2.5 Comparative Study and Selection of Optimum Plan

2.5.1 Basic points for selection

Technically speaking, the most important point involved in selecting the route for this Project lies in the question as to whether the existing structure of the G.R.N.W. Bridge may be reusable or not. In that sense, the basic points for selection through the comparison of construction costs are described hereunder.

(1) The bridge type as may be determined through comparative study of the G.R.N.W. Bridge shall apply to the St. Louis Bridge, as the economic advantage of using the same method of construction is obvious.

(2) In the case that only the substructure of the existing bridge may be reused, comparison must be made with material (fabrication) and maintenance costs together with the erection costs, because little difference is anticipated whether it is metal or concrete, judging from the seal of erection equipment and the actual cost of erection. Each one alternative, which is considered economically advantageous by comprehensive judgement from technical experiences and local conditions, has been proposed for both metal type and concrete type.

(3) In case of new construction or additional work, study must be made basically from the span composition, as material and structural type must be suitable for each span length. If the metal structure is taken up for study from the material point-of-view, there will remain very little room for further evaluation because of such obvious disadvantages as an increased requirement of foreign currency and maintenance and control costs; therefore, it may not be considered except in the case of unfavourable geological conditions or for the large-span sections. On the other hand, if the concrete structure is selected, its structural type can easily be determined from technical experiences.

(4) From the viewpoints mentioned above, the work starts with preliminary design, then quantity is computed and construction cost is estimated. The results obtained in the process of design and calculation are shown hereunder, while the St. Louis Bridge is referred to such an extent as may be deemed necessary.

2.5.2 Superstructure

(1) In the case of utilizing the existing superstructure, the damage distributed on the sectional area of the main girder, as revealed by the corrosion test result, is regarded as being equivalent to that for the main girder placed under the worst condition. Both the upper and lower flanges are determined to accord with Corrosion Criteria Grade C. For stress check calculation, allowance is given by reducing 2 mm from each thickness of the upper and lower flanges. This implies that the present thickness of the flanges has been fully evaluated to the possible extent.

(2) The result of a material test on a test piece reveals that the yield point strength meets with Grade 43 - Class 280 of BS 153. However, the allowable stress is decided at 138 N/mm^2 = 1377 kg per cm^2 against bending which conforms to Grade 43 - Class 230, with due consideration to the structure aged at 70 and the required allowance for residual stress of the rolled shaped-steel. This indicates that the boundary limit has been set on the quality of material.

(3) For transformation of the existing structure into the road bridge, all the additional members will have to be jointed together by bolts, except the special portion which requires welding for repairing. The result of chemical analysis on the test piece implies that contained elements are ill-balanced, for it contains carbon and sulphur to a greater extent, which is unsuitable for welding.

(4) Configuration of additional members is shown in Figures IX-2-1 - IX-2-4.

(5) Please refer to Table IX-2-2 for stress checking results and approximate steel weight of the main girder and the additional members.

(6) The result of checking at wind load has proved that the lower lateral bracings of the G.R.N.W. Bridge and also on the downstream side of the St. Louis Bridge are fully assured of safety, while bracing is required on the upstream side of the St. Louis Bridge.

(7) In case of the metal structure, rust-preventive painting will be required at a frequency of once every five years for maintenance purposes.

(8) With regard to the St. Louis Bridge, the construction site of the existing railway bridge is of the shortest bridge length. When the separate 2-lane bridge will be newly constructed on the upstream side, the following problems will arise in regard to the route alignment.

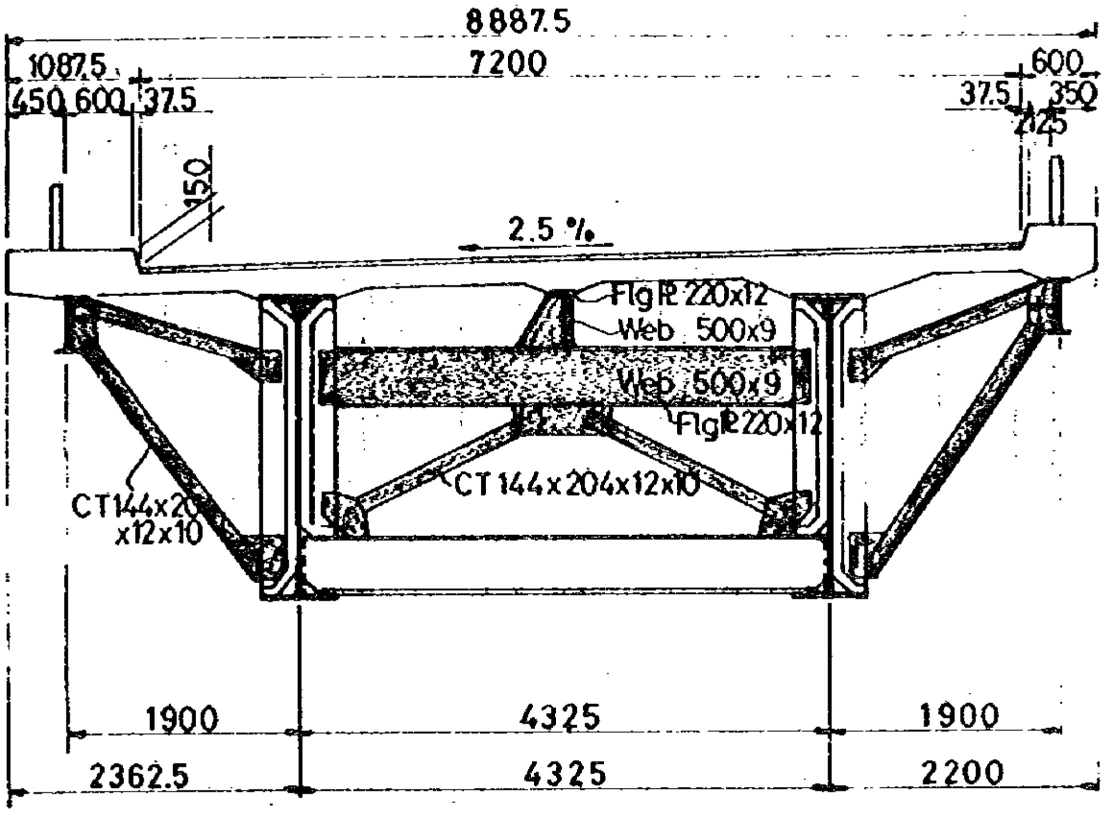
Namely, because of topographic restrictions, if the new bridge is of mono-span construction same as the existing railway bridge, higher abutments than those of the existing bridge must be constructed. Furthermore, it will require backfilling work to a great extent and also construction of a high retaining wall for slope protection.

On the other hand, as another alternative to avoid the problems mentioned above, there is plan to construct a 3-span bridge with two piers to make the bridge length longer, to lower the abutment heights and to minimize earth work. When these two alternatives are compared, there is very little room for option between them in respect of technical aspects and construction workability as well as stability of structures. Therefore, from the economic evaluation point-of-view, either of these can be finally selected after a rough estimation of the construction costs. It should be noted, however, that the construction plan of the mono-span bridge requires the abutment to be of a height of 17 m and the retaining wall to be up to 11 m in height, which may be affected by soil pressure with a resultant increase in construction cost.

Figure IX-2-1 G.R.N.W. Bridge

Additional Members To Be Provided

Cross Section



------- Additional Members

Figure IX-2-2 G. R. N. W. Bridge
Additional Members To Be Provided

Side - Elevation & Plan

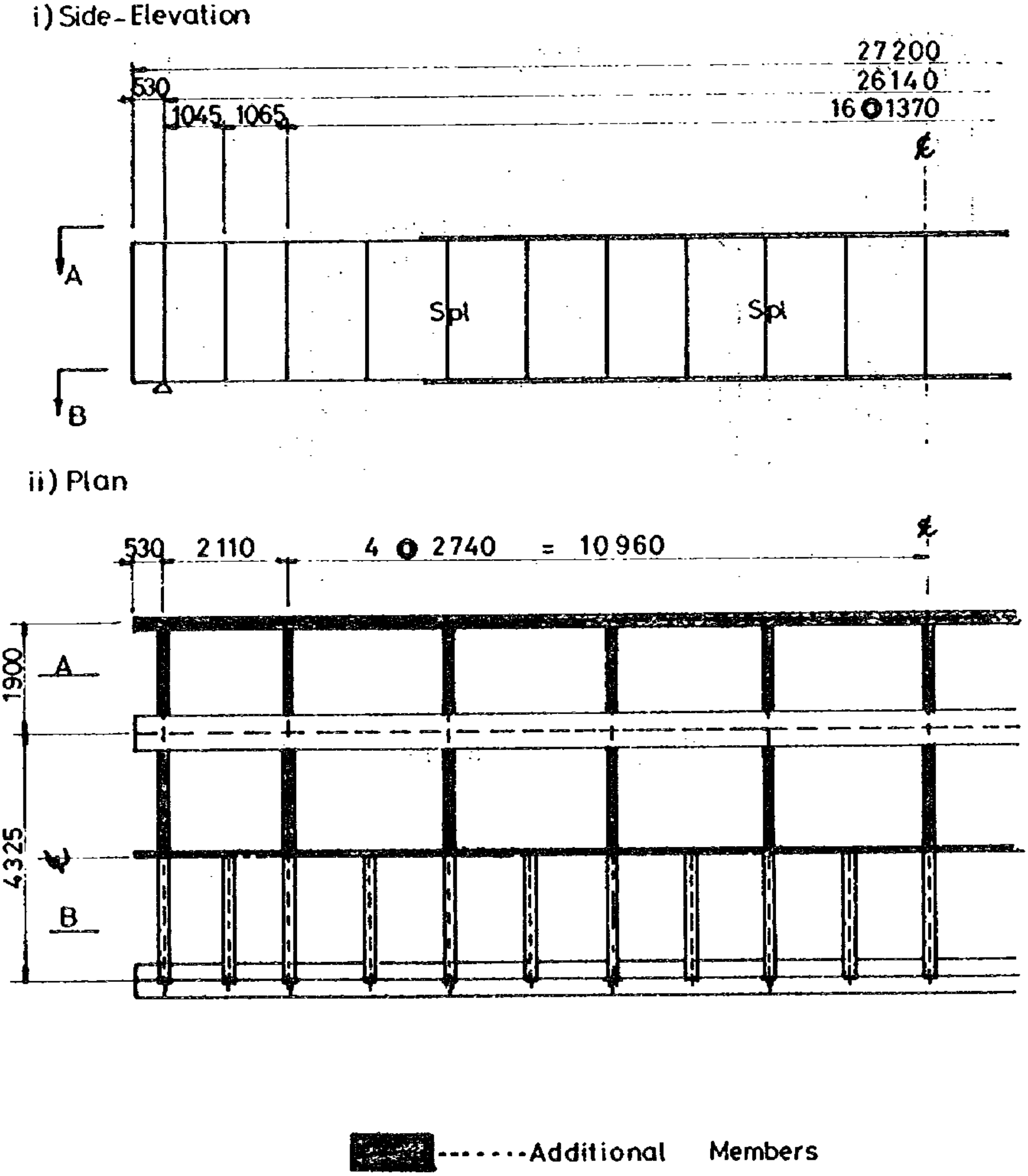
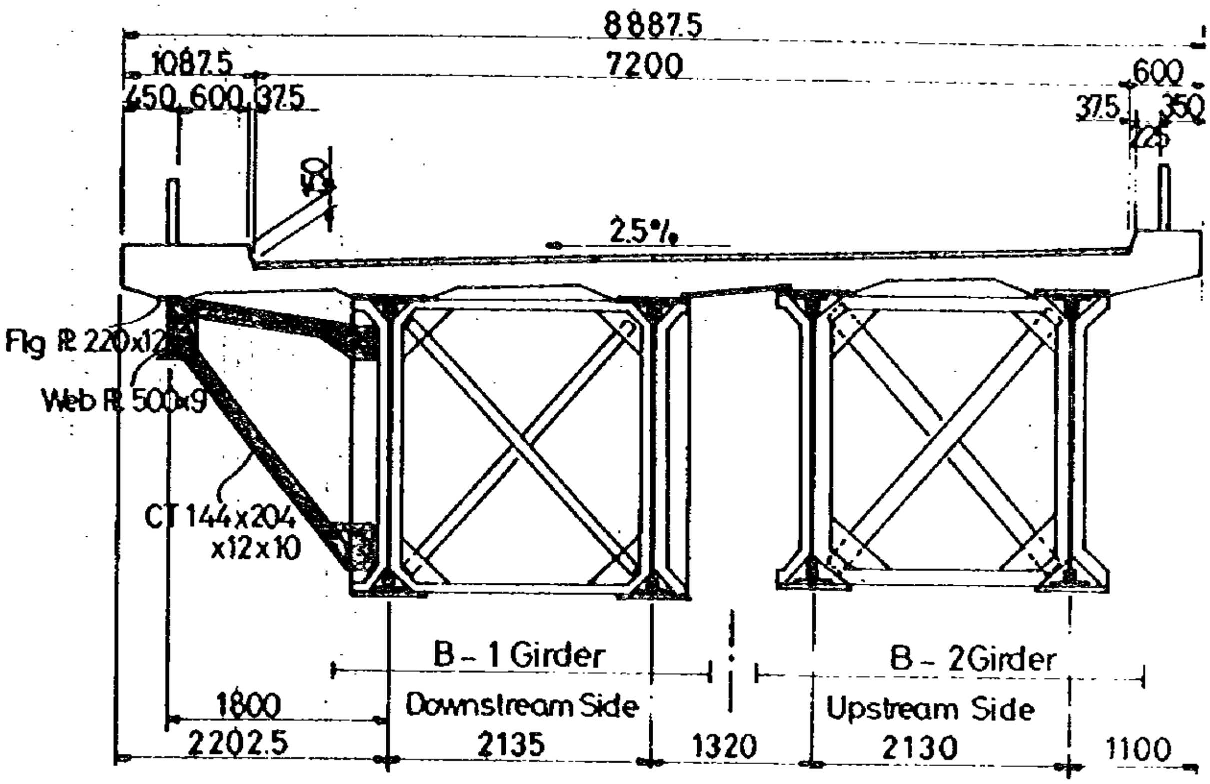


