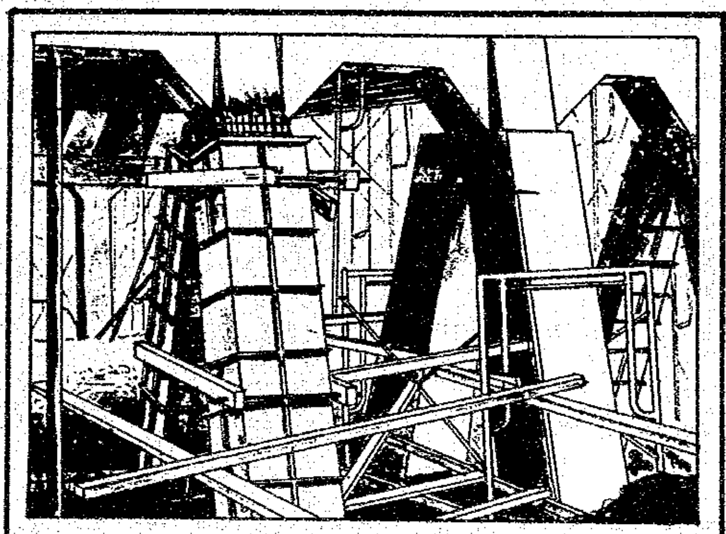
CHAPTER 14

COST ESTIMATE



CHAPTER 14

COST ESTIMATE

14.1 General

The cost estimate started with an extensive data collection exercise and field survey at several existing bridge sites and at a few bridge construction sites as well as interview surveys with some local contractors to ensure that the unit price analysis and results were firmly based on the real situation in Malaysia.

Objective of the study is to estimate the maintenance and rehabilitation project cost for each of the study bridges, amounting to 205 bridges.[1]

To achieve the above objective, the following procedures were applied.

- Assessment of the indirect cost items and project cost composition and determination of multiplier factors of these items.

- Review of main work items derived from the preliminary design of 20 bridges and identification of the associated subsidiary work items.

- Analysis of the unit price of each pay item (or each rehabilitation method) based on above review results.

- Establishment of standard unit prices applicable to all the bridges based on assessment of the unit prices analyzed.

- Estimate of the maintenance and rehabilitation project cost covering all the study bridges.

Note: (1.) After commencement of the Study, 11 number of the bridges have been replaced or being constructed by the Government. Thus, the total number of the bridges has been reduced from 216 bridges to 205 bridges.

14.2 Unit Price Analysis for the 20 Bridges

14.2.1 Basic Condition

Following basic conditions were applied in the cost estimate:

- Price level of labour, material and equipment is based on December, 1991.
- The unit rates are derived from market investigation and from JKR.
- The unit rates are in and around Kuala Lumpur and the local deviation of the rates is not considered in the estimate.
- Except for the direct cost, other costs such as contractor's overhead and profit, detailed design and supervision cost are computed using the multiplier factors.
- Production rate in the unit price analysis is basically based on standard production rates of various work items in Japan after some modification was made with due consideration of Malaysian local conditions.

14.2.2 Structure of Project Cost

Project cost, in general, consists of construction cost, land acquisition and compensation, engineering cost, administration cost and contingency. The construction cost is divided into prime construction cost and contractor's overhead and profit. The prime construction cost is further subdivided into direct cost comprising of labour cost, material cost and equipment cost and indirect cost such as field supervision cost and common preliminary work cost.

Structure of the project cost is depicted in Figure 14-1 and the main cost items are briefly described below.

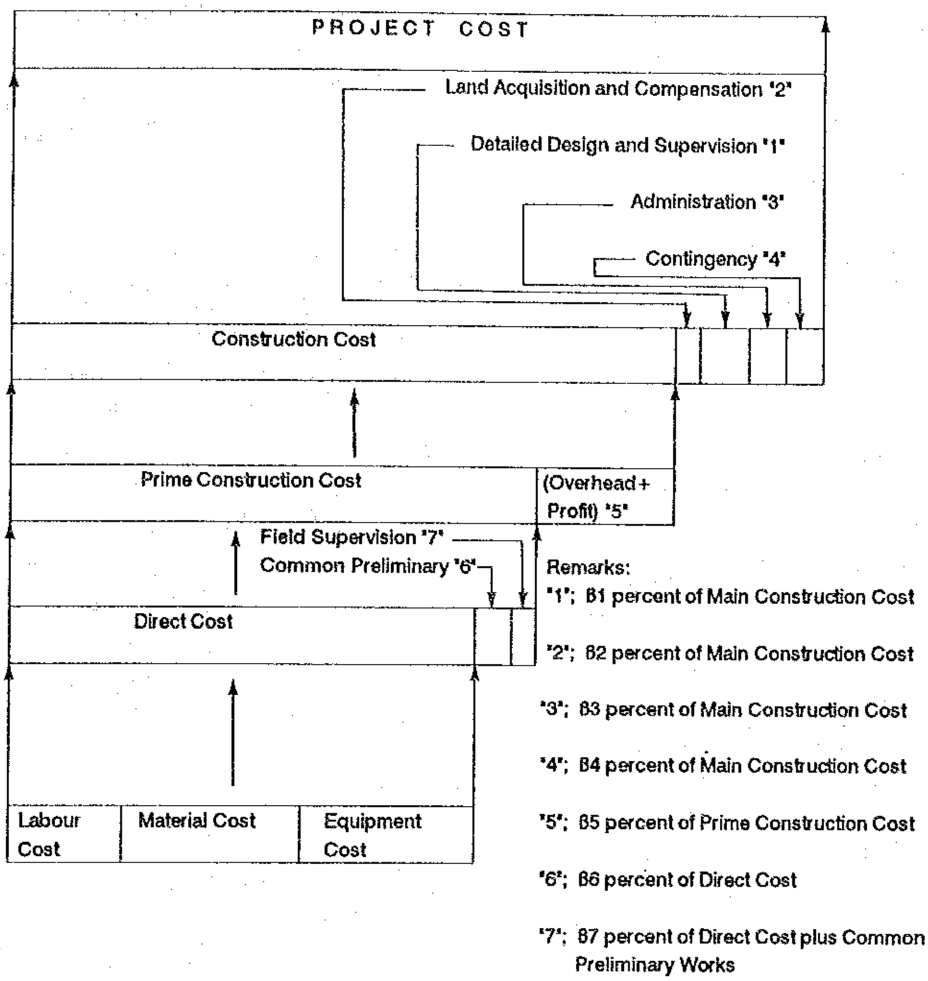
(1) **Direct Cost**

The direct cost of each pay item is estimated based on the quantities derived from the preliminary design. This comprises of labour cost, material cost and equipment cost.

- **Labour Cost**

Labour cost includes wages, income tax and all fringe benefits such as vacation, sick leave, medicare, EPF contributions and workmen's compensation. All these follow government regulations. The labour cost is estimated on the basis of data researched from the market investigation.

Figure 14-1 Components of Project Cost



- **Material Cost**

All materials for the rehabilitation works can be procured from the Malaysian market. The materials cost to be used in the cost estimate are adjusted according to the prevailing escalation rate and on the basis of price level at the end of 1991.

- **Equipment Cost**

The cost of construction equipment is estimated on the basis of market investigation. It is considered that the equipment expense per unit per hour includes depreciation cost, operator's wages, cost of maintenance, fuel and lubricants necessary for equipment operation and repair.

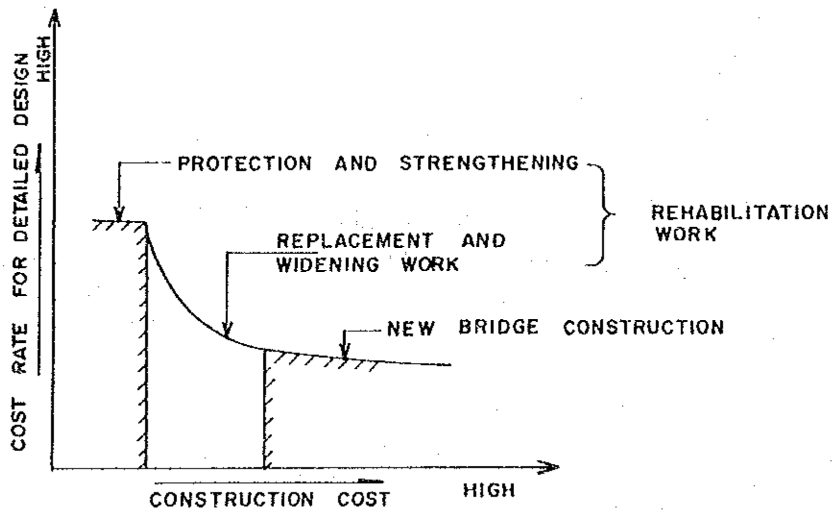
The unit rate of labour, material and equipment applied in the Study are shown in Appendix R of Volume III.

(2) Engineering Cost

Engineering cost consists for detailed design and construction supervision and it is assumed to be 10% (6% for the detailed design and 4% for supervision) of the construction cost.

In general, cost rate of detailed design is inversely proportional to the construction cost. Furthermore, among bridge projects, rehabilitation design cost is relatively higher than that for a new bridge construction because the rehabilitation work is complicated and requires special techniques. These concepts can be depicted as a cost rate curve shown in Figure 14-2.

Figure 14-2 Relationship between Construction Cost and Cost Rate for Detail Design



From the above, 6% for the detailed design is adopted in this Study instead of 4% as used in NALS.

While for construction supervision, 4% is applied in this Study which is 2% lower than that for NALS, assuming that management of the service is required for scattered project locations.

(3) Land Acquisition and Compensation Cost

In a new bridge construction, a considerable amount of land acquisition and compensation costs are required. While, in the rehabilitation work no additional land acquisition cost is necessary, only a small amount of compensation cost may be required where detour road is provided. However, these costs can be incorporated into the construction cost. Therefore in the Study, the land acquisition and compensation cost are neglected i.e. considered as zero percent.

(4) Administration Cost

Administration cost is expenses by the Government arising from implementation of the project and is assumed to be 3% of the construction cost.

(5) Contingency

Contingency is divided into physical contingency and price contingency as described below:

- Physical contingency is mainly to cover unforeseeable or unavoidable design and cost estimate items, generally depending on the level of study. For feasibility study level, 15% of the construction cost is considered in the study.

- Price contingency allows for future price escalation and fluctuation of exchange rates. Therefore, at this stage price contingency is not considered.

(6) Overhead and Profit

This item including taxes is assumed to be 20% of the prime construction cost through the market study.

(7) Common Preliminary Works

This cost is to cover expenditure required to run contractor's site office, warehouse, laboratory and for other common temporary works. In this study, 5% of the direct cost is adopted since transportation and individual temporary works have been incorporated in the direct cost.

(8) Field Supervision

Contractor's field supervision cost covering mainly contractor's field management staff cost is assumed to be 4% of the direct cost.

A summary of the multiplier factors applicable to this study is tabulated in Table 14-1 together with comparison of the figures adopted in NALS.

Table 14-1 Summary of Applicable Multiplier Factors Compared with Those Adopted in NALS

Factor	Description	Axle Load Study (%)	This Study (%)
ß 1	Detailed Design and Supervision	4 6	6 4
ß 2	Land Acquisition and Compensation	Excluded in the study	0
ß 3	Administration	5	3
ß 4	Contingency i) Physical Contingency ii) Price Contingency	– 15	15 See (5)
ß 5	Overhead + Profit	30	20
ß 6	Common Preliminary Works	10	5
ß 7	Field Supervision	6	4

Consequently the project cost is given by the following computation based on the structure of project cost and is the one hundred sixty eight (168) percent of the Direct Cost.

$$
\begin{aligned}
\text{Project Cost} &= \text{Direct Cost} \times \{1 + \beta 6 + (1 + \beta 6)\ \beta 7\} \times (1 + \beta 5) \times (1 + \beta 4 + \beta 3 + \beta 2 + \beta 1) \\
&= \text{Direct Cost} \times \{1 + 0.05 + (1 + 0.05) \times 0.04\} \times (1 + 0.20) \times (1 + 0.15 + 0.03 + 0 + 0.10) \\
&= \text{Direct Cost} \times 1.68
\end{aligned}
$$

14.2.3 Unit Price Analysis

In order to analyze unit prices of the respective rehabilitation work items, required materials, equipment and labour are listed and the unit quantity of each item (or subitem) is firstly calculated based on standard construction methods. The unit price consisting of basically labour cost, material cost and equipment cost is in general given by the following formula.

$$U.P. = \sum_{i}^{m} \alpha_i L_i + \sum_{i}^{n} \beta_i M_i + \sum_{i}^{o} \gamma_i E_i$$

Where:

U.P.	:	Unit Price
L_i	:	Labour unit rate
M_i	:	Material unit rate
E_i	:	Equipment unit rate
α_i, β_i, γ_i	:	Production rate of each item

It is, however, difficult to estimate the accurate production rates of respective items in the rehabilitation works because of the lack of the rehabilitation work records in Malaysia.

To this end, the following procedures are taken so as to ensure the analysis results are as precise as possible.

(1) The production rate stated in the Cost Estimate Manual published by the Ministry of Construction in Japan is modified taking into account labours' skillfulness, unit material usage, efficiency of equipment, operator's capability and so on in Malaysia as well as based on those in similar projects in ASEAN countries.

(2) Applying the modified production rates of various items, the unit prices are calculated using the above mentioned formula.

(3) The production rate applied in the above calculation is calibrated based on comparison with unit prices obtained from JKR and market research.

(4) Finally the unit price of each work item is recalculated using the calibrated production rate.

Example calculation sheets which elaborate the above methodology for derivation of unit prices for several work items are enclosed in Appendix-P of Volume III. A summary of unit price for each pay item under 20 bridges is tabulated in Table 14-2.

14.3 Standard Unit Prices of Respective Rehabilitation Methods

One of the main purposes of the Study is to establish an implementation program for the bridge rehabilitation covering all the study bridges which in turn requires cost estimate of all the bridges.

In this regard, rehabilitation methods and the work quantities for the rest of the bridges, which were discarded either from the visual inspection or from the detailed survey, were designated during the supplemental survey and are presented in Chapter 13.

Therefore, standard unit prices applicable to the other bridges are prepared in this section based on the assessment of the unit price for the 20 bridges.

14.3.1 Classification of Unit Prices for the 20 Bridges

The unit prices analyzed for 20 bridges were reviewed from an applicability viewpoint to the other bridges and were classified into the following four categories.

Category A : Where the unit prices are not affected by the job site condition and work the sequences are similar in every bridge. Thus the unit price will be applicable to the rehabilitation method in other bridges without any modification.

Table 14-2 SUMMARY OF UNIT PRICE FOR REHABILITATION WORKS

(Unit: M$)

	MAIN PAY ITEMS	UNIT	ITEM* No.	FEDERAL BRIDGES																	SPECIAL BRIDGES		
				114920	161140	166510	237200	317000	319110	341800	346740	520850	546550	546980	563880	567840	634850	5001070	5603340	5903120	Dembe	Samanhic	371000
Super – Structure	1. Gunning	m2	I.502	621.66																			
	2. Gunning with rebar	m2	I.502.1									621.84											
	3. Patching (Type A)	m2	I.512.1					221.45		221.46										763.99			
	4. Patching (Type B)	m2	I.510				268.96			270.97	269.08		269.17	269.12									
	5. Prepacked lining	m2	I.509																				
	6. Prepacked lining w/ rebar	m2	I.513										3182.34				3162.40						
	7. Epoxy injection (Type A)	m	I.514						119.87														
	8. Epoxy injection (Type B)	m	I.526																			119.82	119.87
	9. Protective coating	m2	I.401.1						32.38		32.36											136.21	
	10. Waterproof layer	m2	I.518													47.80	47.81						
	11. Steel bonding plate	m2	I.313						826.54		926.88			926.55									
	12. Repainting	m2					57.99															875.84	
	13. Adding cross beam (steel)	t	I.537																	58.00			
	14. Attachment of steel plate	t																		4758.97			
	15. Replacement to R.C Slab	m2			626.97																	939.34	
Sub – Structure	1. Epoxy Injection (Type A)	m	I.513						119.86									544.45	501.51		949.72		
	2. Epoxy Injection (Type B)	m	I.514						136.26														
	3. Protective Coating	m2	I.526						32.38														
	4. Concrete lining (Wall)	m2			184.15							198.05						600.81	2093.15				
	5. Concrete lining (Column)																						
	(a) 410 diameter (Steel Piles)	m																			416.77		
	(b) 300 x 300 (R.C Piles)	m					1739.78																
	(c) 310 x 310 (R.C Piles)	m								2036.00									3033.60				
	(d) 360 x 360 (R.C Piles)	m		754.35																			
	(e) 380 x 380 (R.C Piles)	m													1640.60								
	(f) 390 x 390 (R.C Piles)	m												1077.23									
	(g) 550 x 560 (R.C Piles)	m								2297.07													
	(h) 610 x 610 (R.C Piles)	m								2297.07													
	(i) 900 diameter (R.C Piles)	m							626.01														
	6. Crosshead lining (prepacked)																						
	(a) Prepacked lining + rebar	m2	I.509							3162.39													
	(b) Prepacked lining	m2	I.510											36763.13									
	7. Patching (Type A)	m2	I.512.1								221.43												
	8. Patching (Type B)	m2	I.512												288.49	268.49	258.33						256.67
	9. Replacement of Abut. by rigid frame.	m												8563.67									
Incidental Facilities	1. Extension drainage pipes.	No	I.534	390.76			390.76		390.76		390.77												
	2. Water drop	m	I.526.1						93.35		93.35			93.36	93.36								
	3. Expansion joints (Type A)	m	I.531				3023.66													3023.56			
	4. Expansion joints (Type B)	m	I.532					1189.75	1189.75	1189.75				1189.76	1189.73								
Temporary Work	1. Detour road	m	I.116		489.70	899.61													334.07				
	2. Temporary bridge	m	I.118.3					6778.84															
Scaffolding	1. Substructure – ground support	m3	I.119		12.12					12.12				12.12	12.12						12.12		
	2. Superstructure – "	m3	I.119	12.12			12.12										12.11			12.12			
	3. Superstructure – Hanging	m2	I.119.1					21.25	21.25	21.25	21.26										21.25	21.25	21.25
Functional Rehabilitation	1. Adding sidewalk	m2			2493.14					2100.01													
	2. Widening carriageway	m2														2754.21							
	3. Raising grade	m2						1134.36															
Total Replacement		m2				1987.13																	
River Training	1. Slope Protection																						
	(a) Type A	m2			111.21	164.18	149.85			401.90											138.73		
	(b) Type B	m2																					
	(c) Type C	m2									218.00												
	(d) Type D	m2																					96.87
	2. Foot Protection																						
	(a) Type A	m2																					
	(b) Type B	m2																					
	(c) Type C	m2						178.28															
	(d) Type D	m2																					
	3. Riverbed protection																						
	(a) Type A	m2			185.50						120.93												
	(b) Type B	m2																					
	4. River Alignment																						
	(a) Type A	m				152.50					4743.18												
	(b) Type B	m																					

Remark :

* means the Item Number of Process Cost

Category B : Where the unit prices are slightly affected by the job site condition but the work sequences are similar in every bridge. Thus average unit price of those for 20 bridges is considered as the standard unit price. These items are replacement to R.C. Slab, concrete wall lining and detour roads. In the calculation of the average, the extremely low or high unit prices due to special site condition are excluded.

Category C : Where the unit prices are mainly for functional rehabilitation works. Thus these unit prices are only applicable to the other bridges provided that rehabilitation method, the work scale and bridge type of the other bridge are the same as those in the original unit price.

Category D : Where the unit prices are considerably affected by the job site condition and size of the bridge member to be rehabilitated. These are for concrete pile lining and hydraulic rehabilitation works and are not applicable to other bridges without standardization of these unit prices.

14.3.2 Standard Unit Price Analysis

The unit prices under Category A are applicable to other bridges with the same rehabilitation methods and the average of the unit prices under Category B is also applicable to other bridges with the same rehabilitation methods.

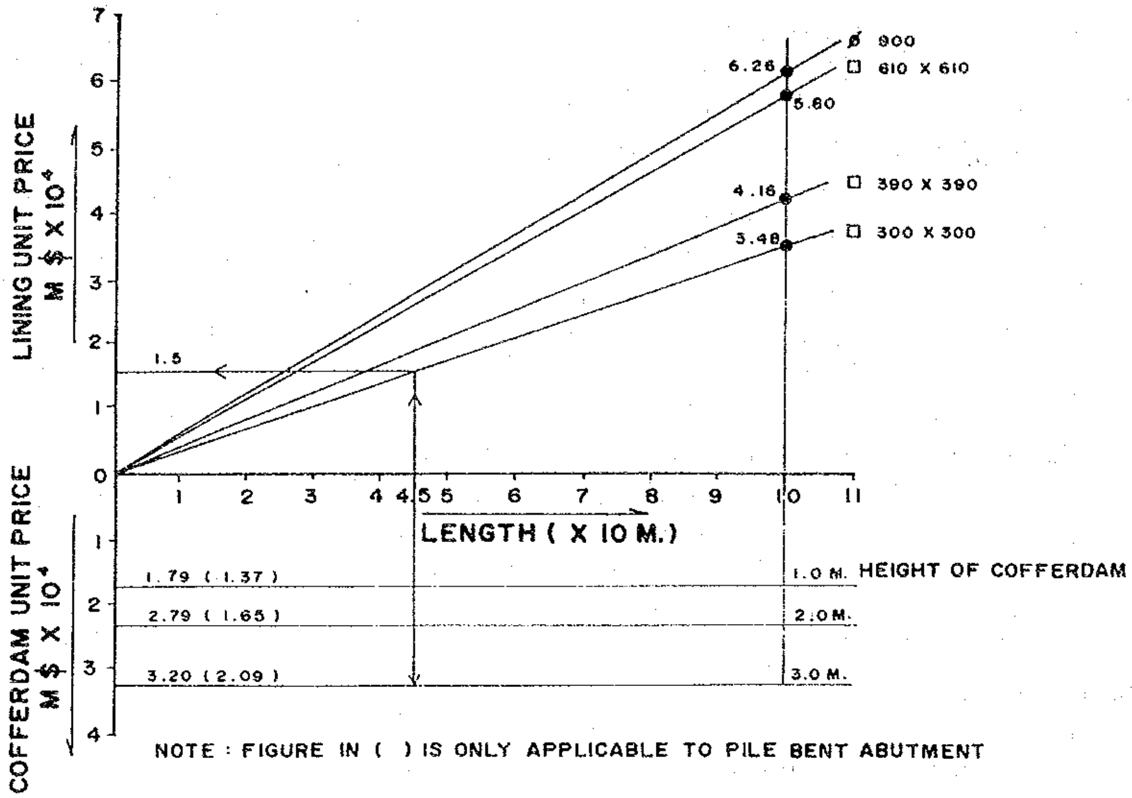
While the unit prices under Category C are only applicable to other bridges if conditions of the original estimate meet those of other bridges. If not, individual unit price analysis is required to estimate the cost of the bridge.

For the unit prices under Category D covering concrete pile lining and hydraulic rehabilitation plan, standardization of these unit prices is presented below;

(1) Concrete pile lining

Each unit price for the concrete lining which has been analyzed in the cost estimate for 20 bridges is plotted in a X-Y graph on a different pile size basis to derive a relationship between pile length and the construction cost with the cofferdam. After calibration by interpolation method, standard unit price of the pile lining for different size of piles was obtained as shown in Figure 14-3.

Figure 14-3 Relationship for Standard Unit Price of Concrete Pile Lining



(2) Hydraulic Rehabilitation Plan

Hydraulic rehabilitation plan consists of slope protection, footing protection, river bed protection and river realignment and furthermore each plan has different work methods as mentioned in Chapter 12.

To this end, standard unit quantities of each rehabilitation method are firstly estimated referring to the standard design presented in section 12.4. Based on these quantities, standard unit price of each hydraulic rehabilitation method is estimated using the formula stated in 14.2.3.

Consequently, based on the above mentioned exercises, the standard unit price of the individual rehabilitation method which will be used to estimate the cost of the rest of the bridges is prepared and is summarized in Table 14-3.

