CHAPTER 18 COST ESTIMATE

18.1 General

One of the objective for the Study is to estimate the rehabilitation and reconstruction cost for each bridge studied, amounting to 100 bridges. Based on the results of the Preliminary Rehabilitation Design, the cost estimate was carried out on the 10 representative bridges. Besides, additional calculation was carried out on 9 bridges out of 10 for the purpose of estimation on the assumption of reconstruction plan. These results were extended to the cost estimate for the remaining 90 bridges for which Preliminary Bridge Inspection was done.

The following procedures were applied in this Study.

- 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 rehabilitation design of 10 bridges and identification of the associated subsidiary work items.

- Analysis on the unit price of each work item or each rehabilitation method based on above consideration.

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

- Assessment of foreign and local portion and estimate of economic cost based on the analysis of project cost in recent studies conducted in Sri Lanka together with consideration of tax duties.

18.2 Unit Price Analysis

18.2.1 Basic Conditions

Basic conditions considered in the cost estimate are as follows:-

- Price level of labour, material and equipment is based on October, 1995.

- The unit price are prepared based on RDA standard and market investigation.

- Since the data of rehabilitation cost is limited in Sri Lanka, the data obtained from rehabilitation in Japan was supplementary applied.

- Except for direct construction cost, other cost such as indirect cost, engineering fees, and contingencies are computed using the multiplier factors.

18.2.2 Composition of Project Cost

Project cost consists of construction cost, land acquisition/compensation cost, engineering fees for detailed design and construction supervision, administration cost of the Government and contingencies. The construction cost is divided into direct construction cost and indirect construction cost.

(1) Direct Construction Cost

The direct construction cost of each work items was estimated based on the quantities derived from the preliminary rehabilitation design.

(2) Indirect Construction Cost

The indirect cost consists of common preliminary work, field supervision, etc. The indirect construction cost was assumed to be 25% of the direct construction cost through the market investigation.

(3) Land Acquisition and Compensation Cost

In the rehabilitation work, additional land acquisition and compensation are not necessary and 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. In the reconstruction work, the amount of land acquisition cost is small. Therefore, the land acquisition and compensation cost are neglected in the Study.

(4) Engineering Fees for Detailed Design and Construction Supervision

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

(5) Administration Cost

Administration cost is expense by the Government arising from implementation of the project and is assumed to be 2% of the local currency portion of the construction cost.

(6) 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 the Study. For feasibility study level, 20% of the construction cost is considered in the Study.

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

In addition, these cost can be divided into foreign portion, local portion and tax portion based on the analysis of project cost in recent studies conducted in Sri Lanka as follows:-

Table 18.1 Composition of Project Cost

	Foreign	Local	Tax	Total
Construction cost	(1) = 65% of (4) 65	(2) = 10% of (4) 10	(3) = 25% of (4) 25	(4) 100
Land acquisition / Compensation Cost	-	-	-	-
Engineering fees	75% of (5) 7.5	15% of (5) 1.5	10% of (5) 1	(5) = 10% of (4) 10
Administration	-	2% of (2) 0.2	-	0.2
Contingency	20% of (1) 13	20% of (2) 2	20% of (3) 5	20% of (4) 20
Total [in %]	85.5 [65.7]	13.7 [10.5]	31 [23.8]	130.2 [100.0]

18.2.3 Unit Price Analysis

Unit price applied in this Study are calculated by the procedure as follows:-

(1) Unit Rate for Labour, Material and Equipment

The unit rate for cost of labour, material and equipment were estimated on the basis of RDA standard and data researched from the market investigation and attached in Appendix S-1.

(2) Work Item Rate

The work item rate for work cost of concrete, transportation, formwork, excavation, etc. were estimated on the basis of RDA standard and data researched from the market investigation and attached in Appendix S-2. The rate covers overhead and profit for cotractors.

(3) Unit Price

Unit price for work items such as concrete works of abutment, concrete works of pier, construction of PSC/PRE per square metres were estimated using the work item rate and attached in Appendix S-3.

18.3 Standard Unit Price

One of the main purpose of the Study is to establish an implementation programme for the bridge rehabilitation covering all the bridges studies which requires cost estimate. In this regard, additional preliminary design was carried out 9 bridges out of 10 for the purpose of estimate on the assumption of reconstruction plan.

Therefore, standard unit prices applicable to other 90 bridges are prepared in this section based on the assessment of the unit price for the 10 bridges.

(1) Cost Estimate for 10 Representative Bridges

Construction cost for 10 representative bridge was estimated on each work items to be rehabilitated based on its rehabilitation method determined as mentioned in chapter 14. Simultaneously reconstruction cost for 9 bridges were estimated. The contents are as follows:-

SER No.	Proposed Rehabilitation Plan	Reconstruction Plan
85	Additional footway	-
77	Reconstruction	-
53	Repair of superstructure	O
33	Reconstruction	-
59	Redeck & widen	O
20	Redeck & widen	O
70	Repair of superstructure	O
7	Repair of super & substructure	O
211	Widen and repair of substructure	O
212	Repair of super & substructure	O

(2) Standard Unit Price

The standard unit prices applicable to other 90 bridges are prepared based on the results of above study and attached in Appendix S-4.

18.4 Project Cost Estimate

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

The construction cost of each bridge is shown in Table 18.2.

Table 18.3 shows the project cost classified into priority of rehabilitation and type of superstructure.

Table 18.2. Summary of Rehabilitation Plan for the 100 Bridges

(1/5)

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width Exist.	Overall Width Propd.	Damage Rating Deck	Damage Rating Main Frame	Damage Rating Abut.	Damage Rating Pier	Damage Rating Wing Wall	Damage Rating Overall	Rehabilitation Plans from Structural View Point	Work Period (month)	Construction Cost (SLR)
1	AA002	98/1K		RCB	30.00	3	9.30	11.00	4	4	2	2	2	4.0	Reconstruction by RSC/PRE	18.5	33,785,000
175	AB027	1/2M		RSJ/COR	4.40	1	9.70	9.80	3	4	3	-	3	4.0	Reconstruction by RCB	7.0	3,226,000
122	B 045	19/1K		ST.TR/T/RCS	18.50	1	3.68	9.20	2	4	1	-	1	4.0	Reconstruction by PSC/POS	14.0	16,391,000
129	B 127	2/7K	1900	ARCH/BR	4.60	1	5.25	9.20	-	4	3	-	3	4.0	Reconstruction by RCB	7.0	3,180,000
33	B 157	12/3K	1945	ST.TR/T/RCS RSJ/RCS	68.85	3	3.64	9.80	3	4	2	2	1	4.0	Reconstruction by St.BOX & PSC/PRE	28.0	252,563,000
18	B 158	16/7K	1935	RSJ/RCS	31.20	3	3.70	9.20	2	4	2	2	2	4.0	Reconstruction by PSC/PRE	18.5	34,829,000
72	B 248	9/4K		ST.TR/T/COR	12.10	1	4.30	9.20	2	4	2	-	2	4.0	Reconstruction by PSC/PRE	13.0	7,836,000
38	B 265	8/1K		RSJ/T	17.02	3	3.49	9.20	4	4	4	4	4	4.0	Reconstruction by PSC/POS	14.0	10,080,000
144	B 379	1/1K		RSJ/RCS	3.10	1	6.38	9.80	4	4	2	-	2	4.0	Reconstruction by RCB	7.0	2,275,000
31	B 114	3/3M		RSJ/RCS	12.38	2	3.45	9.20	2	4	2	4	3	4.0	Reconstruction by PSC/PRE	13.0	7,949,000
32	B 437	2/1K		RSJ/COR	10.20	1	3.70	9.20	3	2	4	-	2	4.0	Reconstruction by PSC/PRE	13.0	4,768,000
35	B 454	3/1K	1945	RSJ/RCS	22.30	5	3.30	9.20	2	2	4	4	4	4.0	Reconstruction by PSC/PRE	14.0	11,631,000
86	AA002	199/3K		PSC/PRE	7.40	1	9.80	-	2	3	4	-	2	4.0	Repair (patching for soffit of beam)	1.5	74,000
202	B 304	14/5K	1993	BAILEY	9.15	1	4.80	-	-	-	(4)	-	(4)	(4.0)	Repair (protection of abutment against scouring)	1.0	593,000
212	AA002	138/1K	1975	PSC/PRE	62.48	3	11.90	-	2	4	3	2	2	4.0	Repair (patching for soffit of beam, crack injection for super & substructure)	1.5	4,257,000
91	AA004	169/9K		RC/BOX	13.80	3	7.30	-	-	4	4	3	-	4.0	Repair (grouting and crack injection for main slab)	1.0	396,000
7	B 425	20/4K		PSC/PRE, RCB	139.18	18	6.85	-	1	4	3	1	4	4.0	Repair (prepacked concrete for RC-beam, patching for substructure, crack injection for super & substructure)	6.0	19,379,000
20	B 264	25/7K		RSJ/COR	14.35	2	4.29	7.00	3	4	2	1	2	4.0	Rehabilitation (redecking, replacement of damaged girder, widening of super & substructure)	9.0	3,778,000
150	B 444	4/5K		RSJ/COR	7.90	1	4.31	7.00	4	4	3	-	3	4.0	Rehabilitation (redecking, widening of super & substructure)	8.0	2,079,000
61	B 379	7/6K		BAILEY	33.50	1	4.75	-	(4)	(1)	-	-	-	(3.2)	Repair (redecking by steel plate)	2.0	1,057,000
62	B 423	29/3K		CAUSEWAY	15.02	4	3.66	9.20	-	4	3	2	-	4.0	Reconstruction	12.0	28,448,000
63	B 423	27/2K		CAUSEWAY	7.00	3	3.30	9.20	-	4	4	3	2	4.0	Reconstruction by PSC/PRE	10.0	23,390,000
68	B 164	1/5K		RSJ/BUC (+PSC/PRE)	46.90 50.60	4 5	4.55	5.00	3	3	4	3	3	4.0	Rehabilitation (redecking, widening of super & substructure, grouting for abutment)	9.0	10,029,000
128	B 097	15/4K	1915	ST.TR/T/RCS	14.67	1	3.09	-	4	3	4	-	3	4.0	Rehabilitation (redecking, repair of substructure)	5.0	1,417,000
208	B 172	10/4K		BAILEY	18.30	1	4.12	-	(3)	(1)	-	-	-	(2.4)	Repair (redecking by steel plate, mat gabion for scouring)	2.0	2,143,000
119	AB026	3/1K		ARCH/BR RSJ/	10.37	1	7.05	7.00	4	2	2	-	2	3.2	Reconstruction by PSC/PRE	13.0	8,292,000