Figure IX-2-3 St. Louis River Bridge Additional Members To Be Provided Cross Section

i) Sway Bracing Section



ii) Intermediate Section

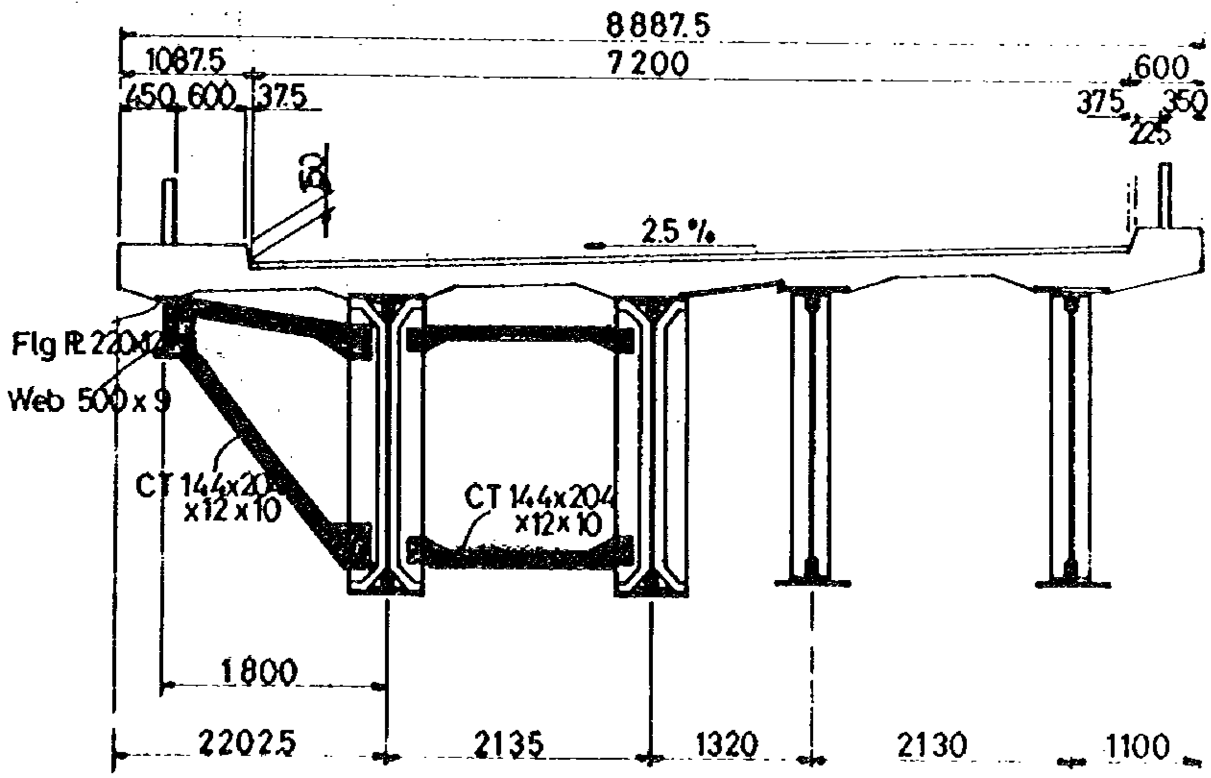


Figure IX-2-4 St. Louis River Bridge
Additional Members To Be Provided
Side Elevation & Plan

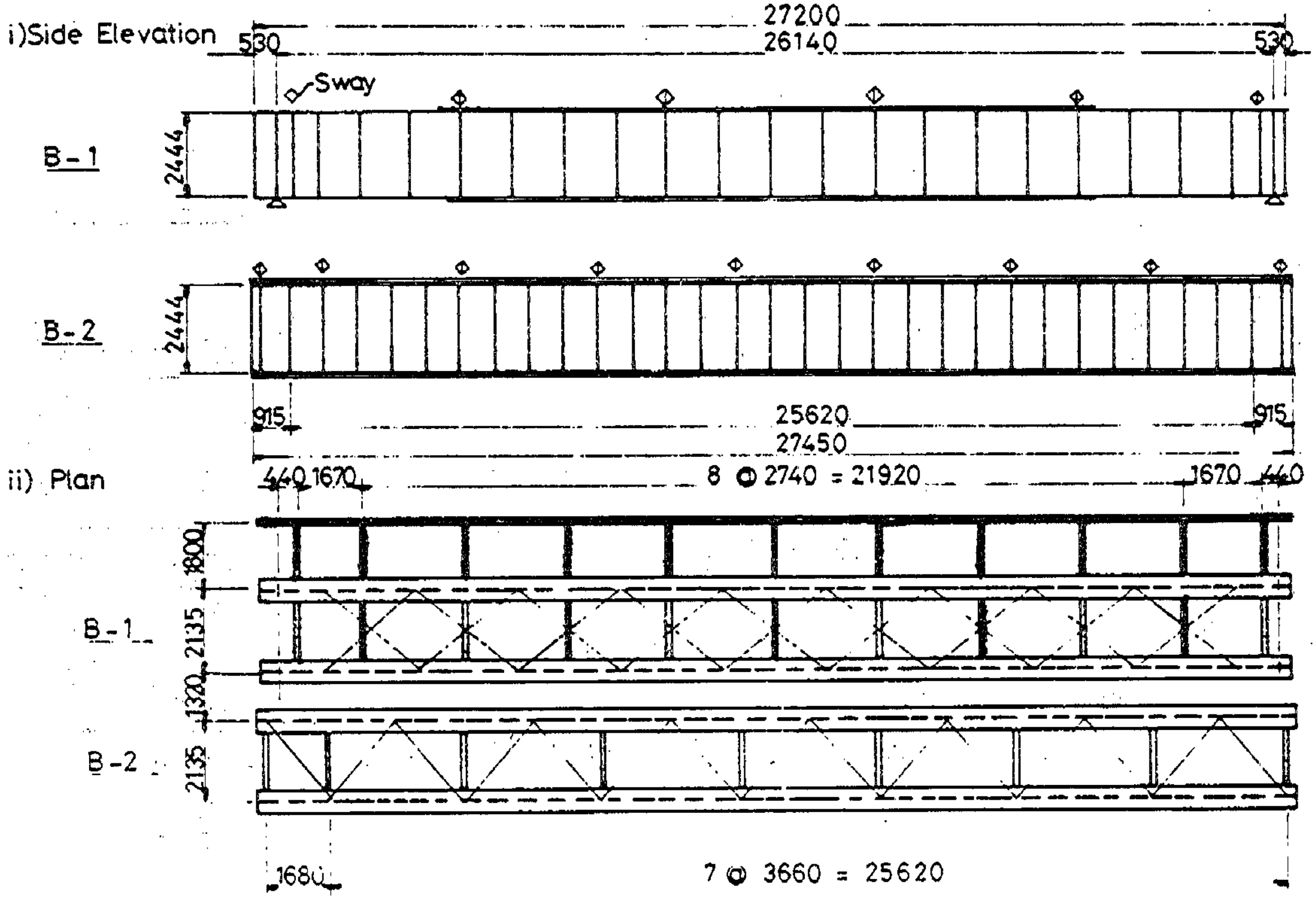


Table IX-2-2 Main Girder Stress Checking Result

		Live load	Bending moment at span center (tm)			Main girder stress (kg/cm^2)	Allowable stress	Material test result	Steel weight (t)
			Dead load	Live load	Total				
Railway bridge (G.R.N.W.)		BS 153 RA 1-Loading *21 units	81.0	598.0	679.0 (1.00)	** σc = 892 σt = 1,100	o London County Council (General Powers) Act, 1909 Tensile strength 44 - 52 kg/mm^2	Tensile strength 46 kg/mm^2 Yield point strength 29 kg/mm^2	48 t/1-span 336 t/7-span
2-lane road bridge	G.R.N.W.	BS 153 HA-Loading	432.7	370.4	803.1 (1.18)	σc = 1,055 σt = 1,302	Allowable stress Tension Compression Bending 1,181 kg/cm^2	do	Additional members 16.3 t/1-span 114.1 t/7-span
2-lane road bridge	St. Louis River, 2-girder on down stream	do	451.0	334.7	785.7 (1.16)	σc = 1,032 σt = 1,274	o BS 153, 1972 Grade 43 Yield point strength 2,350 kg/cm^2	Estimated same as above.	Additional members
2-lane road bridge	St. Louis River, 2-girder on up stream	do	257.2	155.5	412.7 (0.61)	σc = 440 σt = 558	Allowable stress Bending 1,377 kg/cm^2	-	12.4 t

* Locomotive weight = 85 t, 21 units = 84 t

** Sectional area damaged loss, estimated at 2 mm for upper and lower flanges. Sectional areas of angle plates are taken into account for stress calculation.

2.5.3 Substructure

(1) When the existing substructure is to be used, there arises a special problem related to the allowable bearing capacity of soil for the stability calculation of piers. Through comprehensive judgement from such as the past performance of the existing railway bridge against traffic load, the conditions of river bed, the foundation strata as well as the results of the soil tests, the allowable bearing capacity of soil at the bridge site is determined at Qa = 50 tons per m^2, by using the specific formulas in Terazaghi's book entitled "Soil Mechanics" (revised edition) as well as "the Specification for Highway Bridge Substructure Design, Japan".

Soil reaction force of the pier for each structural type is shown in Table IX-2-3.

(2) As the result of water depth sounding around the piers, it is known that the scoured damage is minor. However, since the footing embedment of the existing pier is limited to only 1 m or so, considerable footing embedment is desired to assure safety from scouring. Therefore, some possible measures should be taken in the near future. The newly installed piers are designed to have deeper embedment of a footing.

