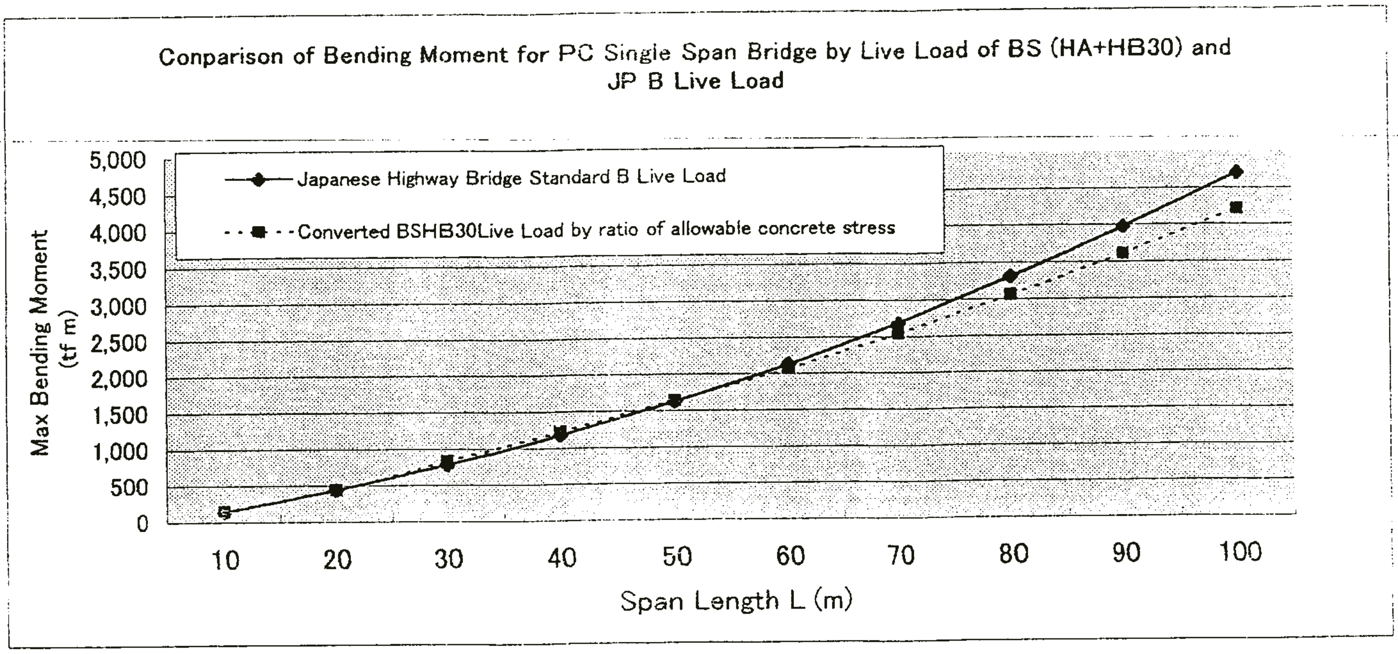
Ratio of Bending Moment for RC and PC Bridge by Live Load of BS (HA+HB30) and JP B Live Load

ii) PC Single Span Bridge

Conparison of Bending Moment for PC Single Span Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Carriadgeway Width = 7.4m