(2/5)

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width Exist.	Overall Width Propd.	Damage Rating Deck	Damage Rating Main Frame	Damage Rating Abut.	Damage Rating Pier	Damage Rating Wing Wall	Damage Rating Overall	Rehabilitation Plans from Structural View Point	Work Period (month)	Construction Cost (SLR)
78	B 199	5/5K	1918	RSJ/BUC	124.40	12	4.52	7.40	4	3	2	1	2	3.2	Rehabilitation (redecking, widening of super & substructure)	15.5	34,708,000
80	AA003	96/7K	1898	ST.TR/T/COR	104.03	4	4.24	-	4	3	2	2	2	3.2	Rehabilitation (redecking, repair of main frame)	11.5	17,228,000
34	B 264	7/1K		ST.TR/T/COR	27.23	2	4.33	-	4	2	2	2	2	3.2	Rehabilitation (redecking, repair of main frame)	6.0	3,331,000
40	B 421	66/2K	1930	RSJ/BUC	21.00	2	4.70	7.00	4	3	2	2	2	3.2	Rehabilitation (redecking, widening of super & substructure)	9.0	5,527,000
42	B 464	5/1K	1904	ST.TR/T/COR	59.20	3	4.29	-	4	2	2	2	2	3.2	Rehabilitation (redecking, repair of main frame)	8.0	8,214,000
44	AA004	196/7K		RSJ/BUC	31.15	3	4.50	5.00	4	2	2	3	3	3.2	Reconstruction by PSC/PRE	18.0	29,931,000
87	AA002	256/1K		PSC/PRE	4.85	1	5.60	-	4	2	3	-	2	3.2	Repair (grouting for loose stone of abutment)	1.0	7,000
178	AA004	192/2K		ST.TR/D/COR	43.60	4	4.60	-	4	2	2	2	2	3.2	Rehabilitation (redecking, repair of main frame)	7.5	5,958,000
21	B 421	8/1K	1930	ST.TR/T/COR RSJ/BUC	26.22 10.50	1 1	4.22	-	4	2	2	2	2	3.2	Rehabilitation (redecking, repair of main frame)	8.0	4,880,000
24	B 454	19/2K		RSJ/T	13.60	2	3.06	5.00	4	2	2	3	2	3.2	Rehabilitation (redecking, widening of super & substructure)	8.0	1,177,000
55	B 093	8/10K		RSJ/BUC	20.90	2	4.50	5.00	4	2	1	1	1	3.2	Rehabilitation (redecking, widening of super & substructure)	6.0	2,346,000
56	B 093	3/7K		RSJ/BUC	10.10	1	4.57	5.00	4	2	1	-	1	3.2	Rehabilitation (redecking, widening of super & substructure)	5.0	1,057,000
74	B 466	6/5K	1940	RSJ/BUC	10.30	1	5.60	5.60	4	2	2	2	3	3.2	Rehabilitation (redecking, widening of substructure)	5.0	1,179,000
127	B 093	12/2K		RSJ/COR	10.20	1	4.25	4.50	4	2	3	-	1	3.2	Rehabilitation (redecking, widening of super & substructure)	5.0	1,053,000
133	B 188	5/2M		RSJ/BUC	9.00	1	3.60	5.00	4	1	1	-	1	3.2	Rehabilitation (redecking, widening of super & substructure)	6.5	1,593,000
27	AA002	87/1K	1898	ARCH/ST	35.20	3	7.60	9.80	-	1	2	3	3	3.0	Reconstruction by PSC/PRE	18.0	35,720,000
66	B 111	7/1K	1930	ST.TR/T/COR	36.80	2	5.50	-	2	3	2	2	1	3.0	Repair (main frame)	3.5	1,032,000
70	B 295	3/6K	1960	RSJ/RCS	43.23	5	5.93	7.50	2	2	3	2	2	3.0	Rehabilitation (redecking, widening of super & substructure)	10.0	5,407,000
75	AA002	62/2K	1932	ST.TR/T/RCS	40.50	1	5.68	-	3	3	2	-	3	3.0	Rehabilitation (redecking, repair of main frame)	7.5	6,199,000
108	AA033	5/3K		RSJ/BUC	5.70	1	3.70	7.50	3	3	2	-	2	3.0	Rehabilitation (redecking, widening of super & substructure)	5.5	1,421,000
120	AB029	12/2K		RSJ/RCS	4.25	1	7.03	7.50	3	3	2	-	2	3.0	Repair (recovering of main girder with RC)	3.0	927,000
197	B 288	10/3K	1918	ST.TR/T/DEC	52.80	2	5.48	-	2	3	2	2	2	3.0	Repair (main frame)	3.5	1,444,000
17	B 437	3/1K		RSJ/BUC	10.35	1	3.42	5.00	3	2	3	-	2	3.0	Rehabilitation (redecking, widening of super & substructure)	8.0	1,834,000

(3/5)

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width Exist.	Overall Width Propd.	Damage Rating Deck	Damage Rating Main Frame	Damage Rating Abut.	Damage Rating Pier	Damage Rating Wing Wall	Damage Rating Overall	Rehabilitation Plans from Structural View Point	Work Period (month)	Construction Cost (SLR)
47	AA007	70/8K	1918	ARCH/ST	14.57	1	6.30	7.50	-	2	3	-	1	3.0	Rehabilitation (widening of arch, repair of wing wall)	5.0	3,012,000
93	AA005	21/4K	1926	ST.TR/T/BUC	98.30	2	9.01	-	2	2	2	3	2	3.0	Repair (main frame)	5.0	2,808,000
102	AA010	25/2K	1920	RSJ/COR	17.20	2	5.54	7.50	3	3	2	2	2	3.0	Rehabilitation (redecking, widening of super & substructure)	12.0	3,456,000
123	B 079	23/2K		RCB	12.02	2	4.28	7.00	3	1	3	1	3	3.0	Rehabilitation (widening of super & substructure)	2.0	1,725,000
151	B 445	14/2K		RSJ/BUC	10.10	1	4.66	7.50	3	3	3	-	2	3.0	Rehabilitation (redecking, widening of super & substructure)	8.5	2,683,000
154	B 445	14/3K		RSJ/BUC	10.35	1	4.60	5.00	3	3	3	-	2	3.0	Rehabilitation (redecking, widening of super & substructure)	5.0	1,030,000
52	AA017	2/2K		RSJ/COR	10.50	1	4.30	7.50	3	3	1	-	1	3.0	Reconstruction by PSC/PRE	13.0	4,833,000
65	AA011	24/3K	1967	RSJ/RCS	9.70	1	5.65	7.50	2	3	2	-	2	3.0	Rehabilitation (redecking, widening of super & substructure)	8.5	2,577,000
77	AA019	3/2K	1869	RSJ/BUC ST.TR/T/COR	79.66 39.22	8 2	5.66	9.20	3 3	3 3	2 -	2 2	3 -	3.0	Reconstruction by PSC/POS & PSC/PRE	30.0	121,239,000
89	AA004	163/9K		RSJ/COR	4.80	1	4.22	7.50	3	2	3	-	3	3.0	Rehabilitation (redecking, widening of super & substructure)	7.5	1,354,000
147	B 419	6/2K		RSJ/BUC	9.84	1	4.68	7.00	2	3	3	-	2	3.0	Rehabilitation (redecking, widening of super & substructure)	8.0	2,212,000
148	B 419	24/2K		RSJ/BUC	8.40	1	3.60	7.00	3	3	3	-	2	3.0	Reconstruction by PSC/PRE	8.0	5,696,000
173	B 304	17/1K	1940	RSJ/BUC	6.80	1	5.70	7.00	2	3	3	-	2	3.0	Rehabilitation (redecking, widening of super & substructure)	7.5	1,471,000
209	B 146	21/1K	1861	ARCH/ST RSJ/COR	4.40	1	7.26	-	3	3	2	-	2	3.0	Rehabilitation (redecking)	4.5	372,000
19	B 207	10/3K	1890	ST.TR/T/COR	32.38	1	4.28	-	2	3	3	-	3	3.0	Repair (main frame)	3.5	920,000
26	B 462	10/1K		ST.TR/T/COR	19.00	1	4.26	-	3	2	2	-	1	3.0	Rehabilitation (redecking, rapair of main frame)	5.5	2,258,000
30	B 014	8/1K		RSJ/COR	20.70	2	5.60	7.00	3	3	2	3	3	3.0	Rehabilitation (redecking) Repair (crack injection for abutment)	6.0	2,881,000
39	B 349	30/2K	1927	RSJ/COR	23.10	3	3.87	7.00	2	3	2	2	2	3.0	Rehabilitation (redecking, widening of super & substructure)	9.0	4,135,000
57	B 116	2/2K		RSJ/BUC	9.20	1	5.65	7.10	3	3	2	-	2	3.0	Rehabilitation (redecking, widening of super & substructure)	5.0	1,954,000
131	B 127	1/2K	1900	RSJ/COR	4.73	1	4.27	7.00	2	3	2	-	2	3.0	Reconstruction by RCB	5.0	2,466,000
135	B 249	5/9K		RSJ/BUC	9.30	1	4.60	5.00	3	3	3	-	3	3.0	Rehabilitation (redecking, widening of superstructure)	5.0	972,000

