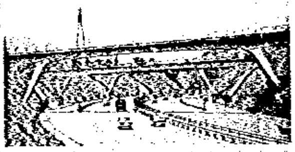
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF TRANSPORT AND HIGHWAYS
ROAD DEVELOPMENT AUTHORITY (RDA)

THE STUDY ON THE OUTER CIRCULAR HIGHWAY TO THE CITY OF COLOMBO

FINAL REPORT

VOLUME 3 OF 5



MAIN TEXT II

ANNEX I
TRAFFIC SURVEY DATA & TRAFFIC MODEL RESULTS

ANNEX II
GROUND SURVEY DATA

FEBRUARY 2000

ORIENTAL CONSULTANTS COMPANY LIMITED

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The following foreign exchange rate is applied in the study :

Sri Lankan Rs.= 1.6 YEN (as of December 1999)

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ABBREVIATIONS

(In alphabetical order)

1. AASHTO: American Association of State Highway and Transportation Officials
2. ADB: Asian Development Bank
3. B/C: Benefit / Cost Ratio
4. BOI: Board of Investment (of Sri Lanka)
5. BS: British Standards
6. CBR: California Boring Ratio
7. CEA: Central Environment Agency (of Sri Lanka)
8. CKE: Colombo-Katunayake Expressway
9. CMR: Colombo Metropolitan Region
10. CMRSP: Colombo Metropolitan Regional Structure Plan
11. CPU: Computer Processing Unit
12. CUTS: Colombo Urban Transport Study
13. dpi: dots per inch
14. DS Divisional Secretaries
15. EIA: Environmental Impact Assessment
16. EIRR: Economic Internal Rate of Return
17. ERD: Department of External Resources, Ministry of Finance and Planning (of Sri Lanka)
18. FIRR: Financial Internal Rate of Return
19. GB: Gigabyte
20. IEE: Initial Environmental Evaluation
21. ISE: Initial Social Examination
22. JBIC: Japan Bank for International Cooperation
23. JICA: Japan International Cooperation Agency
24. JRSO: Japan Road Structure Ordinance
25. MOTH: Ministry of Transport and Highways (of Sri Lanka)
26. MFE: Ministry of Forest and Environment (of Sri Lanka)
27. NAASRA: National Association of Australian State Road Authorities
28. NEA: National Environmental Act
29. NPV: Net Present Value
30. OCH: Outer Circular Highway
31. OD: Origin-Destination (matrix)
32. OECF: Overseas Economic Cooperation Fund, Japan
33. PCU: Passenger-Car Unit
34. PCU-km: Passenger-Car-Unit Kilometers (car-usage output from traffic assignment

model)

35. QV func.: Quantity-Velocity function (input used in traffic assignment model)
36. RAM: Random Access Memory
37. RDA: Road Development Authority (of Sri Lanka)
38. R^2: Coefficient of Determination
39. SIDA: Swedish International Development Cooperation
40. STRADA: System for Traffic Demand Analysis (transportation demand model from JICA)
41. UDA: Urban Development Authority
42. VCR: Volume-Capacity Ratio (road link congestion index in traffic assignment model)
43. Vmax: Velocity Maximum (max. velocity for road links in traffic assignment model)

CHAPTER 11

CONSTRUCTION PLAN

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CHAPTER 11 CONSTRUCTION PLAN

11.1 General

Construction planning is mainly comprised of i) establishing a construction method and ii) preparing a construction time schedule. The results of this work are utilized in estimating construction costs and establishing a project implementation schedule.

11.2 Basic Conditions of Construction Plan

(1) Staged Construction

Since the OCH project requires large-scale construction work, it is desirable both economically and technically to phase this work over a period of time. After careful study, it is planned to construct the OCH in two stages in order to obtain optimal results in regards to meeting traffic demand and investment scheduling:

Initial Stage : Initial construction of a four-lane dual carriageway highway for the entire length of the OCH.

Final Stage : Widening from four to six lanes sections requiring greater capacity due to increases in traffic demand.

Based on the initial structure of a four-lane carriageway, there are three alternative methods shown below for widening a carriageway from four to six lanes.

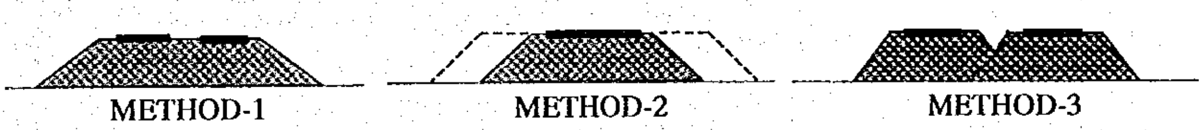


Fig. 11.1 Staged Construction

Method - 1 : The initial carriageway is paved for four lanes, but can be widened to six lanes by simply paving the median area.

Method - 2 : The initial carriageway can only accommodate four paved lanes. Widening to a paved six-lane structure requires future widening of the earthworks and paving of the outer lanes.

Method - 3 : The initial structure has the capacity to accommodate six lanes, but requires that the central median area be filled and paved.

Of the above-mentioned three methods, the initial investment for Method-1 would be too large and it would be difficult to attain a reasonable economic return and is therefore not considered. In terms of cost and socioeconomic impacts, Method-3 is preferable to Method-2 for the following reasons:

- Removal of residences or businesses abutting the OCH is not required.
- Renovation of interchanges is not required.
- Less equipment and manpower is required.
- Improvement of traffic safety during the final construction stage is possible.
- There is less demolition and reconstruction of slope protection facilities.