Since the future scoured depth is estimated at 1.5 - 2 m, it is advisable that the scoured portion should be backfilled and the wire cylinder containing cobble stones should be spread within the scope of 6 m, apart from the side of the pier walls. The formula developed by Andru for the estimation of scoured depth is

$$\frac{Ds}{h} \fallingdotseq 1.8,$$

where Ds : Scoured depth from water surface (m)

h : Water depth (m)

Table IX-2-3 Soil Reaction of Piers (G.R.N.W.)

		Superstructural reaction (t)			Soil reaction			Wind load in combination with live and dead loads (Lateral direction)		
		Dead load	Live load	Total	Dead Weight (t)	Total Vertical Stress (t)	Soil reaction (t/m^2)	Horizontal Force (t)	Moment (tm)	Soil reaction (t/m^2)
Railway bridge		48.0	372.0	420.0 (1.00)	1,561.7	1,981.7 (1.00)	40.7	27.7 7.9	895	49.3 32.1
2-lane road bridge	Use of existing bridge	258.0	200.9	458.9 (1.09)	1,452.9	1,911.8 (0.96)	39.3	31.8 7.2	948	48.1 30.2
	Composite girder	268.2	200.9	469.1 (1.12)	1,515.1	1,984.2 (1.00)	40.8	25.7 7.5	792	48.4 33.2
	PCT-girder	426.2	200.9	627.1 (1.49)	1,515.1	2,142.2 (1.08)	44.0	25.7 7.5	792	51.6 36.4

- Allowable bearing capacity of soil Qa = 50 t/m^2
  At wind time (25% increase) Qaw = 62.5 t/m^2
- Dead weight of the pier in case of road bridge construction adjusted in accordance with the proposed roadway verticul alignment.
- Footing bottom area = 48.64 m^2 (3.8 m x 12.8 m)

From the result of the hydrological survey, the high water level at the bridge site is calculated at:

$$h = 2.04 \text{ m}$$

$$\text{Then, } Ds = 1.8\ h = 1.8 \times 2.04 = 3.67 \text{ m}$$

Therefore, scoured depth = 3.67 - 2.04 = 1.63 m

(3) Study of the allowable limit for adjacent construction

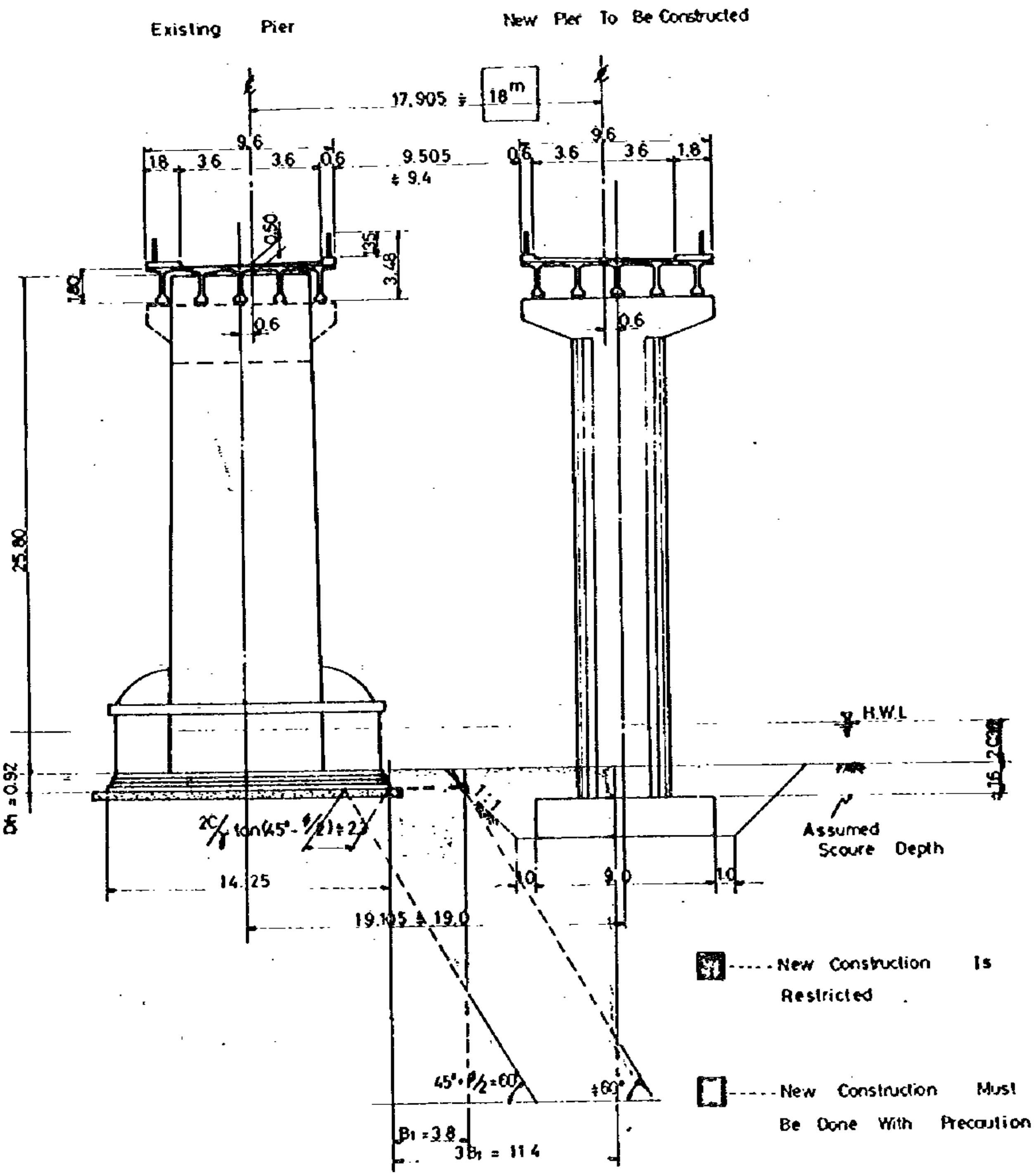
The plan for using the railway track route (Link - B) includes the construction of the 2-lane road bridge, as the 2nd-term project, on the upstream side of the existing bridge. In this case, route selection must be made carefully beyond the extent wherein undesirable effect may be transmitted to the existing bridge at the time of substructural construction.

If it is assumed that the new footing would be provided below the predicted depth of scouring (1.6 m), then the bottom level of those new footings would be positioned about 2.5 m lower than the existing footing bottom level. Excavation for new footings should not endanger the constant bearing capacity of soil by removing or loosening the soil within the area influenced largely by stress stemming from the existing structure. In order to meet such requirements, the distance between the centers of the existing and newly proposed roads should be maintained at $\ell = 18$ m, as shown in Fig. IX-2-5.

2.5.4 Selection of the optimum plan

(1) After calculation of quantity and review of construction method on each structural type, the following alternatives of three different categories have been compared by roughly estimated construction costs. For the G.R.N.W. Bridge,

Figure IX-2-5
Study Of Adjacent Construction



a.
- The plan to utilize both superstructure and substructure of the existing bridge.
- The plan to renew the superstructure with metal (composite girder) utilizing the substructure of the existing bridge.
- The plan to renew the superstructure with concrete (PCT) utilizing the substructure of existing bridge.

(Table IX-2-4)

b.
- The plan to newly construct a 7-span superstructure and substructure of concrete.
- The plan to newly construct a 5-span supersturcture and substructure of concrete.
- The plan to newly construct a 3-span superstructure and substructure of concrete.

(Table IX-2-5.)

For St. Louis Bridge,

c.
- The plan to construct a mono-span bridge with concrete superstructure and substructure. (at additional installation)
- The plan to construct a 3-span bridge with concrete superstructure and substructure. (at additional installation)

(Table IX-2-6.)

(2) By comparing category a with category b above, it is clear that utilization of the existing bridge requires less cost. As indicated in the Table IX-2-5, the short span structure is more economical when the bridge is to be newly constructed. The Table IX-2-4 also reveals that the plan to utilize both superstructure and substructure of the existing bridge requires the least initial investment.

On the other hand, however, since the superstructure of metal requires rust-preventive painting, at least once every 5 years, the plan to construct concrete superstructure (PCT girder) utilizing the existing bridge substructure is the most economical plan 10 years later, if the maintenance cost for the metal superstructure is taken into account at a discount rate of 10 percent per annum.

(3) Assuming that the target year for the bridge to enter into service would be 1982 to 1983 and the benefit of this Project would become accruable from 20 years later, or 2002 to 2003, both superstructure and substructure of the existing bridge would be 90 years of material age, reaching to a service life of 70 years excluding the grace period of 20 years.
In case of reusing the metal superstructure, it has to be scrapped within the remaining 10 years at the material age of 100, if it is estimated as the maximum life years.

In this instance, the cost required for removal of the superstructure including distruction of the slab still having sufficient residual value and, also, the cost for reconstruction of the bridge structure must be taken into account. Therefore, in the long range the plan to utilize existing superstructure becomes less economical.

With regard to the substructure, since the concrete structure would contain no such maintenance problem as rust prevention as in the case of the metal structure, it is justifiable to believe that sufficient margin can be allowed for the durable service life.

(4) The component ratio of foreign and local currency and the total amount of construction cost may be the decisive factor of the Project. In view of the present economic situation in which most materials have to be imported but outflow of foreign currency needs to be curbed to a possible extent, the pattern of construction cost which has a greater share of the local currency portion is preferable. In this sense, the concrete structure plan including a greater ratio of the local currency portion in material cost would be commendable although the heavy erection equipment has no particular economic merit.

(5) Maintenance should allow for some extra cost to be incurred by administration on and above the direct cost for construction, because establishment of an administration system and employment of administrative personnel will be required. Again in this instance, the concrete structure plan is advantageous, in that only small cost may be incurred.

(6) The existing metal superstructure would be of commercial value as scrapped iron and could be used as material for production of reinforcing bars. Therefore, the cost saving can be expected to some extent, even though the sum may be only small in total.

(7) In conclusion, it is recommended that the optimum structure for the proposed G.R.N.W. Bridge construction should be designed for PC post tensioning T-girder type while utilizing the existing substructure. The same type mentioned above should be applied to the St. Louis bridge.

(8) As a problem particular to the St. Louis Brdige, the two alternatives of a single-span or a three-span have been compared in anticipation of an additional 2-lane road. As the result of cost comparison, the 3-span bridge plan is recommended, since it has some economical advantage on the other.

Table IX-2-4 Construction Cost Comparison by Superstructural Types for G.R.N.W. Bridge (Link-B)

Unit: x 1000 Rp.

	Currency	Utilization of existing bridge		Composite girder		PC T-girder
Girder fabrication and erection	Local	1,520		890		1,590
	Foreign	2,820		5,040		3,090
	Total	4,340		5,930		4,680
Girder descent or removal Pier strengthening	Local	480		490		490
	Foreign	1,440		1,480		1,480
	Total	1,920		1,970		1,970
Total	Local	2,000		1,380		2,080
	Foreign	4,260		6,520		4,570
	Total	6,260		7,900		6,650
Maintenance	5 years	406	* 252	260	* 161	0
	10 "	406	* 156	260	* 100	0
	15 "	406	* 97	260	* 62	0
	20 "	406	* 61	260	* 39	0
Total			6,830		8,260	6,650
		To support girder by bent ↓ Chipping and reinforcement of pier top ↓ Girder descent ↓ Erection of members by three-legged crane		Simultaneous drawout and removal of 7 spans ↓ Chipping and reinforcement of pier top ↓ New bridge erection by launching girder		Simultaneous drawout and removal of 7 spans ↓ Chipping and reinforcement of pier top ↓ T-girder erection by use of erection girder

* Discounted at the rate of 10%

Table IX-2-5 Construction Cost Comparison by Number of Span for G.R.N.W. Bridge (Link-B)

Unit: x 1000 Rp.