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width Exist.	Overall Width Propd.	Damage Rating Deck	Damage Rating Main Frame	Damage Rating Abut.	Damage Rating Pier	Damage Rating Wing Wall	Damage Rating Overall	Rehabilitation Plans from Structural View Point	Work Period (month)	Construction Cost (SLR)
136	B 272	15/2K		RSJ/DEC	30.50	5	4.28	7.00	1	2	3	2	3	3.0	Rehabilitation (widening of super & substructure)	8.5	3,821,000
25	B 454	6/6K		RSJ/RCS	24.20	4	3.28	5.00	2	2	2	3	2	3.0	Reconstruction by PSC/PRE	9.0	14,157,000
41	B 454	15/3K	1924	RCS	10.30	2	3.63	-	-	2	3	2	3	3.0	Repair (hand rail)	1.0	100,000
67	B 157	23/2K	1960	RSJ/BUC	19.10	4	3.34	5.00	2	2	3	2	2	3.0	Rehabilitation (redecking, widening of super & substructure)	9.0	5,242,000
69	B 188	5/4K		ST.TR/T/RCS	12.60	1	3.06	-	1	3	2	-	-	3.0	Repair (main frame)	2.5	338,000
76	AA002	62/1K	1929	ST.TR/T/RCS	90.90	2	6.25	-	2	2	2	2	2	2.0	Repair (main frame)	4.5	2,583,000
79	AA003	43/1K	1918	ST.TR/T/COR	69.20	3	5.18	-	2	2	2	1	3	2.0	Repair (main frame)	3.5	1,954,000
84	AA001	110/2K	1933	ARCH/S	68.30	3	7.80	-	3	1	1	1	1	2.4	Rehabilitation (redecking)	12.0	6,482,000
85	AA001	91/2K	1894	ARCH/BR	68.90	4	7.50	-	-	2	2	2	1	2.0	Rehabilitation (additional footway, widening of super & substructure)	12.0	5,492,000
99	AA009	5/1K	1860	ST.TR/D/COR	124.80	6	10.30	-	3	2	2	2	3	2.4	Rehabilitation (redecking, repair of main frame)	12.0	16,629,000
195	B 288	10/2K		RSJ/COR	5.50	1	6.06	7.50	-	2	1	-	1	2.0	Rehabilitation (redecking, widening of super & substructure)	7.5	1,462,000
201	B 288	10/5K		ARCH/CO	7.20	2	8.06	-	-	1	2	-	2	2.0	Repair (grouting for wing wall)	1.0	7,000
36	AA010	48/1K		RSJ/COR	31.12	3	5.52	7.50	2	2	2	1	2	2.0	Reconstruction by PSC/PRE	18.0	31,579,000
138	B 304	25/3K		RSJ/BUC	10.30	1	5.47	7.00	3	2	2	-	2	2.4	Rehabilitation (redecking, widening of super & substructure)	8.0	2,711,000
211	B 146	8/3K	1942	RSJ/RCS	23.60	3	3.83	7.00	2	2	2	1	1	2.0	Rehabilitation (redecking, widening of super & substructure)	9.0	17,423,000
210	B 146	6/3K		RSJ/RCS	23.70	3	4.20	7.00	1	2	1	1	2	2.0	Rehabilitation (redecking, widening of super & substructure)	9.0	7,615,000
2	AA010	75/1K		RSJ/COR	122.60	12	5.55	7.50	2	2	1	1	2	2.0	Rehabilitation (redecking, widening of super & substructure)	17.0	35,803,000
43	AA004	206/9K		ARCH/BR	39.40	3	4.70	-	-	2	2	1	2	2.0	Repair (cleaning & grouting)	1.0	100,000
45	AA004	209/1K		ARCH/CO	28.40	2	4.25	-	-	2	1	1	2	2.0	Repair (cleaning & grouting)	1.0	100,000
58	B 157	44/3K	1930	RSJ/RCS (covered with concrete)	10.35	1	3.96	5.00	2	2	2	(4)	-	2.0	Reconstruction by PSC/PRE	15.0	24,015,000
59	B 157	43/4K	1924	RSJ/BUC	51.00	5	3.56	5.00	2	2	2	2	2	2.0	Rehabilitation (redecking, widening of super & substructure)	9.0	7,607,000
103	AA012	16/1K	1970	RCS	6.64	1	6.64	-	-	-	2	-	2	2.0	-	-	-
130	B 127	7/1K	1917	ST.TR/T/COR	24.73	1	4.54	-	1	2	1	-	2	2.0	Repair (main frame)	3.0	679,000
53	AA021	36/3K	1899	ST.TR/T/RCS	39.95	1	3.65	-	1	2	1	-	1	2.0	Repair (main frame)	3.5	1,148,000
60	B 300	15/6K	1933	CAUSEWAY	7.87	3	4.60	9.20	-	2	1	1	2	2.0	Reconstruction by PSC/PRE	9.0	19,365,000
46	AA007	73/5K		ARCH/ST	11.70	1	5.80	7.50	-	1	1	-	1	1.0	Rehabilitation (widening)	6.0	1,085,000

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width Exist.	Overall Width Propd.	Damage Rating Deck	Damage Rating Main Frame	Damage Rating Abut.	Damage Rating Pier	Damage Rating Wing Wall	Damage Rating Overall	Rehabilitation Plans from Structural View Point	Work Period (month)	Construction Cost (SLR)
106	AA026	69/1K		RSJ/RCS	16.30	2	4.70	7.50	2	1	1	1	1	1.6	Rehabilitation (redecking, widening of superstructure)	9.0	785,000
22	B 431	2/3K	1978	BAILEY	162.30	5	4.17	-	(2)	(1)	(1)	(1)	-	(1.6)	-	-	-
71	B 227	1/5M	1994	PSC/PRE	16.20	1	5.98	-	1	1	1	-	1	1.0	-	-	-
73	B 423	44/3K		RCS	7.60	2	4.00	-	1	-	1	1	3	1.5	Repair (grouting for substructure)	1.0	7,000
															Total		1,044,361,000

Table 18.3 Financial (Project) Cost of Rehabilitation for the 100 Bridges (Unit : Rs)

		1st Priority				2nd Priority		Others		Total	
		Reconst		Repair & Reinforcement							
RSJ/BUC RSJ/COR RSJ/RCS RSJ/DEC	RSJ/T l= 3.7m ~ l= 10.5m	9	97.335.000	7	75.970.000	22	94.357.000	16	212.442.000	54	480.104.000
ST.TR/T/RCS ST.TR/T/DEC ST.TR/T/COR ST.TR/D/COR ST.TR.T.BUC	l= 9.3m ~ l= 51.0m	3	360.381.000	5	35.571.000	9	218.210.000	5	6.957.000	22	621.119.000
ARCH/S	[l= 22.8m]	-		-		1	8.440.000	-		1	8.440.000
BAILEY	l= 18.3m ~ l= 33.5m	-		3	4.938.000	-		1		4	4.938.000
RCB RCS RC/BOX	l= 3.8m ~ l= 9.7m	1	43.988.000	2	516.000	1	2.246.000	3	139.000	7	46.889.000
PSC/PRE PSC/POS	l= 4.9m ~ l= 16.2m	-		4	30.870.000	1	9.000	1		6	30.879.000
CAUSEWAY	l= 2.6m ~ l= 3.7m	2	67.493.000	-		-		1	25.213.000	3	92.706.000
ARCH/BR ARCH/CO ARCH/STO	l= 3.6m ~ l= 17.2m	3	61.444.000	-		4	11.566.000	3	1.673.000	10	74.683.000
Total nos. of bridge types (Total nos. of bridges) FINANCIAL COST		18(16)	630.641.000	21(19)	147.865.000	38(35)	334.828.000	30	246.424.000	107(100)	1.359.758.000

18.5 Economic Cost

Economic cost of the project in recent studies conducted in Sri Lanka can be shown in terms of percent of the financial cost. However, they have not explored in detail to arrive at the percentages. As shown in Table 18.4 the percentages vary in 83 - 89% for the total cost of the project while they are in 76 - 80% if the share in the cost of structure and bridges are taken up. Taxation system is complex in Sri Lanka where additions of turnover tax and defense levy have been implemented beside customs and excise duties and other charges. In 1994 the defense levy increased from 3.5 to 4.5% on the CIF. Detailed analysis need be conducted in the stage of detailed engineering study.