(2) Framework of Construction

A construction plan is developed within the framework of the following construction parts, taking into account the OCH construction strategy shown in Fig.11.2. The construction of the OCH is executed in the order of the part numbers. Note also that part 4 is to remain as a four-lane structure, while all the other parts will be upgraded to a six-lane structure.

Part No.	Part	Construction Phase	
		Initial Stage	Final Stage
1	Bandaragama – Kottawa	4	6
2	Kottawa – Kadawata	ditto	ditto
3	Kadawata – CKE (Kerawalapitiya)	ditto	ditto
4	Bandaragama - Panadura	ditto	4

(3) Quantities of Major Works Items

Selection of the construction method is based on actual work quantities and site conditions.

(4) Road Network for Hauling Materials

The construction of the OCH involves the hauling of large quantities of embankment/ pavement materials.

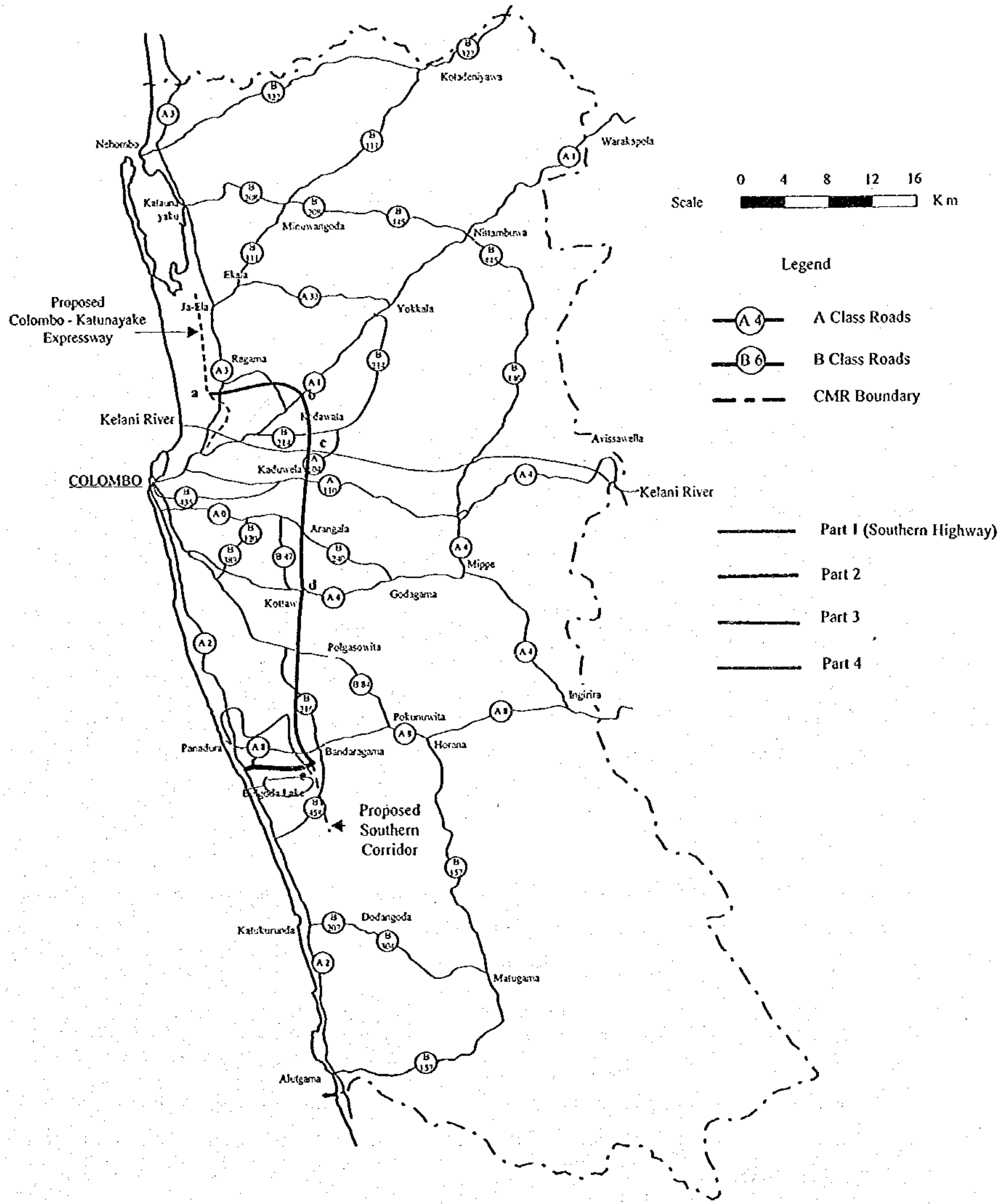


Fig.11.2 OCH Construction Strategy

The project area has a sufficient existing road network for the hauling of said materials. However, the pavement strength of existing local roads is sometimes insufficient. Therefore, pavement strengthening/repair will be necessary. However, the construction of new roads is unlikely.

On the other hand, the construction of some temporary roads will be required in order to transport the construction materials, together with the use of parallel roads.

11.3 Construction Method

11.3.1 Equipment Intensive Construction

To realize cost efficiency gains via a shorter construction period, the intensive use of mechanical equipment for construction will be adopted.

11.3.2 Earthwork

(1) Cutting (Hilly and/or Rolling Terrain)

In hilly and/or rolling areas where the topography and profile indicates the need for cutting, excavation work (including the removal of soil to a stockpile) will be carried out.