	Currency	7-span	5-span	3-span
Superstructure	Local	1,590	2,110	2,710
	Foreign	3,090	4,090	5,260
	Total	4,680	6,200	7,970
Substructure	Local	1,120	900	700
	Foreign	2,090	1,670	1,300
	Total	3,210	2,570	2,000
Total	Local	2,710	3,010	3,410
	Foreign	5,180	5,760	6,560
	Total	7,890	8,770	9,970

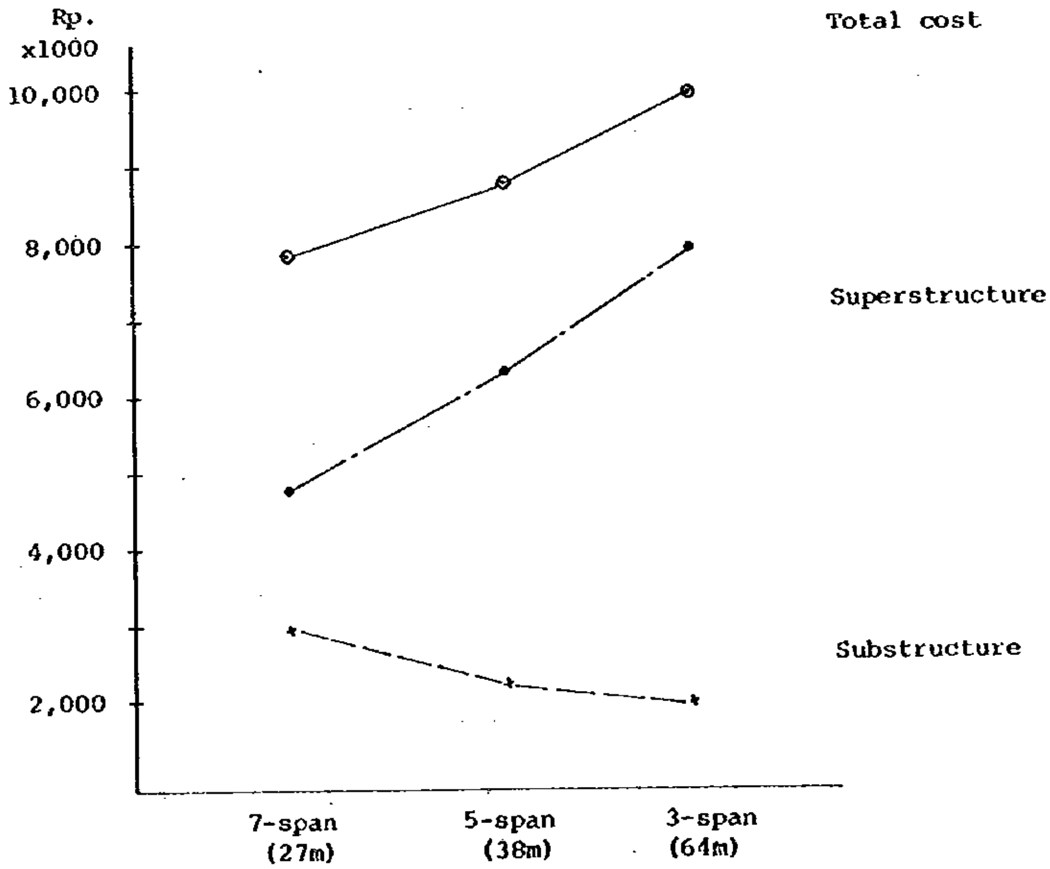


Table IX-2-6 Cost Comparison of Additional Construction for the St. Louis River Bridge

Unit: x 1000 Rp.

	Single span	3-span
Superstructure	920	2,350
Substructure	960	690
Retaining wall	1,040	-
Banking	520	160
Total	3,440	3,200

CHAPTER X CONSTRUCTION SCHEDULE AND COST

CHAPTER X CONSTRUCTION SCHEDULE AND COST

1. Foreward

This Chapter shows the construction cost estimation for each of the alternatives presented in Chapter VI. To facilitate staged construction, on the basis of the results of economic analysis and traffic volume estimation, the construction cost has been estimated for each of the Links mentioned at the end of Chapter VI.

Further, in order to reduce the initial investment and allow early operation of the road, construction cost for the first two lanes out of the proposed four-lane road (Links B, C and D) has been estimated (except for earthwork which must be carried out simultaneously for all four lanes.)

2. Construction Period

The construction period has been estimated for both the alternative P_2, i.e. the first stage of the staged construction P4.S, which would provide high economic effects, and the package construction P_4.

Assuming that detailed design would be completed by December, 1979, the work schedules for P_4 and P_2 are shown in Tables X-1-1 and X-1-2, respectively. According to the tables, the works of both P_4 and P_2, which would require a total of 30 months, will be commenced in January, 1980 and completed and ready for operation in July, 1982. On the other hand, the work for the second stage of P4.S, which would require 28 months to be completed, will be commenced in 1987 and completed and ready for operation in May, 1989. Principal mechanical equipment needed for those works is represented in Table X-2.

Although there are some differences in the size of the remaining Alternative Plans, they can be completed in approximately the same period of time through increased or decreased use of the mechanical equipment.

3. Construction Cost

The estimated construction cost for each of the Alternative Plans is shown in Table X-3. The construction cost by Link is shown in Table X-4, with details appearing in Appendix X-1.

(1) Conditions for estimation

a) The currency is Mauritius Rupee

b) The conversion rate is set at Rs 1.00 = $0.16

c) All prices are as of December, 1977.

(2) Unit cost of materials, equipment and labor

a) Unit cost of materials

Where the Mauritius Government has set up standard unit prices for materials, these materials are used. Standard materials and their unit prices are as follows:

Aggregate	Crushed stone	32 Rs/ton
	Crushed gravel	34 Rs/ton
Cement		22.7 Rs/50 kg
Reinforcing steel	ø25 - 9 mm	2,225 - 2,625 Rs/ton
Nail		3.2 Rs/kg

The market price of principal materials is as follows:

Bitumen		1,420 Rs/ton
Timber	Local timber	1,400 Rs/m^3
	Imported timber	2,000 Rs/m^3

Different timbers are used for different sections. Imported timber is used for long members and local timber is used for other parts.

Unit prices changed by respective manufacturing plants are used for reinforced concrete pipes and U-type concrete ditches.

For special materials such as PC steel lines for bridges, Japanese prices are used with some adjustment after comparing them with Mauritian prices.

b) Labor cost

Labor cost is calculated on the basis of the minimum Mauritian labor wages stipulated on the Government Notice No. 154 of 1976, with a 40% contingency as advised by construction companies.

c) Construction equipment and machinery

The field survey shows that construction companies in Mauritius are well-stocked with equipment and machinery, all of which have been imported from abroad. The hire rate of this machinery used in the construction cost estimation has been computed on the basis of C.I.F. Port Louis.

Of the above machinery, that used in connection with asphalt paving has an extremely low operating rate, so that a special hire rate has been set up for this machinery.

d) Land acquisition

Costs for land acquisition and compensation have been obtained from the Ministry of Housing, Lands and Town and Country Planning.

(3) Construction Cost

Construction cost has been computed on the basis of: costs for similar civil engineering works recently performed in Mauritius as obtained from the Ministry of Works; construction costs in Mauritius obtained from Mauritian construction companies; and the prevailing market price provided by manufacturing companies such as raw concrete manufacturers.

(4) Expenses to be paid to builders

According to the Ministry of Works, miscellaneous expenses for a construction project of this size will amount to 25% of the actual construction cost.

(5) Contingency

A contingency fund totaling 15 % of the construction cost has been set aside to supplement shortages caused by design change and other contingencies.

(6) Detailed design cost

Detailed design cost covers costs for topographical and road length survey, geological survey and actual design cost, set at the following rate.

Topographical and road survey	.....	1.0%
Geological survey	....	0.5%
Design cost	....	5.0%
Total Detailed design cost	.....	6.5% of total construction cost

(7) Work supervising cost

The cost for supervising the construction works includes labor cost for supervising staff, cost for setting up supervising offices, transportation and testing expenses which accounts for 6 % of the total construction cost.

(8) Rate of domestic and foreign currencies

Unit construction cost is estimated both in domestic and foreign currencies, with the ratio of domestic and foreign currencies in the total construction cost as follows:

Domestic currency	38 %
Foreign currneoy	62 %

4. Maintenance Cost

Maintenance cost comprises costs incurrable for daily maintenance and checking and costs for overlay performed at regular intervals.

(1) Daily maintenance cost

This includes road cleaning and the cutting of grass along side road surfaces and the center strip bands. Manpower needed for this work is two persons per kilometer for four-lane roads. 100% of this labor cost is required as material and transportation costs. 50% of the above expense is set aside as maintenence works cost.

(2) Overlay cost

Continual driving of automobiles causes road surface wear. Judging from the estimated traffic volume, repair of such road wear will be necessary every ten years, requiring overlay of a pavement 4 cm thick.

Maintenance cost per kilometer based on the above requirements has been calculated as follows:

Daily maintenance cost

$365 \times 6/7 \times 2 \times 17.28 \times 2 \times 1.5 \fallingdotseq 33,375$ Rs/km.year

Overlay cost

Area to be paved : $14.4 \times 1,000 = 14,400$

Asphalt concrete volume: $14,400 \times 0.04 \times 2.32 = 1,336.3$

Overlay cost : $1,336.3 \times 280 = 374,164$ Rs/km

5. Construction and Maintenance Cost by Year

Table X-5 shows construction and maintenance cost by year for each of the Alternative Plans.

Table X-1-1 Work Schedule

Alternative P_4 and P_2
(First Stage of P_4.S)

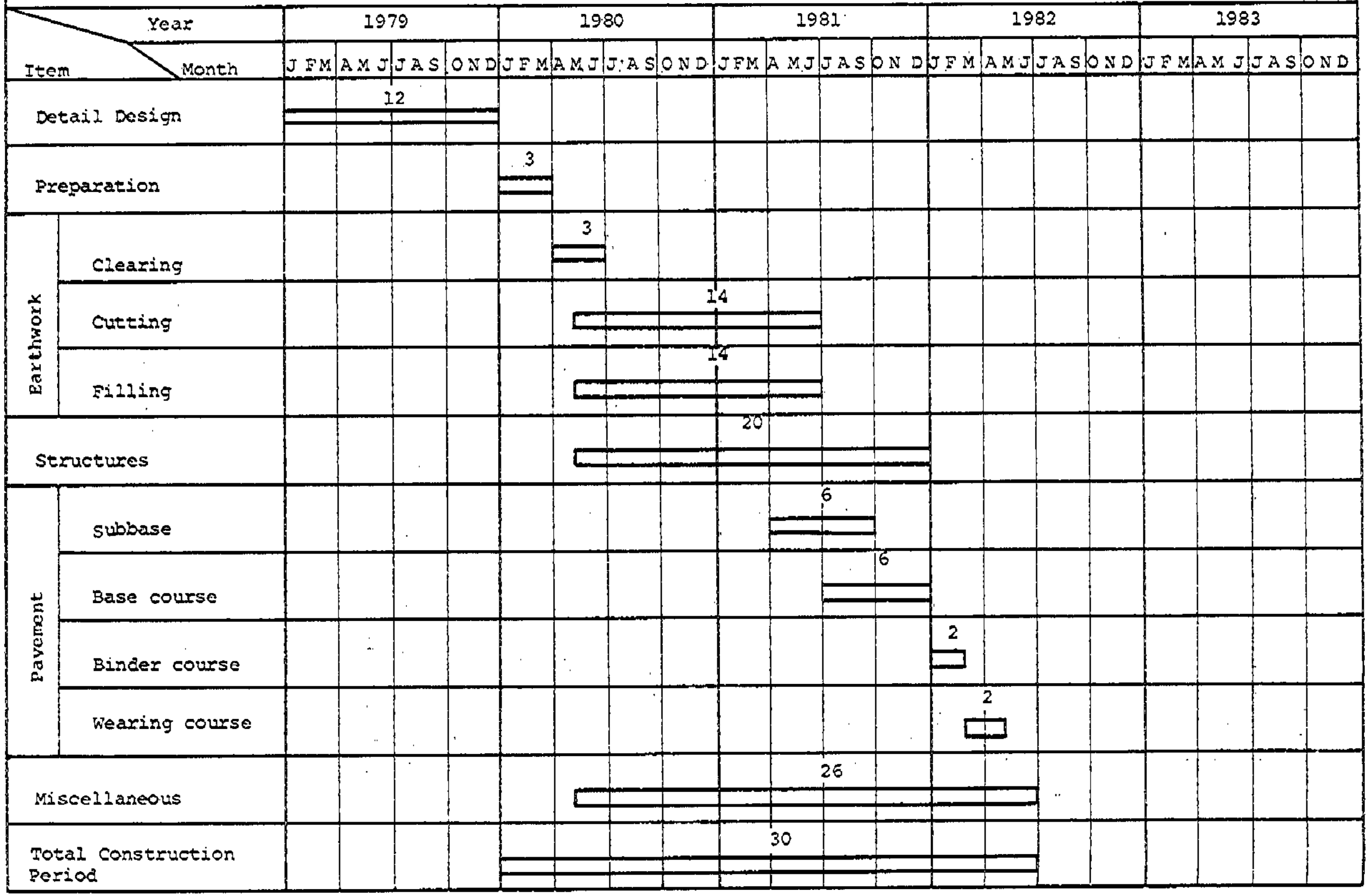


Table X-1-2 Work Schedule

Alternative P4.S (Second Stage)