Table 18.4 Economic Cost in Percentage

Project Name	Total in project	Bridge & Struct.
1. Pref-feasibility study of Outer Ring Road to City of Colombo with a Link to Ratnapura (Consulting Engineers & Architect Ass. October, 1993)	83%	76%
2. Review study of the Previous Feasibility Study of Colombo-Katunayake Expressway Construction (JBSI, NK, KK and Acer, October, 1991)	84%	78%
3. Base Line Road Feasibility Study (WS Watkins Int. February, 1991)	89%	80%

When the project is formulated by bridges and structures such as this master plan study, the transfer elements of such taxes and charges will be higher than common road projects since bridge project depend much on imported machines. It is determined to calculate the economic cost by multiplying 76% of the financial cost.

$$\text{Economic Cost of Bridge Project} = \text{Financial Cost of Project} \times 0.76$$

CHAPTER 19 ECONOMIC EVALUATION

19.1 General

As discussed in previous chapters, this master plan study will present rehabilitation programs for 100 bridges which are selected through discussions with RDA. They have been inspected and studied from viewpoints of physical conditions, traffic volumes, functional category of the road and so on. Various comparative ratings were conducted, resulting in the classification of 3 groups in the order of priority to be realized in 15 years up to 2010. Economic evaluation is conducted for rehabilitation plan of each bridge, where the plan was determined by technical studies including field inspection.

It is noted that the economic assessment of a road improvement project is a combination of various sub-projects; some are worthy for individual evaluation while others are not since there are complexities in measuring the benefit to be taken into cost benefit streams. Specifically, the traffic flow and associated VOC are measured for a section of road, 5 km, 30km, 100 km etc. in which a number of sub-projects are integrated to materialize the benefit. Savings in VOC are normally measured not on s spot but by traveling a certain length of roads. The road in which the bridge is located is not subject of this study, but it would be better if the bridge can be assessed with feasibility of the road.

Without knowing overall road development plan, the 3 groupings shown in Table 7.2 is considered appropriate since it has considered in traffic and its growth on the major network of roads together with bridge's technical assessment. Economic and population development forecast was taken in although no road development master plan is determined yet. With this understanding the result of economic evaluation for each bridge will not be used to alter the 3 grouping, but may present minor revisions and recommendations if necessary.

Economic benefit is measured by two elements; one is the savings in VOC enumerated by 'with and without' the rehabilitation and the other is assumed probability of bridge deterioration in the future years. The economic evaluation for each group is calculated also in 19.3. A discussion for financial problems of the cost scale of this bridge master plan is shown in 19.4.

19.2 Economic Benefits and Vehicle Operation Cost

19.2.1 Economic Benefits

Economic benefits are discussed commonly in various project evaluation. It should be emphasized that there are quantitative and qualitative benefits. The former is in 19.2.2 and the latter of qualitative ones is noted as under:

a. Socio-economic benefits

Better services will be realized to the community in such manners as efficient administrative functions, cultural and educational services, health and welfare matters, etc.

b. Disbenefits

Noise, air pollution and accidents are examples of disbenefits which should be minimized with the improvement of roads and bridges.

c. Savings in Passenger Time

Time savings in transport sector are quantified in some cases while in other cases they are not taken in cost benefit assessment. In Sri Lanka the economy along inter city roads are predominantly in agriculture in which savings in time is considered better not included in the benefit stream. Activities are different from urban lives. The situation that data related to the time evaluation is scarce is another reason.

19.2.2 Vehicle Operation Cost

Benefits in the economic evaluation of road projects are normally quantified by estimating savings in the vehicle operation cost (VOC), which are thought to be realized by road improvements. VOC has been estimated in recent feasibility studies in Sri Lanka such as Transport Sector Planning Study of 1988, Base Line Road Feasibility of 1991, Pre-feasibility Study of Outer Ring Road to Colombo with a Road Link to Ratnapura of 1993 and others.

In similar manner to those studies, it is necessary to update VOC in 1995 prices in this Bridge Development Master Plan Study. Updating is conducted by reviewing those recent studies and by studying prices in market and tax-duty elements in May-

June in 1995. The results are shown in economic cost of travel assuming good/fair conditions on surfaced roads in terms of Rs. per 1000 km for representative vehicle types as in Table 19.1, while Tables.1 ...8 in Appendix T present the calculation process of unit VOC components.

Table 19.1 VOC Summary, 1995

(Economic Cost, Rs/1000Km)

	M/C Trishow	Car 1300CC	Pickup D Cab	Mini Bus 16 Seats	Med Bus 26 Seats	Large Bus 50 Seats	Truck 6t 2 axles	Truck 12t 3 axles
Fuel	296	896	1054	1265	1581	2846	2951	3689
Oil	7	20	28	40	80	160	1600	200
Tyres	99	297	270	270	1320	1546	1187	1979
Dep	3541	10625	5425	4677	3707	3422	2455	3685
Repair La	200	600	600	750	900	1500	1200	1200
Repair pa	118	354	400	267	423	9125	7856	12283
Crew W	-	-	120	113	83	75	90	75
Overhead	-	-	400	250	167	250	333	333
Total (1)	4261	12792	8297	7632	8261	18924	17672	23444

19.3. Economic Evaluation

19.3.1 Traffic Growth

Traffic growth was forecast for major classes of roads in the previous chapters 2 and 3 in which it was determined the traffic volumes in general will grow about 1.3 times every 5 years; i.e. the annual rate of 5.7%. It showed the growth trends will be different among the roads, but the ranges of variation will be moderate. In the case of bridge study, however, the traffic volumes on bridges differ generally from the traffic count stations since they are not on the same site even on the same section. In the case of traffic flow simulation the calculated link volumes are different from the actual volumes on bridges since the simulated link volumes do not include local trips and intra- zonal short distance trips, while the bridge traffic does.

Accordingly, the counted traffic data in the RDA filing at a point close to the bridge is thought to represent the traffic on each bridge subject under the study while the timing is adjusted to 1995 by using the 5.7% rate. Traffic in the future years are estimated by using this annual growth rate for bridges and vehicle types. When the estimated volume in the future years exceeds 5000 vehicles per day, the rate is reduced to 4.7% since the rate tapers off when the volume becomes larger. The 5000 volume is the approximated minimum level of full daily capacity of 2-lane roads.

19.3.2 Vehicle Type Composition

Traffic count data filed in RDA were reviewed to find if there are different percent compositions by roads. It can be grouped into two; one by roads of A01 - A04 classes and another on other roads. The difference is larger between the two groups on percentages of small vehicles and motor cycles as below, the first group has the larger percent in small cars, while the latter has a larger percent in motor cycles. Those percentages are used according to the classification of the road on which the bridge is located.

	Motor cycles	Small cars	Pickup trucks	Medium trucks	Heavy trucks	Buses	Mc/Mi buses	Total
A01-04	18	22	20	17	1	11	11	100
Others	30	13	19	18	0	10	10	100

(In percentages)

19.3.3 Large Truck Conversion

When a bridge is strengthened its loading capacity, it may be possible heavy/large trucks can pass through, resulting in savings in transport cost per unit of cargo compared to the case where transport is constrained to medium trucks and smaller vehicles. As in the above percent figures the share by heavy trucks (3 or 4 axles) are in very small percent, and savings estimated by conversion of medium to heavy trucks are marginal and considered not necessary be included in this evaluation. Percentages of medium and heavy trucks are not altered 'with and without project'.

19.3.4 Widening

It is common the traffic in one direction on the one lane bridge need to stop letting the traffic on another direction to pass through. When the existing one lane bridge is replaced or reinforced to have an eventual 2-lane width of 5m or more, traffic will be benefited by smooth movement with no need of waiting and queuing. The benefit is measured by savings in VOC where the road length of 100m both sides and the bridge length is taken on which the balance of VOC with and without is calculated. The 'VOCs without' are assumed higher by 30% because of inferior road conditions, while 'those with' are tabulated by using the figures in Table 19.1.