Table 14–3 SUMMARY OF STANDARD UNIT PRICE FOR EACH REHABILITATION METHOD

	REHABILITATION ITEMS	UNIT	CATEGORY	UNIT PRICE (M$) DIRECT COST (1)	UNIT PRICE (M$) PROJECT COST (2)	REMARKS
Super – Structure	1. Guniting	m2	a	620.00	1040.00	Cement exceptionally developed for guniting
	2. Guniting with rebar	m2	a	760.00	1280.00	Cement exceptionally developed for guniting
	3. Patching (Type A)	m2	a	220.00	370.00	Depth < 25 mm
	4. Patching (Type B)	m2	d	270.00	450.00	25mm < depth < 50mm
	5. Prepacked lining	m2	a	2980.00	5010.00	Depth = 100mm
	6. Prepacked lining w/ rebar	m2	a	3160.00	5310.00	Depth = 100mm
	7. Epoxy injection (Type A)	m	a	120.00	200.00	Width = 0.2 ~ 0.6mm
	8. Epoxy injection (Type B)	m	a	140.00	230.00	Width = 0.6 ~ 3.0mm
	9. Protective coating	m2	a	32.40	54.40	Cleaning and 3–coatings (acrylic resin)
	10. Waterproof layer	m2	a	47.80	80.40	4 – coatings(chloroprene) and pavement (50mm)
	11. Steel bonding plate	m2	a	930.00	1560.00	Grouting epoxy resin
	12. Repainting	m2	a	58.00	97.50	Blasting and 3 – coatings (epoxy resin)
	13. Adding cross beam (steel)	t	a	4760.00	7990.00	Added at span center
	14. Attachment of steel plate	t	a	930.00	1570.00	Bolted cover plate
	15. Replacement to R.C Slab	m2	b	560.00	940.00	Buckle plate bridge 950$/m2 * with addtional girder
Sub– Structure	1. Epoxy Injection (Type A)	m	a	120.00	200.00	Width = 0.2 ~ 0.6mm
	2. Epoxy Injection (Type B)	m	a	140.00	230.00	Width = 0.6 ~ 3.0mm
	3. Protective Coating	m2	a	32.40	54.40	Cleaning and 3–coatings (acrylic resin)
	4. Concrete lining (Wall)	m2	b	190.00	320.00	Dry work, 1390$/m2 * with cofferdam(H=1.0)
	5. Concrete lining (Column)					
	(a) 410 diameter (Steel Piles)	m	d	–	–	Refer to Fig 14–3
	(b) 300 x 300 (R.C Piles)	m	d	–	–	Refer to Fig 14–3
	(c) 310 x 310 (R.C Piles)	m	d	–	–	Refer to Fig 14–3
	(d) 360 x 360 (R.C Piles)	m	d	–	–	Refer to Fig 14–3
	(e) 380 x 380 (R.C Piles)	m	d	–	–	Refer to Fig 14–3
	(f) 390 x 390 (R.C Piles)	m	d	–	–	Refer to Fig 14–3
	(g) 550 x 550 (R.C Piles)	m	d	–	–	Refer to Fig 14–3
	(h) 610 x 610 (R.C Piles)	m	d	–	–	Refer to Fig 14–3
	(i) 900 diameter (R.C Piles)	m	d	–	–	Refer to Fig 14–3
	6. Crosshead lining (prepacked)					
	(a) Prepacked lining + rebar	m2	a	3160.00	5310.00	Depth = 100 mm
	(b) Prepacked lining	m2	a	2980.00	5010.00	Depth = 100 mm
	7. Patching (Type A)	m2	a	220.00	370.00	Depth < 25 mm
	8. Patching (Type B)	m2	a	270.00	450.00	25 mm < Depth < 50 mm
	9. Replacement of Abut. by rigid frame.	m	c	8550.00	14390.00	Portal type pier, PC pile 500x500x41.0 m
Incidental Facilities	1. Extension drainage pipes.	No	a	390.00	660.00	Extension and binding with metal strip
	2. Water drop	m	a	93.40	160.00	Bonding strip (F R P)
	3. Expansion joints (Type A)	m	a	3020.00	5080.00	Rubber seal joint (Span > 10m)
	4. Expansion joints (Type B)	m	a	1190.00	2000.00	Blind type (Span < 10m)
Temporary Work	1. Detour road	m	b	590.00	1000.00	Embarkment hieght 4.0 ~ 5.0m, 330$/m2 for hieght 1.0m
	2. Temporary bridge	m	a	6780.00	11390.00	Steel frame with wooden deck
Scaffolding	1. Substructure – ground support	m3	a	12.10	20.40	Prefablicated pipe support
	2. Superstructure – "	m3	a	12.10	20.40	Prefablicated pipe support
	3. Superstructure – Hanging	m2	a	21.30	35.90	Steel tube with wooden planks
Functional Rehabilitation	1. Adding sidewalk (Concrete)3)	m2	c	1560.00	2620.00	B=2x2m, L=3@12.1m, 760$/m2 * for Superstructure
	2.Adding sidewalk (steel)3)	m2	c	1940.00	3260.00	B=2x2m, L=21.0m, 960$/m2 * for Superstructure
	3. Widening carriageway	m2	c	2440.00	4110.00	B=2x3.55m, L=2@6.24m, 370$/m2 * for Superstructure
	4. Raising grade	m2	c	1480.00	2490.00	B=9.11m, L=30.0m, Superstructure alone
Total Replacement		m2	c	1990.00	3340.00	B=12.6m, L=15.0m, 830$/m2* for Superstructure
River Training	1. Slope Protection					
	(a) Type A	m2	d	140.00	230.00	Height=3m, Slope 1:15 Stone Masonry
	(b) Type B	m2	d	200.00	340.00	Height=3m, Slope 1:1 Concrete Block Masonry
	(c) Type C	m2	d	140.00	240.00	Height=3m, Slope 1:2 Concrete Block Pitching
	(d) Type D	m2	d	120.00	200.00	Height=3m, Slope 1:2 Concrete Frame
	2. Foot Protection					
	(a) Type A	m2	d	16.40	27.50	Depth = 1m, Dumped Stone
	(b) Type B	m2	d	33.40	56.10	Depth = 1m, Gablon
	(c) Type C	m2	d	180.00	290.00	Depth = 1m, Concrete Block
	(d) Type D	m2	d	590.00	990.00	Depth = 2m, Sheet Pile alone
	3. Riverbed protection					
	(a) Type A	m2	d	260.00	440.00	Depth = 1m, Gablon
	(b) Type B	m2	d	320.00	540.00	Depth = 3m, Dumped Stone and Gadlon
	4. River Alignment					
	(a) Type A	m	d	310.00	510.00	Spur Dike High = 2.0m
	(b) Type B	m	d	320.00	530.00	Groyne by Concrete Pile Block

Remark : Number 1) indicate the unit price for Direct Cost
2) indicates Unit Price for Project Cost (=1.68 x Direct Cost)
3) indicates that the width is the total width of walkway including curb
4) indicate the width of carriageway
Synbol (*) indicates that the Unit Cost is Direct Cost

14.4 Project Cost Estimate

In the supplemental bridge survey covering 199 bridges, rehabilitation methods for each bridge were identified and the corresponding work quantities were also estimated accordingly. The standard unit prices applicable to most of the rehabilitation methods of those bridges were analyzed in the previous section based on the assessment of the unit prices covering various rehabilitation methods for 20 bridges from the detailed survey.

However, some of these standard unit prices are not applicable to several rehabilitation methods such as widening of carriageways, adding sidewalks, raising bridge grade as well as total replacement, the unit price of which depends on the bridge type and configuration of the bridge. Those unit prices are individually estimated referring to breakdown of unit prices of similar rehabilitation methods.

The project cost of each bridge can be obtained by adding each rehabilitation work item amount assigned to the bridge, the amount was calculated by multiplying the estimated quantity of rehabilitation work by the corresponding standard unit price.

The project cost of each bridge is shown in Table 14-4 and the total project cost covering 205 bridges amounts to M$58,148,268, while the cost breakdown of each bridge is attached in Appendix-R of Volume III.

Table 14-4 Summary of Cost Estimate for All Study Bridges (1)

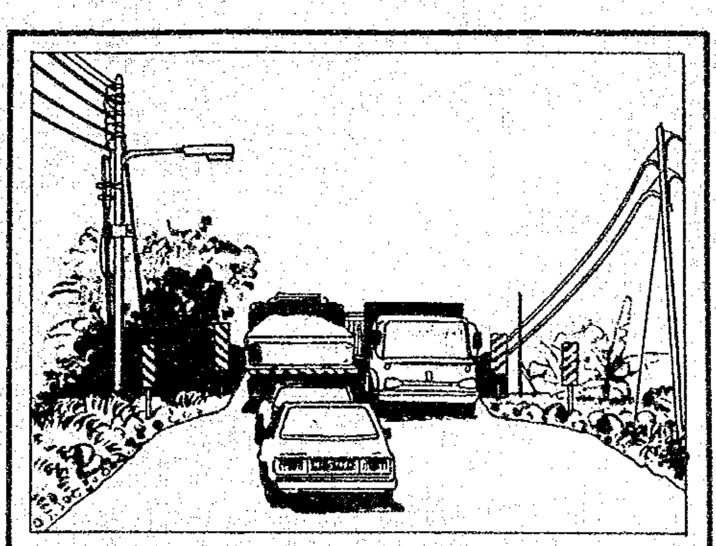
No.	Key	State	Year Built	Max. Span (m)	No of Spans	Bridge Length (m)	Type of Bridge	Rehabilitation Plans: Reconstruction	Rehabilitation Plans: Widening	Rehabilitation Plans: Reinforcement	Rehabilitation Plans: Protection	Direct Cost (M$)	Project Cost (M$)	Remarks
1	00102590	Johor	1955	1.80	2	3.60	BOX				•	3,829	6,433	
2	00108100	Johor	1954	15.90	3	27.40	RCB				•	77,104	129,535	
3	00108990	Johor	1937	2.18	1	2.18	BOX				•	3,782	6,354	
4	00112630	Johor	1960	6.27	1	6.27	RCS				•	26,862	45,128	
5	00113760	Johor	1955	6.83	3	20.34	RCB		•		•	142,271	239,015	
6	00114920	Johor	1955	6.43	2	12.86	RCB				•	112,917	189,701	Included in detailed survey
7	00116580	Johor	1947	2.44	2	4.83	BOX				•	31,354	52,675	
8	00121260	Johor	1955	2.42	1	2.42	BOX					0	0	Bridge has been replaced
9	00121280	Johor	1950	2.83	1	2.83	BOX					0	0	Bridge has been replaced
10	00125250	N.Sembilan	1940	6.70	1	6.70	RCB				•	3,926	6,596	
11	00128254	N.Sembilan	1930	9.58	1	9.58	SBC				•	27,476	46,160	
12	00145100	Selangor	1935	1.85	1	1.85	SBE				•	1,616	2,715	
13	00146800	Selangor	1965	12.13	3	25.91	IT				•	58,283	97,915	
14	00148800	Perak	1962	2.40	1	2.40	BOX				•	2,158	3,625	
15	00149820	Perak	1963	12.08	3	36.24	IT				•	48,659	81,747	
16	00151360	Perak	1960	9.08	7	63.56	RCB				•	90,341	151,773	
17	00155390	Perak	1970	1.81	2	3.62	BOX			•		298,271	501,093	
18	00159100	Perak	1948	11.50	3	31.30	SBB					0	0	Bridge has been replaced
19	00161140	Perak	1950	9.77	2	19.11	SBB		•	•		402,568	676,314	Included in detailed survey
20	00161290	Perak	1955	8.09	2	16.18	SBB		•	•		256,226	430,460	
21	00166220	Perak	1945	5.67	1	5.67	SBB			•		87,093	146,316	
22	00166510	Perak	1935	10.72	1	10.72	SBG	•	•			502,038	843,424	Included in detailed survey
23	00184400	Kedah	1950	2.61	2	12.20	RCB			•		113,090	189,991	
24	00184900	Kedah	1950	5.20	1	5.20	RCS			•		60,603	101,813	
25	00184980	Kedah	1950	4.64	1	4.64	RCS				•	22,923	38,511	
26	00186210	Kedah	1940	3.23	1	3.23	SBB			•		38,546	64,757	
27	00228540	Pahang	1955	6.26	1	6.26	SBB			•		59,269	99,572	
28	00228970	Pahang	1965	3.03	1	3.03	BOX				•	82,255	138,188	
29	00230850	Pahang	1967	6.40	1	6.40	PRB				•	41,724	70,095	
30	00231790	Pahang	1960	7.75	1	7.75	RCB					0	0	No defect detacted
31	00232880	Pahang	1963	11.08	1	11.08	PRB				•	153,680	258,182	
32	00237200	Pahang	1960	8.90	3	26.70	SBC				•	223,645	375,724	Included in detailed survey
33	00303220	Johor	1940	4.84	1	4.84	SBE				•	49,955	83,924	
34	00303430	Johor	1940	4.90	1	4.90	SBC				•	46,790	78,607	
35	00303890	Johor	1940	4.58	2	9.16	RCS		•		•	101,419	170,384	
36	00304060	Johor	1963	36.65	5	92.25	RCS				•	146,830	246,674	
37	00304390	Johor	1928	3.35	1	3.35	SBC			•		90,971	152,831	
38	00306390	Johor	1974	16.57	5	64.57	IT				•	186,007	312,492	
39	00306710	Johor	1969	18.90	7	51.96	IT				•	203,621	342,083	
40	00313150	Johor	1950	4.40	1	4.40	SBE		•		•	111,662	187,592	
41	00313520	Pahang	1960	1.80	2	3.60	RCS		•		•	114,609	192,543	
42	00314160	Johor	1964	5.50	2	11.00	PRB				•	231,031	388,132	
43	00316745	Pahang	1965	3.67	1	5.67	RCS			•		86,534	145,377	
44	00317000	Pahang	1974	45.78	9	397.32	PCB			•		2,053,043	3,449,112	Included in detailed survey
45	00319110	Pahang	1962	30.46	7	121.96	PCB				•	293,327	492,789	Included in detailed survey
46	00319690	Pahang	1960	5.67	2	11.34	PRB				•	84,013	141,142	
47	00323070	Pahang	1965	10.42	3	31.26	RCB				•	108,330	181,994	
48	00326020	Pahang	1965	5.73	1	5.73	PRB				•	58,172	97,729	
49	00326950	Pahang	1965	5.88	4	23.52	PRB				•	164,067	275,633	
50	00336310	Pahang	1958	12.00	3	36.00	RCB		•		•	260,757	438,072	
51	00337240	Pahang	1957	6.58	1	6.58	RCS				•	50,661	85,110	
52	00338580	Terengganu	1965	28.03	16	219.13	PCB	•				7,014,000	11,783,520	Total replacement
53	00339210	Terengganu	1963	15.22	10	152.20	PCB			•		668,494	1,123,070	
54	00341800	Terengganu	1955	12.10	3	36.14	RCB		•		•	795,186	1,335,912	Included in detailed survey
55	00346740	Terengganu	1973	30.50	9	152.26	PCB			•		3,314,414	5,568,216	Included in detailed survey
56	00354190	Terengganu	1960	5.59	2	11.18	PRB					0	0	Bridge has been replaced
57	00354830	Terengganu	1963	5.95	3	17.85	PRB				•	57,151	96,014	
58	00356790	Terengganu	1959	5.90	9	53.10	PRB				•	46,590	78,271	
59	00357200	Terengganu	1959	5.94	3	5.94	PRB				•	50,746	85,253	
60	00357270	Terengganu	1957	5.89	2	11.78	PRB				•	46,374	77,908	
61	00361490	Terengganu	1960	6.01	3	18.03	PRB				•	96,131	161,500	
62	00363630	Terengganu	1965	5.84	1	5.84	PRB				•	38,081	63,976	
63	00366660	Kelantan	1952	5.41	6	32.46	PRB			•		569,968	957,546	Replacement of superstructure
64	00366890	Kelantan	1951	4.79	2	9.58	RCS			•		135,089	226,950	
65	00368300	Kelantan	1955	4.84	2	9.68	RCS			•		115,329	193,753	
66	00505380	Johor	1966	11.88	4	47.52	RCS				•	398,364	669,252	
67	00506670	Johor	1971	15.09	3	36.17	IT				•	201,999	339,358	
68	00507230	Johor	1965	11.77	3	35.21	PCB				•	172,596	289,961	
69	00507810	Johor	1968	12.09	5	47.83	IT				•	342,079	574,693	
70	00510560	Johor	1960	10.42	3	31.24	RCB				•	143,454	241,003	
71	00512960	Johor	1965	11.30	3	30.22	RCB				•	500,759	841,275	
72	00514300	Johor	1960	10.45	3	22.07	IT				•	80,263	134,842	
73	00514370	Johor	1950	6.31	1	6.31	RCB			•		42,352	71,151	
74	00514860	Johor	1955	6.97	9	46.03	RCB					0	0	Bridge has been replaced
75	00516890	Johor	1966	6.30	3	17.82	RCB				•	64,416	108,219	
76	00519360	Melaka	1955	6.22	7	42.70	RCS				•	224,286	376,800	
77	00519550	Melaka	1940	4.95	1	4.95	PRB				•	2,931	4,924	
78	00519700	Melaka	1961	4.88	1	4.88	PRB		•		•	75,406	126,682	
79	00520130	Melaka	1960	6.46	1	6.46	PRB				•	7,449	12,514	
80	00520850	Melaka	1950	4.27	1	4.27	SBE				•	24,166	40,599	Included in detailed survey
81	00521300	Melaka	1950	6.90	1	6.90	RCB			•		119,370	200,542	
82	00521710	Melaka	1960	10.72	1	10.72	RCB		•	•		190,089	319,350	
83	00521980	Melaka	1960	7.13	2	14.26	RCB			•		154,356	259,368	
84	00522760	Melaka	1930	7.47	1	7.47	SBE			•		23,979	40,285	
85	00523300	Melaka	1950	9.33	1	9.33	SBE				•	3,910	6,569	
86	00523620	Melaka	1960	7.58	2	15.16	PRB				•	79,013	132,742	
87	00524420	Melaka	1950	3.60	1	3.60	RCS			•		58,181	97,744	
88	00524990	Melaka	1960	1.85	1	1.85	BOX				•	4,439	7,458	
89	00529600	N.Sembilan	1950	3.05	1	3.05	SBB			•		62,282	104,634	
90	00532850	N.Sembilan	1970	11.02	5	53.24	RCB				•	195,200	327,936	
91	00534450	N.Sembilan	1965	8.83	4	35.32	RCB				•	158,606	266,794	
92	00534570	Selangor	1960	6.95	4	32.54	RCB			•		240,817	404,573	
93	00535660	Selangor	1960	14.70	5	61.34	RCB				•	369,620	620,962	
94	00538970	Selangor	1950	2.30	1	2.30	BOX			•		27,730	46,586	
95	00540780	Selangor	1960	7.30	3	11.94	RCB					0	0	Bridge has been replaced
96	00540910	Selangor	1950	6.29	1	6.29	SBB			•		86,857	145,920	
97	00541000	Selangor	1950	3.24	1	3.24	SBB			•		98,542	165,551	
98	00541210	Selangor	1950	4.73	1	4.73	SBB			•		52,711	88,554	
99	00546560	Selangor	1969	10.64	3	30.94	RCS			•		21,854	36,715	Included in detailed survey
100	00546980	Selangor	1969	10.64	3	30.94	RCS			•		682,598	1,146,765	Included in detailed survey
101	00549550	Selangor	1965	12.61	6	63.56	SBC				•	161,078	270,611	
102	00555290	Perak	1960	2.46	2	4.92	BOX				•	35,677	59,937	
103	00556900	Perak	1958	7.33	1	7.33	RCS				•	45,136	75,828	
104	00563880	Perak	1972	14.07	3	41.59	IT				•	122,189	205,278	Included in detailed survey
105	00567840	Perak	1960	6.06	2	12.12	PRB		•		•	247,092	415,115	Included in detailed survey
106	00569650	Perak	1950	2.83	1	2.83	SBB			•		40,390	67,855	
107	00700660	Kedah	1964	18.40	1	18.40	PCB		•		•	131,527	220,965	
108	00700750	Kedah	1970	15.36	1	15.36	RCS			•		192,022	322,597	
109	00701810	Kedah	1970	30.52	3	48.60	PCB				•	115,506	194,050	
110	00702630	Kedah	1960	9.54	1	9.54	RCB				•	71,353	119,873	
111	00703330	Perlis	1965	24.80	1	24.80	PCB				•	34,348	57,705	

Table 14-4 Summary of Cost Estimate for All Study Bridges (2)

No.	Key	State	Year Built	Max. Span (m)	No of Spans	Bridge Length (m)	Type of Bridge	Rehabilitation Plans: Reconst-ruction	Widen-ing	Reinfor-cement	Protec-tion	Direct Cost (M$)	Project Cost (M$)	Remarks
112	00706230	Perlis	1950	6.63	1	6.63	SBB					0	0	Bridge has been replaced
113	00800350	Pahang	1950	3.47	1	3.47	SBB			•		36,847	61,903	
114	00803050	Pahang	1950	9.04	2	18.08	SBB			•		133,607	224,460	
115	00803900	Pahang	1952	5.47	2	10.94	SBB			•		152,865	256,813	
116	00810120	Pahang	1950	6.90	1	6.90	SBB			•		50,191	84,321	
117	00813470	Pahang	1960	11.67	1	11.67	PRB				•	106,163	178,354	
118	00818060	Pahang	1980	30.49	1	30.49	PCB					0	0	No defect detected
119	00822340	Kelantan	1982	31.13	3	90.91	PCB				•	224,624	377,704	
120	00834850	Kelantan	1960	4.63	3	13.71	RCS			•		334,175	561,414	Included in detailed survey
121	00834950	Kelantan	1960	3.34	1	3.34	RCS			•		49,807	83,676	
122	00836900	Kelantan	1960	6.69	2	12.02	RCB				•	47,848	80,385	
123	00838100	Kelantan	1941	4.48	2	9.72	RCS		•	•		238,665	400,957	
124	00901360	N.Sembilan	1960	5.74	1	5.74	RCS			•		44,238	74,320	
125	00901420	N.Sembilan	1950	3.24	1	3.24	SBB			•		89,512	150,380	
126	00901700	N.Sembilan	1950	3.63	1	3.63	SBB			•		38,678	64,979	
127	00901960	N.Sembilan	1950	9.07	2	18.14	SBB			•		182,113	305,950	
128	00902270	N.Sembilan	1950	3.11	1	3.11	SBB			•		36,635	61,547	
129	00902360	N.Sembilan	1950	3.11	1	3.11	SBB			•		82,961	139,374	
130	00902430	N.Sembilan	1950	3.10	1	3.10	SBB			•		61,829	103,873	
131	00902440	N.Sembilan	1950	3.10	1	3.10	SBB			•		46,176	77,576	
132	00904330	N.Sembilan	1950	7.77	1	7.77	SBB			•		52,964	88,980	
133	00906190	N.Sembilan	1950	9.54	1	9.54	SBB			•		61,149	102,730	
134	00907010	N.Sembilan	1930	6.36	1	6.36	SBB			•		48,659	81,747	
135	00908400	N.Sembilan	1935	10.70	5	36.70	SBE			•		197,813	332,326	
136	00911990	Pahang	1951	10.77	4	32.96	SBB			•		166,462	279,656	
137	01105770	N.Sembilan	1970	6.18	3	18.32	PRB				•	48,743	81,892	
138	01800060	Perak	1960	3.68	1	3.68	RCS		•		•	61,984	104,133	
139	01800670	Perak	1950	4.78	1	4.78	SBC		•		•	140,256	235,680	
140	02305040	Johor	1950	6.29	2	12.28	SBB			•		69,445	116,668	
141	02305970	Johor	1950	5.68	2	7.60	RCS			•		70,879	119,077	
142	05001070	Johor	1919	4.77	1	4.77	SBB			•		76,328	128,231	Included in detailed survey
143	05001890	Johor	1950	5.05	1	5.05	SBB			•		70,316	118,131	
144	05002590	Johor	1940	4.75	1	4.75	SBB			•		63,363	106,450	
145	05100840	N.Sembilan	1950	9.41	1	9.41	SBB					0	0	Bridge has been replaced
146	05101360	N.Sembilan	1940	3.31	1	3.31	SBB			•		51,367	86,297	
147	05101460	N.Sembilan	1950	3.26	1	3.26	SBB			•		48,315	81,169	
148	05102060	N.Sembilan	1950	4.74	1	4.74	SBB			•		53,697	90,211	
149	05102260	N.Sembilan	1960	4.81	1	4.81	SBB			•		42,118	70,758	
150	05102380	N.Sembilan	1960	3.21	1	3.21	SBB			•		38,574	64,804	Replacement of superstructure
151	05102670	N.Sembilan	1960	3.21	1	3.21	SBB		•	•		81,470	136,870	
152	05103030	N.Sembilan	1950	3.79	1	3.79	SBB			•		42,514	71,424	
153	05103300	N.Sembilan	1958	9.62	2	16.08	SBB			•		94,362	158,528	
154	05200280	N.Sembilan	1932	4.66	1	4.66	SBB			•		77,869	130,820	
155	05202450	Selangor	1955	12.11	1	12.11	RCB			•		33,110	55,625	
156	05203510	Selangor	1950	1.60	2	3.20	BOX				•	2,808	4,717	
157	05204870	Selangor	1964	18.24	3	54.50	SBC				•	177,869	298,820	
158	05300470	N.Sembilan	1950	9.35	1	9.35	SBB			•		114,593	192,516	
159	05300960	N.Sembilan	1950	6.27	1	6.27	SBB			•		60,159	101,034	
160	05301190	N.Sembilan	1950	4.84	1	4.84	SBB					0	0	Bridge has been replaced
161	05302050	N.Sembilan	1950	8.45	1	8.45	SBB			•		69,120	116,122	
162	05302160	N.Sembilan	1950	6.31	1	6.31	SBB			•		58,390	98,095	
163	05302340	N.Sembilan	1940	6.70	1	6.70	SBB			•		91,943	154,464	
164	05403460	Selangor	1950	6.56	1	6.56	RCS				•	43,206	72,586	
165	05403570	Selangor	1960	3.05	1	3.05	BOX			•		182,838	307,168	
166	05801510	Perak	1950	5.60	1	5.60	SBB			•		47,899	80,470	
167	05801620	Perak	1950	3.67	1	3.67	SBB			•		69,077	116,049	
168	05803340	Perak	1950	4.97	1	4.97	SBB			•		63,140	109,435	Included in detailed survey
169	05901000	Perak	1950	4.88	1	4.88	SBC			•		30,941	51,981	
170	05901070	Perak	1950	4.71	1	4.71	SBC				•	41,341	69,453	
171	05901480	Perak	1950	1.95	2	3.90	SBC				•	86,229	144,865	
172	05901580	Perak	1950	7.63	1	7.63	SBC				•	25,889	43,494	
173	05901690	Perak	1930	9.53	1	9.53	SBC			•		73,646	123,725	
174	05902030	Perak	1950	3.56	1	3.56	SBC				•	23,220	39,010	
175	05902230	Perak	1950	8.21	1	8.21	SBC				•	32,430	54,482	
176	05902690	Perak	1950	6.80	1	6.80	SBC				•	25,289	42,486	
177	05902920	Perak	1950	8.77	1	8.77	SBC				•	66,158	111,145	
178	05903120	Perak	1950	10.88	3	23.18	SBC			•		251,883	423,163	Included in detailed survey
179	05905010	Pahang	1961	30.74	4	122.36	PCB				•	171,852	288,711	
180	05905290	Pahang	1930	6.05	1	6.05	SBB			•		55,030	92,450	
181	05906010	Pahang	1930	6.35	1	6.35	SBB			•		52,457	88,128	
182	06000970	Perak	1930	3.14	1	3.14	SBE	•				132,117	221,957	Total replacement
183	06001330	Perak	1960	5.02	1	5.02	RCB			•		26,402	44,355	
184	06005070	Perak	1950	7.20	4	27.14	SBC				•	29,956	50,343	
185	06005220	Perak	1960	7.01	1	7.01	RCB				•	10,564	17,748	
186	06005740	Perak	1960	5.80	3	21.95	RCB				•	22,559	37,899	
187	06006050	Perak	1950	5.08	1	5.08	SBB			•		73,953	124,241	
188	06403300	Pahang	1930	12.31	1	12.31	SBB			•		73,643	123,720	
189	06403900	Pahang	1930	11.91	1	11.91	SBB			•		67,027	112,603	
190	06404270	Pahang	1930	10.91	1	10.91	SBB			•		63,637	106,910	
191	06404940	Pahang	1930	6.21	1	6.21	SBB			•		103,266	173,487	
192	06405650	Pahang	1930	6.31	1	6.31	SBB			•		48,001	80,642	
193	06406260	Pahang	1930	4.80	1	4.80	SBB		•	•		108,272	181,897	
194	06701200	Kedah	1930	6.05	1	6.05	RCB				•	2,284	3,837	
195	06701230	Kedah	1940	6.13	2	12.26	RCB				•	34,137	57,350	
196	06701690	Kedah	1968	30.64	3	91.52	PCB				•	167,911	282,090	
197	06702060	Kedah	1950	7.16	1	7.16	SBE				•	45,049	75,682	
198	07000230	Perak	1950	5.88	1	5.88	SBB			•		92,381	155,200	
199	07001790	Perak	1970	14.80	3	44.36	IT				•	125,255	210,428	
200	07002480	Perak	1950	3.88	1	3.88	SBB			•		77,369	129,980	
201	07602330	Perak	1950	6.35	1	6.35	SBB			•		46,947	78,871	
202	07602480	Perak	1930	5.34	1	5.34	SBB			•		67,671	113,687	
203	07604020	Perak	1950	6.35	1	6.35	SBB		•	•		124,277	208,785	
204	07604160	Perak	1950	3.23	1	3.23	SBB		•	•		59,556	100,054	
205	07604750	Perak	1950	9.34	1	9.34	SBB			•		66,561	111,822	
206	07606390	Perak	1950	3.07	1	3.07	SBB			•		37,591	63,153	
207	08601000	N.Sembilan	1950	9.62	1	9.62	SBB			•		87,464	146,940	
208	08601190	N.Sembilan	1950	4.64	1	4.64	SBB			•		47,465	79,741	
209	08601410	N.Sembilan	1950	3.68	1	3.68	SBB					0	0	Bridge has been replaced
210	08601830	N.Sembilan	1950	3.75	1	3.75	SBB			•		44,293	74,412	
211	08602160	N.Sembilan	1950	3.70	1	3.70	SBB			•		39,783	66,835	
212	08602600	N.Sembilan	1950	3.00	1	3.00	SBB			•		158,868	266,898	Replacement of superstructure
213	08602840	N.Sembilan	1960	3.08	1	3.08	RCB					0	0	Bridge has been replaced
214	08603735	N.Sembilan	1950	4.86	2	9.72	SBB	•		•		295,995	497,272	Total replacement
215	08603990	N.Sembilan	1930	9.62	1	9.62	SBB			•		61,442	103,223	
216	08604640	N.Sembilan	1950	9.51	1	9.51	SBB		•	•		132,966	223,383	
										Total Amount		34,612,065	58,148,268	