(2) Balance of Cut and Fill

On hilly sections, where the natural ground line crosses the planning section, a balance between cutting and embanking will be carried out taking into account the effective use of resources.

(3) Embankment with Borrow Materials

Fill materials for embankments shall be supplied from borrow pits, which will be located in the vicinity of each site. For slope protection, turfing and/or planting are suitable considering the Sri Lankan climate.

(4) Embankments Susceptible to Displacement (Marshy and/ or Soft Soil Areas)

A few sections of the proposed alignment are located on a peat layer, which is approximately 5 to 10 meters thick. Soft soil such as peat is highly susceptible to long-term settlement caused by traffic loads or other factors. Therefore, methods to strengthen the ground in these areas in order to stabilize embankments should be applied. If a peat layer is less than 7 meters thick, the removal of soil is an efficient method for embankment stabilization.

(5) Major Equipment

The use of the following major earthwork equipment is planned for the OCH construction (Tab. 11.1).

Tab. 11.1 Earthwork Equipment

Main Work	Equipment	
	Hauling distance less than 100m	Hauling distance more than 100m
Clearing	Bulldozer	
Excavation Loading Hauling	Bulldozer - Bulldozer	Tractor Shovel Tractor Shovel/Payloader Dump Truck
Spreading Compaction	Bulldozer/Motor grader Tamping Roller/Tire Roller	

(6) Outline of Earthwork Planning

Tab. 11.2 shows the outline for OCH earthwork, as well as the sources for embankment materials for construction. On average, hauling distance is not more than 2 km.

Tab. 11.2 Outline for OCH Earthwork

Part No.	Location	Outline of Earthworks
1	Bandaragama - A4(Kottawa)	The proposed highway runs through paddy and lowland area. Low embankments less than 2 meters in height are mostly anticipated. Borrow pits shall be situated in the neighboring hills around Kottawa for supplying the embankment materials. Countermeasures due to scouring by the Bolgoda River shall be considered during/after embankment construction.
2	A4 (Kottawa) – A110(Kadawata)	The topography is a combination of rolling and flat land in this section. Where the flat terrain consists of paddy fields, a low embankment less than 2 meters in height will be constructed. Materials for embankment will be obtained from a borrow pit situated in the neighboring hills of Biyagama and from the Kelani River (river sand).
3	A110(Kadawata) – CKE(Kerawalapitiya)	The proposed highway runs through rolling and flat terrain in this section. Approximately 2 kms of the proposed highway will be located in a marshy area lying south of the Matara navy camp. A detailed soil investigation shall be carried out to research the peat layer embankment settlement, which has a direct impact on construction costs. Also, since the IC for CKE is constructed near a swampy area, a soil investigation shall be carried out there to clarify soft soil areas as well. Embankment materials will be obtained from a borrow pit in the neighboring hills of either Nugegoda or Biyagama.
4	Bandaragama – A2(Panadura)	The proposed highway runs above the northern side of the Bolgoda River. Materials are to be obtained from the neighboring hills of Bandaragama, Bolgoda and existing rivers (sandy gravel) for roadway improvement.

11.3.3 Paving Work

The Study Team calculated the pavement structure applying AASHTO standards. Flexible pavement, such as asphalt/concrete, was selected for the OCH itself and for structural add-ons such as bridges, fly-over crossings and culverts.

(1) Main Equipment

The following equipment will be used for the execution of paving work (Tab. 11.3).

Tab. 11.3 Paving Work Equipment

Main Work	Equipment
Sub-grade Preparation	Motor Grader, Tire Roller, Macadam Roller
Sub-base	Motor Grader, Tire Roller, Macadam Roller
Prime/Tack Cost	Asphalt Distributor
Surface Course	Asphalt Mixing Plant, Asphalt Finisher, Macadam Roller, Tire Roller

(2) Material Sources

The sources for paving materials are shown in Tab.11.4.

Tab. 11.4 Sources of Paving Materials

Materials	Location of Quarry	Remarks
Gravel and Sand	Colombo Seashore*	Deposit: 500,000m^3
Sand		Deposit: 250,000m^3
Coarse Aggregate	Kaduwela	Granite
Coarse Aggregate	Northern Mahara	Granite
Coarse Aggregate	Northern Biyagama	Granite

*: Only to be permitted if environmental impacts negligible.

(3) General Descriptions of Materials

1) Sub-base Course Materials

Sub-base course materials will be obtained from existing rivers and/or rock deposits and will be processed as necessary for gradation control.

2) Base Course Materials, Coarse and Fine Aggregate

There are a number of aggregate producers that mainly operate north of the Kelani River and between the Kelani River and Route A4 to the east of the OCH alignment. If demand warrants it, contractors can establish their own quarries and gravel pits, as well as operate their own crushing/ screening plant.

3) Asphalt Concrete

The procurement of hot-mix asphaltic concrete is possible for the construction of asphalt treated base course and surface course.

11.3.4 Bridge and Viaduct Construction

Continuous PC girder bridges are to be built for the two major rivers, i.e., the Kelani and Bolgoda Rivers. Abutments and piers are assumed to be pile foundations in order to ensure bearing capacity. As for minor bridges, slab/ PC girder bridges are assumed.

Viaducts are assumed to be of the same scale as the flyover built in Ragama by the RDA for crossing on existing railway (length: 450 meters).

(1) Main Equipment

The equipment used for bridge construction is shown in Tab.11.5.