19.3.5 Project Cost

The economic project cost is estimated in the chapter 18 by referring to recent feasibility studies in Sri Lanka such as "Base Line Road Feasibility Study (WS Watkins Int. February, 1991), Pre-Feasibility Study of Outer Ring Road to City of Colombo with Road Link to Ratnapura and others (Consulting Engineers and Architects Ass (October, 1993)) and others. A 76% is applied to estimate the economic cost from the financial cost.

19.3.6 Project Benefits

Major components of economic benefits generated by a bridge project is quantified by savings in VOC, where VOC includes no time values of passengers, being shown in Table 19.1 of this chapter. 'VOC without project' is estimated by traffic assuming to run on the detour alternate route during the months of rehabilitation since the damaged bridge would prevent traffic passing, while 'VOC with' is the cost of travel assuming the bridge is rehabilitated. Probability of bridge damages are calculated assuming statistical parameters in the followings in the similar way by referring to studies in Malaysia and others.

19.3.7 Bridge Deterioration

(1) Bridge Unusable Probabilities

A few records are found of bridge history such as year of construction, improvement, design documents, material data, etc. In order to estimate the probable deterioration of each bridge in the future the following statistical analysis is adopted. The analysis was used in other studies by JICA such as 'Feasibility Study on Rehabilitation and Maintenance of Bridges along Arterial Roads (JICA, 1989). The statistical aspects in the following has referred to that study.

Although the oldest year of construction recorded on the bridge or documents was 1932, it is said there are many bridges constructed older than 1932. Majority are thought to have some type of rehabilitation work in the past. The critical point is when the bridge will disrupt the traffic flow, but the answer is hard to know if the bridge history is not filed properly and a statistical theoretical approach is used with parameters attached below. The paper 'Statistical Analysis of Bridge Life' (H. IIZUKA, JSCE 1988) was issued which made a survey of 4377 bridges in Niigata Prefecture of Japan from which the original type of damage probability function was quoted in those bridge studies. The distribution of unserviceability probability distribution function was found close to the normal probability function.

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

$$f(t) = \frac{1}{(2*pie)^\wedge 2 * S}\ E^{-(t-m)^\wedge 2\ /\ 2*S^\wedge 2} \quad = \quad N\{50,\ 16.7^\wedge 2\}$$

where t: bridge's life 1.....100 years
m averaged bridge life, = 50 years
e natural logarithm = 2.71828
S standard deviation = 16.7

(2) Revised Unserviceable Probability Function

Probability function of traffic disruption can be shown with theoretical parameters, while in reality actual disruptions by bridge damages happen unexpectedly and at random resulting in different types of damage and different year. Damages are categorized into 3 types each having its own probability function of traffic disruption, assuming to have a range of 100 years, with the mean of 50 years. The rehabilitation types responding to the extent of each damage is shown below.

(a) Without rehabilitation

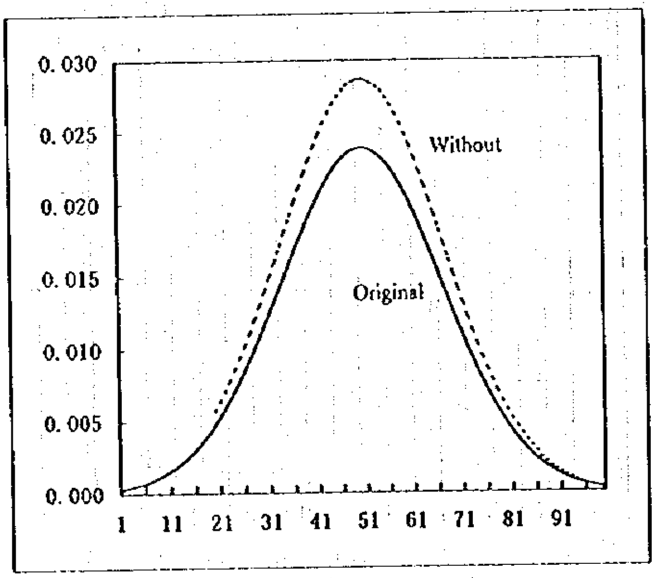
No rehabilitation is assumed, but the probability in the past years were not realized eventually which in turn would increase the probabilities of disruption in the remaining life period. Based on this concept the function is revised to have larger probabilities in the remaining years of life, being shown in Figure 19.1. They are used by the case 'without Project'.

$$f0(t) = N\{50,\ 16.7^{\wedge}2\}$$

$$f1(t) = k1 * f0(t) \qquad (n < t)$$

where $k1 = 1/(1.0 - F0(t < n))$

$$F0(t < n) = \int_0^n f0(t)\,dt$$



In Fig. 19.1 the normal distribution curve of bridge damage over 100 years with a mean of 50 years is shown above———. A bridge subject under this study has some years history in service without damage, though the probability of damage can be calculated but neglected because no damage record is found. The neglected probability of damage in the past, however, may shift to the future years increasing the damage possibilities in the remaining life years. This assumed probability curve is ---------- above, which is named the function of 'without project'. The curve without project is shown in column 'without project' in following tables and Figs, to which a curve of repair, reinforcement, and reconstruction can be compared to estimate the reduced damage possibility and benefits.

Figure 19.1 Normal Probability Function in Bridge Study

(b) Repairing

It means protective and periodic maintenance works such as painting, patching, fence mending, etc. This would keep the values of probability in constant over 5 years after the work is finished and the revised curve will shift toward right accordingly.

$$f2(t) = k2 * f1(n) \qquad (n < t < n+5)$$
$$f2(t) = k2 * f1(t-5) \qquad (n+5 < t)$$
$$\text{where } k2 = 1/(5 * f1(n) + F1(t > n))$$
$$F1(n < t) = \int_0^{\infty} f1(t)\,dt$$

(c) Reinforcement

This type covers various technical approaches. It would increase the traffic capacity and loading capability of trucks, adding foot paths, fences, lighting, etc. It will extend the remaining life of the bridge, which is calculated by assuming less probabilities in those years. In this sense the probabilities are assumed to go down by 20%. (i.e. 16.7 / 0.8 = 20.9).

$$f3(t) = N\{50,\ 20.9\text{^}2\}$$
$$f4(t) = k4 * f3(n3) \qquad (n < t < n+5)$$
$$f4(t) = k4 * f3(t-5-(n-n3)) \qquad (n+5 < t)$$
$$\text{where } k4 = 1/(5 * f3(n3) + F3(t > n3))$$

(d) Reconstruction

The existing bridge should be demolished because of its deterioration degree demonstrates the end of usable life. New bridge should be built at the same site of the demolishable bridge. The same probabilities' function from year 1 to 20 will be redrawn after the construction. The age is zero when it is constructed.

$$f5(t) = f0(t-n) = N\{50+n,\ 16.7\text{^}2\}$$

(e) Balances

The balance a-b, a-c, and a-d, respectively, will be the element of economic savings since the balance will be realized by lowering the probabilities after rehabilitation, and the balance accumulated for 20 years are used for calculation of the benefit stream.

(3) Probability Density Function of Bridge Damage after Rehabilitation

Figure 19.2 and Table 19.2 present the probabilities of bridge damage for assumed ages 30 to understand by scheme. Age 30 means the bridge will have 20 years remaining. Figure 19.3 and Tables 19.3. present the similar concept in scheme for group 1, group 2 and group 3. The age 45 is calculated to have only 5 years remaining to be applicable for the priority group 1, the age 40 group is for the group 2 and the age 35 is for the group 35.

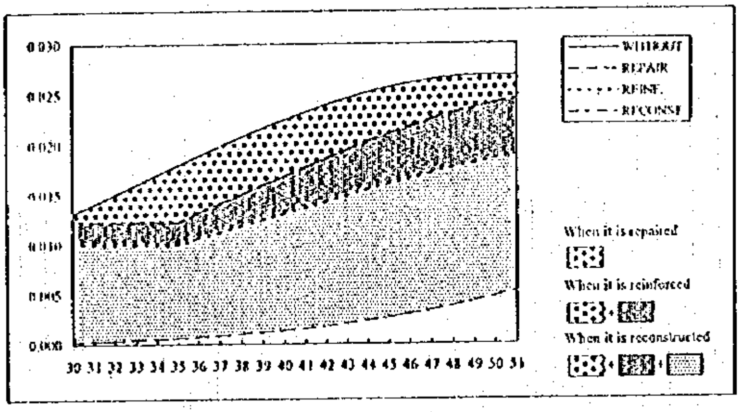


Figure 19.2. Probability Functions for Comparison of Reduced Damages

Table 19.2 Probability Function for Comparison of Reduced Damages

PHYSICAL AGE 30

	ORIGINAL (1)	WITHOUT (2)	REPAIR (3)	REINF. (4)	RECONST. (5)
30	0.01166	0.01312	0.01234	0.01001	0.00027
31	0.01251	0.01407	0.01234	0.01001	0.00032
32	0.01336	0.01503	0.01234	0.01001	0.00038
33	0.01423	0.01601	0.01234	0.01001	0.00046
34	0.01510	0.01698	0.01234	0.01001	0.00054
35	0.01596	0.01795	0.01234	0.01001	0.00063
36	0.01681	0.01891	0.01323	0.01060	0.00074
37	0.01764	0.01985	0.01414	0.01119	0.00087
38	0.01845	0.02076	0.01505	0.01180	0.00101
39	0.01923	0.02163	0.01597	0.01241	0.00117
40	0.01997	0.02246	0.01688	0.01302	0.00136
41	0.02066	0.02324	0.01778	0.01362	0.00156
42	0.02130	0.02396	0.01867	0.01423	0.00179
43	0.02188	0.02461	0.01952	0.01482	0.00205
44	0.02240	0.02519	0.02034	0.01541	0.00234
45	0.02284	0.02569	0.02112	0.01598	0.00266
46	0.02321	0.02611	0.02185	0.01654	0.00301
47	0.02351	0.02644	0.02253	0.01707	0.00339
48	0.02372	0.02668	0.02315	0.01759	0.00381
49	0.02385	0.02682	0.02369	0.01807	0.00427
50	0.02389	0.02687	0.02416	0.01853	0.00476
51	0.02385	0.02682	0.02456	0.01896	0.00529