CHAPTER 15

ECONOMIC EVALUATION



CHAPTER 15

ECONOMIC EVALUATION

15.1 General

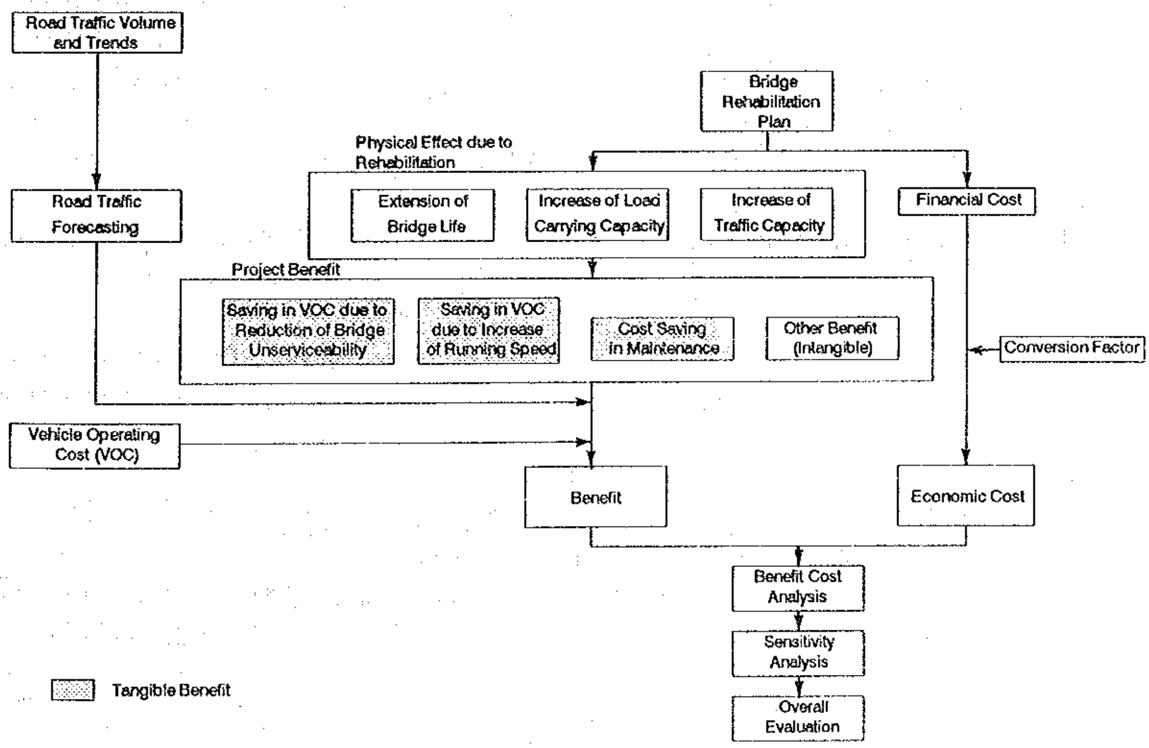
This chapter aims to evaluate the economic viability and to determine the priority of each of the 203 bridges out of 216 study bridges because 11 bridges have been replaced by the Government after this study started and two bridges have no rehabilitation work requirement.

The study methodology was determined based on the following principles:

- The method of evaluation shall be simplified due to the large number of bridges to be evaluated and to the relatively small cost of individual bridge rehabilitation work.
- Future traffic volume shall be estimated by utilizing existing traffic data to the maximum extent.
- The result of economic evaluation shall be easily reviewed by JKR corresponding to the possible changes in the future traffic situation.

In accordance with the above principles for the evaluation, the following procedure was taken as shown in Figure 15-1.

Figure 15-1 Flowchart of Economic Evaluation



1) Select a traffic count station corresponding to each bridge from the traffic census data.
2) Estimate the future traffic volume of each bridge using traffic growth rate included in the above.
3) List possible benefits derived from the proposed bridge rehabilitation work.
4) Formulate an evaluation model to quantify benefits included in the above.
5) Calculate economic benefits using future traffic volume and vehicle operating cost.
6) Convert financial cost into economic cost.
7) Work out economic evaluation by benefit cost analysis.
8) Conduct sensitivity analysis to test evaluation stability.
9) Judge project feasibility considering indirect aspects.

15.2 Traffic Projection

In general, the following three methods can be considered applicable in traffic projection:

- Four-step Model

- Model using Economic Indicators as Parameters

- Trends Model

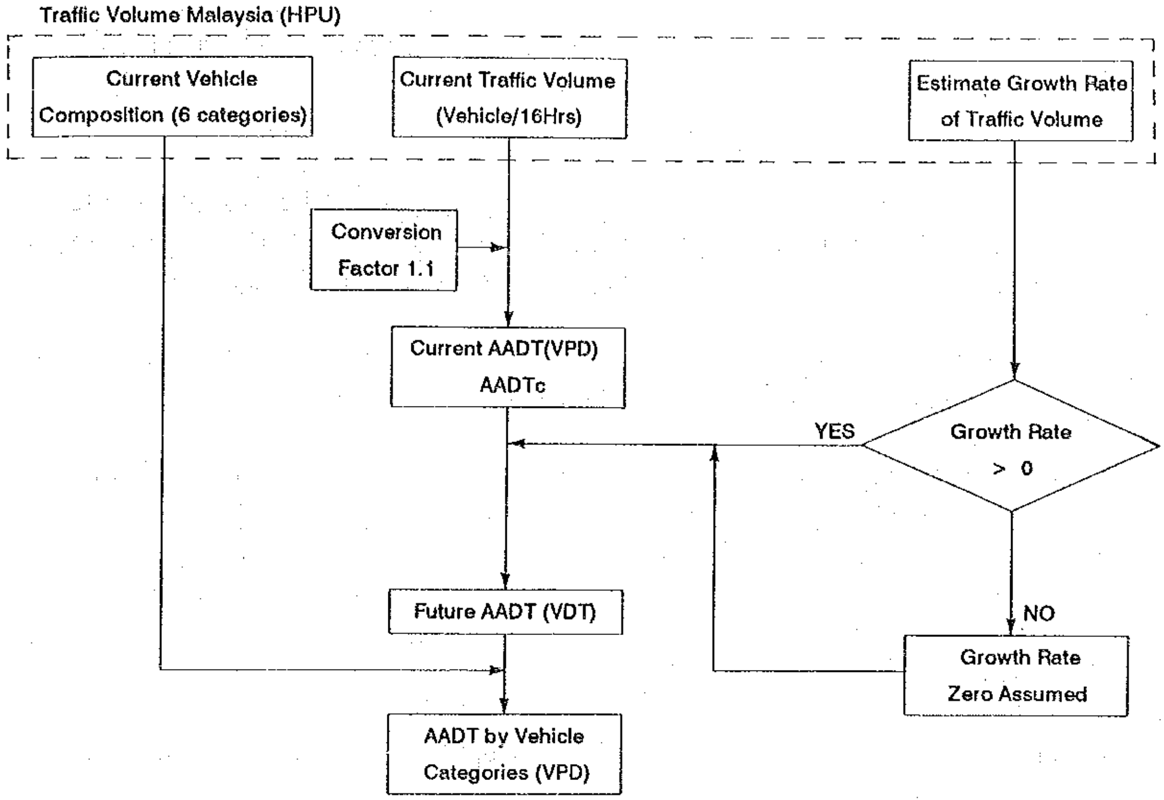
Considering that the study bridges are scattered widely over the country, traffic volume would have to be forecasted in a national scale. The four-step model or the model using economic indicators as parameters, however, would require a considerable amount of computation work and would produce relatively inaccurate results in terms of the traffic volume at bridge site. In Malaysia, traffic count data have been compiled for more than 450 stations in the Peninsular over past 10 years and, therefore, a simple and accurate forecast has become possible using the data as compared to the above stated models. The trends model based on the existing traffic data was adopted for traffic forecast in this study.

The procedure to forecast traffic using the trends model presented in Figure 15-2 is as follows:

1) Identify a traffic count station corresponding to each bridge.
2) Determine traffic volume (16 hours) by vehicle type and growth rate for each bridge.
3) Convert 16-hour traffic volume to daily value (VPD).
4) Set growth rate at zero if it is calculated negative.
5) Calculate future traffic volume using the growth rate.
6) Break down daily traffic volume into those by vehicle type using the present modal shares.

In this Study, "Traffic Volume Malaysia 1989" (HPU. Sept. 1989) was referred to for traffic count data. The data used to estimate future traffic volume for each bridge are shown in Appendix-S of Volume III.

Figure 15-2 Flow of Traffic Projection



15.3 Economic Costs

(1) Cost Components

The cost components to be considered in this study are:

o **Rehabilitation Cost**
Investment cost in order to improve bridge durability and to enhance bridge functions.

o **Maintenance Cost**
Continuously required cost in order to keep bridge serviceability after the rehabilitation.

(2) Conversion to Economic Costs

The economic cost of the project is normally calculated from the estimated financial cost by eliminating taxes and transfers and by applying, if necessary, the shadow prices in cost component. In order to standardize the process, authorized conversion factors from financial to economic prices are published by the Economic Planning Unit (EPU), the Prime Minister's Department. In this study, these factors were taken.

Using the conversion factor, economic cost is derived according to the following formula:

Economic Cost		Conversion Factor		Financial Cost
(EC)	=	(CF)	x	(FC)

Since the conversion factor that can be directly applied to the bridge rehabilitation works was not shown in "National Parameters for Project Appraisal" (EPU, 1986), the average of the following works was adopted as the conversion factor in the study:

Reinforced Concrete Piling	0.78
Excavation and Embankment Building	0.80
Road Surfacing	0.87
Concrete Work for Civil Eng. Structure	0.77
Structural Steel Work	0.78
Average	0.80

(3) **Economic Costs**

The rehabilitation cost estimated for all the bridges in 1991 prices is converted from financial to economic cost as follows:

Project Cost (Financial)	: M$58,148,267
Conversion Factor	: 0.80
Project Cost (Economic)	: M$46,518,614

The maintenance cost varies depending on natural and socio-economical conditions of the area where the bridge is located. In the absence, however, of the unit maintenance cost identified as standards in Malaysia, actual examples in the OECD countries were studied. According to the study results, annual maintenance cost ranges between 0.1 and 2.0 % of the initial construction cost of bridges. Hence, annual maintenance cost was assumed to be 1 % of the new bridge construction cost in this study. In addition, the standard construction cost of a new bridge in Malaysia is about M$2,500 per squaremeter of deck in 1991 market prices.

Maintenance cost after rehabilitation proposed in this study was assumed as follows:

i) **Reconstruction and widening :**
2.5 % of rehabilitation cost for 5 years (0.5%/year)

ii) **Reinforcement :**
5.0 % of rehabilitation cost for 5 years (1.0%/year)

iii) **Protection :**
10.0 % of rehabilitation cost for 5 years (2.0%/year)

These maintenance costs are also subject to conversion.

15.4 Benefit Measurement

15.4.1 Benefit due to Bridge Rehabilitation

Benefits accrued from bridge rehabilitation are :

User Benefit : Benefit of bridge users and adjacent inhabitants directly brought by bridge rehabilitation.

Social Benefit : Indirect social benefit including stabilization of society and improvement of living environment.

Supplier Benefit : Benefit of bridge supplier/administrator including maintenance cost savings.

For each of the benefits above, there are tangible and intangible portions, as described below.

(1) User Benefit

- **Tangible Benefit**

Benefit of bridge users occurs mainly from the savings in vehicle operating cost. More concretely, the following benefits can be quantified:

i) **Savings in vehicle operating cost due to a reduction in unservice durations of bridges.**

Improvement of bridge durability reduces number of days of bridge unservice (extends bridge life) and, therefore, saves vehicle operating cost required for detours.

ii) **Savings in vehicle operating cost due to an increase of vehicle speed**

Bridge widening makes it possible for vehicles to keep running speed on and near the bridge.

- **Intangible Benefit**

i) **Reduction of traffic accidents**

Bridge widening facilitates separation of vehicles and pedestrians. This reduces traffic accidents, though unquantifiable.

ii) **Improvement in Traffic Security**

Improved service level increases punctuality and safety of traffic reducing idle time, though quantification is difficult.

(2) Social Benefit and Supplier Benefit

- **Tangible Benefit**

i) **Maintenance Cost Savings**

The maintenance cost savings can be expected on the bridge administrator side. The benefit comes from the difference in maintenance cost between "with" and "without" project cases.

- **Intangible Benefits**

i) **Access to Public Facilities**

Public facilities such as high schools, hospitals, recreational and social facilities are relatively fewer in the rural areas than in urban. However, people who live on the opposite side of the bridges leading to these public facilities will lose their access to this facilities, if the bridge fails.

ii) **Improvement of Social Environment**

If a bridge is unusable, it is difficult for the military and police authorities to capture criminal elements. The rehabilitation of bridges may have an important contribution to mobility of these government authorities and assist in the improvement of social environment including peace and security.

iii) **Access to Market**

Those who live on the opposite side of the unserviceable bridges may lose the opportunity to sell their agricultural products and to buy daily necessities or production inputs.

iv) **Access to Development Program**

Many rural development programs may be conducted to encourage greater production and improved lived conditions. The unserviceability of bridges may reduce benefits from these programs.

15.4.2 Model for Bridge Life and Unservice

In order to quantify the benefit of reducing unservice duration of bridges, a probabilistic model was introduced.

(1) Bridge Life

Usually it is said that a newly constructed bridge has a 40 to 80-year life span. For example, a 50-year life span is expected in Japan. This life span is mainly fitted for calculating depreciation and taxation and does not reflect the real bridge life span until a bridge is physically unusable. If a bridge is well maintained and repaired, its physical life span could be longer than 50 years. A bridge will be unserviceable because of social factors such as width or loading capacity for increased traffic volume and other administrative reasons.

Therefore, in the study, the bridge life span was defined as the bridge age by which a half of the bridges population would have been statistically unserviceable.

(2) Probability Model for Bridges to be Unusable

In the absence of statistical data as to bridge life in Malaysia, a study in Japan was referred to in this study.

"Statistical Analysis on Bridge Life" (H. Iizuka, JSCE, 1988) dealt with 4,377 bridges in Niigata Prefecture in Japan and obtained a reliability function R(t) based on reliability theory.

Using R(t), the unreliability function F(t) can be expressed as $F(t) = 1-R(t)$. Therefore, the "Unserviceability Probability Density" f(t) is:

$$f(t) = dF(t)/dt = -dR(t)/dt$$

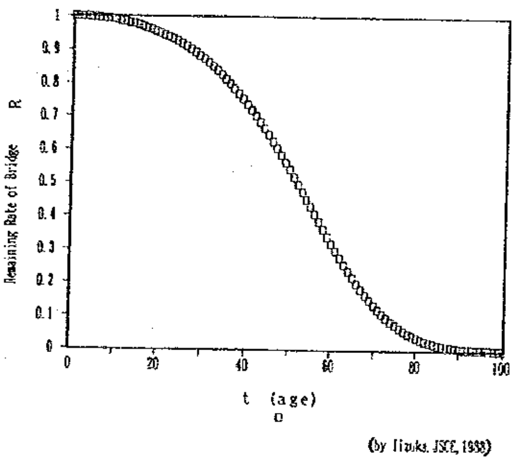
Using R(t) shown in Figure 15-3, f(t) can be calculated. As shown in Figure 15-4, "Unserviceability Probability Density" f(t) can be approximated by the "normal distribution" with an average of 50 years and a standard deviation of 16.7 years. Hence, bridge life applied in this study was determined at 50 years. The following equation shows unserviceability probability density for newly constructed bridges.

$$f(t) = \frac{1}{\sqrt{2\pi}\delta} \epsilon^{-(t-m)^2/2\delta^2} = N\,[m, \delta^2] = N[50,\ 16.7^2]$$

Hence, the cumulative probability that a newly constructed bridge becomes unserviceable by the year t is expressed as follows:

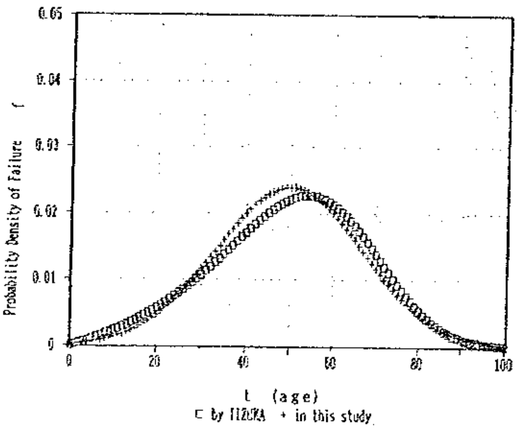
$$F(t) = \int_0^t f(t)dt$$

Figure 15-3 A Example of Reliability Function R(t) in Japan



t	R(t)	t	R(t)	t	R(t)	t	R(t)	t	R(t)
0	1.000								
1	1.000	21	0.946	41	0.720	61	0.297	81	0.032
2	1.000	22	0.940	42	0.703	62	0.276	82	0.027
3	0.999	23	0.933	43	0.684	63	0.256	83	0.023
4	0.999	24	0.926	44	0.665	64	0.236	84	0.019
5	0.998	25	0.918	45	0.646	65	0.217	85	0.016
6	0.997	26	0.910	46	0.626	66	0.199	86	0.013
7	0.995	27	0.902	47	0.605	67	0.182	87	0.011
8	0.994	28	0.893	48	0.584	68	0.165	88	0.009
9	0.992	29	0.883	49	0.563	69	0.150	89	0.007
10	0.990	30	0.873	50	0.541	70	0.135	90	0.006
11	0.987	31	0.862	51	0.519	71	0.121	91	0.005
12	0.985	32	0.851	52	0.497	72	0.108	92	0.004
13	0.982	33	0.839	53	0.474	73	0.096	93	0.003
14	0.978	34	0.826	54	0.452	74	0.085	94	0.002
15	0.975	35	0.813	55	0.429	75	0.075	95	0.002
16	0.971	36	0.799	56	0.406	76	0.066	96	0.001
17	0.967	37	0.785	57	0.384	77	0.058	97	0.001
18	0.962	38	0.770	58	0.362	78	0.050	98	0.001
19	0.957	39	0.754	59	0.340	79	0.043	99	0.001
20	0.952	40	0.737	60	0.318	80	0.037	100	0.001

Figure 15-4 Probability Density of Bridge Unserviceability



t	f(t)		t	f(t)		t	f(t)		t	f(t)		t	f(t)	
	Iizuka	Study		Iizuka	Study		Iizuka	Study		Iizuka	Study		Iizuka	Study
0	0.000	0.000												
1	0.000	0.000	21	0.006	0.005	41	0.018	0.021	61	0.021	0.019	81	0.005	0.004
2	0.000	0.000	22	0.007	0.006	42	0.018	0.021	62	0.020	0.018	82	0.004	0.004
3	0.001	0.000	23	0.007	0.006	43	0.019	0.022	63	0.020	0.018	83	0.004	0.003
4	0.001	0.001	24	0.008	0.007	44	0.019	0.022	64	0.019	0.017	84	0.003	0.003
5	0.001	0.001	25	0.008	0.008	45	0.020	0.023	65	0.018	0.016	85	0.003	0.003
6	0.001	0.001	26	0.009	0.009	46	0.021	0.023	66	0.017	0.015	86	0.002	0.002
7	0.002	0.001	27	0.009	0.009	47	0.021	0.024	67	0.016	0.014	87	0.002	0.002
8	0.002	0.001	28	0.010	0.010	48	0.021	0.024	68	0.016	0.013	88	0.002	0.002
9	0.002	0.001	29	0.010	0.011	49	0.022	0.024	69	0.015	0.013	89	0.001	0.002
10	0.002	0.001	30	0.011	0.012	50	0.022	0.024	70	0.014	0.012	90	0.001	0.001
11	0.003	0.002	31	0.011	0.013	51	0.022	0.024	71	0.013	0.011	91	0.001	0.001
12	0.003	0.002	32	0.012	0.013	52	0.023	0.024	72	0.012	0.010	92	0.001	0.001
13	0.003	0.002	33	0.013	0.014	53	0.023	0.024	73	0.011	0.009	93	0.001	0.001
14	0.004	0.002	34	0.013	0.015	54	0.023	0.023	74	0.010	0.009	94	0.001	0.001
15	0.004	0.003	35	0.014	0.016	55	0.023	0.023	75	0.009	0.008	95	0.000	0.001
16	0.004	0.003	36	0.014	0.017	56	0.022	0.022	76	0.008	0.007	96	0.000	0.001
17	0.005	0.003	37	0.015	0.018	57	0.022	0.022	77	0.008	0.006	97	0.000	0.000
18	0.005	0.004	38	0.016	0.018	58	0.022	0.021	78	0.007	0.006	98	0.000	0.000
19	0.005	0.004	39	0.016	0.019	59	0.022	0.021	79	0.006	0.005	99	0.000	0.000
20	0.006	0.005	40	0.017	0.020	60	0.021	0.020	80	0.005	0.005	100	0.000	0.000

(3) Probability Model for Bridges to be Unusable after Rehabilitation

In order to quantify the benefit of rehabilitation works, a function for bridge unserviceability probability density after rehabilitation should be assumed.

- **Protection**

Protection work is defined to be the work to maintain the design load-carrying capacity of the bridge and to ensure the safety of road users. This effect was assumed based on an engineering study and it found that the probability for a bridge to be unusable will be kept constant over 5 years at the same service level as that at the time protection work completed. In formula :

General formula of probability

$$fo(t) = N\,[50,\ 16.7^2]$$

For a bridge of age n, this can be modified to the following since the bridge is existing without falling down in spite of the probability of falling down in the past:

$$f1(t) = k1 \cdot fo(t) \qquad (t>n)$$

$$\text{where:}\quad k1 = 1/(1.0-Fo(t<n))$$

$$Fo(t<n) = \int_0^n fo(t)\,dt$$

The effect of protection was assumed to extend the bridge durability over 5 years.

Probability after protection

$$f2(t) = k2 \cdot f1(n) \qquad (n<t<n+5)$$
$$f2(t) = k2 \cdot f1(t-5) \qquad (t>n+5)$$

$$\text{where:}\quad k2 = 1/(5 \cdot f1(n) + F1(t>n))$$

$$F1(t>n) = \int_n^{\infty} f1(t)\,dt$$

- **Reinforcement**

Reinforcement work is defined to be the work that enables a bridge to carry heavier loads by strengthening the structure. The effect of bridge reinforcement is to increase bridge durability and to extend bridge life. In this study, the following assumption was adopted:

- The probability for a bridge to be unusable will be kept constant over 5 years at the same level as that at the time work completed. This is the same assumption as "protection work".

- Bridge loading capacity will be improved by 20 %. Hence the probability for a bridge to be unusable will be reduced as much as 80 %.

In formula:

Probability of bridge durability rehabilitated

$$f3(t) = N[m, \delta^2] = N[50, 20.9^2]$$

Cumulative probability

$$F3(t) = \int_0^t f3(t)dt$$

Assuming new age n3 from the following:

$$F3(n3) = Fo(n)$$

Therefore, the bridge gains an extended life of (n-n3) years by reinforcement.

Probability after reinforcement:

$$f4(t) = k4 \cdot f3(n3) \quad (n<f<n+5)$$
$$f4(t) = k4 \cdot f3(t-5-(n-n3)) \quad (t>n+5)$$

Where, $k4 = 1/(5 \cdot f3(n3)+F3(t>n3))$

- **Reconstruction**

The age of a bridge becomes zero upon reconstruction.

In formula:

Probability after reconstruction

$$f5(t) = fo(t-n) = N[50+n, 16.7^2]$$

Figure 15-5 presents schematically the effects of rehabilitation works in terms of probability for bridges to be unusable for ages 20, 30, 40 and 45 years.