Tab. 11.5 Bridge Construction Equipment

Main Work	Equipment
Foundation	Diesel Pile Hammer, Pile Driver, Truck Crane, Floating Crane, Reverse Circulation Drilling Machine.
Structure Excavation	Clamshell, Dump Truck, Barge
Substructure	Transit Mixer, Concrete Pump Truck
Superstructure	Crawler Crane, Erection Truss, Launching Girder
Superstructure	Floating Crane

(2) Construction of the Kelani River Bridge

Construction of the Kelani River Bridge will require the following construction methods:

- An open caisson will be required for substructure construction.
- Cast-in-place concrete piling will be executed by a reverse-circulation-drill method.
- PSC-girders will be erected by means of conventional crane erection method or erection girder method.

1) Construction Yards

A river terrace on the left bank, located in an area with relatively few houses between the Kelani River and Kaduwela Road A110, will be used as work yards for the construction of the Kelani River Bridge. The yards will include a simple ready-mixed concrete plant, pretension girder fabrication yard, material storage yard and workshop, heavy construction equipment parking area, field office, accommodations for workers, and a temporary storage yard for excavated soil.

Since the elevation of the terrace is around 5.5 m here, as compared to a HWL for the river of more than 5.4 m, embanking and leveling of this area to an elevation of + 1.0 m of the HWL will be executed prior to use as yards.

If a simple ready-mixed concrete plant and girder fabrication yards can be secured and shared by all sites for the supply of ready-mixed concrete and precast girders to the multiple bridge-building sites (including this site), then quality control can be improved and construction costs reduced.

2) Protection Work for Existing Roads

Before abutment construction, work to protect pedestrians, animals, and vehicles using Biyagama Road B214 and Kaduwela Road A110 will be carried out.

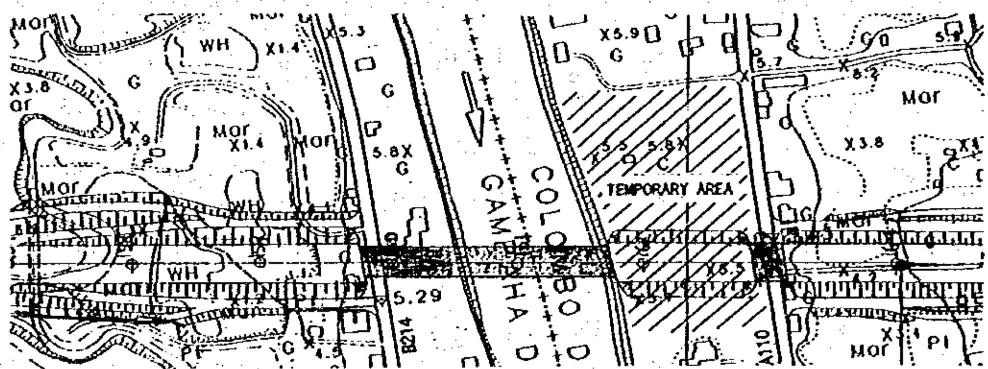


Fig.11.3 Location for Kelani River Bridge

3) Construction of Open Caisson

(a) Man-made Islands

If the elevation of a man made island is LWL + 1.0 m, its embankment height should be about 4.5 m. As water depth is 3 m or more even in the dry season, the periphery of a man-made island is first surrounded with steel sheet piles, then soil to build the island is added. This method is employed in order to prevent the loosening of embankment material during the excavation of the open caisson and the washout of embankment material by the river. Steel sheet piles are driven by a high-powered hammer from a floating crane. Man-made islands for each pier are connected via a temporary jetty.