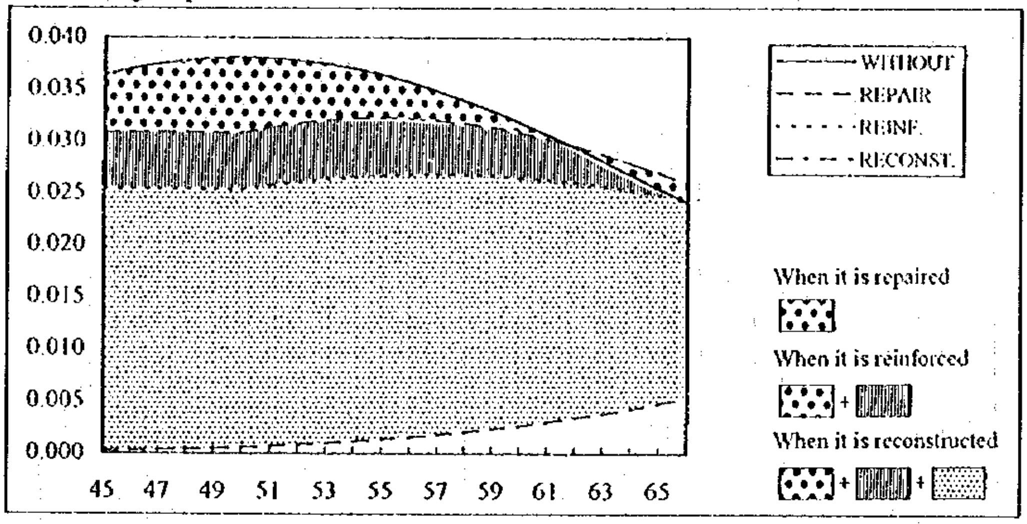
age2030

An example of damage probability for a bridge with assumed age of 30 years is shown. The age 30 means the remaining years are 20 since all are assumed to have 50 year life. Four curves are drawn each responding to a rehabilitation category. Reduced probability of damage is shown by shaded areas:

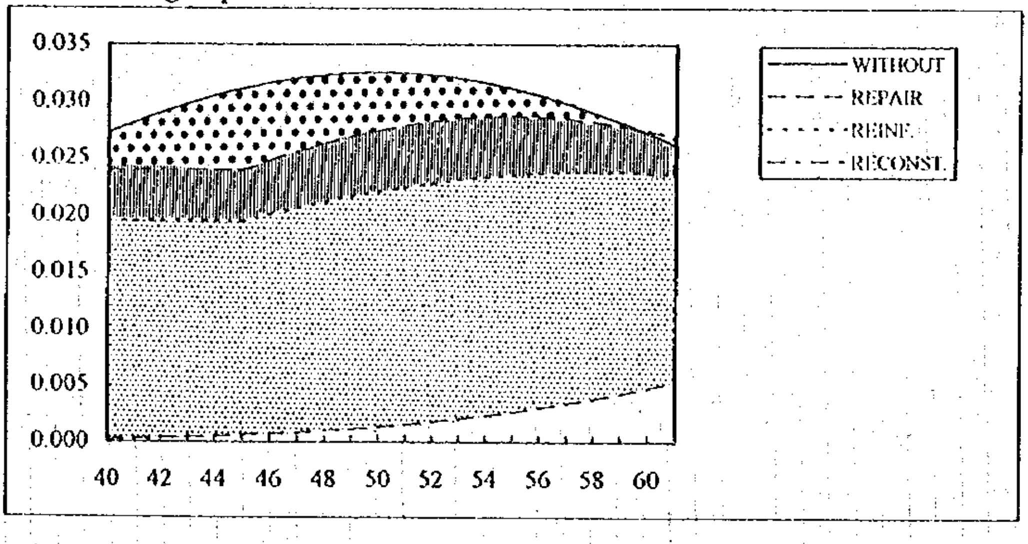
- When it is repaired
- When it is reinforced
- When it is reconstructed

The following Tables and Figs 19.3. are for age 5, age10 and age 15. The balance between each category of rehabilitation and 'without', combination of shaded areas, is the factor of economic benefit supposed to be realized

The first group



The second group



The third group

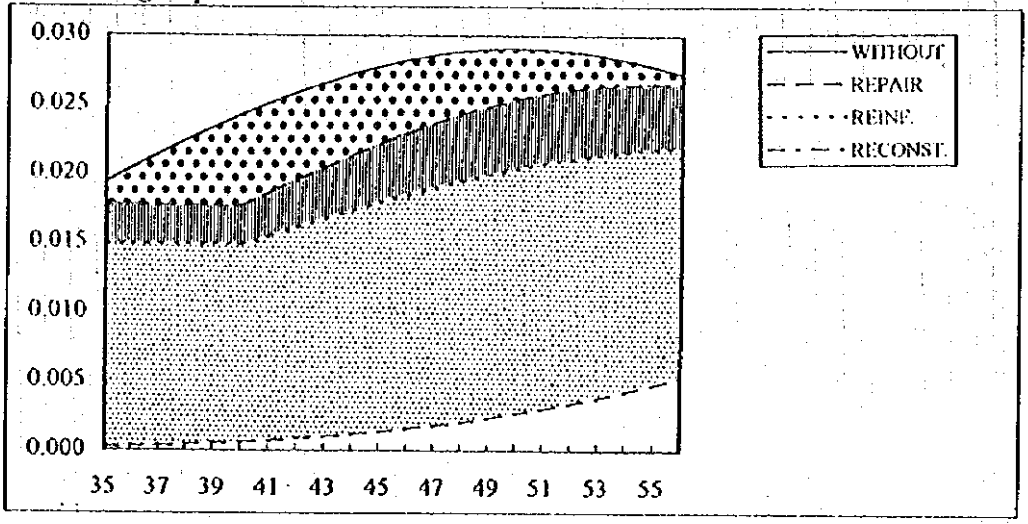


Figure 19.3 Probability Functions of Bridge Damage and Rehabilitations

Table 19.3 Probability Functions of Bridge Damage and Rehabilitations

PHYSICAL AGE 45

	ORIGINAL -1	WITHOUT -2	PROTECT -3	REINF. -4	RECONST. -5
45	0.02284	0.03638	0.03086	0.02536	0.00027
46	0.02321	0.03697	0.03086	0.02536	0.00032
47	0.02351	0.03744	0.03086	0.02536	0.00038
48	0.02372	0.03778	0.03086	0.02536	0.00046
49	0.02385	0.03798	0.03086	0.02536	0.00054
50	0.02389	0.03805	0.03086	0.02536	0.00063
51	0.02385	0.03798	0.03137	0.02574	0.00074
52	0.02372	0.03778	0.03176	0.02607	0.00087
53	0.02351	0.03744	0.03205	0.02634	0.00101
54	0.02321	0.03697	0.03222	0.02655	0.00117
55	0.02284	0.03638	0.03228	0.02671	0.00136
56	0.02240	0.03567	0.03222	0.02680	0.00156
57	0.02188	0.03485	0.03205	0.02683	0.00179
58	0.02130	0.03393	0.03176	0.02680	0.00205
59	0.02066	0.03291	0.03137	0.02671	0.00234
60	0.01997	0.03180	0.03086	0.02656	0.00266
61	0.01923	0.03063	0.03026	0.02635	0.00301
62	0.01845	0.02939	0.02956	0.02608	0.00339
63	0.01764	0.02810	0.02878	0.02575	0.00381
64	0.01681	0.02678	0.02792	0.02537	0.00427
65	0.01596	0.02542	0.02698	0.02494	0.00476
66	0.01510	0.02405	0.02598	0.02446	0.00529