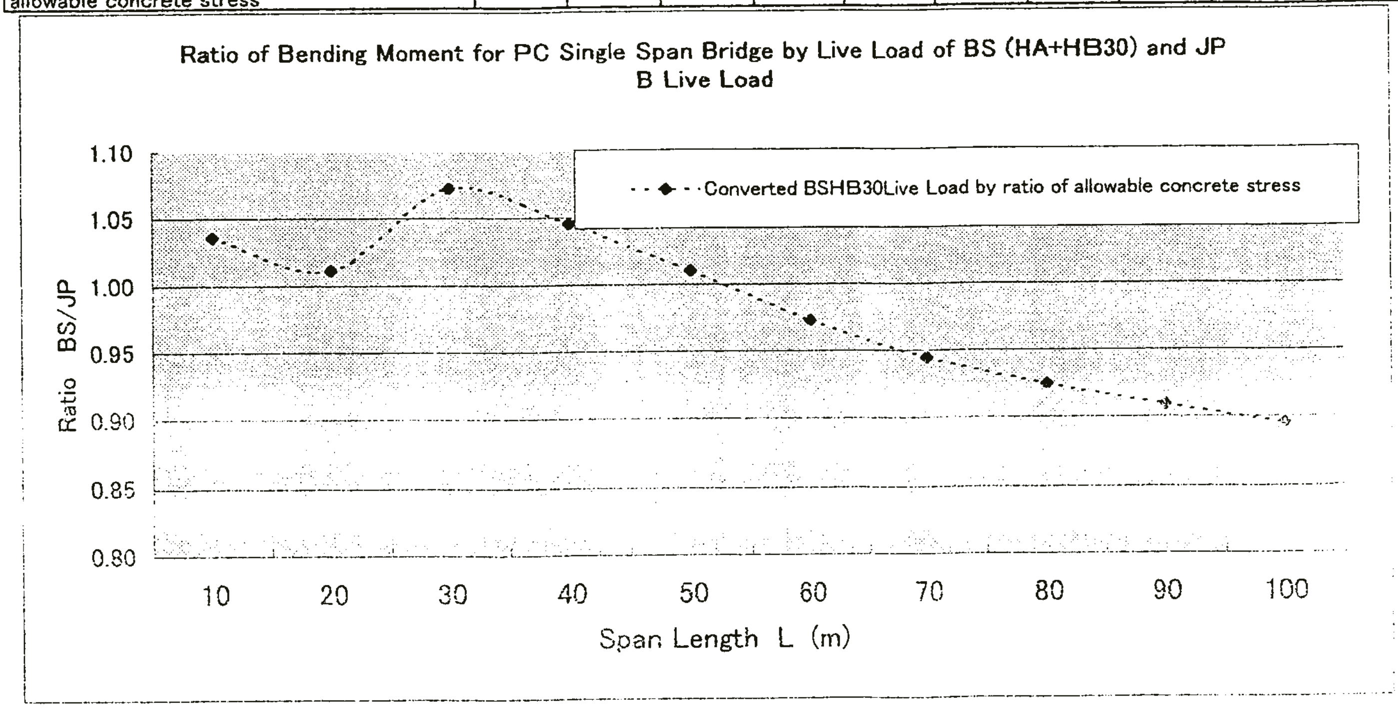
Span Length L (m)	10	20	30	40	50	60	70	80	90	100
Japanese Highway Bridge Standard B Live Loa	140	434	777	1,172	1,622	2,127	2,687	3,303	3,974	4,702
Converted BSHB30Live Load by ratio of allowable concrete stress	145	438	833	1,225	1,638	2,069	2,537	3,054	3,613	4,210



Ratio of Bending Moment for PC Single Span Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Carriadgeway Width = 7.4m

Span Length L (m)	10	20	30	40	50	60	70	80	90	100
Converted BSHB30Live Load by ratio of allowable concrete stress	1.04	1.01	1.07	1.05	1.01	0.97	0.94	0.92	0.91	0.90