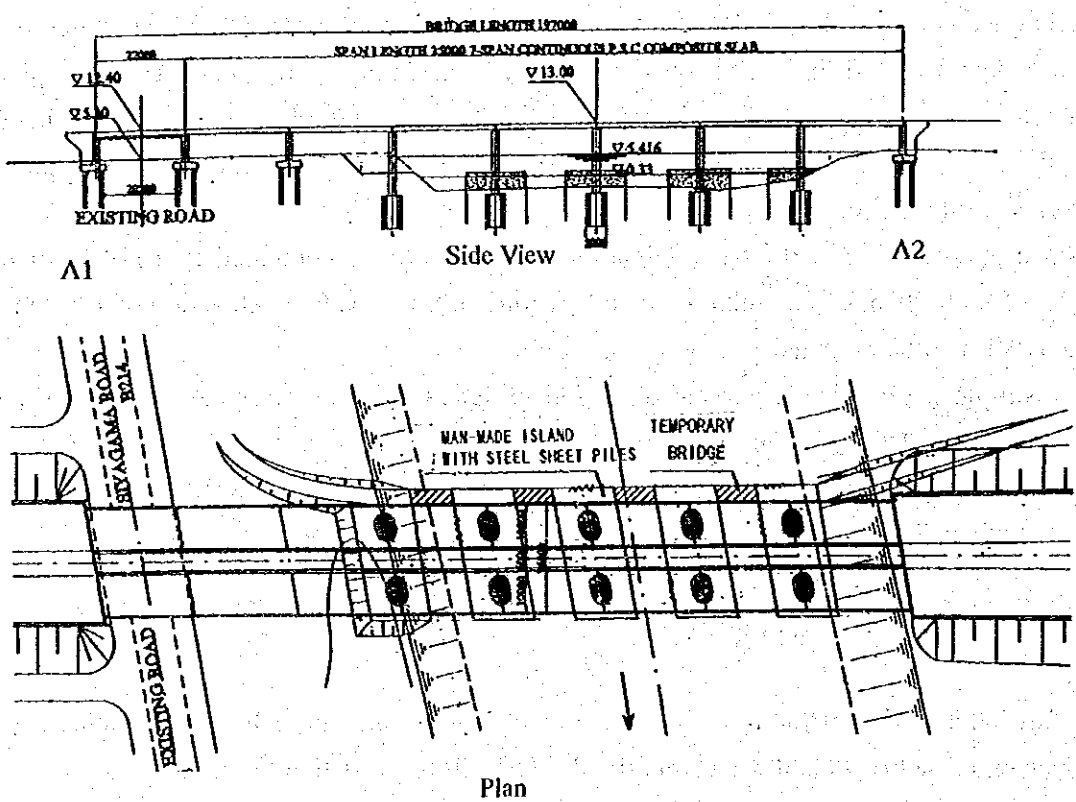


Fig.11.4 Construction of Kelani River Bridge

(b) Excavation for Caissons

Excavation work for open caissons is carried out using a crane, clamshell buckets, etc.. Excavated soil is stored in a temporary storage yard on the left bank of the river for subsequent use as embankment material for the main line on the left bank.

In the case of an open caisson, once settlement has proceeded to a certain degree, it is difficult to correct the inclination. It is therefore essential to thoroughly control settlement during the initial settlement period after excavation, and to proceed with work with the utmost care so as not to cause any inclination.

Generally, a method to reduce friction between the ground and wall surface is employed to promote caisson settlement. If settlement is hard to achieve, it may be possible to press the caisson into the ground in a forced manner by using an earth anchor.

4) Erection of Superstructure

Three spans near the A1 abutment on the right bank of the river and the end span near the A2 abutment on the left bank are erected on existing ground, using either a single 100-ton truck crane or two 50-ton truck cranes. The four spans for the river section may be built applying one of following methods:

(a) Erection with a crane-equipped barge
(b) Erection with a truck crane
(c) Erection via temporary girders

The appropriate method will be selected depending on the conditions of the bridge site.

- Method *(a)* is extremely economical and advantageous if a barge is available and can be towed to the bridge site.
- Method *(b)* consists of erecting a bridge superstructure by first completing a single section of bridge to allow a truck crane to use that section of bridge to continue with the building of superstructure for subsequent spans. This method is most commonly used when the space under a bridge cannot be used for scaffolding. However, this method cannot be used for continuous PC girder bridges.
- Method *(c)* consists of installing superstructure via the use of a gantry crane, for example moving between temporary girders set on the pier substructure. This method enables the continuous installation of girders, reducing the installation period, but its cost is higher than the other methods.

(3) Construction of the Bolgoda River Bridge

1) Construction Yards

The left bank of the Bolgoda River is used for the construction yards. This site has a ground elevation of about 1.5 m and entry is possible from a national highway. The yard is embanked and leveled to an elevation of about 1.0 m greater than the HWL..