Figure 15-5 Probability Density of Bridge Unserviceability after Rehabilitation

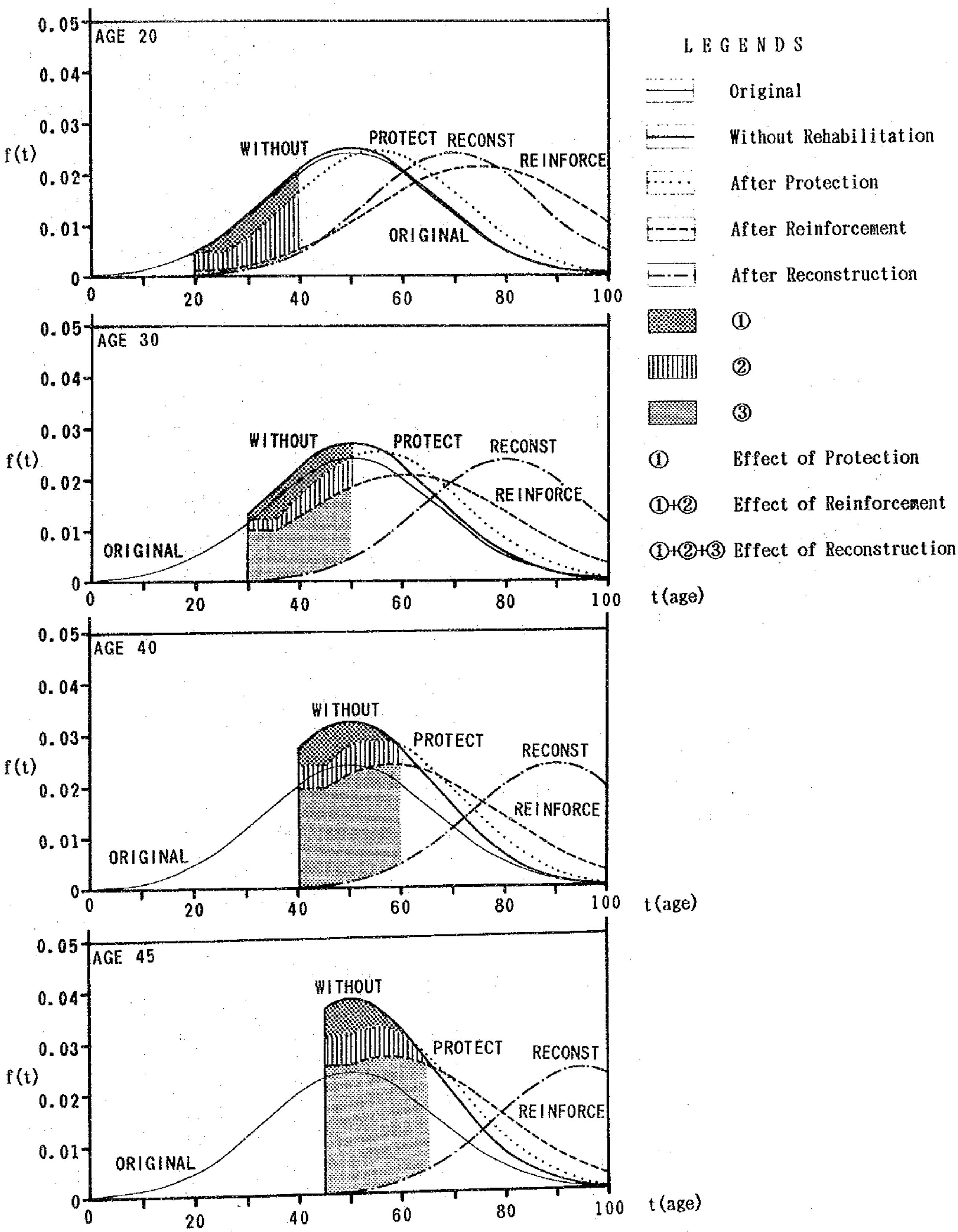


Table 15-1 Probability Density of Bridge Unserviceability after Rehabilitation

EQUIVALENT AGE : 20

	Original	Without	Protect	Reinforce	Reconst
20	0.476%	0.493%	0.482%	0.122%	0.027%
21	0.529%	0.548%	0.482%	0.122%	0.032%
22	0.586%	0.607%	0.482%	0.122%	0.038%
23	0.647%	0.670%	0.482%	0.122%	0.046%
24	0.711%	0.737%	0.482%	0.122%	0.054%
25	0.779%	0.807%	0.482%	0.122%	0.063%
26	0.851%	0.882%	0.536%	0.137%	0.074%
27	0.925%	0.959%	0.594%	0.153%	0.087%
28	1.003%	1.040%	0.655%	0.171%	0.101%
29	1.083%	1.123%	0.721%	0.190%	0.117%
30	1.166%	1.209%	0.790%	0.211%	0.136%
31	1.251%	1.296%	0.862%	0.234%	0.156%
32	1.336%	1.385%	0.938%	0.258%	0.179%
33	1.423%	1.475%	1.017%	0.285%	0.205%
34	1.510%	1.565%	1.098%	0.313%	0.234%
35	1.596%	1.654%	1.182%	0.344%	0.266%
36	1.681%	1.742%	1.267%	0.376%	0.301%
37	1.764%	1.829%	1.354%	0.411%	0.339%
38	1.845%	1.913%	1.442%	0.448%	0.381%
39	1.923%	1.993%	1.530%	0.487%	0.427%
40	1.997%	2.069%	1.617%	0.529%	0.476%
41	2.066%	2.141%	1.704%	0.572%	0.529%

EQUIVALENT AGE : 30

	Original	Without	Protect	Reinforce	Reconst
30	1.166%	1.312%	1.234%	1.001%	0.027%
31	1.251%	1.407%	1.234%	1.001%	0.032%
32	1.336%	1.503%	1.234%	1.001%	0.038%
33	1.423%	1.601%	1.234%	1.001%	0.046%
34	1.510%	1.698%	1.234%	1.001%	0.054%
35	1.596%	1.795%	1.234%	1.001%	0.063%
36	1.681%	1.891%	1.323%	1.060%	0.074%
37	1.764%	1.985%	1.414%	1.119%	0.087%
38	1.845%	2.076%	1.505%	1.180%	0.101%
39	1.923%	2.163%	1.597%	1.241%	0.117%
40	1.997%	2.246%	1.688%	1.302%	0.136%
41	2.066%	2.324%	1.778%	1.362%	0.156%
42	2.130%	2.396%	1.867%	1.423%	0.179%
43	2.188%	2.461%	1.952%	1.482%	0.205%
44	2.240%	2.519%	2.034%	1.541%	0.234%
45	2.284%	2.569%	2.112%	1.598%	0.266%
46	2.321%	2.611%	2.185%	1.654%	0.301%
47	2.351%	2.644%	2.253%	1.707%	0.339%
48	2.372%	2.668%	2.315%	1.759%	0.381%
49	2.385%	2.682%	2.369%	1.807%	0.427%
50	2.389%	2.687%	2.416%	1.853%	0.476%
51	2.385%	2.682%	2.456%	1.896%	0.529%

EQUIVALENT AGE : 40

	Original	Without	Protect	Reinforce	Reconst
40	1.997%	2.720%	2.400%	1.953%	0.027%
41	2.066%	2.815%	2.400%	1.953%	0.032%
42	2.130%	2.902%	2.400%	1.953%	0.038%
43	2.188%	2.981%	2.400%	1.953%	0.046%
44	2.240%	3.051%	2.400%	1.953%	0.054%
45	2.284%	3.112%	2.400%	1.953%	0.063%
46	2.321%	3.162%	2.483%	2.010%	0.074%
47	2.351%	3.202%	2.560%	2.065%	0.087%
48	2.372%	3.231%	2.630%	2.117%	0.101%
49	2.385%	3.249%	2.692%	2.164%	0.117%
50	2.389%	3.254%	2.746%	2.208%	0.136%
51	2.385%	3.249%	2.790%	2.247%	0.156%
52	2.372%	3.231%	2.826%	2.282%	0.179%
53	2.351%	3.202%	2.851%	2.312%	0.205%
54	2.321%	3.162%	2.866%	2.337%	0.234%
55	2.284%	3.112%	2.872%	2.357%	0.266%
56	2.240%	3.051%	2.866%	2.372%	0.301%
57	2.188%	2.981%	2.851%	2.381%	0.339%
58	2.130%	2.902%	2.826%	2.385%	0.381%
59	2.066%	2.815%	2.790%	2.384%	0.427%
60	1.997%	2.720%	2.746%	2.377%	0.476%
61	1.923%	2.620%	2.692%	2.364%	0.529%

EQUIVALENT AGE : 45

	Original	Without	Protect	Reinforce	Reconst
45	2.284%	3.638%	3.086%	2.536%	0.027%
46	2.321%	3.697%	3.086%	2.536%	0.032%
47	2.351%	3.744%	3.086%	2.536%	0.038%
48	2.372%	3.778%	3.086%	2.536%	0.046%
49	2.385%	3.798%	3.086%	2.536%	0.054%
50	2.389%	3.805%	3.086%	2.536%	0.063%
51	2.385%	3.798%	3.137%	2.574%	0.074%
52	2.372%	3.778%	3.176%	2.607%	0.087%
53	2.351%	3.744%	3.205%	2.634%	0.101%
54	2.321%	3.697%	3.222%	2.655%	0.117%
55	2.284%	3.638%	3.228%	2.671%	0.136%
56	2.240%	3.567%	3.222%	2.680%	0.156%
57	2.188%	3.485%	3.205%	2.683%	0.179%
58	2.130%	3.393%	3.176%	2.680%	0.205%
59	2.066%	3.291%	3.137%	2.671%	0.234%
60	1.997%	3.180%	3.086%	2.656%	0.266%
61	1.923%	3.063%	3.026%	2.635%	0.301%
62	1.845%	2.939%	2.956%	2.608%	0.339%
63	1.764%	2.810%	2.878%	2.575%	0.381%
64	1.681%	2.678%	2.792%	2.537%	0.427%
65	1.596%	2.542%	2.698%	2.494%	0.476%
66	1.510%	2.405%	2.598%	2.446%	0.529%

15.4.3 Vehicle Operating Costs (VOC)

The vehicle operating cost plays an essential role in estimating road user savings. This consists of 1) running cost and 2) time cost. NALS developed the evaluation model for vehicle operating cost in Malaysia. In this study, the model (Econom V5.1) was adopted with the following minor modifications:

1) **Updated VOC**

Using the consumer price indices by sector, VOC was updated to the 1991 level.

2) **VOC of Heavy Lorries**

Although NALS calculated VOC separately for 3-axle lorry and 4-axle lorry, the traffic count data does not discriminate between these categories. Hence, in this study an average VOC was calculated for "heavy lorries" assuming a combination of 85 % 3-axle and 15 % 4-axle lorries.

3) **Vehicle Running Speed**

In detour routes which are required when a bridge is unusable, the slowest "flow group" in the model "Econom" was assumed while the fastest "flow group" was adapted on regular routes. In addition, the running speed on bridges before widening was assumed to be half of that on regular routes.

Table 15-2 Vehicle Running Speed assumed for Estimation of VOC

(km/hr)

Vehicle Type	Cars	Light	Medium (2 Ax)	Heavy 1 (3 Ax)	Heavy 2 (4 Ax)
Regular Route	74.38	66.04	55.70	40.91	42.97
Detour Route	54.68	49.89	43.68	35.20	36.34
Before Widening	37.19	33.02	27.85	20.45	21.49

Table 15-3 Vehicle Operating Costs by Vehicle Type

(M$/km)

Vehicle Type	Motor-cycles	Cars & Taxies	Buses	S.Vans & Utilities	Medium Lorries	Heavy Lorries
Regular Route	0.046	0.184	1.517	0.498	0.785	1.059
Detour Route	0.055	0.220	1.859	0.632	0.911	1.147
Before Widening	0.066	0.266	2.761	0.867	1.248	1.579

15.4.4 Benefit Measurement

(1) Equivalent Age of Bridge

Residual life of a bridge differs by structure, traffic volume, geography, present structural conditions and other factors even if physical age is the same. In order to assess residual life of a bridge, a concept of "equivalent age of bridge" was introduced in relation to unserviceability probability based on overall rating from a safety viewpoint, traffic volume and year built. It can be defined as a normalized age on the unserviceability probability density function with an average of 50 years. Hence:

$$\text{Residual Life of Bridge} = \text{Life of Newly Constructed Bridge (50 years)} - \text{Equivalent Age of Bridge}$$

Table 15-4 Assumed Equivalent Age of Bridge

Overall Rating From Safety viewpoint (R)	Traffic Volume (AADT : Vehicle /day)	Year Built	
		Before 1945	After 1945
4.0 <= R	all	45	40
3.5 <= R < 4.0	AADT >= 9,000	45	40
	AADT <= 9,000	40	30
R < 3.5	AADT >= 9,000	40	30
	AADT <= 9,000	30	20

(2) Unservice Duration of Bridges

In order to estimate the unservice duration of bridges, the number of months required for bridge construction was assumed as a function of bridge length as follows:

$$\log (M) = 0.572 \log (L) + 0.043$$

where, M : Standard number of months required for bridge construction
L : Bridge Length (m)

Using "M", number of days of bridge unservice is derived as follows:

$$d = f \times M \times (365/12)$$

where, f : probability for a bridge to be unusable
d : number of days for a bridge to be unusable

(3) Equation for Benefit Calculation

The equations developed for calculating benefits are based on two options, namely 1) bridge rehabilitation (with project) and 2) do nothing (without project).

- **Protection**

$$B1 = \sum_{x} \sum_{i} (fo(x)-fwp(x)) \cdot DBU \cdot AADTxi \cdot (DLo \cdot VOCio - DLw \cdot VOCiw)$$

where, B1 : Benefit from Protection ($)
fo(x) : Probability for a bridge to be unusable in year x without rehabilitation
fwp(x) : Probability for a bridge to be unusable in year x after protection
DBU : Number of days required for bridge construction (day)
AADTxi : Average Annual Daily Traffic of Vehicle type i in year x (vehicles/day)
DLo : Length of detour route (km)
DLw : Length of regular route (km)
VOCio : Vehicle Operating Cost of Vehicle type i in detour route ($/km)
VOCiw : Vehicle Operating Cost of Vehicle type i in regular route ($/km)

- **Reinforcement**

$$B2 = \sum_{x} \sum_{i} (fo(x)-fwr(x)) \cdot DBU \cdot AADTxi \cdot (DLo \cdot VOCio - DLw \cdot VOCiw)$$

where, B2 : Benefit from Reinforcement ($)
fwr(x) : Probability for a bridge to be unusable in year x after reinforcement

- **Reconstruction**

$$B3 = \sum_{x} \sum_{i} (fo(x)-fwc(x)) \cdot DBU \cdot AADTxi \cdot (DLo \cdot VOCio - DLw \cdot VOCiw)$$

where, B3 : Benefit from reconstruction ($)
fwc(x) : Probability for a bridge to be unusable in year x after reconstruction

- **Widening**

$$B4 = \sum_{x} \sum_{i} (AADTxi \cdot (BL+200)/1000 \cdot (VOCio - VOCiw))$$

where, B4 : Benefit from widening ($)
BL : Length of bridge (m)

- **Cost Saving in Maintenance**

$$B5 = \sum_{i} (BL \cdot BW \cdot UCC \cdot Pm)$$

where, B5 : Benefit from cost saving in maintenance ($)
BW : Width of bridge (m)
UCC : Unit cost of bridge construction ($/m^2)
Pm : Rate of annual maintenance cost against to initial construction cost (0.01)

Input data for benefit calculations are shown in Appendix-S1 for traffic volume and in Appendix-S2 for dimensions, rehabilitation methods and estimated costs of bridges. Appendix-S4 shows examples of benefit calculation for 4 bridges of different type in addition to the calculation examples of economic evaluation.

15.5 Economic Evaluation

15.5.1 Parameters of Economic Evaluation

Economic evaluation quantifies cost and benefit and assesses both in comparison. This is usually called "Benefit Cost Analysis". In this analysis, the following three parameters are generally used for decision making and for determining priority:

i) **Benefit Cost Ratio (BCR)**

This ratio is calculated by dividing benefit by cost in terms of net present value:

$$BCR = \left(\sum_{t} Bt/(1+i)^{t} \right) / \left(\sum_{t} Ct/(1+i)^{t} \right)$$

where, Bt : Benefit in year t
Ct : Cost in year t
i : Discount rate

This quantifies the magnitude of net present benefit per net present cost.

ii) **Net Present Value (NPV)**

Unlike benefit cost ratio, this quantifies the magnitude of net present benefit less net present cost.

$$NPV = \left(\sum_t Bt/(1+i)^t \right) - \left(\sum_t Ct(1+i)^t \right)$$

iii) **Internal Rate of Return (IRR)**

This rate is defined to be a discount rate or an interest rate where net present value of the project becomes zero. In other words, this is the highest interest rate that makes the project economically feasible.

$$\text{When} \quad \sum_t (Bt-Ct)/(1+i)^t = 0$$

This "i" is called "Internal Rate of Return".

15.5.2 Discount Rate and Project Life

Discount rate is a parameter to calculate net present value of benefit and cost and is also a criterion to judge project feasibility by comparing it with the internal rate of return of the project. It is, in general, a ratio between present value of goods and future value of the same goods after one year; value of a goods obtained in the future should be less than the value of the same goods readily available at present.

In 1984, the Economic Planning Unit proposed a discount rate of 13 % per annum. Due, however, to the recently achieved economic development, a discount rate of 11 % per annum was taken in this study.

The project life over which economic evaluation is carried out was determined at 20 years starting from 1994, due to the following reasons:

i) Life of bridge materials replaceable or repairable including deck slab that directly receives vehicle load is considered to be about 20 years.

ii) In the calculation using discount rate, the values becomes negligible in comparison with the possible errors included in the accumulated cost after 20 years.

iii) Accuracy of the traffic forecast is considered to be no more than 20 years.

15.5.3 Economic Evaluation Results

Calculation examples are shown in Appendix-S4. The results of the benefit cost analysis for the 203 brides to be rehabilitated are as follows:

(1) Entire Project

The flow of cost and benefit of the project as a whole is shown in Table 15-5.

Table 15-5 Flow of Total Cost and Benefit

(Unit: 1,000M$)

	Cost Flow			Benefit								
	Project Cost	Maintena Cost	Cost Flow	Protection, Reinforcement & Reconstruction: cars	small van	med. lorr	hvy. lorr	buses	M'cycle	Widening	Meintena (without	Benefit Flow
1994	46,519	0	46,519	0	0	0	0	0	0	0	564	564
1995	0	0	0	3,760	3,434	2,837	2,082	2,022	738	8	508	15,388
1996	0	0	0	4,583	4,144	3,400	2,552	2,452	899	7	458	18,495
1997	0	0	0	5,300	4,766	3,885	2,961	2,824	1,040	7	412	21,196
1998	0	0	0	5,909	5,299	4,293	3,311	3,137	1,161	6	371	23,488
1999	0	1,469	1,469	6,411	5,741	4,624	3,602	3,394	1,262	6	335	25,373
2000	0	0	0	6,171	5,553	4,440	3,470	3,258	1,216	5	301	24,414
2001	0	0	0	5,902	5,337	4,238	3,323	3,108	1,164	5	272	23,348
2002	0	0	0	5,608	5,097	4,021	3,163	2,947	1,107	5	245	22,193
2003	0	0	0	5,294	4,838	3,793	2,993	2,776	1,045	4	220	20,965
2004	0	872	872	4,966	4,563	3,556	2,815	2,599	980	4	199	19,682
2005	0	0	0	4,627	4,277	3,313	2,632	2,418	913	4	179	18,362
2006	0	0	0	4,282	3,983	3,067	2,445	2,234	844	3	161	17,020
2007	0	0	0	3,935	3,685	2,821	2,258	2,051	774	3	145	15,673
2008	0	0	0	3,591	3,387	2,578	2,071	1,869	705	3	131	14,334
2009	0	517	517	3,252	3,091	2,340	1,886	1,691	637	3	118	13,018
2010	0	0	0	2,922	2,801	2,108	1,706	1,518	571	2	106	11,735
2011	0	0	0	2,604	2,519	1,885	1,532	1,352	507	2	96	10,497
2012	0	0	0	2,300	2,248	1,672	1,365	1,194	446	2	86	9,312
2013	0	0	0	2,012	1,988	1,470	1,205	1,044	389	2	78	8,188
	46,519 94.2%	2,859 5.8%	49,377 100.0%	83,428 25.0%	76,753 23.0%	60,341 18.1%	47,371 14.2%	43,887 13.2%	16,401 4.9%	80 0.0%	4,984 1.5%	333,245 100.0%

NPV = 333,245 - 49,377 = 283,868 (x M$1000)
BCR = 333,245 / 49,377 = 6.75
IRR = 57.84 %

As a whole, most of the benefit is derived from the reduction of the duration of bridge unservice. The benefit is large enough as compared to the cost with a benefit cost ratio of 6.75 and an internal rate of return of 58 %. Hence, the project is considered to be feasible as a whole.

(2) Individual Bridge

The result of economic evaluations for individual bridges is shown in Table 15-6. Appendix-S3 also shows the same result according to the value order of internal rate of return.

The internal rate of return exceeds 11 % for 197 bridges out of 203. For the remaining 6 bridges, it was also observed that the benefit grew by retarding rehabilitation for 5 years and that the internal rate of return was improved; 3 bridges became feasible with an internal rate of return of more than 11 % and other 3 bridges gained an internal rate of return of at least 6 %.

The project is considered to be carried out for all the bridges including the above 6 for the following reasons:

Table 15-6 Result of Economic Evaluation for Individual Bridges (1)