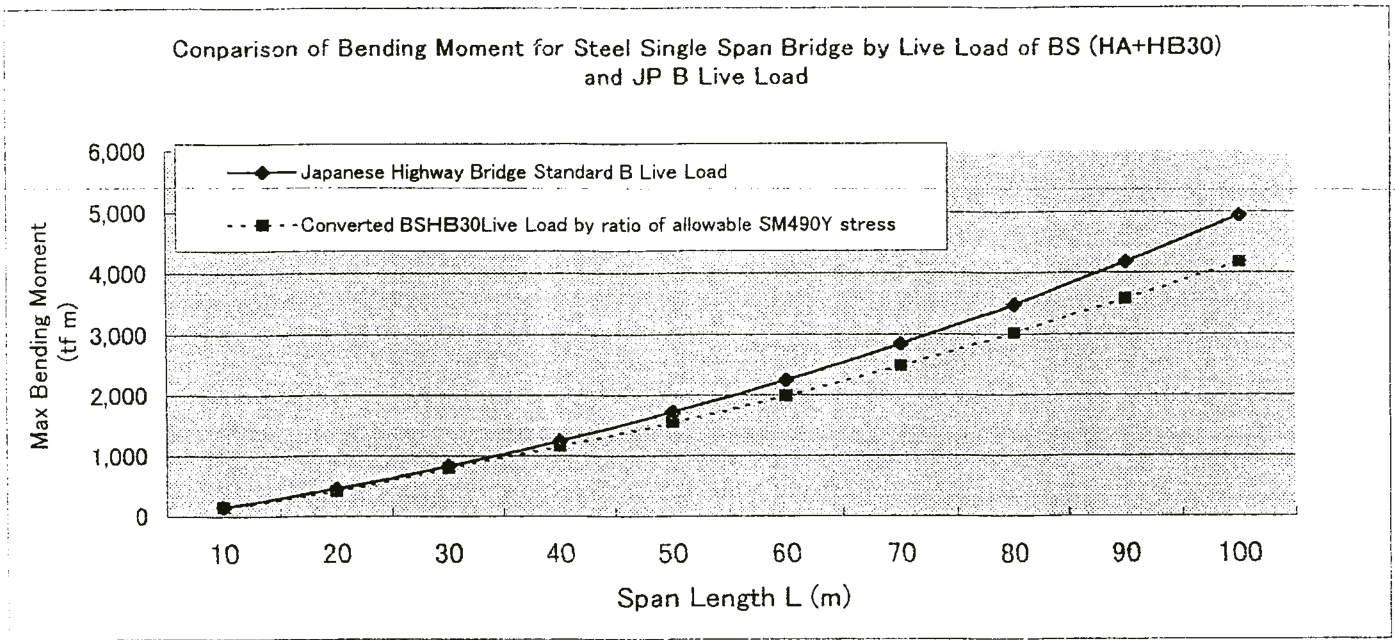


iii) Steel Single Span Bridge

Conparison of Bending Moment for Steel Single Span Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Carriadgeway Width = 7.4m

Span Length L (m)	10	20	30	40	50	60	70	80	90	100
Japanese Highway Bridge Standard B Live Load	145	456	821	1,242	1,717	2,249	2,836	3,479	4,179	4,934
Converted BSHB30Live Load by ratio of allowable SM490Y stress	150	414	786	1,156	1,546	1,985	2,481	3,012	3,575	4,168



Ratio of Bending Moment for Steel Single Span Bridge by Live Load of BS (HA+HB30) and JP B Live Load

Carriadgeway Width = 7.4m

Span Length L (m)	10	20	30	40	50	60	70	80	90	100
Converted BSHB30Live Load by ratio of allowable SM490Y stress	1.04	0.91	0.96	0.93	0.90	0.88	0.87	0.87	0.86	0.84