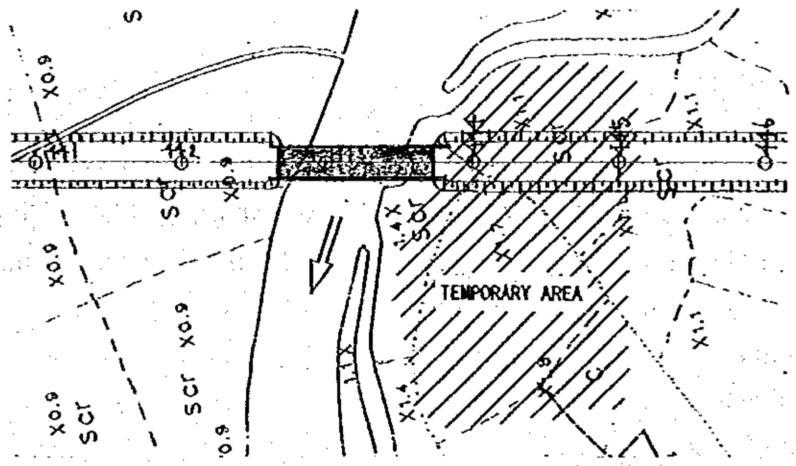


Fig.11.5 Location for Bolgoda River Bridge

2) Construction of Pile Bent Pier

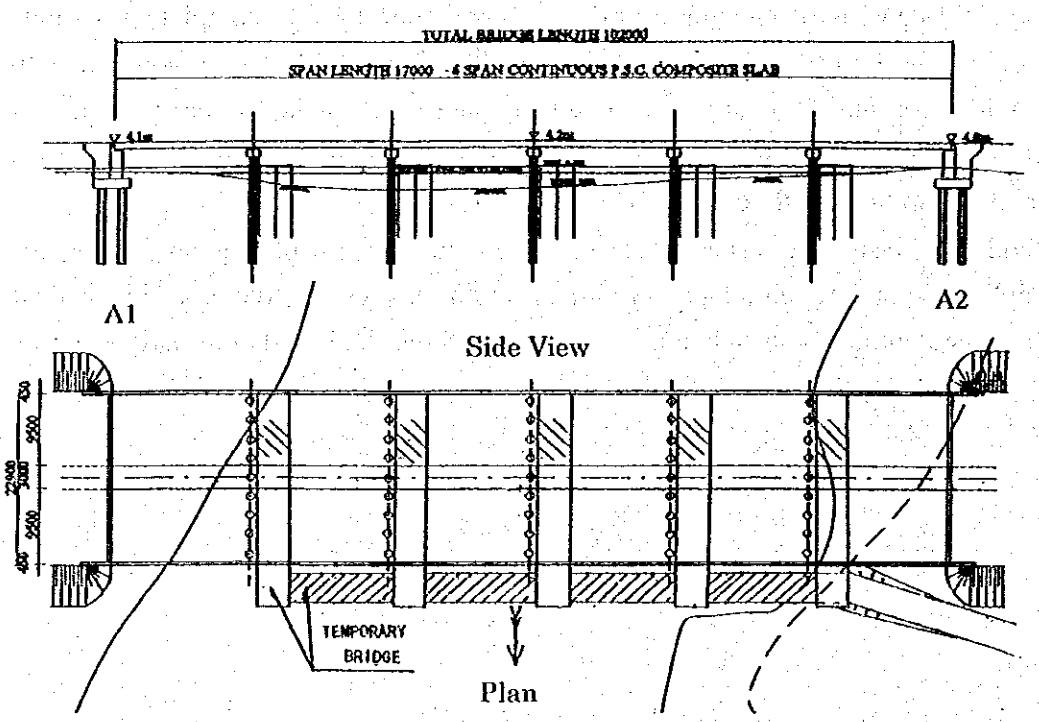


Fig.11.6 Construction of Bolgoda River Bridge

(a) Installation of Temporary Work Jetty

To install cast-in-place piles, a temporary jetty for work is constructed. The elevation of installation is to be LWL + 1.0 m. Temporary work jetties are to be connected with temporary passage jetties. For pier P5 of the A2 abutment where the river is relatively shallow, a man-made island may be used for construction.

(b) Construction of Pile Bend (ø1.0 m RC cast-in-place piles)

Except for the bottom end of piles where soil collapse is highly unlikely, piles will be installed using casings. Casing portions not exposed to water will be left embedded. For casing portions that will be exposed to water, they will be removed since they are susceptible to corrosion.

3) Erection of Superstructure

Both end spans, which are located on land, will be installed using a single 35-ton truck crane. The four spans of the river section may be installed applying one of the following methods:

(a) Erection with a truck crane using installed girders

(b) Draw erection using installed girders

The appropriate method will be selected depending on the conditions of the site. The merits and demerits of these methods are the same as for the Kelani River, except that the installed girder of Method (b) must be set at the central portion of the abutment and pier (median strip of the superstructure).

(4) Overpass and Interchange Structures

As for the construction of overpasses and interchanges at intersections with existing roads, the superstructure will normally be erected by means of a conventional crane.

(5) Railway Crossing

The construction of railway crossings shall be carefully executed to avoid interfering with railway operation. Surveying shall be carried out to determine existing obstacles such as power lines, traffic lights and telecommunications. Then, methods to protect these facilities during construction will be examined. Sufficient discussions shall be held with the client on the construction procedures as well.

(6) Box-Culverts

Confirming the bearing capacity of the foundation is extremely important, since a box-culvert normally applies a spread foundation. Therefore, a foundation test shall be carried out before excavation.

11.3.5 Cross Drainage/ Side Ditch/ Kerb

The size and number of pipe culverts have been estimated based on hydrology calculations. The side ditches, pipe under the center median and kerb are considered in the carriageway design shown in a typical cross section. These quantities are included in the earthworks.

11.3.6 Cross and Side Road Treatment

It is necessary to consider how local roads, which shall either be terminated or connected to the OCH frontage road, will be dealt with in relation to the new highway profile.

11.3.7 Other Accessories

Streetlights, traffic signs, road markings, traffic control units, traffic signals and other traffic control facilities will be employed.

11.4 Land Acquisition and Resettlement

11.4.1 Establishment of Right-of-Way

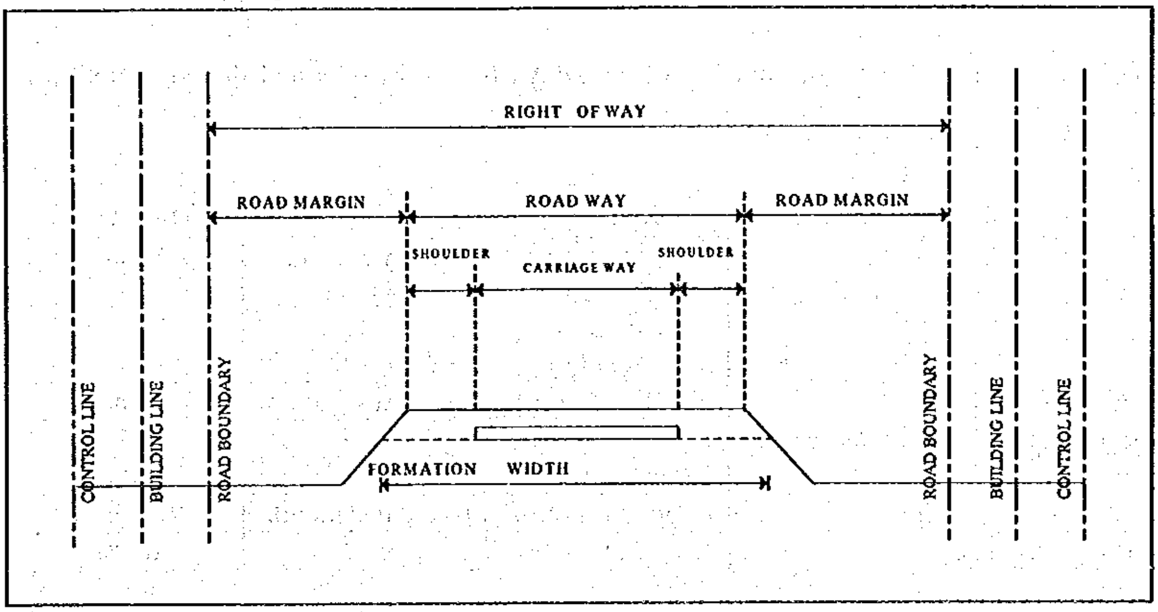
The right-of-way is defined as an area necessary to accommodate all necessary road structures and facilities for the OCH, which has been set out in accordance with the following terms:

a) The RDA shall reserve the right-of-way for the operation of the OCH.
b) Land, such as temporary construction yards, required outside of the designated right-of-way shall be provided under the contractor's obligation.