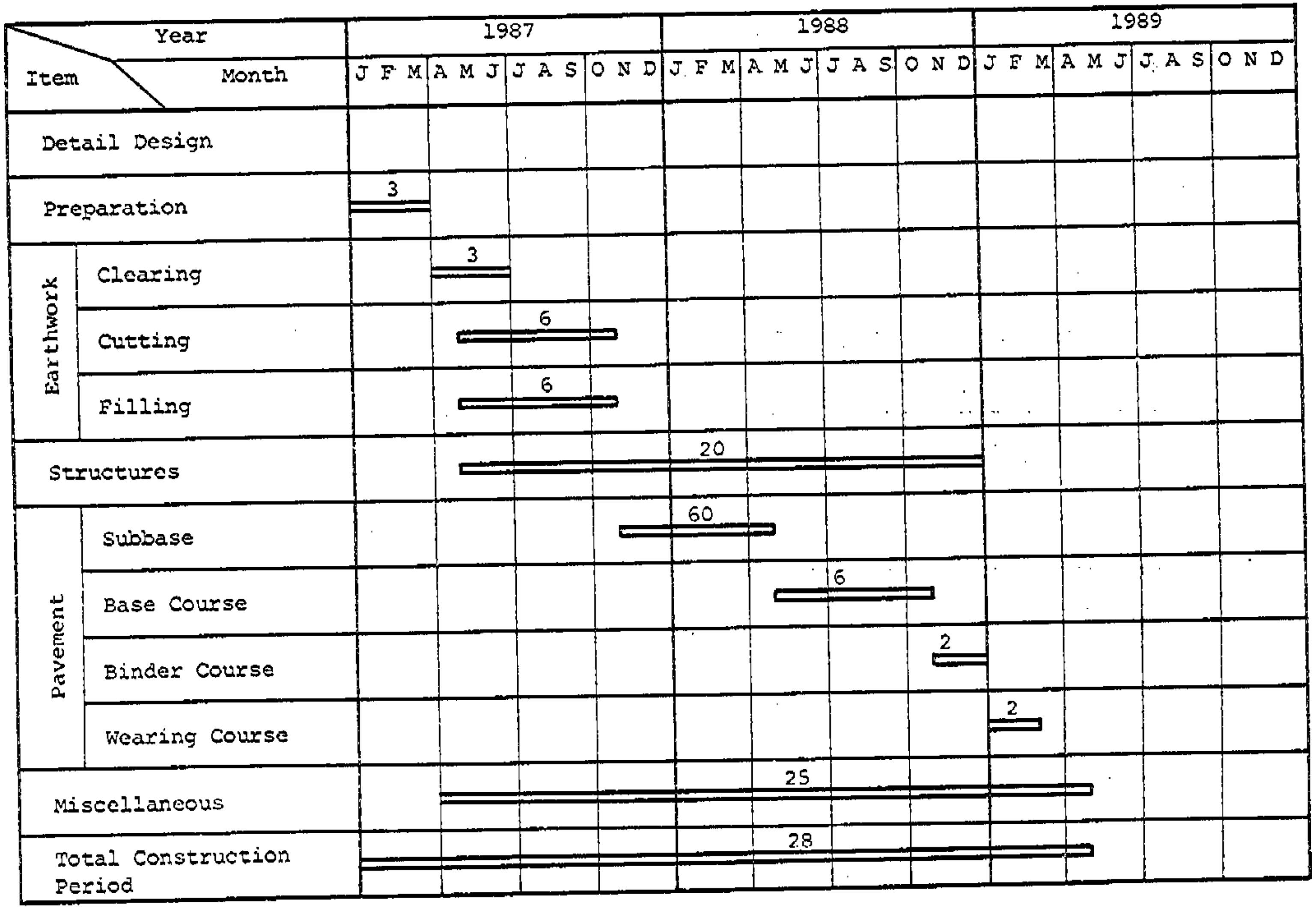


Table X-2 Required Number of Principal Mechanical Equipment

Alternative P_2

Equipment	Type	No,	Remarks
Bulldozer	21 ton	4	
-do-	37 ton	3	with ripper
Excavator	0.6 m^3	2	
Wheel Loader	2 m^3	4	
Dump Truck	8 ton	30	
Grader	3.7 m	2	
Tire Roller	8-20 ton	3	
-do-	12-28 ton	1	
Macadam Roller	10-12 ton	2	
Tandem Roller	13-19 ton	1	three-axes
Asphalt Finisher	2.5-4 m	2	
Asphalt Distributor	3,000 l	1	
Truck Mixer	3 m^3	22	
Truck Crane	5 ton	1	
-do-	30 ton	1	

Table X-3 Construction Cost of the Project

Unit: 1,000 Rs in Dec. 1977 Price

Alternative Plan	P2	P2'	P4	P4'
Link	2-Lane (B)+(C)+(E)	2-Lane (B)+(D)+(E)	4-Lane (B)+(C)+(E)+(F)	4-Lane (B)+(D)+(E)+(F)
Distance (m)	2-Lane 7,977	2-Lane 7,987	4-Lane 6,115 2-Lane 3,162	4-Lane 6,215 2-Lane 3,072
Acquisition	7,681	7,777	9,184	9,280
Clearing	3,740	3,749	3,887	3,896
Earthwork	9,973	11,909	11,792	13,852
Drainage	2,509	2,725	2,915	3,131
Pavement	16,772	17,239	25,469	26,125
Carriageway Equipment	673	737	921	985
Bridge	13,086	13,086	24,531	24,531
Total (Without Acquisition)	46,753	49,445	69,515	72,520
Detail Design (6.5%)	4,518	3,214	4,518	4,714
Supervision (6%)	2,805	2,967	4,171	4,351
Grand Total	61,757	63,403	87,388	90,865

Note: P2 and P4 denotes western route plans, while
P2' and P4' eastern route plans.

Table X-4 Construction Cost by Link

(Unit: 1,000 Rs)

Item \ Link	A	B		C		D		E		F
		2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	Connected "C"	Connected "D"	
Distance (m)	450	1,610		4,505		4,605		1,862	1,772	1,300
Acquisition	114	2,301	2,301	4,281	4,281	4,377	4,377	1,099	1,099	1,503
Clearing	52	732	732	2,328	2,328	2,337	2,337	680	680	147
Earthwork	378	2,418	2,530	6,236	6,571	8,336	8,795	1,319	1,155	1,372
Drainage	35	332	332	1,695	1,695	1,930	1,930	482	463	406
Pavement	820	2,995	4,704	10,827	16,185	11,442	16,989	2,950	2,802	1,630
Carriageway Eq.	135	291	348	339	481	405	547	43	41	49
Bridge	7,993	11,693	23,138	1,393	1,393	1,393	1,393	—	—	—
Total	9,526	20,762	34,085	27,099	32,933	30,219	36,368	6,573	6,241	5,107
Cost per Km 4-Lane			21,171		7,310		7,898			
Cost per Km 2-Lane	21,169	12,896		6,015		6,562		3,530	3,522	3,928
Cost per Km without Bridge 4-Lane			6,799		7,001		7,595			
Cost per Km without Bridge 2-Lane	3,407	5,632		5,706		6,260		3,530	3,522	3,928

Table X-5 Construction and Maintenance Cost by Year

(Unit: 1,000 Rs)

Year \ Plan		P2	P2'	P4	P4'
Construction Cost					
1	1979	3,039	3,214	4,518	4,714
2	1980	28,620	30,095	41,435	43,076
3	1981	20,034	21,066	29,005	30,153
4	1982	8,585	9,028	12,430	12,922
Sub-total		60,278	63,403	87,388	90,865
Maintenance Cost					
1	1982	93	93	139	140
2	1983	186	186	278	279
3	1984	"	"	"	"
4	1985	"	"	"	"
5	1986	"	"	"	"
6	1987	"	"	"	"
7	1988	"	"	"	"
8	1989	"	"	"	"
9	1990	"	"	"	"
10	1991	186	186	278	279
11	1992	1,678	1,680	3,158	3,179
12	1993	186	186	278	279
13	1994	"	"	"	"
14	1995	"	"	"	"
15	1996	"	"	"	"
16	1997	"	"	"	"
17	1998	"	"	"	"
18	1999	"	"	"	"
19	2000	"	"	"	"
20	2001	186	186	278	279
21	2002	893	840	1,579	1,590
Sub-total		5,958	5,961	9,880	9,931
Grand Total		66,236	69,364	97,268	100,796

Maintenance Cost

		P2	P2'	P4	P4'
Distance	2-Lane(km)	7.977	7.987	3.162	3.072
	4-Lane(km)	-	-	6.115	6.215
Maintenance Cost		186	186	278	279
Overlay Cost		1,492	1,492	2,880	2,900