No.	Key	State	District	Year Built	Bridge Length (m)	CARRIAGE WAY (m)	S.F.	Detour Da (Km)	Db (Km)	RouEqui Age	Rehabilitati RC	WD	RE	PR	Economic Cost (M$)	GROWTH RATE (%)	16-Hrs TRAFFIC	NPV	BCR	IRR (1994)	IRR (1999)
1	102590	Johor	J. BAHRU	1955	3.60	15.90	3.3	65	8	30				*	5,146	3.2	22,565	2,323,413	405.8	2571.05%	
2	108100	Johor	KLUANG	1954	27.40	6.91	3.0	52	20	30				*	103,628	4.4	10,693	2,369,553	21.5	147.07%	
3	108990	Johor	KLUANG	1937	2.18	7.40	2.1	52	20	40				*	5,083	4.4	10,693	624,688	111.2	1221.65%	
4	112630	Johor	BATU PAH	1960	6.27	6.11	1.9	105	44	30				*	36,102	7.1	7,758	1,726,129	43.9	243.16%	
5	113760	Johor	SEGAMAT	1955	20.34	6.00	1.9	105	44	30		*		*	191,212	7.1	7,758	3,280,818	17.7	111.71%	
6	114920	Johor	SEGAMAT	1955	12.86	6.28	2.1	105	44	30				*	151,761	2.2	7,758	1,594,090	10.4	86.55%	
7	116580	Johor	SEGAMAT	1947	4.88	7.56	2.3	41	28	30				*	42,140	2.2	7,758	210,841	5.5	53.94%	
8	121260	Johor	SEGAMAT	1955	2.42	6.80		85	28	0					0	0.1	5,667	0	0.0	0.00%	
9	121280	Johor	SEGAMAT	1950	2.83	6.90		83	44	0					0	0.1	5,667	0	0.0	0.00%	
10	125250	N.Sembi	TAMPIN	1940	6.70	6.54	2.6	39	14	30				*	5,277	2.2	5,056	247,121	43.0	315.66%	
11	128254	N.Sembi	REMBAU	1930	9.58	7.45	2.5	8	7	40				*	36,928	2.2	8,477	30,506	1.7	24.49%	
12	145100	Selango	ULU S'GO	1935	1.85	6.20	1.9	82	49	40				*	2,172	2.9	9,537	489,366	203.0	2408.45%	
13	146800	Selango	ULU S'GO	1965	25.91	7.35	2.6	82	49	30				*	78,332	2.8	9,537	1,937,474	23.2	163.86%	
14	148800	Perak	BTG PADA	1962	2.40	7.50	2.3	28	11	30				*	2,900	2.6	8,617	224,401	70.4	453.32%	
15	149820	Perak	BTG PADA	1963	36.24	8.10	2.6	140	60	30				*	65,398	2.6	10,648	5,992,383	83.1	505.77%	
16	151360	Perak	BTG PADA	1960	63.56	6.76	1.4	140	60	30				*	121,418	2.6	10,648	8,233,074	61.8	380.98%	
17	155590	Perak	KINTA	1970	3.62	7.52	1.9	47	12	30			*		400,876	0.8	10,524	495,746	2.2	24.46%	
18	159100	Perak	KINTA	1948	31.30	10.70	3.7	14	14	0					0	2.9	17,791	0	0.0	0.00%	
19	161140	Perak	KINTA	1950	19.11	7.33	3.5	25	14	40		*	*		541,051	-0.3	8,937	347,668	1.6	20.89%	
20	161290	Perak	KINTA	1955	16.18	9.35	2.7	23	12	30		*	*		344,368	-0.3	8,937	278,878	1.8	20.66%	
21	166220	Perak	LRT MATA	1945	5.67	8.79	4.0	88	27	45			*		117,053	1.6	2,946	544,065	5.4	80.41%	
22	166510	Perak	LRT MATA	1935	10.72	7.87	3.6	88	27	40	*	*			674,739	1.6	2,946	2,078,562	4.0	48.74%	
23	184400	Kedah	KOTA SET	1950	12.20	13.86	3.7	39	19	30			*		151,993	0.1	5,057	195,545	2.2	25.77%	
24	184900	Kedah	KOTA SET	1950	5.20	8.40	4.0	39	19	40			*		81,450	0.1	5,057	180,026	3.1	41.74%	
25	184980	Kedah	KOTA SET	1950	4.64	7.00	1.6	39	19	20				*	30,809	0.1	5,057	46,774	2.4	25.36%	
26	186210	Kedah	KOTA SET	1940	3.23	7.15	2.6	15	4	30			*		51,806	3.9	5,057	67,177	2.2	24.29%	
27	228540	Pahang	MARAN	1955	6.26	7.94	2.9	26	3	20			*		79,658	1.2	6,080	479,280	6.7	57.12%	
28	228970	Pahang	MARAN	1965	3.03	7.30	3.0	203	95	20				*	110,550	1.2	6,080	600,114	5.9	46.62%	
29	230850	Pahang	KUANTAN	1967	6.40	6.78	2.8	65	28	20				*	56,077	1.2	6,080	317,185	6.1	48.37%	
30	231790	Pahang	KUANTAN	1960	7.75	10.50	1.0	65	28	0					0	1.2	6,080	0	0.0	0.00%	
31	232880	Pahang	KUANTAN	1963	11.08	6.62	3.5	28	19	30				*	206,546	4.9	6,080	79,950	1.3	15.76%	
32	237200	Pahang	KUANTAN	1960	26.70	7.32	3.4	20	13	30				*	300,579	7.4	12,593	277,805	1.8	21.21%	
33	303220	Johor	K. TINGG	1940	4.84	6.53	2.8	50	14	40				*	67,139	5.1	9,022	806,214	11.8	138.19%	
34	303430	Johor	K. TINGG	1940	4.90	7.72	3.6	50	14	45				*	62,866	5.1	9,022	797,686	12.4	197.01%	
35	303890	Johor	K. TINGG	1940	9.16	6.37	2.1	30	6	30		*		*	136,307	5.1	3,768	178,489	2.3	24.86%	
35	304060	Johor	K. TINGG	1963	92.25	6.99	1.6	15	6	20				*	197,339	5.1	3,768	223,708	2.0	22.63%	
37	304390	Johor	K. TINGG	1928	3.35	8.93	2.8	85	14	30			*		122,265	4.0	3,768	682,210	6.3	55.06%	
38	306390	Johor	K. TINGG	1974	64.57	7.57	1.8	170	70	20				*	249,994	1.1	2,878	1,286,318	5.6	47.35%	
39	306710	Johor	K. TINGG	1969	51.96	7.33	1.4	170	70	20				*	273,666	1.1	2,878	1,068,011	4.5	40.15%	
40	313150	Johor	MERSING	1950	4.40	8.67	1.7	367	153	20		*		*	150,074	0.8	5,746	708,530	5.6	43.62%	
41	313520	Johor	MERSING	1960	3.60	7.56	3.3	367	153	30		*		*	154,034	7.6	5,746	1,848,959	12.7	86.18%	
42	314180	Johor	MERSING	1964	11.00	7.36	1.5	367	153	30				*	310,506	7.6	5,746	3,456,809	11.0	82.28%	
43	316745	Johor	MERSING	1965	5.67	5.35	4.0	367	153	40			*		116,302	7.6	5,746	5,443,578	45.3	437.04%	
44	317000	Pahang	ROMPIN	1974	397.32	7.30	2.4	308	98	20			*		2,759,290	7.6	2,064	27,306,680	10.4	71.49%	
45	319110	Pahang	ROMPIN	1962	121.96	6.74	3.0	308	98	20				*	394,231	6.4	2,064	4,953,286	12.3	72.79%	
46	319690	Pahang	ROMPIN	1960	11.34	6.85	3.1	308	98	20				*	112,914	6.4	2,064	1,236,411	10.8	64.98%	
47	323070	Pahang	PEKAN	1965	31.26	7.30	2.3	140	70	20				*	145,595	1.8	1,751	306,747	2.9	29.17%	
48	326020	Pahang	PEKAN	1965	5.73	6.16	3.5	140	70	30				*	78,183	1.8	1,751	148,258	2.7	30.84%	
49	326950	Pahang	PEKAN	1965	23.52	6.15	3.4	140	70	20				*	220,506	1.8	1,751	144,019	1.6	17.69%	
50	336310	Pahang	KUANTAN	1958	36.00	6.68	2.4	28	11	20		*		*	350,458	1.8	2,626	-169,832	0.5	3.65%	5.75%
51	337240	Pahang	KUANTAN	1957	6.58	6.70	2.7	72	36	20				*	68,088	1.8	2,626	55,612	1.7	19.11%	
52	338580	Terengg	KEMAMAN	1965	219.13	6.72	3.5	74	47	30	*				9,426,816	9.8	4,206	8,082,214	1.8	20.04%	
53	339210	Terengg	KEMAMAN	1963	152.20	6.73	3.4	27	5	20			*		898,456	9.8	4,206	3,539,354	4.7	38.98%	
54	341800	Terengg	KEMAMAN	1955	36.14	6.76	3.5	75	23	30		*		*	1,068,730	1.5	4,206	173,026	1.2	13.18%	
55	346740	Terengg	DUNGUN	1973	152.26	6.72	2.1	54	2	30			*		4,454,573	8.2	6,656	10,359,800	3.2	31.36%	
56	354190	Terengg	K.T.	1960	11.18	7.68		29	8	0					0	19.8	8,191	0	0.0	0.00%	
57	354830	Terengg	K.T.	1963	17.85	7.33	2.8	29	8	30				*	76,811	19.8	8,191	1,448,856	17.9	112.01%	
58	356790	Terengg	K.T.	1959	53.10	6.70	2.3	27	4	20				*	62,617	4.3	4,193	507,608	8.3	63.84%	
59	357200	Terengg	K.T.	1959	5.94	6.70	3.3	56	24	20				*	68,202	4.3	4,465	210,153	3.8	33.36%	
60	357270	Terengg	K.T.	1957	11.78	6.71	2.2	56	24	20				*	62,326	4.3	4,465	357,495	6.1	46.92%	
61	361490	Terengg	BESUT	1960	18.03	6.67	2.0	59	55	20				*	129,200	11.9	4,465	194,395	2.3	23.44%	
62	363630	Terengg	BESUT	1965	5.84	7.29	2.8	50	9	20				*	51,181	11.9	4,465	506,224	9.9	59.10%	
63	366660	Kelanta	P.PUTEH	1952	32.46	5.94	4.0	13	4	40			*		766,037	9.4	8,022	503,505	1.6	19.80%	
64	366890	Kelanta	P.PUTEH	1951	9.58	6.32	2.6	24	4	30			*		181,560	9.4	8,022	942,637	5.9	49.56%	
65	368300	Kelanta	P.PUTEH	1955	9.68	7.62	3.6	22	8	40			*		155,002	7.3	11,036	1,206,997	8.4	91.15%	
66	505380	Johor	PONTIAN	1966	47.52	6.86	3.4	110	24	30				*	535,402	9.4	6,583	5,477,319	10.2	77.21%	
67	506670	Johor	PONTIAN	1971	36.17	7.32	1.8	110	24	20				*	271,486	-0.6	6,583	1,304,744	5.3	45.75%	
68	507230	Johor	PONTIAN	1966	35.21	7.30	2.8	110	24	20				*	231,969	-0.6	6,583	1,323,626	6.1	50.59%	
69	507810	Johor	PONTIAN	1968	47.83	7.30	2.7	110	24	20				*	459,754	-0.6	6,583	1,380,157	3.7	35.26%	
70	510560	Johor	BATU PAH	1960	31.24	7.30	2.6	22	19	30				*	192,802	1.4	7,735	-4,259	1.0	10.67%	12.72%
71	512960	Johor	BATU PAH	1965	30.22	7.32	2.6	41	6	30				*	673,020	5.8	8,836	1,302,978	2.7	29.91%	
72	514300	Johor	BATU PAH	1960	22.07	7.28	2.6	41	16	30				*	107,874	3.7	8,836	988,937	9.2	78.31%	
73	514370	Johor	BATU PAH	1950	6.31	7.16	3.1	41	16	30			*		56,921	3.7	7,741	775,485	13.9	106.50%	
74	514860	Johor	MUAR	1955	46.03	6.10	2.6	41	16	0					0	-5.0	7,741	0	0.0	0.00%	
75	516890	Johor	MUAR	1966	17.82	6.21	2.8	42	30	20				*	86,575	4.1	6,446	200,302	3.1	29.58%	

Table 15-6 Result of Economic Evaluation for Individual Bridges (2)

No.	Key	State	District	Year Built	Bridge Length (m)	CARRIAGE WAY (m)	S.F.	Detour Da (Km)	Db (Km)	RouEqui Age	Rehabilitati RC	WD	RE	PR	Economic Cost (M$)	GROWTH RATE (%)	16-Hrs TRAFFIC	NPV	BCR	IRR (1994)	IRR (1999)
76	519360	Melaka	JASIN	1955	42.70	6.78	2.4	45	19	30				*	301,440	8.7	13,977	2,444,356	8.3	67.48%	
77	519550	Melaka	JASIN	1940	4.95	6.70	2.5	11	1	40				*	3,939	8.7	13,977	298,131	68.9	798.29%	
78	519700	Melaka	JASIN	1961	4.88	6.70	2.1	10	3	30		*		*	101,346	9.7	13,977	126,224	2.2	23.83%	
79	520130	Melaka	JASIN	1960	6.46	6.70	2.4	3	2	30				*	10,011	8.7	13,061	49,724	5.5	54.32%	
80	520850	Melaka	JASIN	1950	4.27	6.72	4.0	22	5	40				*	32,479	7.1	13,061	517,062	15.3	170.59%	
81	521300	Melaka	MELAKA T	1950	6.90	8.14	3.6	46	10	30			*		160,434	7.1	3,391	325,940	2.9	29.51%	
82	521710	Melaka	MELAKA T	1960	10.72	6.53	3.1	10	1	30		*	*		255,460	6.9	13,712	435,933	2.7	27.05%	
83	521980	Melaka	MELAKA T	1960	14.26	6.70	3.1	15	7	30			*		207,494	6.9	19,640	680,972	4.1	38.49%	
84	522760	Melaka	MPM	1930	7.47	14.60	4.0	5	4	45			*		32,228	3.9	8,494	37,100	2.1	29.98%	
85	523300	Melaka	MELAKA T	1950	9.33	8.80	2.3	12	6	30				*	5,255	4.8	8,494	127,537	22.8	217.42%	
86	523620	Melaka	MELAKA T	1960	15.16	6.80	3.0	32	8	20				*	106,194	4.8	3,494	57,077	1.5	16.52%	
87	524420	Melaka	MELAKA T	1950	3.60	5.35	4.0	32	8	40			*		78,195	4.9	7,408	466,202	6.6	76.29%	
88	524990	Melaka	ALOR GAJ	1960	1.85	5.90	1.9	19	3	30				*	5,966	4.9	7,215	97,587	15.7	114.56%	
89	529600	N. Sembi	PD	1950	3.05	4.69	4.0	34	21	40			*		83,707	-2.9	6,920	153,223	2.7	36.86%	
90	532850	N. Sembi	PD	1970	53.24	6.32	2.6	14	4	30				*	262,349	3.8	6,920	320,541	2.1	24.71%	
91	534450	N. Sembi	PD	1965	35.32	6.70	2.8	34	18	30				*	213,435	4.3	6,920	606,126	3.5	37.78%	
92	534570	Selango	SEPANG	1960	32.54	5.56	2.6	42	65	20			*		323,658	4.3	4,607	178,892	1.5	16.68%	
93	535660	Selango	SEPANG	1960	61.34	6.72	3.6	42	65	30				*	496,770	4.3	4,607	-111,922	0.8	7.63%	9.99%
94	538970	Selango	K. LANGA	1950	2.30	8.20	1.9	11	4	20			*		37,269	9.5	4,607	77,088	3.0	27.42%	
95	540780	Selango	K. LANGA	1960	11.94	6.65		89	60	0					0	9.5	17,632	0	0.0	0.00%	
96	540910	Selango	K. LANGA	1950	6.29	6.95	1.7	89	60	30			*		116,736	10.9	17,632	4,558,200	37.9	219.87%	
97	541000	Selango	K. LANGA	1950	3.24	7.48	3.4	89	60	30			*		132,441	9.5	17,632	2,813,030	21.1	134.50%	
98	541210	Selango	K. LANGA	1950	4.73	7.94	3.7	67	21	40			*		70,843	9.5	13,804	4,114,481	55.9	523.66%	
99	546560	Selango	K. SELANG	1969	30.94	7.29	2.6	9	38	20			*		29,372	-1.9	7,986	367,976	12.8	126.35%	
100	546980	Selango	K. SELANG	1969	30.94	6.76	4.0	86	38	40			*		917,412	-1.9	7,986	3,156,590	4.3	56.77%	
101	549550	Selango	K. SELANG	1965	63.56	6.72	2.1	86	38	30				*	216,489	-1.9	8,583	2,032,802	9.4	88.22%	
102	555290	Perak	H. PERAK	1960	4.92	5.40	2.1	175	30	30				*	47,950	6.7	8,014	3,259,630	61.9	323.60%	
103	556900	Perak	H. PERAK	1958	7.33	6.74	1.6	175	30	30				*	60,662	5.8	11,698	3,630,751	54.7	297.62%	
104	563880	Perak	MANJUNG	1972	41.59	7.10	2.3	26	7	20				*	164,222	1.2	3,755	71,056	1.4	15.99%	
105	567840	Perak	KINTA	1960	12.12	6.14	2.7	106	4	30		*		*	332,092	1.3	20,315	3,482,038	11.2	87.70%	
106	569630	Perak	KINTA	1950	2.83	13.00	2.6	13	9	30			*		54,284	4.4	20,315	162,082	3.8	37.56%	
107	700660	Kedah	KOTA SET	1964	18.40	10.54	2.9	12	8	30		*		*	176,772	4.8	10,291	71,202	1.4	16.10%	
108	700750	Kedah	KOTA SET	1970	15.36	7.30	1.3	12	8	30			*		258,078	4.8	10,291	84,083	1.3	14.84%	
109	701810	Kedah	KBG. PAS	1970	48.60	7.95	2.6	43	11	30				*	155,240	4.8	10,291	2,266,779	14.1	107.58%	
110	702630	Kedah	KBG. PAS	1960	9.54	7.40	1.6	32	11	30				*	95,898	4.8	10,291	535,734	6.0	55.35%	
111	703330	Perlis	PERLIS	1963	24.80	7.30	1.4	8	3	30				*	46,164	3.3	8,728	148,106	3.9	43.69%	
112	706230	Perlis	PERLIS	1950	6.63	6.20	1.6	9	5	0					0	5.9	8,728	0	0.0	0.00%	
113	800350	Pahang	BENTONG	1950	3.47	5.54	2.9	78	32	20			*		49,522	2.5	4,287	431,711	9.2	71.02%	
114	803050	Pahang	RAUB	1950	18.08	5.10	3.8	39	22	30			*		179,568	3.7	4,290	468,151	3.5	34.93%	
115	803900	Pahang	RAUB	1952	10.94	5.64	2.8	39	22	20			*		205,450	3.7	5,526	400,586	2.8	27.60%	
116	810120	Pahang	K. LIPIS	1950	6.90	6.00	2.9	76	39	20			*		67,457	7.7	3,763	1,067,572	16.0	100.42%	
117	813470	Pahang	K. LIPIS	1960	11.67	6.20	2.9	500	240	20				*	142,683	16.3	3,030	4,113,491	26.8	107.91%	
118	818060	Pahang	K. LIPIS	1980	30.49	7.31	1.0	500	240	0					0	16.3	3,030	0	0.0	0.00%	
119	822340	Kelanta	GUA MUSA	1982	90.91	7.30	1.0	170	130	20				*	302,163	11.7	3,030	1,979,409	6.9	48.95%	
120	834850	Kelanta	XUALA KR	1960	13.71	6.53	2.9	32	12	30			*		449,131	3.8	7,016	423,265	1.9	21.02%	
121	834950	Kelanta	XUALA KR	1960	3.34	8.20	3.0	32	12	30			*		66,941	3.8	7,016	327,506	5.6	50.90%	
122	836900	Kelanta	MACHANG	1960	12.02	6.69	2.9	43	16	30				*	64,308	5.9	8,521	811,643	12.3	93.24%	
123	838100	Kelanta	MACHANG	1941	9.72	6.70	2.6	13	5	40		*	*		320,766	5.9	8,521	180,448	1.5	18.81%	
124	901360	N. Sembi	K. PILAH	1960	5.74	6.68	4.0	10	2	40			*		59,456	4.6	2,505	39,525	1.6	20.39%	
125	901420	N. Sembi	K. PILAH	1950	3.24	6.70	3.6	39	19	30			*		120,304	4.6	2,505	31,081	1.2	14.06%	
126	901700	N. Sembi	K. PILAH	1950	3.63	6.74	2.3	39	19	20			*		51,983	4.6	2,505	128,674	3.3	31.00%	
127	901960	N. Sembi	K. PILAH	1950	18.14	6.80	4.0	59	20	40			*		244,760	4.6	2,505	699,866	3.7	45.41%	
128	902270	N. Sembi	K. PILAH	1950	3.11	6.74	2.9	34	16	20			*		49,238	4.6	2,546	100,481	2.9	28.06%	
129	902360	N. Sembi	K. PILAH	1950	3.11	6.85	4.0	26	12	40			*		111,499	4.6	2,546	16,865	1.1	13.29%	
130	902430	N. Sembi	K. PILAH	1950	3.10	6.80	3.6	26	12	30			*		83,098	4.6	2,546	21,615	1.2	14.09%	
131	902440	N. Sembi	K. PILAH	1950	3.10	6.90	4.0	26	12	40			*		62,061	4.6	2,546	68,932	2.1	25.84%	
132	904330	N. Sembi	K. PILAH	1950	7.77	5.90	2.9	37	18	20			*		71,184	4.6	3,803	251,040	4.3	37.83%	
133	906190	N. Sembi	JEMPUL	1950	9.54	6.19	2.6	27	16	20			*		82,184	5.1	3,803	155,502	2.8	27.12%	
134	907010	N. Sembi	JELEBU	1930	6.36	6.18	3.4	16	10	30			*		65,398	6.8	3,181	16,597	1.2	14.01%	
135	908400	N. Sembi	JELEBU	1935	36.70	6.10	3.8	120	60	40			*		265,861	6.8	3,181	2,171,524	8.7	96.00%	
136	911990	Pahang	BENTONG	1951	32.96	6.10	3.2	153	71	20			*		223,725	6.2	2,406	2,148,609	10.1	71.15%	
137	1105770	N. Sembi	JEMPUL	1970	18.32	5.56	3.0	210	90	30				*	65,514	31.6	4,599	11,785,260	162.3	633.50%	
138	1800060	Perak	MANJUNG	1960	3.68	6.50	2.3	13	9	30		*		*	83,306	6.0	15,800	45,878	1.5	17.50%	
139	1800670	Perak	MANJUNG	1950	4.78	6.75	2.9	38	30	30		*		*	188,544	6.0	15,800	150,479	1.8	19.95%	
140	2305040	Johor	SEGAMAT	1950	12.28	5.55	2.4	41	29	20			*		93,334	1.6	4,088	171,906	2.7	27.89%	
141	2305970	Johor	SEGAMAT	1950	7.60	6.75	2.6	25	11	20			*		95,261	1.6	4,088	93,972	1.9	20.87%	
142	5001070	Johor	BATU PAH	1919	4.77	5.75	2.8	39	20	40			*		102,585	4.0	10,064	865,706	9.0	102.15%	
143	5001890	Johor	BATU PAH	1950	5.05	6.08	1.7	39	20	30			*		94,505	4.0	10,064	712,478	8.1	87.69%	
144	5002590	Johor	BATU PAH	1940	4.75	5.90	3.4	39	20	40			*		85,160	6.7	10,064	1,100,930	13.2	138.94%	
145	5100840	N. Sembi	SEREMBAN	1950	9.41	6.30	1.7	65	29	0					0	-6.5	5,702	0	0.0	0.00%	
146	5101360	N. Sembi	SEREMBAN	1940	3.31	13.70	3.6	60	29	40			*		69,038	-6.5	5,702	365,428	6.0	79.30%	
147	5101460	N. Sembi	SEREMBAN	1950	3.26	12.60	2.6	60	29	20			*		64,935	-6.5	5,702	289,831	5.2	48.81%	
148	5102060	N. Sembi	K. PILAH	1950	4.74	7.55	4.0	12	5	40			*		72,169	1.6	5,702	69,145	1.9	24.78%	
149	5102280	N. Sembi	K. PILAH	1960	4.81	5.84	2.6	12	5	20			*		56,606	1.6	5,702	64,235	2.1	22.12%	
150	5102380	N. Sembi	K. PILAH	1960	3.21	5.70	2.9	12	5	20			*		51,843	1.6	5,702	42,936	1.8	19.41%	

Table 15-6 Result of Economic Evaluation for Individual Bridges (3)

No.	Key	State	District	Year Built	Bridge Length (m)	CARRIAGE WAY (m)	S.F.	Detour Da (Km)	Detour Db (Km)	RouEqui Age	Rehabilitati RC	WD	RE	PR	Economic Cost (M$)	GROWTH RATE (%)	16-Hrs TRAFFIC	NPV	BCR	IRR (1994)	IRR (1999)
151	5102670	N.Sembi	K. PILAH	1960	3.21	7.32	2.9	12	5	20		*	*		109,496	1.6	5,702	-11,748	0.9	9.66%	10.18%
152	5103030	N.Sembi	K. PILAH	1950	3.79	6.76	2.6	12	5	20			*		57,139	1.6	5,702	48,051	1.8	19.56%	
153	5103300	N.Sembi	K. PILAH	1958	16.08	6.74	1.3	24	6	30			*		126,822	1.6	7,989	547,131	5.1	49.59%	
154	5200280	N.Sembi	SEREMBAN	1932	4.66	9.78	1.7	29	14	40			*		104,656	3.8	7,331	392,749	4.5	55.35%	
155	5202450	Selango	U.LANGAT	1955	12.11	6.92	3.4	12	8	30			*		44,500	4.7	7,501	192,470	5.1	48.13%	
156	5203510	Selango	U.LANGAT	1950	3.20	8.40	1.4	15	8	30				*	3,774	5.4	7,501	99,888	24.7	181.63%	
157	5204870	Selango	U.LANGAT	1964	54.50	7.38	1.9	33	15	30				*	239,056	5.4	7,501	1,043,043	4.9	48.43%	
158	5300470	N.Sembi	PD	1950	9.35	8.90	3.6	23	6	30			*		154,013	2.2	4,213	151,902	1.9	21.87%	
159	5300960	N.Sembi	PD	1950	6.27	8.55	3.4	23	6	30			*		80,827	2.2	9,914	505,097	6.9	62.31%	
160	5301190	N.Sembi	PD	1950	4.84	8.45	4.0	23	6	0					0	2.2	6,816	0	0.0	0.00%	
161	5302050	N.Sembi	SEREMBAN	1950	8.45	6.78	2.1	23	6	20			*		92,898	2.2	6,816	421,194	5.3	45.94%	
162	5302160	N.Sembi	SEREMBAN	1950	6.31	6.90	2.4	23	7	20			*		78,476	2.2	6,816	335,215	5.0	44.17%	
163	5302340	N.Sembi	SEREMBAN	1940	6.70	8.10	2.8	23	7	30			*		123,571	2.2	6,816	273,017	3.1	32.48%	
164	5403460	Selango	PETALING	1950	6.56	9.70	2.1	25	23	30				*	58,069	11.3	8,200	112,499	2.7	29.67%	
165	5403570	Selango	PETALING	1960	3.05	6.90	4.0	25	23	40			*		245,734	11.3	8,200	-28,385	0.9	9.23%	13.15%
166	5801510	Perak	HLR PERA	1950	5.60	6.80	3.6	34	11	30			*		64,376	1.0	5,347	415,560	7.1	65.89%	
167	5801620	Perak	HLR PERA	1950	3.67	6.90	2.1	44	26	20			*		92,839	1.0	5,347	261,652	3.7	35.16%	
168	5803340	Perak	BTG PADA	1950	4.97	6.70	2.9	43	17	20			*		87,548	3.5	4,288	322,500	4.5	39.16%	
169	5901000	Perak	BTG PADA	1950	4.88	6.70	3.3	999	999	30			*		41,585	19.4	5,031	4,269,832	98.1	485.95%	
170	5901070	Perak	BTG PADA	1950	4.71	6.70	3.3	999	999	30				*	55,562	19.4	5,031	2,328,638	38.6	194.30%	
171	5901480	Perak	BTG PADA	1950	3.90	7.20	3.7	999	999	40				*	115,892	19.4	5,031	2,097,401	17.2	170.47%	
172	5901580	Perak	BTG PADA	1950	7.63	6.75	2.4	999	999	30				*	34,795	19.4	5,031	3,113,197	81.2	363.77%	
173	5901690	Perak	BTG PADA	1950	9.53	6.74	3.3	999	999	30			*		98,980	19.4	5,031	6,224,150	60.5	310.49%	
174	5902030	Perak	BTG PADA	1950	3.56	6.60	2.6	999	999	30				*	31,208	19.4	5,031	2,001,496	58.5	272.27%	
175	5902230	Perak	BTG PADA	1950	8.21	6.65	2.9	999	999	30				*	43,586	19.4	5,031	3,238,448	67.6	310.16%	
176	5902690	Perak	BTG PADA	1950	6.80	7.20	2.1	999	999	30				*	33,989	19.4	5,031	2,913,281	77.8	350.60%	
177	5902920	Perak	BTG PADA	1950	8.77	6.75	2.9	999	999	30				*	88,916	19.4	5,031	3,314,761	34.4	178.23%	
178	5903120	Perak	BTG PADA	1950	23.18	6.70	3.2	999	999	30			*		338,530	19.4	5,031	10,173,230	29.4	164.70%	
179	5905010	Pahang	LIPIS	1961	122.36	6.60	1.8	999	999	30				*	230,969	19.4	5,031	15,254,530	60.2	295.57%	
180	5905290	Pahang	LIPIS	1930	6.05	6.90	2.1	999	999	40			*		3,560	19.4	5,031	5,721,855	74.1	627.21%	
181	5906010	Pahang	LIPIS	1930	6.35	6.95	1.0	999	999	40			*		0,502	19.4	5,031	5,888,534	80.0	675.88%	
182	6000970	Perak	MANJUNG	1930	3.14	4.60	4.0	48	19	45	*				177,566	5.7	3,658	1,201,943	7.6	89.14%	
183	6001330	Perak	MANJUNG	1960	5.02	6.40	2.9	48	19	20			*		35,484	5.7	3,658	416,472	12.1	83.22%	
184	6005070	Perak	L&M&SELA	1950	27.14	6.70	3.2	16	21	20				*	40,274	3.0	1,555	3,879	1.1	12.45%	
185	6005220	Perak	L&M&SELA	1960	7.01	6.70	1.9	16	21	20				*	14,198	3.0	5,138	18,533	2.2	24.30%	
186	6005740	Perak	L&M&SELA	1960	21.95	6.90	3.3	11	4	20				*	30,319	5.7	5,138	139,008	5.1	45.51%	
187	6006050	Perak	L&M&SELA	1950	5.08	5.64	2.9	82	34	20			*		99,393	5.7	5,138	1,067,469	11.2	76.65%	
188	6403300	Pahang	JERANTUT	1930	12.31	6.30	2.6	201	57	30			*		98,976	5.4	1,251	1,402,332	14.4	105.80%	
189	6403900	Pahang	JERANTUT	1930	11.91	6.15	3.1	201	57	30			*		90,084	5.4	1,251	1,383,025	15.5	112.64%	
190	6404270	Pahang	JERANTUT	1930	10.91	5.60	3.7	65	20	40			*		85,528	5.4	1,251	460,128	6.1	70.66%	
191	6404940	Pahang	JERANTUT	1930	6.21	5.70	2.6	65	20	30			*		138,790	5.4	1,251	177,131	2.2	23.76%	
192	6405650	Pahang	JERANTUT	1930	6.31	6.65	2.8	65	20	30			*		64,514	5.4	1,251	259,772	4.8	44.30%	
193	6406260	Pahang	JERANTUT	1930	4.80	5.60	4.0	61	20	45		*	*		145,518	5.4	1,251	173,426	2.2	29.36%	
194	6701200	Kedah	K.MUDA/S	1930	6.05	6.80	1.3	33	16	40				*	3,070	4.4	6,483	245,836	72.8	1032.41%	
195	6701230	Kedah	K.MUDA/S	1940	12.26	6.80	2.4	33	16	40				*	45,880	4.4	6,483	326,008	7.4	94.91%	
196	6701690	Kedah	K.MUDA/S	1968	91.52	7.30	2.4	63	6	30				*	225,672	4.4	6,483	2,958,772	12.8	101.65%	
197	6702060	Kedah	BALING	1950	7.16	6.90	1.0	60	28	20				*	60,546	4.4	5,541	268,928	5.0	40.42%	
198	7000230	Perak	HLR PERA	1950	5.88	7.02	2.8	35	15	20			*		124,160	-3.3	5,347	287,906	3.2	32.41%	
199	7001790	Perak	HLR PERA	1970	44.36	7.34	1.7	36	8	20				*	168,342	-3.3	3,851	217,283	2.2	24.11%	
200	7002480	Perak	BTG PADA	1950	3.88	5.60	4.0	37	24	40			*		103,984	-3.3	3,851	50,891	1.5	18.72%	
201	7602330	Perak	K. KANGS	1950	6.35	5.70	2.6	119	56	20			*		63,097	5.0	2,946	831,949	13.5	91.51%	
202	7602480	Perak	K. KANGS	1950	5.34	5.80	4.0	18	8	40			*		90,950	5.5	3,259	108,170	2.1	26.59%	
203	7604020	Perak	HULU PER	1950	6.35	5.60	3.4	103	56	20		*	*		167,028	5.5	2,333	383,989	3.2	29.42%	
204	7604160	Perak	HULU PER	1950	8.23	5.60	2.6	103	56	20		*	*		80,043	5.5	2,333	294,540	4.6	37.97%	
205	7604750	Perak	HULU PER	1950	9.34	7.00	3.7	103	56	30			*		89,458	8.0	1,974	660,005	8.0	63.64%	
206	7606390	Perak	HULU PER	1950	3.07	5.70	3.7	150	90	30			*		50,522	8.0	1,974	470,117	9.8	73.98%	
207	8601000	N.Sembi	SEREMBAN	1950	9.62	6.95	3.4	36	4	20			*		117,552	6.8	3,649	451,727	4.6	38.72%	
208	8601190	N.Sembi	SEREMBAN	1950	4.64	5.00	2.6	36	4	20			*		63,793	6.8	3,649	308,452	5.6	44.12%	
209	8601410	N.Sembi	SEREMBAN	1950	3.68	5.06		36	4	0					0	6.8	3,649	0	0.0	0.00%	
210	8601830	N.Sembi	SEREMBAN	1950	3.75	6.92	2.3	37	5	20			*		59,530	7.4	3,649	287,251	5.6	43.88%	
211	8602160	N.Sembi	SEREMBAN	1950	3.70	6.34	1.7	85	18	20			*		53,468	7.4	3,649	679,080	13.0	84.78%	
212	8602600	N.Sembi	JELEBU	1950	3.00	8.20	2.9	85	18	20			*		213,518	7.4	3,649	427,301	2.9	27.01%	
213	8602840	N.Sembi	JELEBU	1960	3.08	6.29		5	1	0					0	7.4	3,649	0	0.0	0.00%	
214	8603735	N.Sembi	JELEBU	1950	9.72	4.40	5.0	63	55	40	*		*		397,818	8.1	3,376	-12,338	1.0	10.53%	14.33%
215	8603990	N.Sembi	JELEBU	1930	9.62	4.81	2.9	63	55	30			*		82,578	8.1	3,376	238,946	3.7	35.60%	
216	8604640	N.Sembi	JELEBU	1950	9.51	6.21	4.0	18	9	40		*	*		178,706	8.1	3,376	67,933	1.4	16.34%	