The right-of-way for the OCH is given in Fig.11.7 and will include the installation of utilities for electricity and water for highway use on the road shoulders. Utilities for other purposes will not be installed within the right-of-way. The dotted lines shown in the figure, distinguish the following:

- Road boundary: A boundary for defining OCH operation and which is normally categorized as the right-of-way. The border of the road boundary for the OCH is at the edge of the slope drainage.
- Building line: This is the architectural gauge for buildings. Any building will not be allowed to be constructed beyond this line.
- Control line: This line defines an area for use by temporary construction yards. The yards should be 10 to 15 meters from the road boundary in order to accommodate temporary road and drainage facilities.

Fig.11.7 Right-of-Way, Building Line, Control Line



11.4.2 Utility Relocation

Utilities requiring relocation have been identified by the Study Team via on-site inspection and a 1/5000 topographical map. There are high-tension towers and local electricity distribution facilities, water supply and telecommunications facilities, etc. The number of high-tension towers requiring relocation has been worked out during the preliminary design and the relocation cost estimated by the Ceylon Electricity Board in the preceding chapter.

11.5 Construction Time Schedule

11.5.1 Conditions for Scheduling

(1) Critical Construction Period

Taking into account the scale and urgency of the construction of the OCH, the maximum possible construction period was set at 2.5 years for each part.

(2) Weather Conditions

According to rainfall data, the number of workdays for earthworks and the construction of pavement were estimated as shown in Tab. 11.6.

Tab. 11.6 Construction Working Cycle-time(Dry Season/Rainy Season)

Item	Dry Season Jul.- Sep. Dec.- Mar (8 months)	Rainy Season Apr.- Jun. Oct.-Nov. (4 months)	Annual
Number of rainy days	10.1 days/ month	14.0 days/ month	145 days
Working efficiency on a rainy day	65 %	35 %	52.5 %
Number of holidays	5.0 days/ month	4.3 days/ month	60 days
Number of working days	21.5days/ month	16.6 days/ month	229 days
Working efficiency	72 %	55 %	63 %

11.5.2 Time Schedule

The construction time schedule for each construction section was prepared based on the conditions described in Subsection 11.4.1 above, and is shown in Fig 11.8 and 11.9.