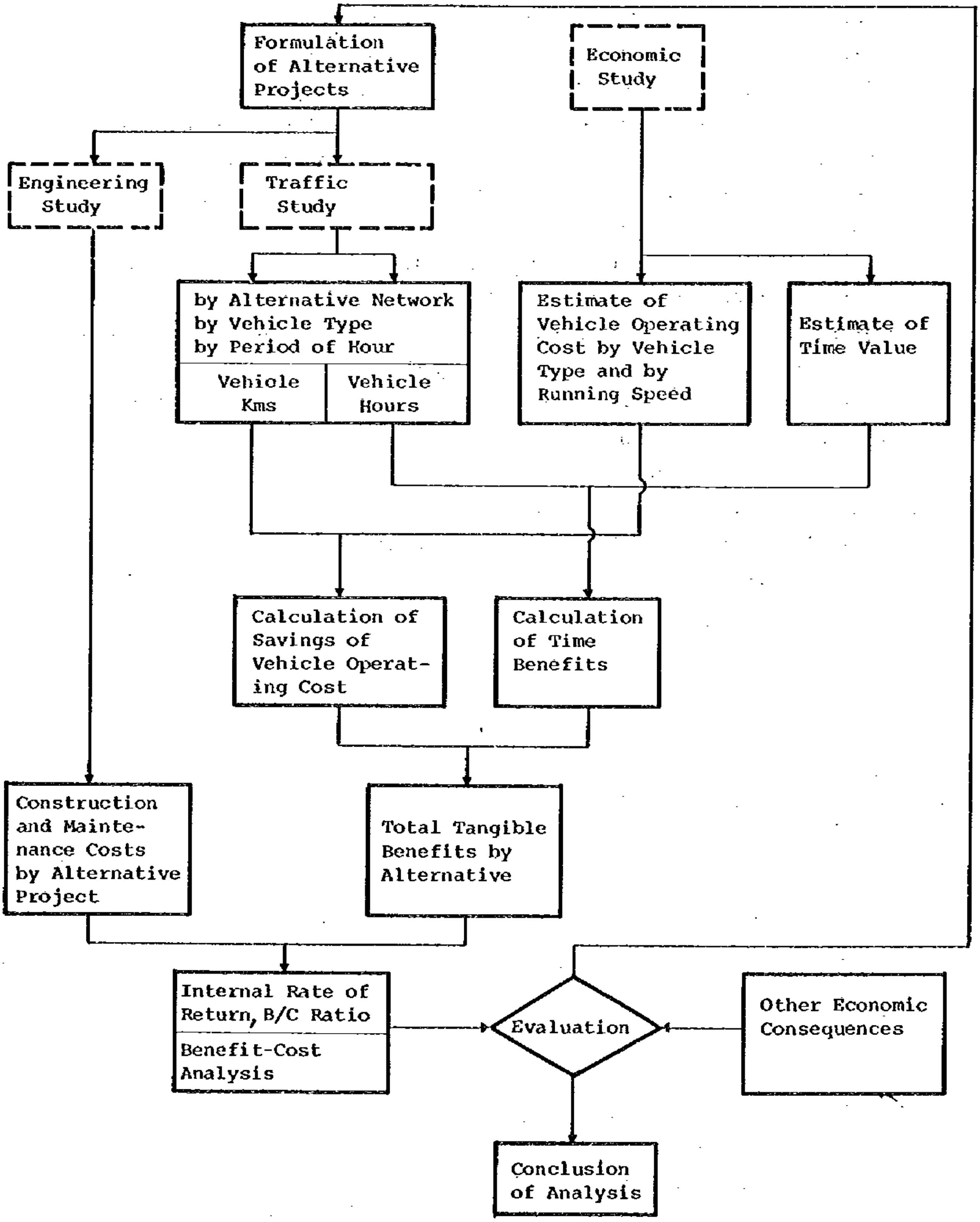
CHAPTER XI EVALUATION OF THE PROJECT

CHAPTER XI EVALUATION OF THE PROJECT

1. Outline of Methodology

As shown in Figure XI-1-1, an outline of the economic evaluation of the project can be explained as follows. Total vehicle-kilometers and total vehicle-hours on each of the alternative networks are compared with those of the existing network to estimate savings of vehicle-kilometers and vehicle-hours; the savings of vehicle operating costs and time benefits due to the implementation of each project will be computed based on the savings mentioned above, the unit vehicle operating cost at respective speed of vehicles on links and the time value. The total savings would constitute the project benefit. Cost-benefit analysis will be made by comparing the benefits with the construction and maintenance costs, and the project will be evaluated by applying the criteria of B/C ratio and the internal rate of return. The implementation of the project brings in not only the direct benefits mentioned above, but also other socio-economic consequences which are also taken into consideration in evaluating the project, though those benefits can hardly be quantified. An optimum plan is identified by taking into consideration the above-mentioned procedures.

Fig. XI-1-1 Outline of a Framework of Economic Evaluation of the Project



2. Review of Alternatives

2.1 Alternatives for Economic Evaluation

Preliminary studies have been conducted on several alternatives in chapters VI and VIII. Some of the alternatives turned out to be impracticable without conducting detailed economic analysis. The results may be summarized as follows:

(1) The capacity of the present road network is extremely limited. It is impossible to cope with a future traffic demand only by replacement of the G.R.N.W. Bridge on the A_1 Road and construction of an access road (Alternative, P_A) forming the most serious bottleneck in the traffic flow.

On the other hand, expansion and improvement of the entire A_1 Road is considered impracticable judging from the recent status in development of area along the route, nor is it recommendable from the viewpoint of city planning.

Similarly, with regard to alternatives such as $P_2 + P_A$, $P_2' + P_A$, $P_4 + P_A$, $P_4' + P_A$, it became obvious that the role of P_A in alleviating traffic congestion was much limited.

(2) The road network including alternatives P_2 and P_2' has a service life only up to around 1990 and it became clear that the construction of a dual 2-lane road between Port Louis and Beau Bassin (P_4 and P_4') would be indispensable to meet the mounting demand in traffic subsequent to 1990.

From the above studies, three alternatives have been selected as given in Table XI-2-1.

Table XI-2-1 List of Alternative Cases for Cost-Benefit Analysis

Alternative Case	Outline Description	Construction Schedule (assumed opening year)
P_4	Construction of Belle Village-S.Hill-Beau Bassin section with dual carriageway along the disused railway	1982
P_4'	- do -	1982
P_4·S	Completion of P_2 (Construction of Belle Village-S. Hill-Beau Bassin section with 2 lanes along the disused railway) by 1982 then expansion to P_4 by 1990	1982 (P_2) 1990 (P_4)

2.2 Review of Construction and Maintenance Costs

Construction and maintenance costs are studied in detail in Chapter X. These costs are reviewed and summarized here for economic evaluation. Project costs comprise detailed design costs, construction costs, and maintenance costs. Maintenance costs include overlay cost required every ten years plus annual costs for routine maintenance. As all the alternative cases listed in the Table XI-2-1 are composed of any of the Alternatives P4, P4' and P4.S or any combination of them, only the costs of these are summarized in Table XI-2-2 below, whilst the cost flow over project life of each alternative is constained in Appendix Table XI-1.

Table XI-2-2 Summary of Project Cost for Alternatives Selected for Cost-Benefit Analysis

000 Rs.

Alternative		Const. Cost	Overlay Cost 1/	Annual Maint. Cost
P_4		87,388	2,880	278
P_4'		90,865	2,900	279
P_4·S	First Stage	61,757	1,492	186
	Second Stage	25,631	1,388	92
	Total	87,388	2,880	278

1/ Overlay cost occurs every ten years after the construction work

3. Calculation of Benefits

3.1 Tangible Benefits

Benefits quantified in this analysis are composed of savings of vehicle operating costs and time benefits to be derived from the implementation of the project. The reduction of distance results in savings of vehicle operating costs while the reduction of time results both in the savings of vehicle operating costs as well as in the time benefits of such road users who are not paid for vehicle operation such as bus passengers, drivers of private cars and passengers of cars and taxis.

Of the two benefits, difficulties are always experienced in evaluating the value of time saved, with accuracy. Value of an hour spent for transportation is estimated in Section 2-4 of this Chapter based on various assumptions.

These benefits are carried over to the road users among whom two different types are included. The first is the traffic user who will divert to the project road and the second is the users who remain on the former roads and will benefit from traffic diversion therefrom which helps lessening traffic congestion on the former roads. Since the Project aims at improving the current and estimated traffic congestion in the project area, the benefit expected to be given to the latter users cannot be ignored.

However, the network for traffic assignment consists not only of the major roads such as the A_1 Road, the Motorway and the project road but also of various access roads and streets connecting to the trunk system in the entire project area. Although it is true that the traffic on these minor roads benefits to a certain extent, such benefit is only considered in sensitivity analysis, because traffic assignment has been continued to the main ones, the benefit of these minor roads can not be estimated with the same accuracy as that of major roads.

3.2 Reduction of Vehicle-Kilometers and Vehicle-Hours

Total vehicle-kilometers and total vehicle-hours of traffic on each alternative network was acquired from the traffic assignment. Savings of vehicle-kilometers and vehicle-hours are computed and summarized in Table XI-3-1 and Figures XI-3-1 and XI-3-2. Details are shown in Appendix Table XI-3-2.

Table XI-3-1 Reduction of Vehicle-Kilometers and Vehicle-Hours by Alternative Case

Savings by Type	Alternative Case	1982 Peak Hours	1982 Off-peak Hours	1987 Peak Hours	1987 Off-peak Hours	1992 Peak Hours	1992 Off-peak Hours	2002 Peak Hours	2002 Off-peak Hours
Reduction of Vehicle-Kilometers	P_4, P_4'	0.4	-0.5	3.4	2.5	7.2	10.8	11.2	37.4
(mil.veh.kms. per year)	P4.S	0.4	-0.3	3.4	2.8	7.2	10.8	11.2	37.4
Reduction of Vehicle-Hours	P_4, P_4'	0.20	0.26	0.54	0.92	1.90	2.31	10.20	17.00
(mil.veh.hrs. per year)	P4.S	0.19	0.24	0.49	0.85	1.90	2.31	10.20	17.00

3.3 Computation of Vehicle Operating Cost

1) Determination of Representative Vehicle

In estimating the vehicle operating costs, 5 types of vehicles were selected, car, van, medium truck, heavy truck and bus for each of which the following specific vehicles were determined as representative, based on the results of the interview survey in which vehicle age and vehicle brand were asked. They are the most widely used and seem to represent future vehicle types.

Fig. XI-3-1 Reduction of Vehicle-Kilometers by Alternative

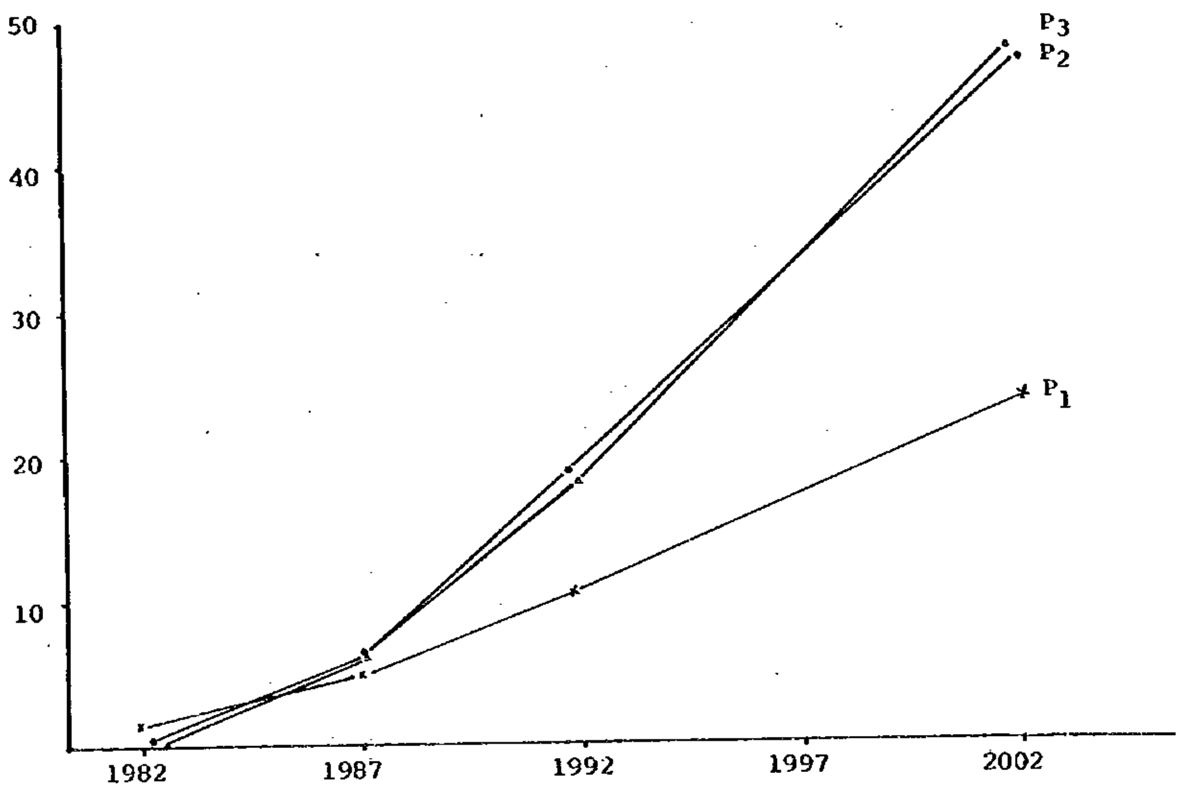
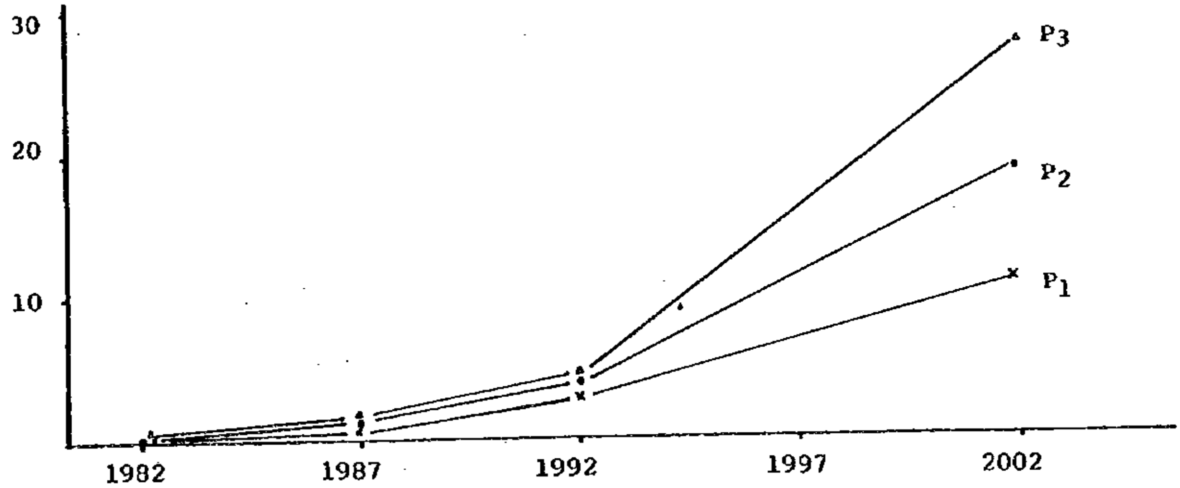