i) The entire project is considered to be fully justified because 97 % bridges are feasible for rehabilitation in 1994 and 99 % in 1999.

ii) For the 3 bridges with an IRR of less than 11 % for rehabilitation in 1999, intangible benefits not included in the calculation in this study can be added due to the service level and reliability of nation-wide road network improved by the proposed rehabilitation.

Figure 15-6 shows the distribution of IRR as classified into 4 categories by bridge. In general, the IRRs on the same routes are similar over a 100 kilometer section, presumably due to the same bridge type, structural condition, maintenance history and similar traffic volume and detour route condition.

In this connection, if the implementation program is formulated only taking into account the values of IRR, bridge rehabilitation works will be concentrated on the same route. Hence, the following adverse effects will arise consequently.

i) Traffic flows in and around a particular route will be largely hindered.

ii) Work capacity of local contractors available will be exceeded.

iii) JKR State and District engineers who manage and supervise the project may be in shortage.

(3) **By State**

Economic evaluation results were compiled by State as shown in Table 15-7. Figure 15-7 presents IRR with project cost by State. The IRR by state ranges between 26 and 99 %, indicating that the project packaged by State is also feasible. The reason for the highest IRR of 99 % in the Perak State is the lack of detour route in case the federal road No.59 becomes impassable. The Pahang State also has a high IRR at 82 % due to the low density of arterial roads. For the Trengganu State, the lowest IRR at 26 % can be attributed to 2 bridges that need reconstruction and large-scale rehabilitation of 10 % and 20 % respectively of the project cost.

The project cost by State is 35 % for Trengganu, 15 % for Pahang, 12 % for Perak and Johore. The Perlis State shares only 0.1 %.

When the implementation program is made only based on the priority by State thus determined, a number of problems as described above might occur considering the large difference in IRR and project cost by State. This might also cause a problem in budget allocation system which needs to be stable and constant by State.

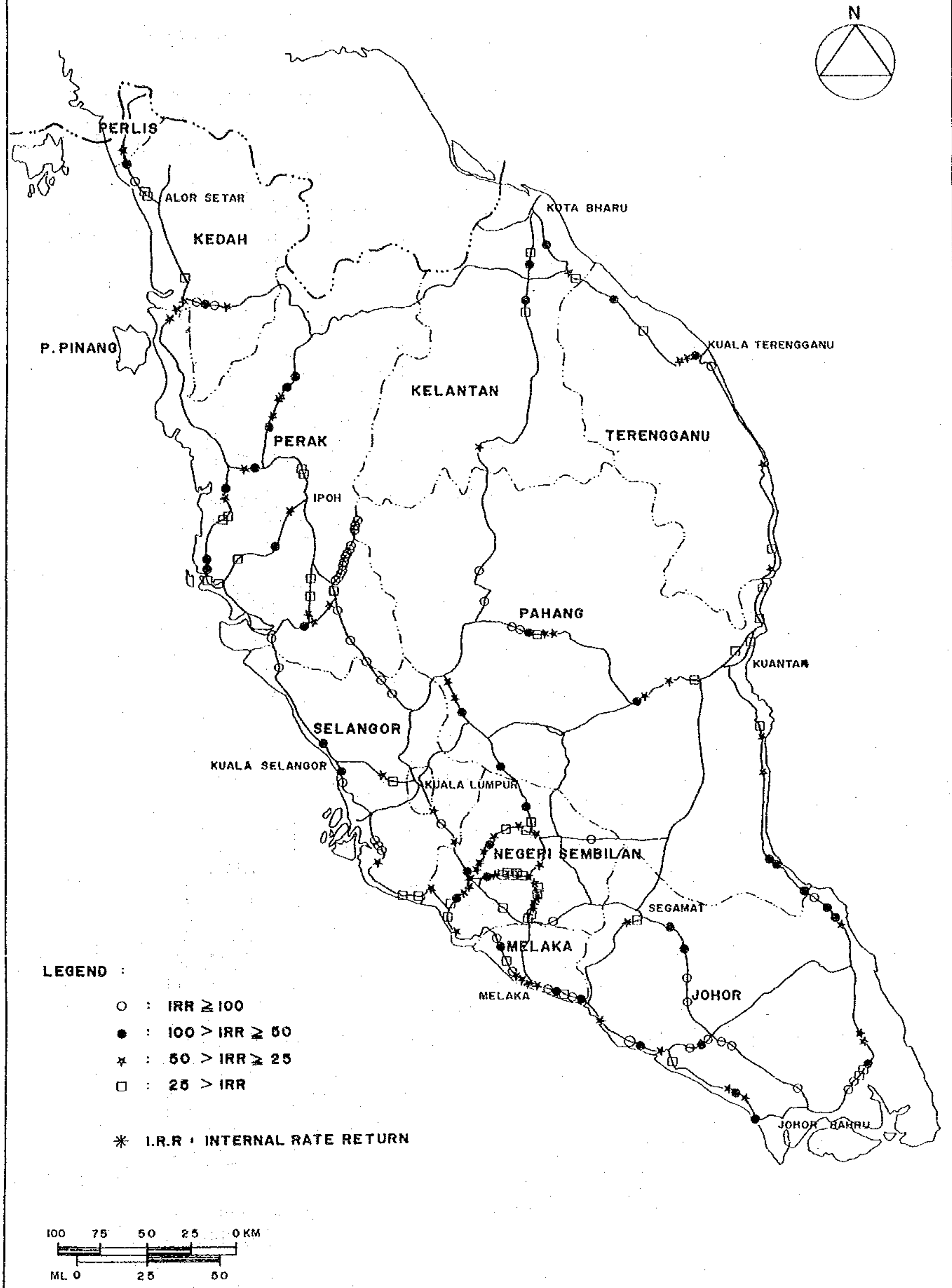


Figure 15-6 IRR Distribution for Individual Bridges

Figure 15-7 IRR and Project Cost by State

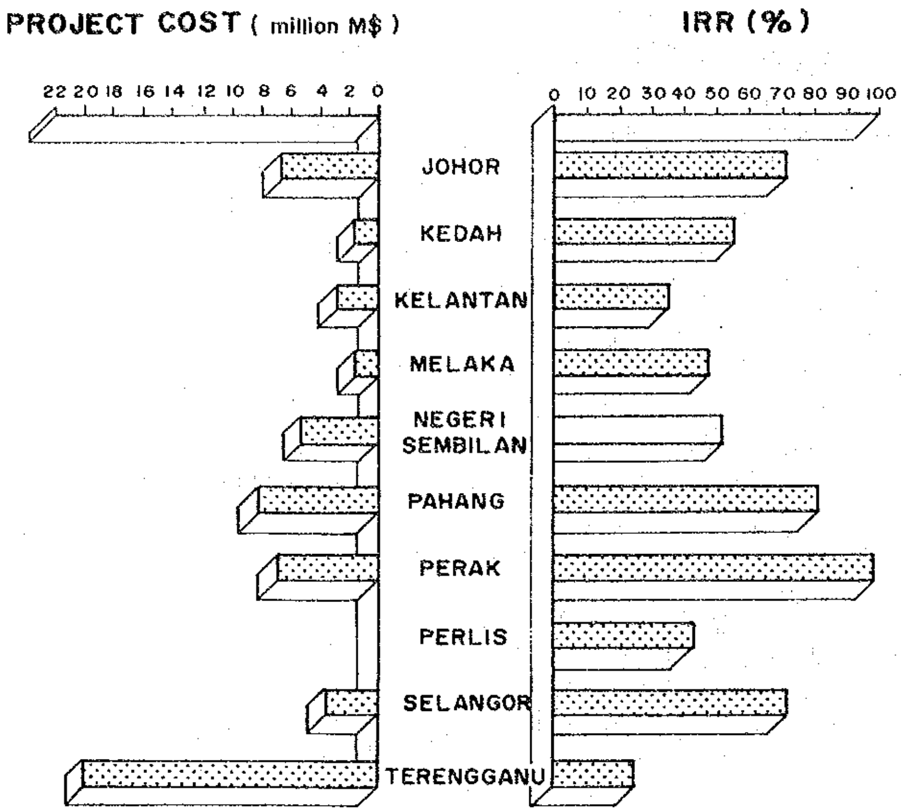


Table 15-7 IRR and Project Cost by State

STATE	NPV	BCR	IRR	PROJECT COST
Johor	44,324,310	8.4	72.90 %	6,827,790
Kedah	7,246,862	6.0	57.01 %	1,671,516
Kelantan	6,375,410	3.6	36.43 %	2,882,385
Melaka	5,663,845	5.1	48.94 %	1,625,577
N.Sembilan	22,787,010	5.9	53.01 %	5,429,610
Pahang	75,086,380	11.4	81.50 %	8,437,400
Perak	75,822,980	13.7	99.27 %	7,076,861
Perlis	148,106	3.9	43.69 %	57,705
Selangor	21,033,490	7.5	72.43 %	3,765,783
Terengganu	25,379,130	2.5	25.67 %	20,373,640
TOTAL	283,867,600	6.7	57.84 %	58,148,267

15.5.4 Sensitivity Analysis

In this study, available traffic data and standardized project cost estimate of respective bridges were adopted considering the enormous number of bridges totalling 203 bridges. This simplification, however, might mislead the conclusion due to over or underestimate of traffic volume and cost. Therefore, these values were intentionally changed and their influence was checked in order to test the stability of the project feasibility. This is called "sensitivity analysis" in general.

The cases of this sensitivity analysis were selected by changing traffic volume and cost as follows:

1) Cost increase by 15 %
2) Cost decrease by 15 %
3) Traffic volume increase by 15 %
4) Traffic volume decrease by 15 %
5) Cost increase by 15 % and traffic volume decrease by 15 %

The result is summarized in Table 15-8. The following can be pointed out:

- Cost decrease improves IRR more rather than traffic volume increase.

- Traffic volume decrease worsens IRR more rather than cost increase.

- With a cost increase of 15 % and a traffic volume decrease of 15 %, the IRR reduces to a considerable extent 76 % of the initial value. This implies that the bridges of an IRR of less than 14.5 % might not be regarded feasible in the worst case. The number of corresponding bridges, however, is 12, still showing a high feasibility as a whole.

15.5.5 Conclusion

The following is concluded as a result of economic evaluation for the 203 bridges. (13 bridges were excluded from the 216 bridges).

1) Implementation of the project for the 203 bridges is well justified because 97 % of bridges are feasible for rehabilitation in 1994 and 99 % in 1999.

2) 6 individual bridges have an IRR less than 11 % for rehabilitation in 1994. Due, however, to possible intangible benefits including to keep entity of the road network, these bridges have been incorporated in the proposed project. Moreover, the IRR of these bridges can be easily improved by retarding rehabilitation work.

Table 15-8 Sensitivity to Fluctuation in Cost and Traffic

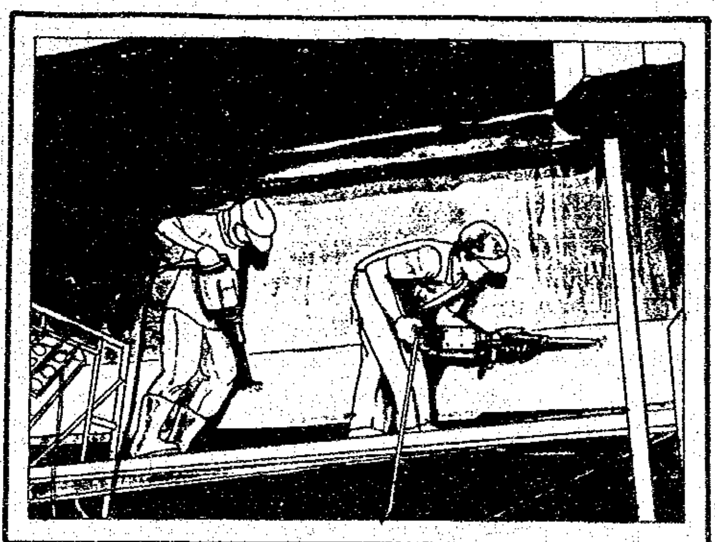
No.	Key	Equiv Age	Project Cost	16-hr Traffic (1988)	Base Case IRR(%)	Cost increased by 15% IRR(%)	Cost increased by 15% % of Base	Cost decreased by 15% IRR(%)	Cost decreased by 15% % of Base	Traffic increased by 15% IRR(%)	Traffic increased by 15% % of Base	Traffic decreased by 15% IRR(%)	Traffic decreased by 15% % of Base	Cost increase 15% Traf decrease 15% IRR(%)	Cost increase 15% Traf decrease 15% % of Base
1	114920	30	189,701	7,758	86.6%	77.8%	89.9%	98.0%	113.2%	96.1%	111.0%	76.7%	88.6%	69.0%	79.7%
2	161140	40	676,314	8,937	20.9%	17.7%	84.7%	25.0%	119.8%	24.3%	116.4%	17.3%	82.9%	14.5%	69.2%
3	166510	40	843,424	2,946	48.7%	42.6%	87.4%	57.0%	116.9%	55.7%	114.3%	41.7%	85.6%	36.5%	74.8%
4	237200	30	375,724	12,593	21.2%	18.6%	87.6%	24.5%	115.6%	23.9%	112.4%	18.4%	86.6%	15.9%	75.1%
5	317000	20	3,449,112	2,064	71.5%	63.8%	89.3%	81.8%	114.4%	79.8%	111.6%	63.1%	88.2%	56.5%	79.0%
6	319110	20	492,789	2,064	72.8%	66.2%	90.9%	81.5%	111.9%	79.4%	109.1%	65.8%	90.5%	59.9%	82.2%
7	341800	30	1,335,912	4,206	13.2%	11.1%	84.2%	15.8%	119.8%	15.3%	116.3%	10.9%	82.3%	8.9%	67.6%
8	346740	30	5,568,216	8,656	31.4%	28.1%	89.7%	35.5%	113.3%	34.9%	111.1%	27.7%	88.3%	24.8%	79.0%
9	520850	40	40,599	13,061	170.6%	150.4%	88.1%	197.9%	116.0%	193.1%	113.2%	147.9%	86.7%	130.5%	76.5%
10	546560	20	36,715	7,986	126.4%	108.8%	86.1%	151.3%	119.8%	141.2%	111.8%	111.4%	88.1%	96.0%	76.0%
11	546980	40	1,146,765	7,986	56.8%	49.6%	87.4%	66.3%	116.8%	64.8%	114.1%	48.6%	85.7%	42.5%	74.8%
12	563880	20	205,278	3,755	16.0%	13.8%	86.1%	18.8%	117.5%	17.8%	111.5%	14.0%	87.6%	11.9%	74.3%
13	567840	30	415,115	20,315	87.7%	78.9%	90.0%	99.3%	113.2%	97.4%	111.1%	77.7%	88.5%	69.9%	79.7%
14	834850	30	561,414	7,016	21.0%	18.5%	88.1%	24.2%	115.1%	23.7%	112.6%	18.2%	86.6%	15.9%	75.7%
15	5001070	40	128,231	10,064	102.2%	89.8%	87.9%	118.7%	116.2%	116.1%	113.6%	88.1%	86.3%	77.5%	75.9%
16	5803340	20	109,435	4,288	39.2%	35.2%	89.8%	44.4%	113.4%	43.5%	111.1%	34.7%	88.6%	31.2%	79.6%
17	5903120	30	423,163	5,031	164.7%	146.3%	88.8%	189.5%	115.0%	185.4%	112.6%	143.9%	87.3%	128.1%	77.8%
	AVERAGE		15,997,907				88.0%		115.8%		112.6%		87.0%		76.3%
	STD. DEVI						1.8%		2.4%		1.9%		2.0%		3.6%

3) If an implementation program is formulated by route or by State automatically, only based on the calculated IRR or other parameters, some problems including work concentration can be anticipated as described below. These problems should be avoided by careful arrangement of the program.

- o Traffic flows in and around a particular route will be largely hindered.
- o Work capacity of local contractors could be exceeded.
- o JKR State and District local engineers who manage and supervise the work may be in shortage.

CHAPTER 16

REHABILITATION PROGRAM



CHAPTER 16

REHABILITATION PROGRAM

16.1 General

It was concluded, based on the economic evaluation carried out in Chapter 15, that all the study bridges are technically and economically viable and the implementation of a bridge rehabilitation project covering all the bridges shall be carried out within the earliest time according to the Government policy as emphasized in "Sixth Malaysia Plan 1991-1995". However, all the study bridges totaling 203 numbers are extensively scattered over the whole Peninsular and the extent of rehabilitation work required for each bridge also varies widely from only simple protection work as part of the structural rehabilitation to total bridge replacement or combined nature consisting of structural, functional and hydraulic rehabilitation works.

Accordingly, in order for the project implementation to be materialized effectively and smoothly, this Chapter presents the implementation schedule with a basic framework for the programming, the funding schedule, the further engineering design and the project management and organization.

16.2 Framework for Programing

Prior to establishment of the implementation schedule, basic frameworks for the programming such as the implementation period and the project packaging are elaborated below.

16.2.1 Implementation Period

In general, the implementation period of a project which is technically and economically feasible will be determined based on the period of preparatory works such as detailed engineering design, tendering activity, land acquisition and the physical construction period. Furthermore contractors' capability, the number of qualified contractors available and government's financial arrangement capability to allocate the required project funds shall be taken into account.

Among the above elements, the critical elements to decide the implementation period in this project are mainly the Government financial arrangement capability and technical aspects that are gradually increasing the risk of loss of structural safety and traffic hazards on the study bridges.

From the financial viewpoint, it is a fact that the Government has allocated M$5,577.6 million for federal roads and bridges development in the "Sixth Malaysia Plan" covering five years from 1991 to 1995. On the other hand, the total project cost[1] amounts to M$58 million, which is equivalent to about 1.0% of the development funds allocated in the "Sixth Malaysia Plan", assuming five year implementation period. Therefore, it is conclusive that the Government presumably has enough capability to allocate the required project funds.

The annual expenditure on bridge maintenance and rehabilitation in Japan is about 4.5% of the total roads and bridges development funds. Therefore, one twelfth[1] of the 4.5% in Japan is equivalent to 0.38%, as compared to the similar funding required for the bridge maintenance and rehabilitation in Malaysia of 1.0%. In comparison between 1.0% in Malaysia and 0.38% in Japan, it can be said that the 1.0% is a remarkably high value taking into account the differences of the present development levels and total number of bridges in these two countries. Nevertheless, the 1.0% is likely to be an acceptable level considering the accumulative maintenance and rehabilitation bills resulted from almost no practical maintenance and rehabilitation works being undertaken since the bridges were built in Malaysia.

From the technical viewpoint, the study bridges were rated as 3, 4 or SSAL in NALS which indicates the necessity or the urgency of rehabilitation work and the Study results also revealed that some of the study bridges have been critically deteriorated/damaged and most of them have suffered various advanced defects. Accordingly it is strongly recommended that immediate rehabilitation work is required to eliminate loss of traffic safety and to decrease risk of bridge failure.

Consequently, it is recommended that five years is suitable as an implementation period mainly from the Government's financial arrangement capability and the technical aspects.

16.2.2 Packaging

With respect to the enormous number of the bridges totaling 203 bridges covered in the Study, it is essential to divide them into five packages taking into consideration the five year implementation period. For the packaging, the economic evaluation results pinpointed various adverse effects if the packaging was done on a road link basis or on a state basis. Those effects are unbalanced budget distribution, causing hindrance of smooth traffic flow, a possibility of shortage of the government management staff on the project, exceeding available contractors' capability in terms of work volumes and decreasing effectiveness of technology transfer from the federal level to the state and the district levels.

Note :(1) The project covers one twelfth of total number of the federal bridges in Malaysia.

Consequently, the following concepts which overcome the above effects are taken into account in the packaging;

- Priority of each bridge implementation is basically determined by the corresponding economic index of IRR.

- In a package, the bridge arrangement within a certain stretch or area shall not be concentrated in order to prevent any hindrance of the present smooth traffic flow, to overload certain contractors and to overcome the shortage of Government staff for management and supervision.

- It is essential to transfer the maintenance and rehabilitation technology from the federal JKR to the state and district JKRs in the project implementation to enhance the JKR engineers and technicians' capability as well as to train a sufficient number of staff. In the transfer of technology, the Study Team believes that continuous training is more effective to ensure the final result than the concentrated type. Therefore, in order to create the project participation opportunity in every project year, the project bridges within a State or District shall be allocated equally in terms of number of bridges throughout the five year implementation period.

Based on the above concepts, the 203 bridges are divided into five packages and a summary of each package is shown in Table 16-1 together with the overall economic index of each package. A list of the bridges and the location map of each package are attached in Table 16-2 to 16-6 and Figure 16-1 to 16-5 respectively.