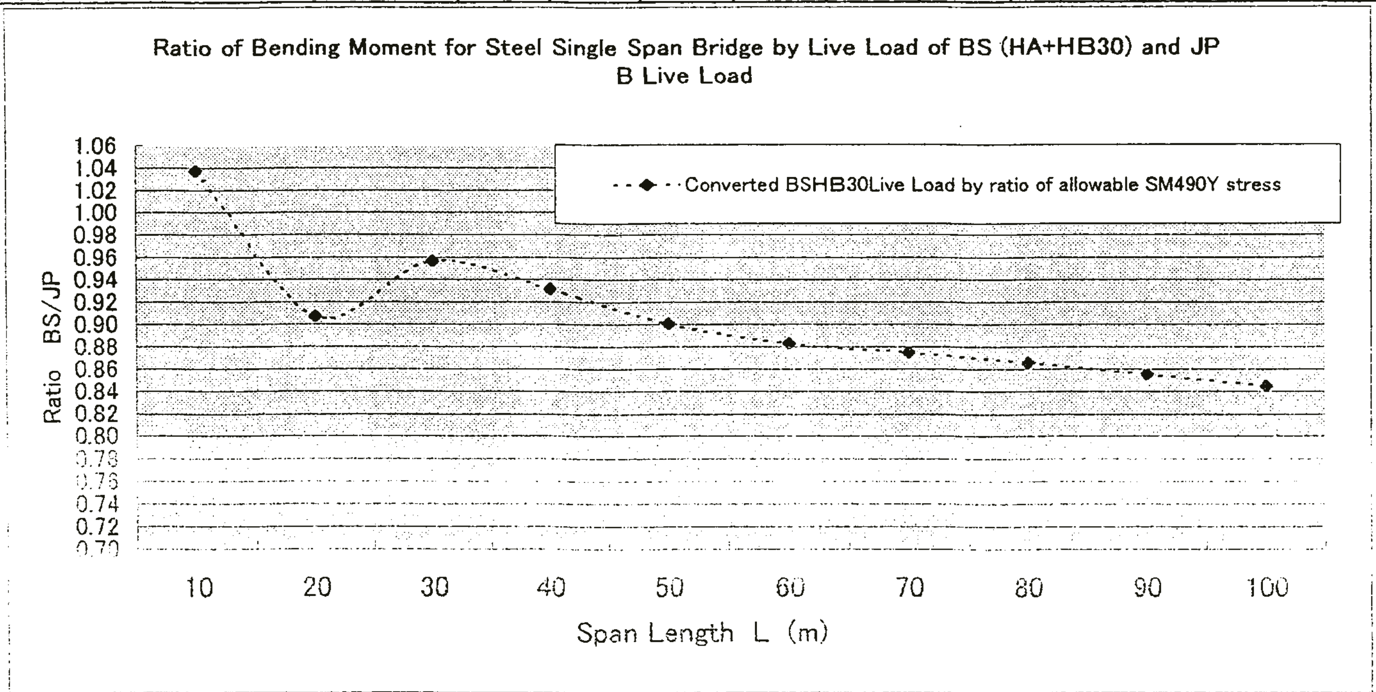
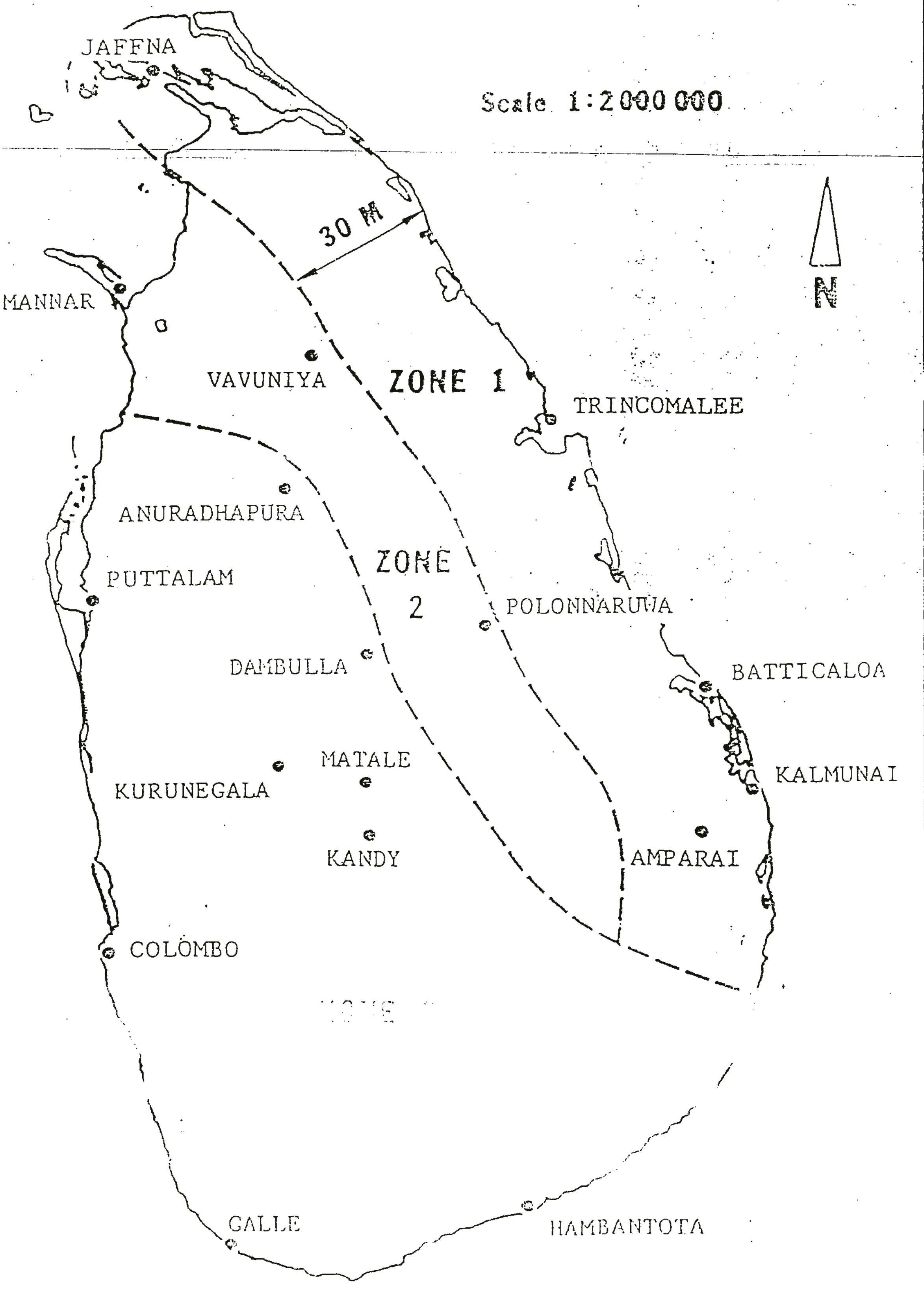