PHYSICAL AGE 40

	ORIGINAL -1	WITHOUT -2	REPAIR -3	REINF. -4	RECONST. -5
40	0.019967898	0.027203245	0.024002879	0.019526227	0.000270186
41	0.020659794	0.028145849	0.024002879	0.019526227	0.000322660
42	0.021299156	0.029016883	0.024002879	0.019526227	0.000383946
43	0.021879711	0.029807802	0.024002879	0.019526227	0.000455238
44	0.022395643	0.030510682	0.024002879	0.019526227	0.000537836
45	0.022841693	0.031118356	0.024002879	0.019526227	0.000633145
46	0.023213242	0.031624536	0.024834589	0.020104067	0.000742677
47	0.023506398	0.032023917	0.025603149	0.020651561	0.000868039
48	0.023718059	0.032312273	0.026301019	0.021165339	0.001010930
49	0.023845969	0.032486532	0.026921208	0.021642176	0.001173130
50	0.023888759	0.032544826	0.027457391	0.022079031	0.001356481
51	0.023845969	0.032486532	0.027904021	0.022473074	0.001562874
52	0.023718059	0.032312273	0.028256416	0.022821717	0.001794226
53	0.023506398	0.032023917	0.028510848	0.023122646	0.002052452
54	0.023213242	0.031624536	0.028664506	0.023373843	0.002339439
55	0.022841693	0.031118356	0.028716042	0.02357361	0.002657031
56	0.022395643	0.030510682	0.028664606	0.023720587	0.00300689
57	0.021879711	0.029807802	0.028510848	0.02381377	0.003390663
58	0.021299156	0.029016883	0.028256416	0.023852519	0.003809732
59	0.020659794	0.028145849	0.027904021	0.023836568	0.004265274
60	0.019967898	0.027203245	0.027457391	0.023766026	0.004758196
61	0.019230097	0.026198103	0.026921208	0.023641378	0.005289084

PHYSICAL AGE 35

	ORIGINAL -1	WITHOUT -2	REPAIR -3	REINF. -4	RECONST. -5
35	0.015959	0.019412	0.01773323	0.01489094	0.00027019
36	0.016811	0.020448	0.01773323	0.01489094	0.00032266
37	0.017644	0.021462	0.01773323	0.01489094	0.00038395
38	0.018453	0.022446	0.01773323	0.01489094	0.00045524
39	0.01923	0.023391	0.01773323	0.01489094	0.00053784
40	0.019968	0.024288	0.01773323	0.01489094	0.00063315
41	0.02066	0.02513	0.0186796	0.01552337	0.00074268
42	0.021299	0.025907	0.01960605	0.01614555	0.00086804
43	0.02188	0.026614	0.0205048	0.01675419	0.00101093
44	0.022396	0.027241	0.02136799	0.01734591	0.00117313
45	0.022842	0.027784	0.02218781	0.01791738	0.00135648
46	0.023213	0.028235	0.02295663	0.01846524	0.00156287
47	0.023506	0.028592	0.02366707	0.01898624	0.00179423
48	0.023718	0.02885	0.02431217	0.01947719	0.00205245
49	0.023846	0.029005	0.02488546	0.01993503	0.00233944
50	0.023889	0.029057	0.0253811	0.02035687	0.00265701
51	0.023846	0.029005	0.02579395	0.02073999	0.00300689
52	0.023718	0.02885	0.0261197	0.02108188	0.00339066
53	0.023506	0.028592	0.02635489	0.02138029	0.00380973
54	0.023213	0.028236	0.02649702	0.02163322	0.00426527
55	0.022842	0.027784	0.02654457	0.02183896	0.0047582
56	0.022396	0.027241	0.02649702	0.02199613	0.00528908

19.3.8 Economic Evaluation

(1) Conditions

The economic cost of rehabilitation and its expenditure in years were studied by engineering studies in the previous chapters. It approximated the months of work and preparations where the latter include months for engineering, budgetary allocations and bidding procedures, etc.

Annual maintenance cost is assessed at 1 % of the project cost and the same amount is posted for 20 years.

Benefit is estimated by normal ways of comparing vehicle travel costs with and without project for 20 years. However, this bridge study use the probability functions of bridge damage, and savings in vehicle travel cost during the months of rehabilitation period are taken in the calculation. The savings in vehicle travel cost is calculated by selecting an alternate detour route for every bridge and the unit VOCs on the detour route are thought to be higher by 30%, which is compared to the cost of the normal rout after the rehabilitation. The balance is the benefit which is forecast to grow at a rate of 5.7% per annum, while the rate is lowered to 4.7% if the traffic volume exceeds ADT 5,000 on the bridge. If the bridge is widened from a one lane to a practical two lane width, additional benefits generated by smooth flow is calculated and added. But there are some with modest traffic volume which are planned not to have 2 lanes, the widening benefit is not included.

(2) Results

Results of the calculation are summarized in Table 19.4 . Each group showed justifiable return figures. The calculation of each bridge is in Appendix U. There are some bridges with lower return values even in the first priority group. Main reasons are high cost caused by difficult natural conditions, small traffic, etc. However, it is concluded those are in minor numbers and there would be no need of re-organize the groupings.

Table 19.4 Summary of Economic Evaluation

Group	Nos. of Bridges	Tot. Fin. Cost Rs million	Tot. Econ. Cost Rs million	Averaged EIRR %	Economic NPV 12% Rs million	Economic B/C ratio 12%
1st	35	778.5	576.3	21.46	2.36	1.97
2nd	35	334.8	254.4	35.91	3.08	3.80
3rd	30	246.4	187.3	14.62	-0.01	1.40
Total	100	1359.7	1018.0	24.46	1.72	2.44

19.4 Financial Study

19.4.1 Budgetary Expenditures of RDA

Expenditures of RDA during 1990-94 was supplied by RDA as shown in Table 19.5 where figures are in current prices of each year. The total amount for RDA in 1990 was Rs. 1,155 million in 1990 which increased to Rs. 2,651 million in 1994. Expenditures are not in a stable tendency of changes, for example the nominal rate of increase was 23% in the period, but 11% if a provisional budget in 1995 is included. The rate of increase in constant prices of RDA's total annual expenditure is calculated at 7% in 1990-95.

Table 19.5 RDA's Annual Expenditures, 1990-95

(Rs million in current prices & (%))

Year	Rehabilitaion Invest.			Routine Maintenance			Admin.	Total
	Roads	Bridges	Total	Roads	Bridges	Total		
1990	877	10	887	-	-	177	91	1155
	(76)	(1)	(77)			(15)	(8)	(100)
1991	1210	36	1246	-	-	201	111	1558
	(78)	(2)	(80)			(13)	(7)	(100)
1992	1150	86	1236	-	-	170	117	1523
	(76)	(6)	(82)			(11)	(7)	(100)
1993	2345	152	2497	-	-	181	182	2860
	(82)	(6)	(88)			(6)	(6)	(100)
1994	1520	156	1676	-	-	717	258	2651
	(57)	(6)	(63)			(27)	(10)	(100)

Source: RDA, May 1995

19.4.2 RDA's Budgetary Distribution

Data in Table 19.5 indicate investment on roads and bridges increased two times in the five years, but routine maintenance was in the same amount which consequently decreased its percentage share in the same period. (It was told the 1994's figure Rs 717 million of the routine maintenance included 'preventive works' which would be re-distributed among major classification items.) The probable expenditure distribution in 1995 can be assumed as in Table 19.6 by reviewing data in the above table.

Table 19.6 Estimated Expenditures, 1995

(Rs million in current prices)

	Rehabilitaion Invest.			Routine Maintenance			Admin.	Total
	Roads	Bridges	Total	Roads	Bridges	Total		
Rs mill	1856	212	2068			318	212	2651
(%)	(70)	(8)	(78)			(14)	(8)	(100)

19.4.3 Forecast Expenditures up to 2010

It is evident the routine maintenance of bridges was included in 'roads' since the amount for 'bridges' was relatively small in the past being shown in previous table of 19.5. However, bridge rehabilitation plan will develop as suggested here, certain amount should be allocated in 'bridge maintenance'. Thus a 2% is taken into consideration in Table 7.

Assuming the percent distribution in 1995 of the above table be stable over the years in the future, the expenditures of RDA can be figured out for 15 years as tabulated in Table 19.7. Annual increase of the amount is set at 5% per annum up to 2005, and 4% beyond by taking into account the growth trend of GDP. National economic growth was discussed in Chapter 2; however, no long term forecast is shown by the government. It is noted the rate of growth becomes less when the socio-economic indicators grow substantially, i.e. GDP can grow consecutively, but the related annual rate will taper off generally with it. The budget scale will grow at a lower rate.