Table 16-1 Summary of Each Package

	Package No.	No's of Bridges	Total Project Cost (M$)	Overall Economic Index	
				IRR	BCR
	I	64	10,480,400	94.9%	12.03
	II	46	11,306,579	77.7%	10.01
	III	37	13,998,253	45.3%	5.14
	IV	29	11,508,034	38.7%	4.13
	V	27	10,855,002	28.6%	2.82
TOTAL	5	203	58,148,268	57.8%	6.75

Table 16-2 List of Bridges Under Package I

No.	Key	State	District	Year Built	Max. Span (m)	No of Spans	Bridge Length (m)	Type of Bridge	Rehabilitation Plans <*1 RC	WD	RF	PR	Direct Cost (M$)	Project Cost (M$)	IRR (%)	Total Amount of Each State (M$)
1	00102590	Johor	J. BAHRU	1955	1.80	2	3.60	BOX				*	3,829	6,433	2571.05	1,404,635
3	00105590	Johor	KLUANG	1937	2.19	1	2.19	BOX				*	3,782	6,354	1221.65	
43	00316745	Johor	MERSING	1965	3.67	1	3.67	RCS			*		86,534	145,377	437.04	
4	00112830	Johor	BATU PAHAT	1960	6.27	1	6.27	RCS				*	26,862	45,128	243.18	
34	00303430	Johor	K. TINGGI	1940	4.90	1	4.90	SBC				*	46,790	78,607	107.01	
144	05002590	Johor	BATU PAHAT	1940	4.75	1	4.75	SBB			*		63,363	106,450	139.94	
5	00113760	Johor	SEGAMAT	1955	6.93	3	20.34	RCS		*		*	142,271	239,015	111.71	
88	00505300	Johor	PONTIAN	1956	11.90	4	47.52	RCS				*	399,354	659,252	77.21	
75	00516890	Johor	MUAR	1965	6.30	3	17.82	RCS				*	64,418	108,219	29.59	
191	06701200	Kedah	K.MUDA/SIK	1930	6.05	1	6.05	RCB				*	2,284	3,837	1032.41	299,700
109	00701810	Kedah	KBG. PASU	1970	30.52	3	48.60	PCB				*	115,508	194,050	107.59	
24	00184900	Kedah	KOTA SETAR	1950	5.20	1	5.20	RCS			*		60,603	101,813	41.74	
122	00836900	Kelantan	MACHANG	1960	6.69	2	12.02	RCB				*	47,648	80,365	93.24	357,814
65	00366300	Kelantan	P.PUTEH	1953	4.64	2	9.88	RCS			*		115,329	193,753	91.15	
121	00834950	Kelantan	KUALA KRAI	1960	3.34	1	3.34	RCS			*		49,807	83,676	50.90	
77	00519550	Melaka	JASIN	1940	4.95	1	4.95	PRB				*	2,931	4,924	798.29	197,579
85	00523300	Melaka	MELAKA TGH	1950	9.33	1	9.33	SBE				*	3,910	6,569	217.42	
80	00520650	Melaka	JASIN	1950	4.27	1	4.27	SBE				*	24,166	40,599	170.59	
66	00524990	Melaka	ALOR GAJAH	1960	1.65	1	1.65	BOX				*	4,439	7,458	114.56	
87	00524420	Melaka	MELAKA TGH	1950	3.60	1	3.60	RCS			*		58,181	97,744	76.29	
84	00522780	Melaka	M.P MELAKA	1930	7.47	1	7.47	SBE			*		23,979	40,283	20.98	
197	01105770	N.Sembilan	JEMPUL	1970	6.10	3	18.32	PRB				*	48,745	81,892	633.50	1,185,610
10	00123250	N.Sembilan	TAMPIN	1940	6.70	1	6.70	RCB				*	3,928	6,598	315.68	
135	00908400	N.Sembilan	JELEBU	1935	10.70	5	36.70	SBE			*		197,813	332,326	98.00	
211	08502180	N.Sembilan	SEREMBAN	1950	3.70	1	3.70	SBB			*		39,783	66,835	84.76	
146	05101360	N.Sembilan	SEREMBAN	1940	3.31	1	3.31	SBB			*		51,367	86,297	79.30	
159	05300960	N.Sembilan	P. DICKSON	1950	6.27	1	6.27	SBB			*		60,139	101,034	62.31	
153	05103300	N.Sembilan	K. PILAH	1958	9.62	2	16.08	SBB			*		94,362	158,528	49.59	
127	00901960	N.Sembilan	K. PILAH	1950	9.07	2	18.14	SBB			*		182,113	305,950	45.41	
11	00128254	N.Sembilan	REMBAU	1930	9.58	1	9.58	SBC				*	27,478	46,160	24.49	
181	05905010	Pahang	LIPIS	1930	6.35	1	6.35	SBB			*		52,457	88,129	675.98	1,735,839
180	05905290	Pahang	LIPIS	1930	6.05	1	6.05	SBB			*		55,030	92,450	627.21	
169	05403900	Pahang	JERANTUT	1930	11.91	1	11.91	SBB			*		67,027	112,605	112.64	
117	00913470	Pahang	K. LIPIS	1950	11.67	1	11.67	PRB				*	106,163	178,354	107.91	
43	00319110	Pahang	ROMPIN	1962	30.48	7	121.98	PCB				*	293,327	492,769	72.79	
136	00911590	Pahang	BENTONG	1961	10.77	4	32.96	SBB			*		166,462	279,656	71.15	
27	00228540	Pahang	MARAN	1955	6.26	1	6.28	SBB			*		59,269	99,572	57.12	
29	00230550	Pahang	KUANTAN	1967	6.40	1	6.40	PRB				*	41,724	70,096	48.37	
114	00903050	Pahang	RAUB	1950	9.04	2	18.08	SBB			*		133,607	224,460	34.93	
49	00326020	Pahang	PEKAN	1965	5.73	1	5.73	PRB				*	58,172	97,729	30.64	
15	00149920	Perak	BTG PADANG	1963	12.08	3	36.24	IT				*	48,659	81,747	505.77	1,327,413
169	05901000	Perak	BTG PADANG	1950	4.88	1	4.88	SBC			*		30,941	51,981	485.95	
14	00149900	Perak	BTG PADANG	1962	2.40	1	2.40	BOX				*	2,158	3,625	453.32	
102	00555290	Perak	H. PERAK	1980	2.46	2	4.92	BOX				*	35,677	59,937	323.80	
201	07802330	Perak	K. KANGSAR	1950	6.35	1	6.35	SBB			*		46,947	78,871	91.51	
192	08000970	Perak	MANJUNG	1930	3.14	1	3.14	SBE	*				132,117	221,957	89.14	
105	00567840	Perak	KINTA	1960	6.06	2	12.12	PRB		*		*	247,092	415,115	87.70	
21	00166220	Perak	LRT MATANG	1945	5.67	1	5.67	SBB			*		87,093	146,316	80.41	
137	06006050	Perak	LAMA SELAMA	1950	5.09	1	5.09	SBB			*		73,953	124,241	76.65	
208	07806390	Perak	HULU PERAK	1950	3.07	1	3.07	SBS			*		37,591	63,153	73.96	
166	05901510	Perak	HLR PERAK	1950	5.60	1	5.60	SBB			*		47,899	80,470	65.69	
111	00703330	Perlis	PERLIS	1963	24.60	1	24.60	PCB				*	34,349	57,705	43.69	57,705
12	00145100	Selangor	ULU S'GOR	1935	1.85	1	1.85	SBE				*	1,616	2,715	2408.45	753,760
98	00541210	Selangor	K. LANGAT	1950	4.73	1	4.73	SBB			*		52,711	88,554	523.66	
88	00540910	Selangor	K. LANGAT	1950	6.29	1	6.29	SBB			*		86,857	145,920	219.87	
158	05203510	Selangor	U.LANGAT	1950	1.60	2	3.20	BOX				*	2,808	4,717	181.63	
99	00546560	Selangor	K.SELANGOR	1969	10.64	3	30.94	RCS			*		21,854	36,715	126.35	
164	05403460	Selangor	PETALING	1950	6.56	1	6.56	RCS				*	43,206	72,586	29.87	
92	00534570	Selangor	SEPANG	1980	6.95	4	32.54	RCB			*		240,817	404,573	18.69	
57	00354930	Terengganu	K.TERENGGANU	1963	5.95	3	17.85	PRB				*	57,151	96,014	112.01	3,158,117
58	00358790	Terengganu	K.TERENGGANU	1939	5.90	9	53.10	PRB				*	46,590	78,271	63.84	
62	00365630	Terengganu	BESUT	1965	5.84	1	5.84	PRB				*	38,081	63,976	59.10	
55-1	00346740	Terengganu	DUNGUN	1973	30.50	9	152.26	PCB			*		942,824	1,583,944	31.36	
54	00341900	Terengganu	KEMAMAN	1955	12.10	3	36.14	RCB		*		*	795,186	1,335,912	13.16	
	64	Bridges							Grand Total				6,238,332	10,480,400	–	10,480,400

Note : <*1 RC Means Reconstruction (Total Replacement)
WD Means Widening Carriageway or Adding Sidewalk
RF Means Reinforcement Work
PR Means Protection Work
<*2 Construction of this bridge is divided into two subpackages consisting of bridge and hydraulic rehabilitation.
This work is carried out in two consecutive years.

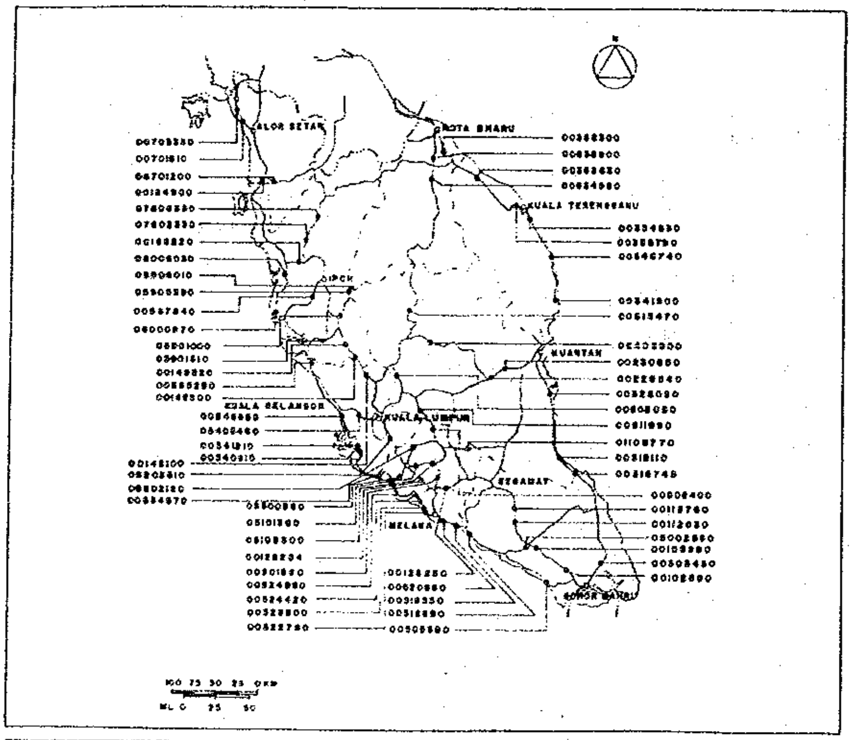


Figure 16-1 Location Map of Bridges Under Package I

Table 16-3 List of Bridges Under Package II

No.	Key	State	District	Year Built	Max. Span (m)	No of Spans	Bridge Length (m)	Type of Bridge	Rehabilitation Plans <*1 RC	WD	RF	PR	Direct Cost (M$)	Project Cost (M$)	IRR (%)	Total Amount of Each State (M$)
2	00108100	Johor	KLUANG	1954	15.90	3	27.40	RCB				*	77,104	129,535	147.07	1,368,723
33	00303220	Johor	K TINGGI	1940	4.64	1	4.64	SBE				*	49,955	83,924	138.19	
73	00614370	Johor	BATU PAHAT	1950	6.31	1	6.31	RCB			*		42,352	71,151	106.50	
142	05001070	Johor	BATU PAHAT	1919	4.77	1	4.77	SBB			*		76,329	128,231	102.15	
8	00114920	Johor	SEGAMAT	1955	6.43	2	12.86	RCB				*	112,917	189,701	86.55	
41	00313520	Johor	MERSING	1960	1.80	2	3.60	RCS		*		*	114,609	192,543	86.18	
42	00314190	Johor	MERSING	1954	5.50	2	11.00	PRB				*	231,031	380,132	82.28	
37	00304360	Johor	K TINGGI	1928	3.35	1	3.35	SBC			*		90,971	152,831	55.06	
7	00115560	Johor	SEGAMAT	1947	2.44	2	4.88	BOX				*	31,354	52,675	53.94	
196	08701690	Kedah	K MUDA/SIK	1968	30.64	3	91.52	PCB				*	167,911	282,090	101.65	357,772
197	08702080	Kedah	BALING	1950	7.16	1	7.16	SBE				*	45,049	75,682	40.42	
64	00365890	Kelantan	P.PUTEH	1951	4.79	2	9.58	RCS			*		135,089	226,950	49.56	604,654
119	00822340	Kelantan	GUA MUSANG	1962	31.13	3	90.91	PCB				*	224,824	377,704	48.95	
76	00519360	Melaka	JASIN	1955	6.22	7	42.70	RCS				*	224,286	376,800	67.48	389,314
79	00520130	Melaka	JASIN	1960	6.48	1	6.48	PRB				*	7,449	12,514	54.32	
154	05200290	N.Sembilan	SEREMBAN	1932	4.68	1	4.68	SBB			*		77,869	130,820	55.35	1,064,410
147	05101460	N.Sembilan	SEREMBAN	1950	3.28	1	3.28	SBB			*		48,315	81,169	48.61	
132	00904330	N.Sembilan	K PILAH	1950	7.77	1	7.77	SBB			*		52,964	88,980	37.83	
91	00534450	N.Sembilan	P. DICKSON	1968	8.83	4	35.32	RCB				*	158,906	266,794	37.78	
215	08603990	N.Sembilan	JELEBU	1930	9.62	1	9.62	SBB			*		61,442	103,223	35.60	
126	00901700	N.Sembilan	K PILAH	1950	3.63	1	3.63	SBB			*		38,679	64,979	31.00	
129	00902270	N.Sembilan	K PILAH	1950	3.11	1	3.11	SBB			*		36,635	61,547	29.06	
212	08602600	N.Sembilan	JELEBU	1950	3.00	1	3.00	SBB			*		158,868	266,898	27.01	
179	05905010	Pahang	LIPIS	1961	30.74	4	122.36	PCB				*	171,852	288,711	295.57	1,401,261
188	08403300	Pahang	JERANTUT	1930	12.31	1	12.31	SBB			*		73,643	123,720	105.80	
116	00810120	Pahang	K LIPIS	1950	6.90	1	6.90	SBB			*		50,191	84,321	100.42	
113	00800350	Pahang	BENTONG	1950	3.47	1	3.47	SBB			*		36,847	61,903	71.02	
190	08404270	Pahang	JERANTUT	1930	10.91	1	10.91	SBB			*		63,637	106,910	70.66	
46	00319690	Pahang	ROMPIN	1960	5.67	2	11.34	PRB				*	84,013	141,142	84.98	
28	00229970	Pahang	MARAN	1985	3.03	1	3.03	BOX				*	82,255	138,188	46.82	
192	08405650	Pahang	JERANTUT	1930	6.31	1	6.31	SBB			*		48,001	80,642	44.30	
32	00237200	Pahang	KUANTAN	1960	8.90	3	26.70	SBC				*	223,845	375,724	21.21	
18	00151580	Perak	BTG PADANG	1960	9.08	7	63.56	RCB				*	90,341	151,773	380.98	1,419,936
172	05901580	Perak	BTG PADANG	1950	7.63	1	7.53	SBC				*	25,889	43,494	363.77	
176	05902690	Perak	BTG PADANG	1950	6.60	1	6.60	SBC				*	25,299	42,498	350.60	
103	00556900	Perak	H. PERAK	1958	7.33	1	7.33	RCS				*	45,136	75,828	297.62	
183	06001330	Perak	MANJUNG	1960	5.02	1	5.02	RCB			*		26,402	44,355	83.22	
205	07604750	Perak	HULU PERAK	1950	9.34	1	9.34	SBB			*		66,561	111,822	63.64	
22	00166510	Perak	LRT MATANG	1935	10.72	1	10.72	SBG	*	*			502,038	843,424	48.74	
186	08005740	Perak	L&M&SELAMA	1960	5.90	3	21.95	RCB				*	22,558	37,898	45.51	
106	00569630	Perak	KINTA	1950	2.63	1	2.83	SBB			*		40,390	67,855	37.56	
13	00146900	Selangor	ULU S'GOR	1965	12.13	3	25.91	IT				*	56,283	97,815	163.96	534,077
97	00541000	Selangor	K. LANGAT	1950	3.24	1	3.24	SBB			*		98,542	165,551	134.50	
101	00549550	Selangor	K SELANGOR	1966	12.61	6	63.56	SBC				*	161,078	270,611	98.22	
60	00357270	Terengganu	K TERENGGANU	1957	5.89	2	11.78	PRB				*	46,374	77,906	46.92	4,147,432
59	00357200	Terengganu	K TERENGGANU	1959	5.94	3	5.94	PRB				*	50,746	85,253	33.36	
55-2	00346740	Terengganu	DUNGUN	1973	30.50	9	152.26	PCB			*		2,371,590	3,984,271	31.36	
	46	Bridges							Grand Total				6,730,108	11,306,579	—	11,306,579

Note : <*1 RC Means Reconstruction (Total Replacement)
WD Means Widening Carriageway or Adding Sidewalk
RF Means Reinforcement Work
PR Means Protection Work

<*2 Construction of this bridge is divided into two subpackages consisting of bridge hydraulic rehabilitations. These works is carried out in two consecutive years.

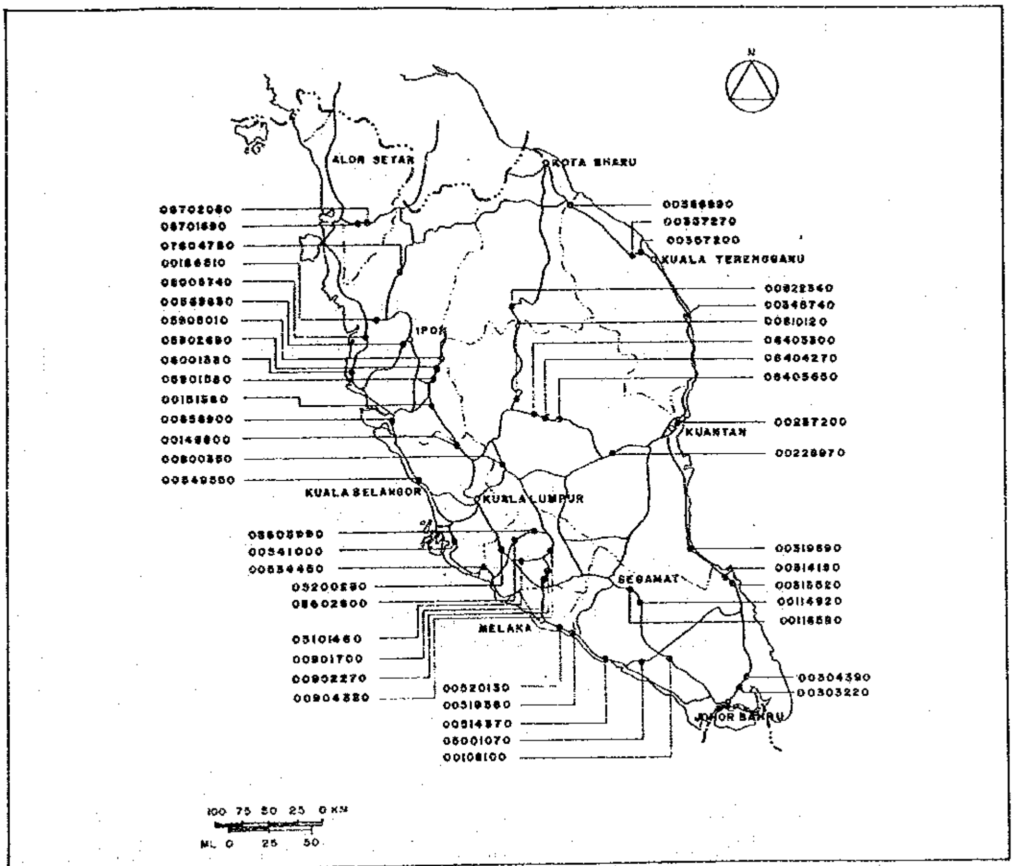


Figure 16-2 Location Map of Bridges Under Package II

Table 16-4 List of Bridges Under Package III

No.	Key	State	District	Year Built	Max. Span (m)	No of Spans	Bridge Length (m)	Type of Bridge	Rehabilitation Plans <*1 RC	WD	RF	PR	Direct Cost (M$)	Project Cost (M$)	IRR (%)	Total Amount of Each State (M$)
72	00514300	Johor	BATU PAHAT	1960	10.45	3	22.07	IT				*	80,263	134,842	79.31	1,385,101
143	05001890	Johor	BATU PAHAT	1950	5.05	1	5.05	SBB			*		70,316	118,131	67.69	
69	00507230	Johor	PONTIAN	1966	11.77	3	35.21	PCB				*	172,598	289,961	50.59	
38	00306390	Johor	K. TINGGI	1974	16.57	5	64.57	IT				*	186,007	312,492	47.35	
40	00313150	Johor	MERSING	1950	4.40	1	4.40	SBE		*		*	111,652	187,592	43.62	
39	00308710	Johor	K. TINGGI	1969	18.90	7	51.96	IT				*	203,621	342,083	40.15	
196	06701230	Kedah	K.MUDA/SIK	1940	6.13	2	12.26	RCB				*	34,137	57,350	94.91	367,214
110	00702830	Kedah	KBG. PASU	1960	9.54	1	9.54	RCB				*	71,353	119,873	55.35	
23	00184400	Kedah	KOTA SETAR	1950	2.61	2	12.20	RCB			*		113,060	189,991	25.77	
120	00034350	Kelantan	KUALA KRAI	1960	4.63	3	13.71	RCS			*		334,175	561,414	21.02	561,414
83	00521980	Melaka	MELAKA TGH	1960	7.13	2	14.28	RCB			*		154,398	259,368	38.49	459,910
81	00521300	Melaka	MELAKA TGH	1950	6.90	1	6.90	RCB			*		119,370	200,542	29.51	
161	05302050	N.Sembilan	SEREMBAN	1950	8.45	1	8.45	SBB			*		69,120	116,122	45.94	1,037,570
162	05302160	N.Sembilan	SEREMBAN	1950	6.31	1	8.31	SBB			*		58,390	98,095	44.17	
209	09601190	N.Sembilan	SEREMBAN	1950	4.64	1	4.64	SBB			*		47,465	79,741	44.12	
89	00529800	N.Sembilan	P. DICKSON	1950	3.05	1	3.05	SBB			*		62,262	104,634	36.86	
133	00906190	N.Sembilan	JEMPUL	1950	9.54	1	9.54	SBB			*		61,149	102,730	27.12	
131	00902440	N.Sembilan	K. PILAH	1950	3.10	1	3.10	SBB			*		46,175	77,576	25.84	
148	05102060	N.Sembilan	K. PILAH	1950	4.74	1	4.74	SBB			*		53,697	90,211	24.78	
149	05102260	N.Sembilan	K. PILAH	1960	4.81	1	4.81	SBB			*		42,119	70,758	22.12	
124	00901360	N.Sembilan	K. PILAH	1960	5.74	1	5.74	RCS			*		44,236	74,320	20.39	
216	09004640	N.Sembilan	JELEBU	1950	9.51	1	9.51	SBB		*	*		132,966	223,383	16.34	
44-1	00317000	Pahang	ROMPIN	1974	45.70	9	397.32	PCB <*2			*		1,411,392	2,371,139	71.49	2,371,139
173	05901890	Perak	BTG PADANG	1950	9.53	1	9.53	SBC			*		73,846	123,725	310.49	1,458,730
175	05902230	Perak	BTG PADANG	1950	8.21	1	8.21	SBC				*	32,430	54,482	310.16	
174	05902030	Perak	BTG PADANG	1950	3.56	1	3.56	SBC				*	23,220	39,010	272.27	
204	07604180	Perak	HULU PERAK	1950	3.23	1	3.23	SBB		*	*		59,556	100,054	37.97	
187	05801820	Perak	HLR PERAK	1950	3.67	1	3.67	SBB			*		69,077	116,049	35.16	
198	07000230	Perak	HLR PERAK	1950	3.88	1	5.88	SBB			*		92,381	155,200	32.41	
202	07602480	Perak	K. KANGSAR	1950	5.34	1	5.34	SBB			*		67,671	113,697	26.59	
17	00155590	Perak	KINTA	1970	1.81	2	3.62	BOX			*		298,271	501,095	24.48	
135	06005220	Perak	L&M&SELAMA	1960	7.01	1	7.01	RCB				*	10,564	17,746	24.30	
139	01800870	Perak	MANJUNG	1950	4.78	1	4.78	SBC		*		*	140,286	235,680	19.95	
100	00546980	Selangor	K.SELANGOR	1969	10.64	3	30.94	RCS			*		682,598	1,146,765	56.77	1,146,765
53	00339210	Terengganu	KEMAMAN	1963	15.22	10	152.20	PCB			*		668,494	1,123,070	38.98	5,212,410
61	00361490	Terengganu	BESUT	1960	6.01	3	16.03	PRB				*	96,131	161,500	23.44	
52-1	00336560	Terengganu	KEMAMAN	1965	29.03	16	219.13	PCB <*3	*				2,338,600	3,927,840	20.04	
	37	Bridges							Grand Total				8,332,294	13,998,253		13,998,253

Note : <*1 RC Means Reconstruction (Total Replacement)
WD Means Widening Carriageway or Adding Sidewalk
RF Means Reinforcement Work
PR Means Protection Work

<*2 This bridge is constructed continuously over a two year period.

<*3 This bridge is constructed continuously over a three year period.