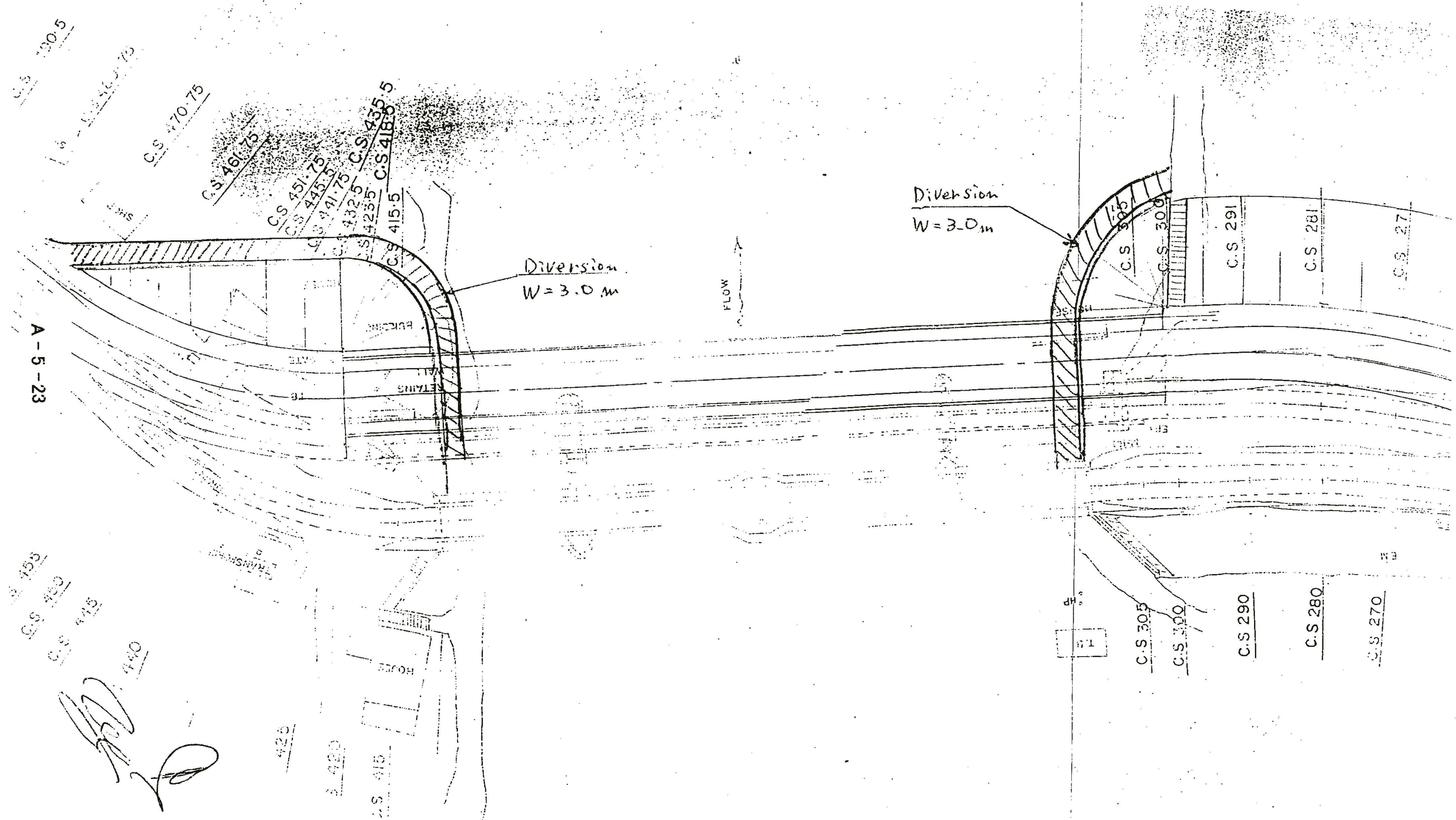
Fig. 2·1

SRI LANKA

WIND LOADING. ZONES



Diversion Plan around Muwagama Bridge



Appendices

6. Other Relevant Data

(Present Condition of the 11Bridges under the First Survey)