Fig.11.8 Construction Time Schedule for Initial Stage

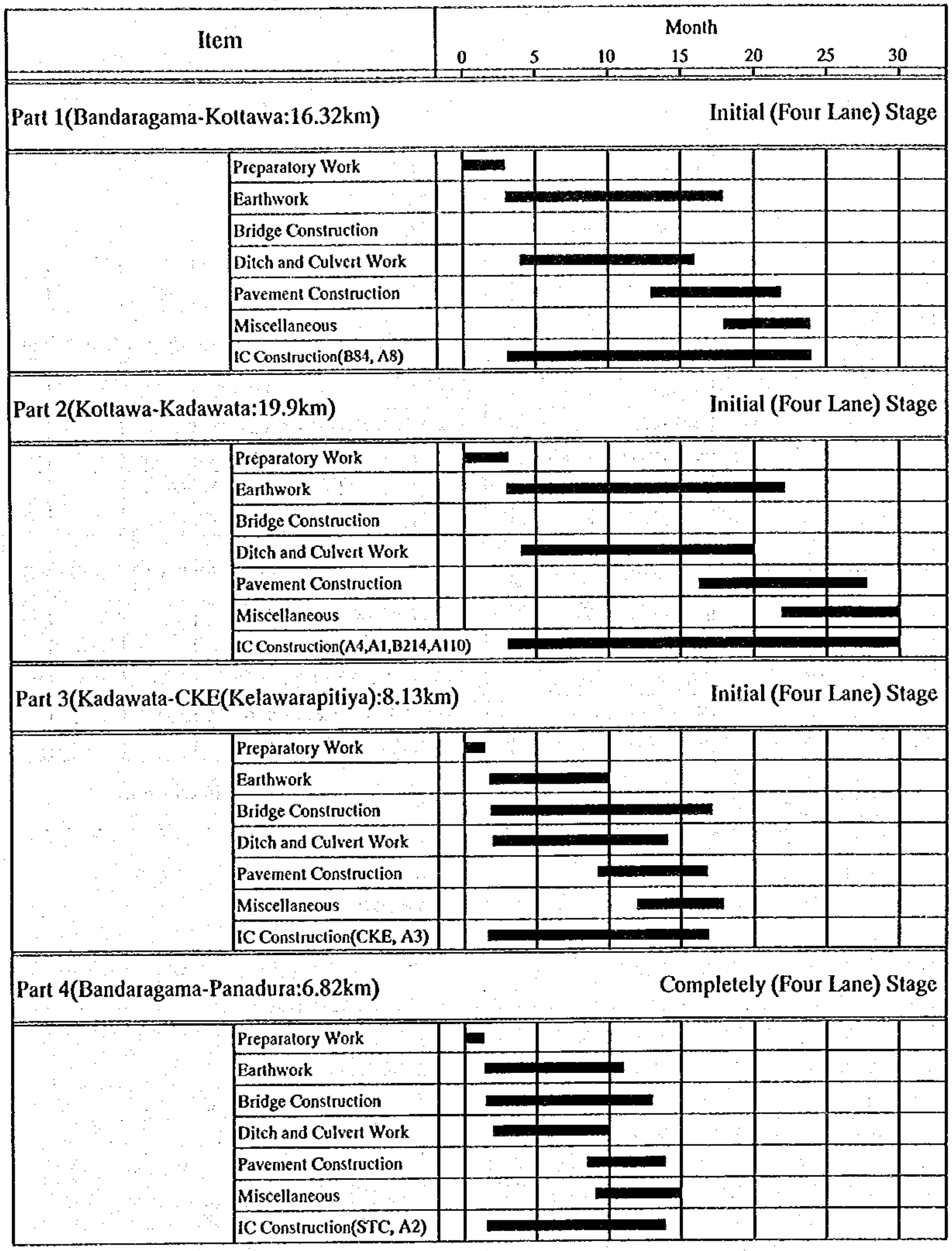
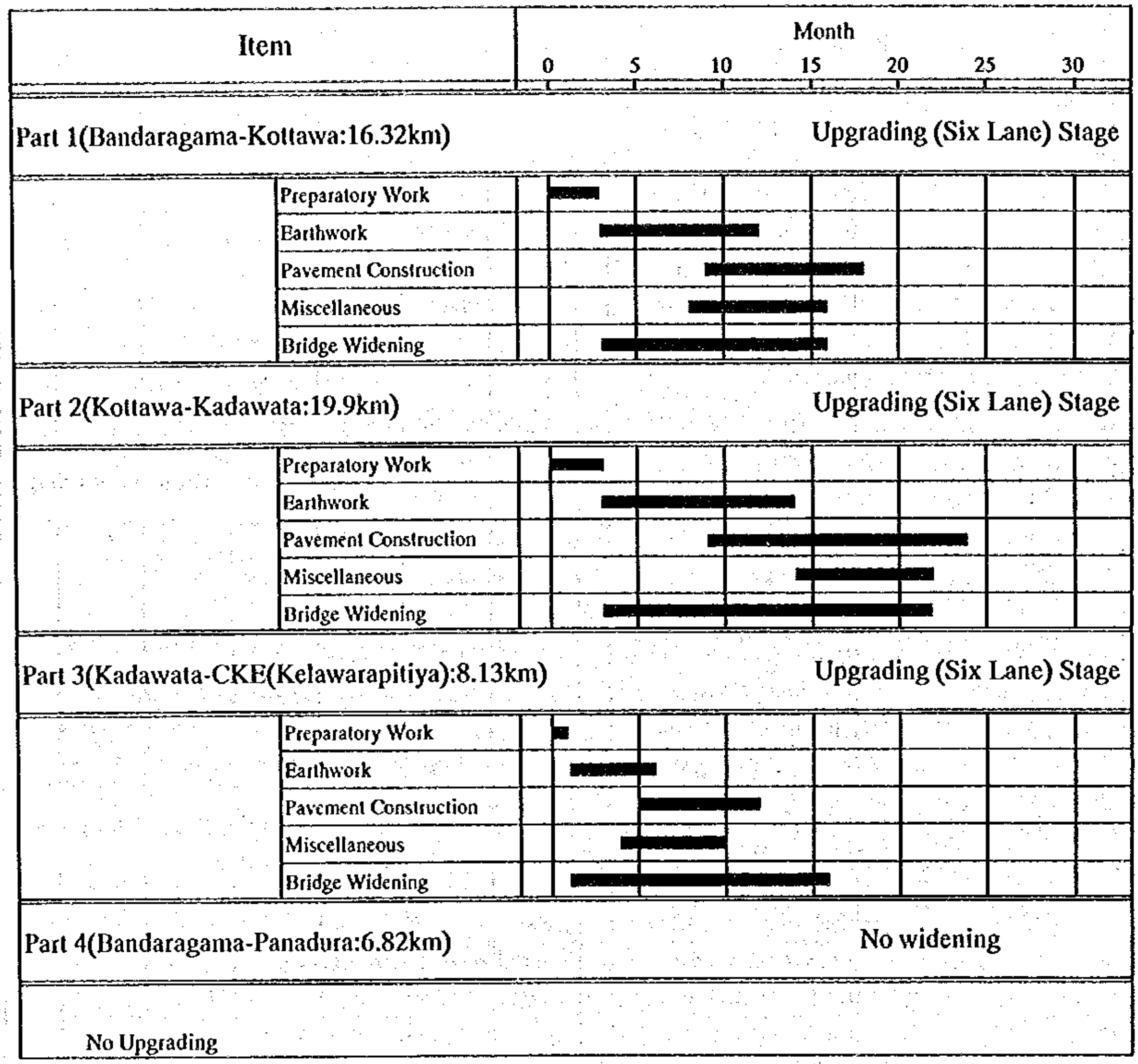


Fig.11.9 Construction Time Schedule for Final Stage



11.6 Construction Schedule

A construction schedule has been prepared for each construction stage (i.e., the initial and final stages) of the OCH. The detailed design for the initial four-lane stage will commence by the beginning of 2002 for a 1.5 year period, and construction will be executed in 2.0 - 2.5 years from the beginning or middle of 2003. The implementation of construction for a six-lane upgrade is dependent on traffic demand and the government policy regarding investment.