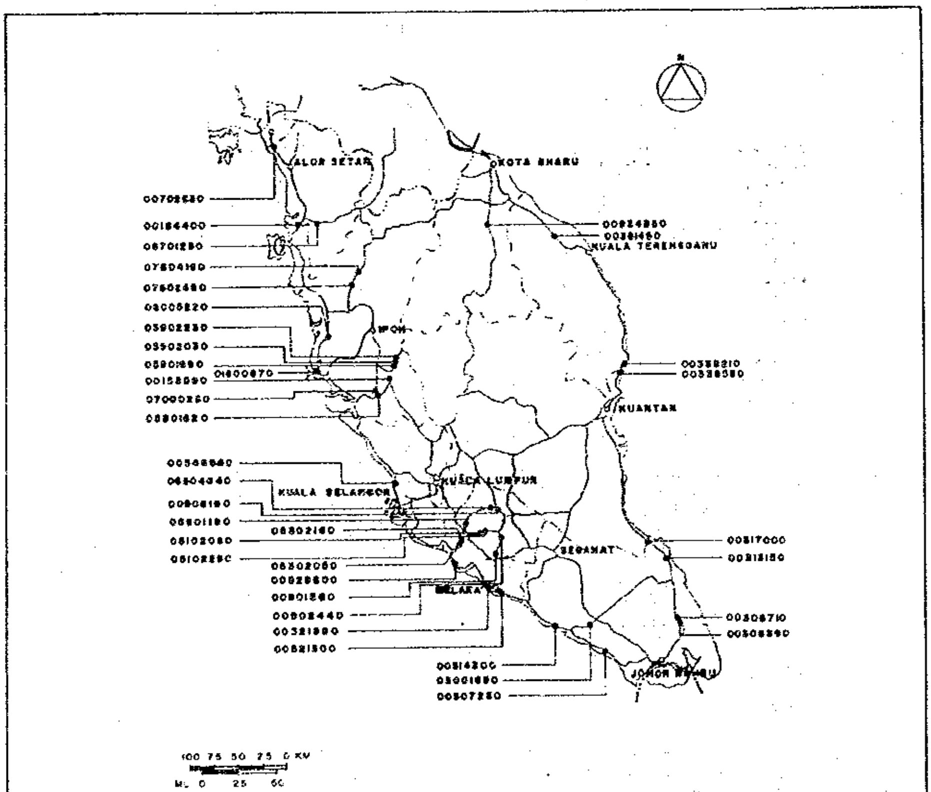


Figure 16-3 Location Map of Bridges Under Package III

Table 16-5 List of Bridges Under Package IV

No.	Key	State	District	Year Built	Max. Span (m)	No of Spans	Bridge Length (m)	Type of Bridge	Rehabilitation Plans <*1 RC	WD	RF	PR	Direct Cost (M$)	Project Cost (M$)	IRR (%)	Total Amount of Each State (M$)
67	00506870	Johor	PONTIAN	1971	15.09	3	36.17	IT				*	201,999	339,350	45.75	1,297,301
71	00512960	Johor	BATU PAHAT	1965	11.30	3	30.22	RCB				*	500,759	841,275	29.91	
140	02305040	Johor	SEGAMAT	1950	6.29	2	12.29	SBB			*		69,445	116,668	27.89	
25	00184900	Kedah	KOTA SETAR	1950	4.64	1	4.64	RCS				*	22,923	38,511	25.38	324,233
26	00186210	Kedah	KOTA SETAR	1940	3.23	1	3.23	SBB			*		38,546	64,757	24.29	
107	00700660	Kedah	KOTA SETAR	1964	18.40	1	18.40	PCB		*		*	131,527	220,965	16.10	
63	00366660	Kelantan	P.PUTEH	1952	5.41	6	32.46	PRB			*		569,969	957,546	19.90	957,546
92	00521710	Melaka	MELAKA TGH	1960	10.72	1	10.72	RCB		*	*		190,089	319,350	27.05	319,350
210	09601930	N.Sembilan	SEREMBAN	1950	3.75	1	3.75	SBB			*		44,293	74,412	43.88	1,025,600
207	09601000	N.Sembilan	SEREMBAN	1950	9.62	1	9.62	SBB			*		87,464	146,940	39.72	
163	05302340	N.Sembilan	SEREMBAN	1940	6.70	1	6.70	SBB			*		91,943	154,454	32.49	
90	00532850	N.Sembilan	P. DICKSON	1970	11.02	5	53.24	RCB				*	195,200	327,938	24.71	
152	05103030	N.Sembilan	K. PILAH	1950	3.79	1	3.79	SBB			*		42,514	71,424	19.56	
150	05102380	N.Sembilan	K. PILAH	1960	3.21	1	3.21	SBB			*		38,574	64,804	19.41	
130	00002430	N.Sembilan	K. PILAH	1950	3.10	1	3.10	SBB			*		61,929	103,873	14.09	
134	00907010	N.Sembilan	JELEBU	1930	6.36	1	6.36	SBB			*		48,659	81,747	14.01	
44-2	00317000	Pahang	ROMPIN	1974	45.78	9	397.32	PCB <*2			*		641,651	1,077,974	71.49	1,526,975
193	06406260	Pahang	JERANTUT	1930	4.90	1	4.90	SBB		*	*		108,272	181,897	29.36	
47	00323070	Pahang	PEKAN	1965	10.42	3	31.26	RCB				*	108,330	181,994	29.17	
51	00337240	Pahang	KUANTAN	1957	6.58	1	6.58	RCS				*	50,661	85,110	19.11	
170	05901070	Perak	BTG PADANG	1950	4.71	1	4.71	SBC				*	41,341	69,453	194.30	1,420,990
177	05902920	Perak	BTG PADANG	1950	8.77	1	8.77	SBC				*	66,158	111,145	178.23	
171	05901480	Perak	BTG PADANG	1950	1.95	2	3.90	SBC				*	86,229	144,865	170.47	
206	07604020	Perak	HULU PERAK	1950	6.35	1	6.35	SBB		*	*		124,277	208,785	29.42	
199	07001790	Perak	HLR PERAK	1970	14.80	3	44.36	IT				*	125,255	210,428	24.11	
19	00181140	Perak	KINTA	1950	9.77	2	19.11	SBB		*	*		402,568	676,314	20.89	
157	05204970	Selangor	U.LANGAT	1964	18.24	3	54.50	SBC				*	177,869	298,820	49.43	708,199
155	05202450	Selangor	U.LANGAT	1955	12.11	1	12.11	RCB			*		33,110	55,625	49.13	
94	00536970	Selangor	K. LANGAT	1960	2.30	1	2.30	BOX			*		27,730	46,586	27.42	
165	05403570	Selangor	PETALING	1960	3.05	1	3.05	BOX			*		182,838	307,168	9.23	
52-2	00338580	Terengganu	KEMAMAN	1965	28.03	18	219.13	PCB <*3	*				2,338,000	3,927,840	20.04	3,927,840
	29	Bridges							Grand Total				6,850,021	11,508,634		11,508,034

Note : <*1 RC Means Reconstruction (Total Replacement)
WD Means Widening Carriageway or Adding Sidewalk
RF Means Reinforcement Work
PR Means Protection Work
<*2 This bridge is constructed continuously over a two year period.
<*3 This bridge is constructed continuously over a three year period.

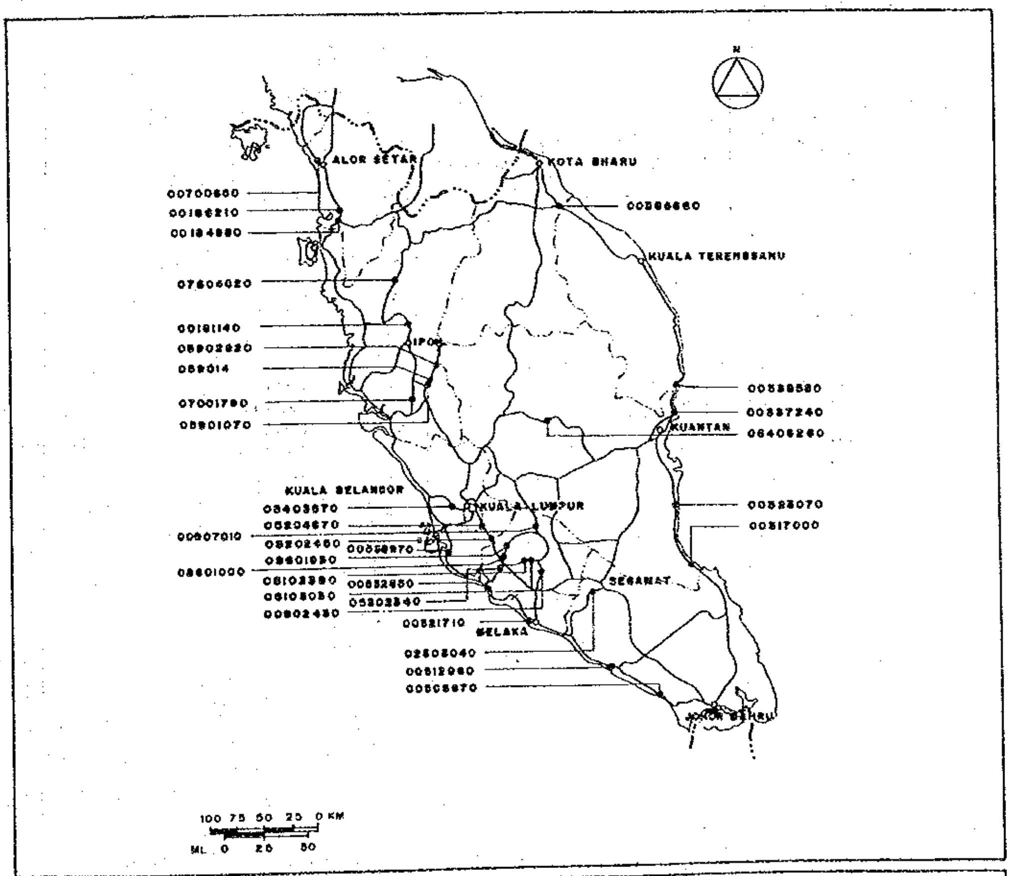


Figure 16-4 Location Map of Bridges Under Package IV

Table 16-6 List of Bridges Under Package V

No.	Key	State	District	Year Built	Max. Span (m)	No of Spans	Bridge Length (m)	Type of Bridge	Rehabilitation Plans <*1 RC	WD	RF	PR	Direct Cost (M$)	Project Cost (M$)	IRR (%)	Total Amount of Each State (M$)
69	00507810	Johor	PONTIAN	1969	12.09	5	47.63	IT				*	342,079	574,693	35.26	1,351,831
35	00303890	Johor	K. TINGGI	1940	4.58	2	9.16	RCS		*		*	101,419	170,364	24.66	
36	00304060	Johor	K. TINGGI	1963	36.65	5	92.25	RCS				*	148,830	246,874	22.63	
141	02306970	Johor	SEGAMAT	1950	5.88	2	7.60	RCS			*		70,879	119,077	20.97	
70	00510560	Johor	BATU PAHAT	1960	10.42	3	31.24	RCB				*	143,454	241,003	10.67	
108	00700750	Kedah	KOTA SETAR	1970	15.38	1	15.36	RCS			*		192,022	322,597	14.04	322,597
123	00838100	Kelantan	MACHANG	1941	4.48	2	9.72	RCS		*	*		238,665	400,957	18.81	400,957
73	00519700	Melaka	JASIN	1961	4.88	1	4.88	PRB		*		*	75,406	126,682	23.63	259,424
88	00523820	Melaka	MELAKA TGH	1960	7.59	2	15.16	PRB				*	79,013	132,742	16.52	
158	05300470	N.Sembilan	P. DICKSON	1950	9.35	1	9.35	SBB			*		114,593	192,518	21.87	1,116,412
125	00901420	N.Sembilan	K. PILAH	1950	3.24	1	3.24	SBB			*		89,512	150,380	14.06	
129	00902380	N.Sembilan	K. PILAH	1950	3.11	1	3.11	SBB			*		82,981	139,374	13.29	
214	08603735	N.Sembilan	JELEBU	1950	4.96	2	9.72	SBB	*		*		295,995	497,272	10.53	
151	05102670	N.Sembilan	K. PILAH	1960	3.21	1	3.21	SBB		*	*		81,470	136,870	9.86	
115	00803900	Pahang	RAUB	1952	5.47	2	10.94	SBB			*		152,865	256,813	27.60	1,402,187
191	06404940	Pahang	JERANTUT	1930	6.21	1	6.21	SBS			*		103,266	173,487	23.76	
49	00326950	Pahang	PEKAN	1966	5.89	4	23.52	PRB				*	164,067	275,633	17.69	
31	00232690	Pahang	KUANTAN	1963	11.08	1	11.06	PRB				*	153,860	258,182	15.76	
50	00336310	Pahang	KUANTAN	1958	12.00	3	36.00	RCB		*		*	260,757	438,072	5.00	
178	05803120	Perak	BTG PADANG	1950	10.98	3	23.18	SSC			*		251,883	423,163	164.70	1,452,792
168	05803340	Perak	BTG PADANG	1950	4.97	1	4.97	SBB			*		65,140	109,435	39.16	
20	00161290	Perak	KINTA	1955	8.09	2	16.18	SBB		*	*		256,226	430,480	20.83	
200	07002480	Perak	BTG PADANG	1950	3.98	1	3.98	SBB			*		77,380	129,980	18.72	
138	01800060	Perak	MANJUNG	1960	3.68	1	3.68	RCS		*		*	61,984	104,133	17.50	
104	00563660	Perak	MANJUNG	1972	14.07	3	41.59	IT				*	122,189	205,279	15.99	
184	08005070	Perak	L&M&SELAMA	1950	7.20	4	27.14	SBC				*	29,936	50,343	12.45	
93	00535660	Selangor	SEPANG	1960	14.70	5	61.34	RCB				*	369,820	620,982	7.63	620,962
52--3	00338580	Terengganu	KEMAMAN	1965	28.03	16	219.13	PCB <*2	*				2,338,000	3,927,840	20.04	3,927,840
	27	Bridges							Grand Total				6,461,310	10,855,002		10,855,002

Note : <*1 RC Means Reconstruction (Total Replacement)
WD Means Widening Carriageway or Adding Sidewalk
RF Means Reinforcement Work
PR Means Protection Work
<*2 This bridge is constructed continuously over a three year period.

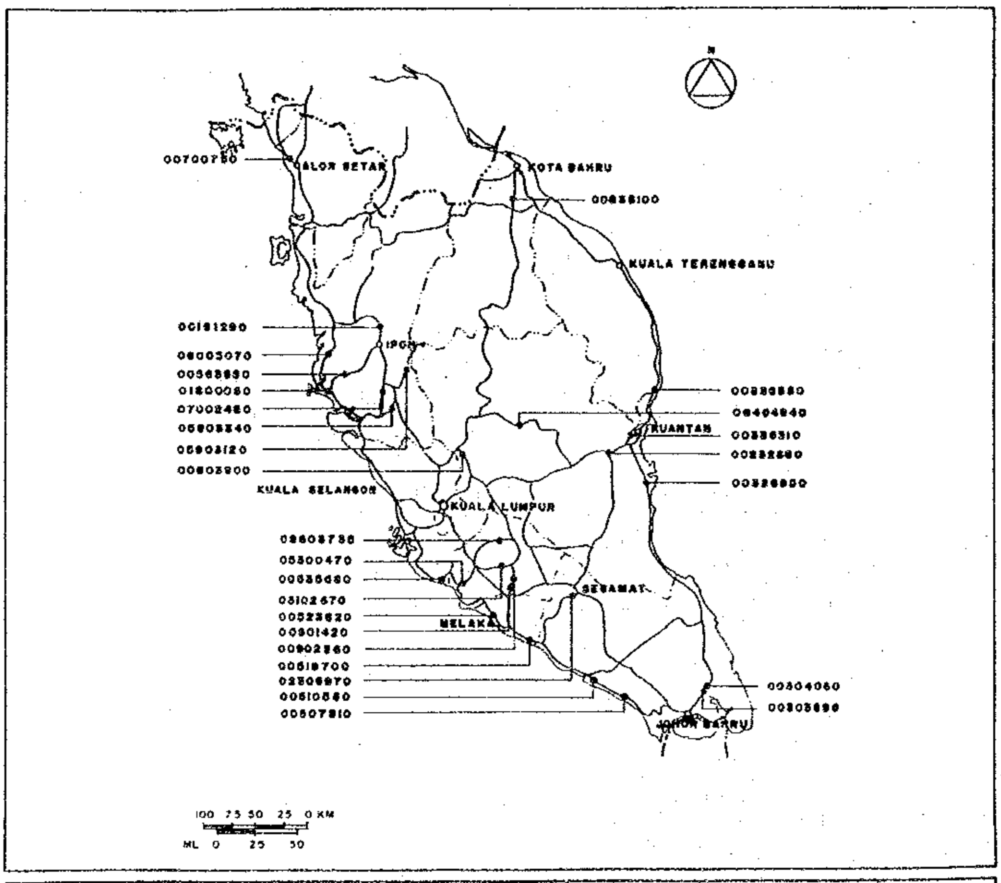


Figure 16-5 Location Map of Bridges Under Package V

16.3 Implementation Schedule

In principle, it is assumed that construction including tendering of each package shall be completed within one Malaysian fiscal year (which is from January 1st to December 31) because the project funds will be financed by the Government of Malaysia.

Main work items for the scheduling are detailed engineering design, tendering activities and construction. The outline and required time duration of each item are described hereinunder:

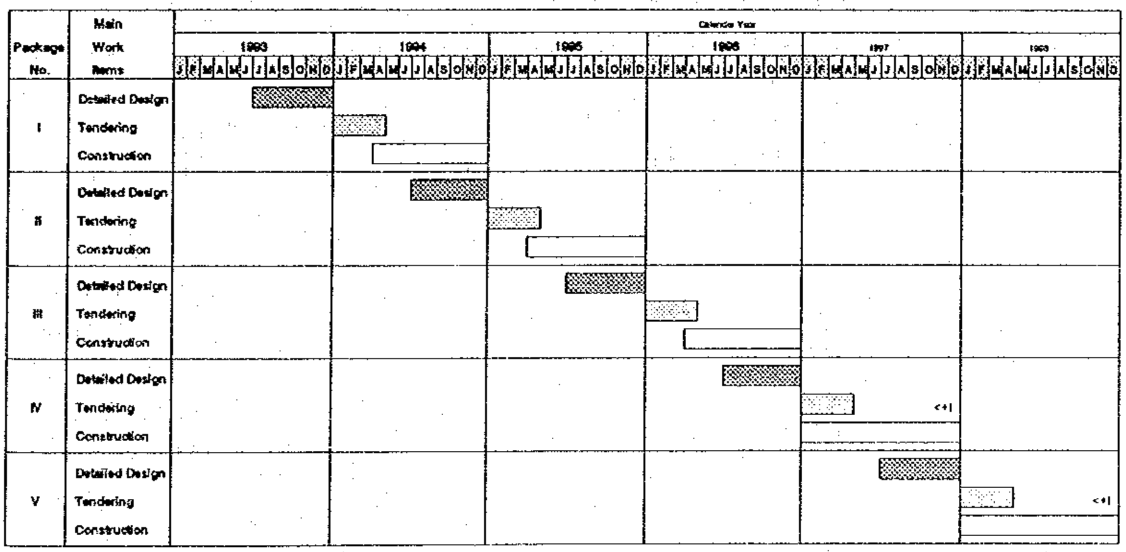
The detailed design which should be carried out one year in advance of the construction involves topographic survey, subsoil survey, structural survey, structural assessment, cost estimate and preparation of tender documents. It will take about six months to complete the design of each package.

The tendering activities including prebid conference, tender evaluation, and negotiation with the contractor shall commence on the first week of January of each fiscal year and will take four months to complete.

The construction of each package shall commence on the first week of April and be completed by the end of December in principle. Out of 203 study bridges, only two bridges, with construction period of more than 24 months, will be implemented for two consecutive years.

Assuming commencement of the package I in 1994, the project will be completed by the end of 1998. The overall implementation schedule is depicted in Figure 16-6.

Figure 16-6 Implementation Schedule



Note : : [ ] indicate rainy season from November to February.
<+|: Rehabilitation works for Bridge No. 317000 and 308580 are carried out continuously during the two or three years from 1996 to 1999
: Fiscal year in Malaysia from January 1 to December 31

16.4 Funding Schedule

The total project cost, as estimated in Chapter 14, is 58.148 million Malaysian Ringgit at December 1991 price level. In light of the implementation schedule, the project funding schedule of each year is shown in Table 16-7.

Table 16-7 Project Funding Schedule

Classification		Amount for Each Year (Million M$)						Grand Total
		1993	1994	1995	1996	1997	1998	
Construction Cost		-	8.188	8.833	10.936	8.991	8.480	45.428
Engineering Cost	Detailed Design	0.678	0.343	1.075	0.305	0.325	0.0	2.726
	Supervision	-	0.328	0.353	0.437	0.360	0.339	1.817
Administration		-	0.246	0.265	0.328	0.270	0.254	1.363
Contingency		-	1.228	1.325	1.640	1.349	1.272	6.814
Grand Total		0.678	10.333	11.851	13.646	11.295	10.345	58.148

Note : Price level of those amounts is based on December, 1991.

16.5 Further Engineering Design

Prior to commencement of the tendering and construction of each package, detailed engineering design of each bridge must be carried out by the Bridge Unit in Federal JKR. The detailed design covers the following items;

- **Topographic Survey**
  - Topographic survey at bridge site
  - River cross section survey
- **Subsoil Investigation**
  - Mechanical boring at proposed pier and abutment sites
  - Field test and sampling
  - Laboratory test
  - Existing pile length measurement (if required)
- **River Hydrological Survey**
  - Field inspection from hydraulic viewpoint
  - Hydrological analysis
- **Detailed Structural Survey**
  - Structural details measurement
    - Structural dimension survey
    - Crack/corrosion mapping survey
    - Concrete cover, rebar size and spacing survey
    - Steel thickness measurement

- Material strength measurement
  - Concrete strength
  - Structural steel strength
  - Reinforcement bar strength
- Measurement of material deterioration degree
  - Carbonation test
  - Chloride test
  - Sulphate test
  - Rebar corrosion test
- Bridge function survey
- Full scale bridge loading test (if required)

▪ **Detailed Rehabilitation Design**
- Establishment of design criteria
- Structural assessment of bridges
- Detailed rehabilitation design
- Preparation of drawings
- Estimate of work quantities
- Construction planning

▪ **Cost Estimate**
- Unit price analysis
- Cost estimate of each project bridge

▪ **Preparation of Tender Documents**
- Instructions to tenderers
- Form of contract
- General condition of contract
- Technical specification
- Bill of quantities
- Tender drawings

16.6 Project Management and Organization

JKR is the technological arm of the Government and serves as the implementing agency for carrying out infrastructure projects in the whole country. JKR is divided into three levels of management and organization structure that consist of the Federal, State and District levels.

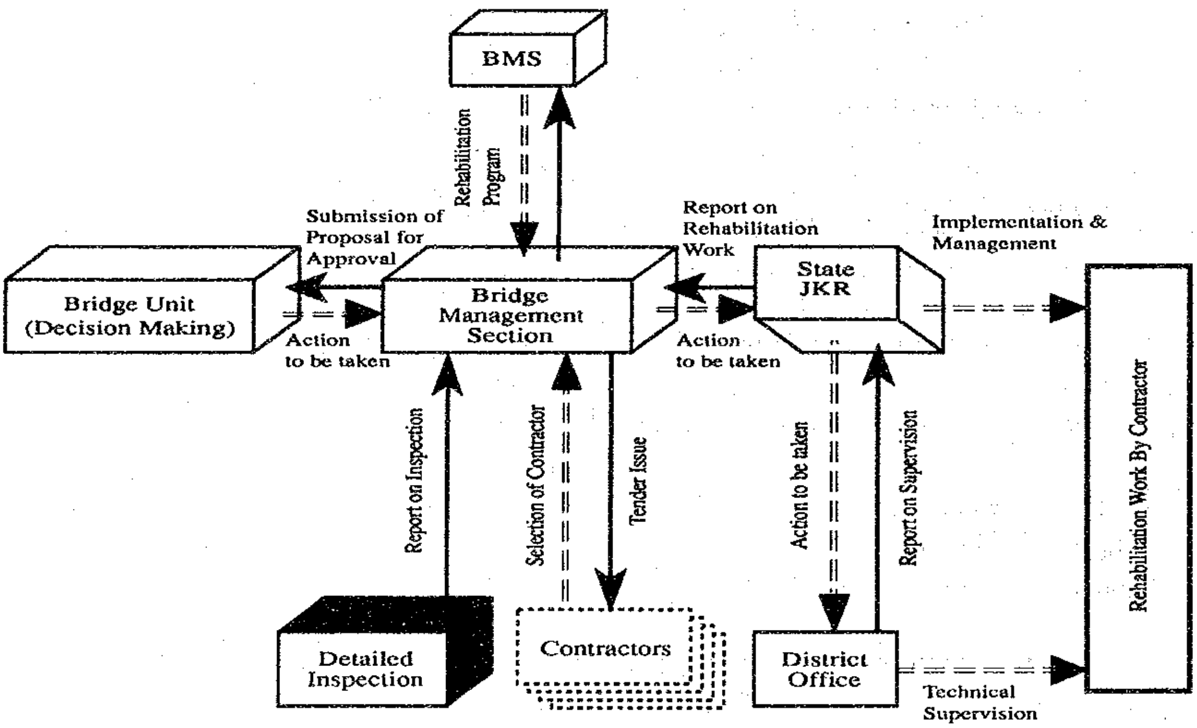
The Roads Branch out of 15 Branches in the Federal JKR is responsible for planning, construction and maintenance of the federal roads and bridges and development schemes as well as formulating roads standards, policies and advising the State JKRs on matters pertaining to the state roads. The Bridge Unit under the Roads Branch is responsible for establishing design standard and carrying out the design, construction and rehabilitation of the federal bridges.

The Federal JKR has 13 State JKR offices located in respective States which are responsible for the planning, implementation and maintenance of the state development projects as well as administration and monitoring the federal projects carried out in the State. Under the State JKRs, there are 72 District Offices on the Peninsular. Each of these is under a District Engineer who is responsible to the State Director for implementation and maintenance of projects in that District.

Under such situation, the Bridge Unit is the executing agency for the implementation of the project. The responsibilities of the agency are to carry out the detailed rehabilitation design and tendering activities. While the State JKR and the District JKR is responsible for construction management and monitoring of the project and the direct construction supervision respectively.

Schematic interrelationship between those agencies is depicted in Figure 16-7 which indicates the direction of flow and responsibility and function of the agencies concerned.

Figure 16-7 Schematic Interrelationship between the Agencies



In principle, the project shall be executed on a contract basis by contractors selected through competitive biding. Therefore the Government must organize a construction supervision team(s) to manage and supervise the contractors' field works but the size of the staff of the organization depends on the number of bridges to be rehabilitated, their location and scale of the respective rehabilitation works. For reference purpose, a typical organization is shown in Figure 16-8, assuming it is required to manage and supervise a subproject covering about 15 to 20 bridges at a time.

Figure 16-8 Typical Organization for Construction Supervision