Fig. XI-3-2 Reduction of Vehicle-Hours by Alternative



Vehicle Type	Respective Brand Name
Car:	Renault 12-L
Van/Pick-up:	Commer 1-ton van
Medium Truck:	Bedford 6-ton truck
Heavy Truck:	Leyland 12-ton trailer-truck
Bus:	Bedford 44-seater bus

The general characteristics of the representative vehicles were surveyed by interviewing motor dealers, garage operators, etc. during the field survey and are summarized in Table XI-3-2.

Table XI-3-2 Characteristics of Representative Vehicles

Type of Vehicle / Characteristics	Passenger Car	Van, Pick-up	Medium Truck	Heavy Truck	Bus
Model	Renault 12.L	Commer	Bedford	Leyland	Bedford
Loading Capacity	5 pass.	1 ton/ 8 pass.	6 tons	12 tons	44 pass.
Number of Axles	2	2	2	3	2
Number of Tyres	4	4	6	10	6
Fuel used	Gasoline (Super)	Gasoline (Regular)	Diesel	Diesel	Diesel
Max. Cruising Speed (km/h)	125	110	90	90	90
Average Running Speed (km/h)	55	50	40	40	30
Average Annual Kilometrage (km)	16,000	24,000	30,000	40,000	55,000
Average Life (years)	10	14	15	14	10
Lifetime Kilometrage (km)	160,000	336,000	450,000	560,000	550,000

Source: based on the results of interviews with drivers, dealers and transportation companies

2) Composition of Vehicle Operating Cost

Vehicle operating cost is composed of the following items.

- ° depreciation of the vehicle
- ° fuel consumption
- ° engine-oil consumption
- ° type wear
- ° maintenance (spare parts)
- ° maintenance (labour)
- ° interest
- ° insurance
- ° license and registration fees, road taxes, etc.
- ° wages
- ° overheads

3) Computation Method of Vehicle Operating Costs

The cost items composing the vehicle operating cost were analyzed and computed in the form of cost per kilometer at different speeds for each type of vehicle. The computation process based on the following assumptions is explained in detail in Appendix XI-4.

(1) Each cost item is expressed in the equation form in which respective cost is defined as the function of vehicle operating speed which enables processing to be done by computer. The following materials are mainly based on:

- "Quantification of Road User Savings", IBRD, 1966.
- "Tables for Estimating Vehicle Operating Costs on Rural Roads in Developing Countries", by S.W. Abaynayaka, H. Hide, G. Morosiuk and R. Robinson, Transport and Road Research Laboratory, Department of the Environment, Berkshire, 1976.

(2) Influence of various gradients of roads on vehicle operating costs is considered.

(3) Influence of surface conditions of roads on vehicle operating costs is not considered because all the roads on which traffic is assigned are paved.

(4) Costs are computed both for economic and financial costs based on 1977 prices.

4) Vehicle Operating Costs

Vehicle operating costs, therefore, vary depending on operating speed and road gradient. Table XI-3-3 shows examples of the vehicle operating costs for each type of vehicle on paved road and at average operating speed. Vehicle operating costs under other conditions of speed and road gradient are summarized in Appendix Table X-6.

3.4 Estimate of Time Value

Time value is taken into account only for private cars and bus passengers, because savings of time for commercial vehicles are reflected in vehicle operating costs. Value of an hour differs by type of road user as well as by his trip purpose. In general, time value is considered to be linked with earning values, though it can not be evaluated accurately.

Time value of passengers of private cars and bus passengers were estimated based on per capita income, wages of workers and through interviews, as the necessary data and information on income distribution, characteristics of bus passengers were not obtainable.

The average household income of private car owners is estimated to be about 4,500 Roupees per month for 150 work hours and, therefore, the average value of an hour becomes 30 Rupees. The average monthly income of a bus passenger will be at the level somewhere between per capita GNP per month and the average monthly wage of workers. Considering that the per capita GNP is around 340 Rupees per month and the average monthly wage is 650 Rupees per month is 1976, the average monthly wage of a bus passenger is estimated to be 550 Rupees in 1977 for 150 work hours and the average value of an hour for a bus passenger is 3.5 Rupees.

However, all of the saved time would not neccesarily be devoted for reproductive economic activities; some might be spent for leisure, etc. Therefore, 50% of the above value was estimated to be the time value. The time value of co-passenger of the private car is computed or its owner's income and an average occupancy per bus was considered 25 passengers.

- Time value of private car: 15 Rupees per hour
- Time value of bus: 46 Rupees per hour

Table XI-3-3 Vehicle Operating Cost at Average Running Speed, 1977

(Rs./km)

Cost Item	Economic Cost					Financial Cost				
	P. Car	Van, Pick-up	M. Truck	H. Truck	Bus	P. Car	Van, Pick-up	M. Truck	H. Truck	Bus
1. Depreciation	0.2339	0.1534	0.1788	0.3919	0.2066	0.3503	0.1957	0.2283	0.4999	0.2551
2. Fuel Consumption	0.1133	0.1421	0.2633	0.3706	0.2980	0.1418	0.1779	0.3032	0.4268	0.3432
3. Engine Oil Consumption	0.0057	0.0078	0.0115	0.0136	0.0115	0.0067	0.0091	0.0133	0.0157	0.0133
4. Tyre Wear	0.0312	0.0609	0.1430	0.2722	0.1311	0.0378	0.0742	0.1757	0.3348	0.1610
5. Maintenance Cost (Spare Parts)	0.0337	0.0567	0.1690	0.3072	0.4090	0.0504	0.0723	0.2157	0.3919	0.5051
6. Maintenance Cost (Labour)	0.0368	0.0296	0.0783	0.1476	0.2787	0.0374	0.0301	0.0796	0.1500	0.2833
7. Interest	0.1467	0.1381	0.1738	0.3529	0.1296	0.2198	0.1762	0.2219	0.4502	0.1600
8. Insurance	0.0743	0.0396	0.0475	0.0475	0.0432	0.0781	0.0417	0.0500	0.0500	0.0455
9. License Fee, Road Tax, etc.	-	-	-	-	-	0.0406	0.0383	0.0736	0.1177	0.0207
10. Wage	-	0.2704	0.5201	0.4077	0.2390	-	0.2750	0.5251	0.4134	0.2440
11. Overhead	-	0.0899	0.1585	0.2311	0.1747	-	0.1091	0.1886	0.2850	0.2031
Total	0.6756	0.9885	1.7438	2.5423	1.9214	0.9629	1.1196	2.0750	3.1354	2.2343

Note: Fuel consumption is calculated on flat roads.
Average running speed used for calculation is as follows;

1)	Passenger Car	55 km/h	4)	Heavy Truck	40 km/h
2)	Van, Pick-up	50 "	5)	Bus	30 "
3)	Medium Truck	40 "			

3.5 Alternative-wise Benefit Calculation

Alternative-wise benefits have been calculated by the following two main factors:

(1) The savings of vehicle operating costs, which are defined by multiplying the operating costs of different typed vehicles corresponding to link-wise vehicle speeds determined by the distribution of traffic volume, by the savings of different typed vehicle-kilometers on each alternative and (2) the savings of vehicle-hours, which are defined by multiplying the time values of different typed vehicles, by the savings of different typed vehicle-hours on each alternative.

A sevies of these calculations have been made by using computers and the total savings of vehicle operating costs and time estimated in terms of the base year for each alternative are given in Tables XI-3-4 and XI-3-5, respectively. As shown in these tables, the results of the alternatives, P_2 and P_2', indicate that much greater benefits are obtainable when converting the existing 2-lane road into the 4-lane one on and after 1992, compared with the case of remaining the existing 2-lane road unchanged.

Table XI-3-4 Savings due to the Reduction of Vehicle Operating Cost by Alternative

Rs. million/year

Alternative Case	Savings on Major Roads				Savings on Other Roads			
	1982	1987	1992	2002	1982	1987	1992	2002
P_2, P_2'	3.39	10.84	24.21	41.69	1.01	5.96	20.79	105.11
P_4, P_4'	3.43	11.00	28.44	77.58	1.27	6.30	21.46	130.42
P_4·S	3.34	10.84	28.44	77.58	1.01	5.96	21.46	130.42

Table XI-3-5 Time Benefits due to the Reduction of Vehicle Running Hours by Alternative

Rs. million/year

Alternative Case	Car (on Major Roads)				Car (on Other Roads)			
	1982	1987	1992	2002	1982	1987	1992	2002
P_2, P_2'	2.78	6.71	17.11	55.81	0.82	3.69	14.69	140.69
P_4, P_4'	2.99	7.38	21.55	110.89	1.11	4.22	16.25	186.41
P_4·S	2.78	6.71	21.55	110.89	0.82	3.69	16.25	186.41

Alternative Case	Bus			
	1982	1987	1992	2002
P_2, P_2'	1.8	6.4	13.3	34.5
P_4, P_4'	1.8	6.4	14.3	47.4
P_4·S	1.8	6.4	14.3	47.4

4. Economic Evaluation

4.1 Cost-Benefit Analysis

1) Methodology

Economic evaluation of the project is based on the cost-benefit analysis which is arrived at by comparison of costs and benefits. As the costs and benefits, however, appear at different points of time, they must be measured and compared with common criteria. The economic viability of the project is reached by computing the B/C ratio and internal rate of return.

(1) Benefit-Cost Ratio

The B/C ratio can be obtained by comparison of the costs and benefits which appear at different times and in different amounts over the project life and are adjusted with an adequate discount rate and then converted to the present value, being expressed in the following formula. The project becomes feasible, when the BCR exceeds 1.0.

$$BCR = \frac{\sum_{t=1}^{n} \left(\frac{Bt}{(1+r)^t} \right)}{\sum_{t=1}^{n} \left(\frac{Ct+AEt}{(1+r)^t} \right) - \frac{S}{(1+r)^n}}$$

where

BCR: benefit-cost ratio
n: period of measuring benefits and costs
r: discount rate
Bt: benefit at year t
Ct: construction cost at year t
AEt: maintenance cost at year t
S: residual value of the project

(2) Internal Rate of Return

The internal rate of return is the rate which enables the right side and the left side of the following equation to be equal. The project is deemed feasible when the internal rate of return exceeds the opportunity cost of capital.

$$\sum_{t=1}^{n}\left(\frac{Bt}{(1+r)^{t}}\right) = \sum_{t=1}^{n}\left(\frac{Ct+AEt}{(1+r)^{t}}\right) - \frac{S}{(1+r)^{n}}$$

2) Conditions for Analysis

The cost-benefit analysis is arrived at based on the following conditions.

a. The period of measuring costs and benefits: 20 years are assumed for the period of measuring benefits and cost from 1982, the assumed opening year of the project, up to the year 2002.

b. The residual value of the project: As 20 years are assumed as the life of the project, the residual value of the initial investment is nil, whilst the residual value of the additional investment scheduled for the period is considered based on the project life of 20 years.

c. The discount rate: As it is difficult to estimate the discount rate which theoretically should be equal to the opportunity cost of capital in Mauritius, a discount rate of 12% is assumed while other possible rates are considered in sensitivity tests of the cost-benefit analysis.

3) Sensitivity Analysis

In order to check the economic viability of the project, the sensitivity analysis is applied from the following aspects.

a. when the benefits on the minor roads apart from the trunk roads (A_1, Motorway and project road) are excluded and also when included.

b. when the time benefits are neglected, when only 50% included, and when 100% included.

c. when the construction and maintenance costs increase by 20%.

d. when the discount rates are 10%, 12% and 15%, respectively.

The cost-benefit analysis in this exercise is basically based on the assumption that the benefits given to the traffic on the minor roads are excluded and 50% of the time benefits is included,while the B/C ratio and the internal rate of return are computed for the following combination of sensitivity cases for each alternative case.

case(1) when the saving of vehicle operating costs and time benefits for the traffic on the minor roads are excluded and when only 50% of time benefits are included.

case(2) when the benefits for the traffic on minor roads and time benefits are excluded.

case(3) when 100% of time benefits are included, but the benefits for the traffic on minor roads are excluded.

case(4) when only the savings of vehicle operating costs for all the traffic are included.

case(5) when all the savings of vehicle operating costs and 50% of time benefits for all the traffic are included.

case(6) when all the savings of vehicle operating costs and time benefits for all the traffic are included.

case(7) when different discount rates of 10%, 12% and 15% are applied for each sensitivity case of (1) through (6).

case(8) when the construction and maintenance costs increase by 20% for each sensitivity case of (1) through (7).

Among the cases stated above the most conservative one is (2), whilst the most optimistic case is (6). The case on which this study stands is case (1) due to the reasons explained in the sections 3-1 and 3-3 of this Chapter.

4.2 Results of the Cost-Benefit Analysis

According to Table XI-4-1 showing the results of the cost-benefit analysis on each alternative, it is concluded that economic feasibility is higher in the order of P_4·S, P_4 and P_4'. It is evident the staged construction contributes to an increase in benefits. In each alternative, the internal rate of return exceeds 20%.

Table XI-4-1 Results of Cost-Benefit Analysis for the Alternatives

Alternative	Discount Rate (%)	Rs. million		B/C Ratio	Internal Rate of Return (%)
		Cost	Benefit		
P_4	10	78.4	238.1	3.04	
	12	75.8	182.7	2.41	20.8
	15	72.4	126.1	1.74	
P_4'	10	81.4	238.1	2.93	
	12	78.8	182.7	2.32	20.4
	15	75.2	126.1	1.68	
P_4·S	10	64.7	235.8	3.64	
	12	61.7	180.8	2.93	23.8
	15	57.7	124.6	2.16	

Table XI-4-2 gives the results of sensitivity analysis for the selected alternatives (P_4' and P_4·S). According to the table, even in the most conservative one, Case (2), with a 20 % rise in construction costs, it was judged that the project would economically be feasible except the Alternative P_4 based on the assumption of a 15 % discount rate.

Table XI-4-2 Results of Sensitivity Analysis for the Selected Alternatives

<P_4>

Sensitivity Case	Cost : ±0%				Cost : +20%		
	B/C Ratio			Internal Rate of Return(%)	B/C Ratio		
	r= 10%	r= 12%	r= 15%		r= 10%	r= 12%	r= 15%
①	3.0	2.4	1.7	20.8	2.5	2.0	1.5
②	1.7	1.4	1.0	15.1	1.4	1.2	0.8
③	4.3	3.4	2.5	24.9	3.6	2.9	2.1
④	3.4	2.7	1.9	21.4	2.8	2.2	1.6
⑤	5.6	4.4	3.1	26.8	4.7	3.6	2.6
⑥	7.8	6.0	4.2	30.9	6.5	5.0	3.5

<P_4·S>

Sensitivity Case	Cost : ±0%				Cost : +20%		
	B/C Ratio			Internal Rate of Return(%)	B/C Ratio		
	r= 10%	r= 12%	r= 15%		r= 10%	r= 12%	r= 15%
①	3.6	2.9	2.2	23.8	3.0	2.4	1.8
②	2.1	1.7	1.3	17.5	1.7	1.4	1.0
③	5.2	4.2	3.1	28.5	4.3	3.5	2.6
④	4.1	3.3	2.4	24.3	3.4	2.7	2.0
⑤	6.7	5.3	3.8	30.2	5.6	4.4	3.2
⑥	9.3	7.3	5.2	34.8	7.7	6.1	4.4

4.3 Identification of Optimum Alternative

The results of the cost-benefit analysis imply that there are little differences in the benefit-cost ratios and the interval rates of return between the two alternatives, each of which offers high economic feasibility. In order to identify an optimum alternative, accordingly, factors other than those reflected in the cost-benefit analysis should be taken into consideration. According to the comparative studies on P_4 and P_4', each route location is different between S. Hill and Beau Bassin, but P_4 costs less than P_4' for construction and is slightly superior in road structure. From the view point of urban planning, each of them has little problems. For this reason, the current survey has ranked P_4

above P_4'.

$P_4 \cdot S$ is the one that P_4 is divided into two construction stages, but similar to P_4 in all other respects including route location and final road specifications. In comparison with the package construction, the staged construction has such advantages as to make investment more effectively to meet the actual traffic demand and to enable the project to be realized in investing a small amount of the initial funds. On the contrary, the staged construction has such a disadvantageous point as to enable the overall construction costs to increase when foreign constructors have a contract to construct the project road. In addition, the construction costs may be increased by the existence of a discrepancy between the estimated and the actual costs by inflation and, thereby necessitating adjustment of such uncertain factors.

Under these circumstances, the alternative P_4 with the package construction would be deemed desirable for adopting as an optimum plan unless there exist some constraints in budgets, for the construction scale of the project road is not so large and there is no particular merit in adopting the staged construction. The flows of benefits and costs on P_4 and $P_4 \cdot S$ are represented in Tables XI-4-3 and XI-4-4, respectively.

Table XI-4-3 Flow of Costs and Benefits for Selected Alternative, P_4

(000Rs.)

	Cost					Benefit		
		r=0%			r= 12%	r= 0%	r= 12%	% of Time Benefit
	Const. Cost	Overlay Cost	Maint. Cost	Total				
1979	4,518	-	-	4,518	4,518	-	-	
1980	41,435	-	-	41,435	36,996	-	-	
1981	29,005	-	-	29,005	23,123	-	-	
1982	12,430	-	139	12,569	8,946	2,914	2,074	41.1
1983	-	-	278	278	177	7,293	4,635	
1984	-	-	278	278	158	9,127	5,179	
1985	-	-	278	278	141	11,423	5,787	
1986	-	-	278	278	126	14,296	6,467	
1987	-	-	278	278	112	17,892	7,226	38.5
1988	-	-	278	278	100	21,645	7,805	
1989	-	-	278	278	90	26,186	8,431	
1990	-	-	278	278	80	31,680	9,107	
1991	-	-	278	278	71	38,326	9,837	
1992	-	2,880	278	3,158	724	46,366	10,626	38.7
1993	-	-	278	278	57	52,371	10,716	
1994	-	-	278	278	51	59,155	10,807	
1995	-	-	278	278	45	66,817	10,899	
1996	-	-	278	278	40	75,471	10,992	
1997	-	-	278	278	36	85,246	11,085	
1998	-	-	278	278	32	96,288	11,180	
1999	-	-	278	278	29	108,759	11,275	
2000	-	-	278	278	26	122,846	11,371	
2001	-	-	278	278	23	138,758	11,467	
2002	-	1,440	139	1,579	117	78,365	5,782	50.5
Total	87,388	4,320	5,560	97,268	75,818	1,111,224	182,748	

Table XI-4-4 Flow of Costs and Benefits for Selected Alternative, P4'S

(000Rs.)

	Cost				Benefit			
		r=0%			r= 12%	r= 0%	r= 12%	% of Time Benefit
	Const. Cost	Overlay Cost	Maint Cost	Total				
1979	4,518	-	-	4,518	4,518	-	-	
1980	28,620	-	-	28,620	25,554	-	-	
1981	20,034	-	-	20,034	15,971	-	-	
1982	8,585	-	93	8,678	6,177	2,840	2,021	40.3
1983	-	-	186	186	118	7,105	4,515	
1984	-	-	186	186	106	8,887	5,043	
1985	-	-	186	186	94	11,115	5,631	
1986	-	-	186	186	84	13,903	6,289	
1987	-	-	186	186	75	17,390	7,024	37.7
1988	8,971	-	186	9,157	3,302	20,482	7,386	
1989	14,097	-	186	14,283	4,599	24,124	7,767	
1990	2,563	-	232	2,795	803	31,680	9,107	
1991	-	-	278	278	71	38,326	9,837	
1992	-	1,492	278	1,770	406	46,366	10,626	38.7
1993	-	-	278	278	57	52,371	10,716	
1994	-	-	278	278	51	59,155	10,807	
1995	-	-	278	278	45	66,817	10,899	
1996	-	-	278	278	40	75,471	10,992	
1997	-	-	278	278	36	85,246	11,085	
1998	-	-	278	278	32	96,288	11,180	
1999	-	-	278	278	29	108,759	11,275	
2000	-	1,388	278	1,666	154	122,846	11,371	
2001	-	-	278	278	23	138,758	11,467	
2002	-10,252	746	139	-9,367	-690	78,365	5,782	50.5
Total	77,136	3,626	4,824	85,586	61,655	1,106,294	180,820	

4.4 Other Socio-economic Effects by Implementation of the Project

The implementation of the project does offer not only the direct benefits enjoyed by road users as explained, but the following secondary benefits:

(1) Improvement of living environment along the A_1 Road is expected on the grounds that most of the transit traffic will be absorbed by the project road and traffic congestion on the A_1 Road will be considerably alleviated.

In addition, this project road has been so designed as to be extended toward Quatre Bornes in the south of Beau Bassin and to be smoothly connected with the Ring Road from the Motorway Junction to Port Louis.

The above-mentioned effects will be multiplied by the implementation of the project road.

(2) The A_1 Road is the only main road in the project area and the area along the A_1 Road has considerably been urbanized, but further development of the urbanized area has been obstructed by shortage of road capacity and, without taking remedial measures, aggravation of urban functions and degeneration of urban environment due to traffic congestion is inevitable. The execution of the project will provide a new main road running in the outskirts of the existing urban area. Especially, the cities such as Coromandel and Beau Bassin will be provided with main roads including the existing one in the east and the west and, thereby it is anticipated to contribute to possible expansion of the optimum urban area.

(3) Unless the project road is constructed, there will be no alternative road capable of coping with increased traffic volume generated by the implementation of the Pointe aux Sables Development Plan.

Potential development of the project area is affected not only by the Pointe aux Sables Development Plan, but by the completion of the project road to a large degree.

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