Table 19.7 Forecast Expenditures, 1995-2010

(Rs million in prices of 1995)

Year	Rehabilitaion Invest.			Routine Maintenance			Admin.	Total
	Roads	Bridges	Total	Roads	Bridges	Total		
Distrib.	0.7	0.08	0.78	0.12	0.02	0.14	0.08	1
1995	1856	212	2068	265	53	318	212	2651
1996-00	10482	1198	11680	1797	299	2096	1198	14975
Aver/Yr	2096	240	2336	359	60	419	240	2995
2001-05	11842	1353	13195	2030	338	2368	1353	16917
Aver/Yr	2368	271	2639	406	68	474	271	3383
2006-10	13062	1493	14555	2239	373	2612	1493	18660
Aver/Yr	2612	299	2911	448	75	522	299	3732
Tot.96-10	35386	4044	39430	6066	1010	7076	4044	50552

19.4.4 Bridge Rehabilitation Plan

(1) Total Bridges

The number of bridges under the RDA is 4430 in total, which can be grouped in to 253 requiring rehabilitation works and the remaining 4177 under routine maintenance as discussed in Chapter 4. The 253 bridges will be discussed in the following subsection 2). It should be noted the remaining bridges 4430 - 253 = 4177 are assumed generally in fair conditions maintained by routine work. They are generally in shorter length and/or serving for less traffic. From the view point of proposing a financial framework of RDA, there is urgent need to have updated inventory files of all bridges. The files can be used to figure out a long term rehabilitation plan as well as budget framework.

(2) Rehabilitation Plan

Currently, this study covers 100 bridges for master plan presentation, while RDA had presented a list of 206 bridges for rehabilitation plan including the 100 bridges. However, as shown in Table 20.8, there is likely a total of 253 bridges which require a rehabilitation program over the 15 years unto 2010. Since there are no data of current conditions of 153 bridges, the scale and pattern of their cost over the three periods are forecast by taking into account those of the 100 bridges.

* If the cost distribution pattern of the 100 bridges over the three period is adopted, the cost of the first period would be far larger than the other periods because reconstruction is concentrated in the first 5 years.

* In order to have less variation of cost among the periods, the cost of 153 bridges is divided evenly over the periods and added to the costs estimated for the 100 bridges. The tabulation is in Table 19.8.

In Table 19.8, the cost of Rs.1474 million for 86 bridges in the first period remains higher than the other periods since relatively large cost is accompanied by reconstruction of bridges which is proposed to be executed urgently in this first period. The total cost for the second is Rs.1030 million and that for the third is Rs.941 million and the total is Rs.3445 million.

Table 19.8 Rehabilitation Plan of 253 Bridges

(Cost in Rs million, 1995 Prices)

	Initial 100 Bridges		Secondary 153 Bridges		Total 253 Bridges	
	Nos	Cost	Nos	Using the Av. Cost	Bridges in number	Cost
	a	b	c	d	h	i
1996-00	35	779	51	695	86	1474
2001-05	35	335	51	695	86	1030
2006-10	30	246	51	695	81	941
Total	100	1360	153	2085	253	3445

(3) Budget and Master Plan Cost

The estimated investment budget for bridges in RDA was shown before in Table 19.7 which is copied in Table 19.9. The bridge investment budget for rehabilitation in the 3 periods will be Rs 4044 million, while the plan cost in the periods will be Rs 3445 million. It seems enough surplus remain at Rs.599 million in the total of the 3 periods, however, if thorough investigation goes on the remaining 4066 bridges (classified as "no defects bridges" 3551+515=4066 in Table 20.8), it is likely new findings requiring rehabilitations are coming up. It would require much cost over the 3 periods and result in negative balance against the estimated budget. In this sense, the inventory survey of all bridges by RDA is the urgent necessity. The extensive inventory survey should be the preliminary action to develop the bridge rehabilitation programme over 15 to 20 years in the future.

Table 19.9 Budget Estimate and Rehabilitation of Bridges

(Rs million in 95 prices)

Year	Estimated Budget for Bridges	Bridge Rehabilitation Cost			Surplus or Shortage
		Initial 100 Br.	Secondary 153 Br.	Total 253 Bri.	
	a	b	c	d=c+b	e=a-d
1996-00	1198	779	695	1474	-276
2001-05	1353	335	695	1030	323
2006-10	1493	246	695	941	552
Total	4044	1360	2085	3445	599

(4) Other Bridges

According to the data of RDA, 111 bridges have been rehabilitated in the past resulting in 4066 bridges for technical inspection (4439 - 253 - 111 = 4066). It is likely they are generally not deteriorated since none is included in the urgent plan of 206 bridges of RDA. However, if the recommended inventory study is implemented, there will be some which need rehabilitation enforcing to increase the number and cost of the rehabilitation plan of the 253 bridges. The budget scale estimated will be insufficient if this enlarged rehabilitation plan is implemented. Different options to adjust the budget scale should be explored at the earliest time along with the development of an overall bridge rehabilitation and maintenance plan.

CHAPTER 20 CONCLUSION AND RECOMMENDATIONS

20.1 Conclusion

20.1.1 Bridge Master Plan

(1) Studies on Bridges

The numbers of existing bridges on national trunk road (A-class trunk roads and B-class trunk road) in Sri Lanka is about 4,430. Out of 4,430 bridges, the bridges which were classified to be rehabilitated urgently by RDA are defined as candidate bridges for the Study and amounted to a total of 206. And out of these bridges, 101 bridges were selected for the bridge master plan based on the S/W.

Assessment methods applied in the Study are broadly divided into two categories consisting of preliminary inspection covering a representative 101 bridges and detailed survey or 10 typical bridges selected from those 101 bridges.

Of which 100 bridges were selected and studies by various engineering viewpoints. Traffic forecast passing those bridges were conducted to recognize the traffic demand on major corridors. A rate of 5.7% per annum was estimated as a general tendency of road traffic growth in the coming years.

Main results of the preliminary engineering surveys are summarized as in the following:

1) Member Condition of Each Main Structure

- Deck and main frame have suffered advanced deterioration as compared to other members such as abutments piers and wing walls.

2) Bridge Condition of Each Bridge Type

- Steel girder such as RSJ/BUC and RSJ/COR was found to be the most defective bridge.

- Truss bridge requires some weep holes on lower chord to prevent corrosion caused by remaining water at lower chord.

- Some of PSC/PRE have inadequate concrete cover for PC tendons at the soffit of beam.

3) River Hydrological Survey

- Generally, many abutments which were built in old days jut out into the river in order to shorten a bridge length in Sri Lanka. And wing wall is impossible to be connected with abutment because the structure type of abutment is stone masonry or brick masonry. Therefore, retaining wall is used to cover back-filling instead of wing wall. However, the foundation of retaining wall is not so strong compared with the abutment, and it is often seen that there are many large cracks caused by scouring or settlement of the ground surrounding the foundation.

- Whereas there are no protections at the side embankment of abutment, and some parts of embankment have been washed away because of poor maintenance.

- Slope protection of the river bank should be given to the front of abutment and surrounding area because the water level changes substantially. Embankment will be scoured unless this protection is carried out.

4) Structural Survey

- Based on the concrete cover measurement of PSC/PRE beams the cover of PC tendons at the soffit was inadequate and it was observed that there were many flakings due to construction deficiencies. According to the new specification by RDA, the cover will be changed from 25mm into 50mm.

- From the Schmidt hammer test results, each concrete member has adequate compressive strength compared with a design strength.

5) From Full Scale Bridge Loading Test

- The assessment of the loading test results has proven that steel girder bride acts like a half-composite beam and some load distribution action by deck slab can be expected.

- PSC/PRE beam which is used as a standard design in RDA has an adequate lateral load distribution action without any transverse direction prestressing.

6) From Environmental Examination

- From the assessment of an initial environmental examination, it was revealed that there was no necessity to carry out an

Environmental Impact Assessment because an estimated environmental impact can be reduced by some countermeasures for impact.

(2) Determination of Rehabilitation Priority

Prior to the preliminary rehabilitation design, rehabilitation priority was determined considering function of roads, traffic volume and damage degree of bridges.

The 100 bridges are grouped into 3 periods with priority order. In each period, the rehabilitation are categorized into repair, reinforcement and reconstruction. They are in Table 20.1 through Table 20.3.

Table 20.1 Connection between Function of Roads and Damage Degree of Bridge

Function of Road		Damage Degree of Bridges				
Road by Priority	Traffic Volume	4.0	3.2	3.0	2.4 to 2.0	under 2.0
1st	Over 5,000 veh./day	1,175	-	27,66,70, 75,108,120, 197	76,79,84, 85,99,195, 201	-
2nd	more than 3,000 veh./day	32,86,202, 212	119	17,47,93, 102,123, 151,154	36	46,106
3rd	more than 2,000 veh./day	91	78,80	52,65,77, 89, 147,148, 173,209	138,211,216	-
4th	more than 1,000 veh./day	7,18,20,33, 129,150	34,40,42, 44,87,178	19,26,30, 39,57,131, 135,136	2,43,45,58, 59,103,130	-
5th	less than 1,000 veh./day	31,35,38, 61,62,63, 68,72,122, 128,144,208	21,24,55,56, 74,127,133	25,41,67, 69	53,60	22,71,73
under going or planned		139				
Sub- Total		25	16	34	20	5

The priority of road section was determined based on the importance of the road function. The road function (which is for lows) was selected in the order of five ranking groups considering connection of provincial capitals and district centers and places of national importance.

The Damage Degree of Bridges (Rating) (which is for columns) shown in Table 20.1 indicates overall evaluation for bridges.

Table 20.2 Bridge Rehabilitation by Priority

	4.0	3.2	3.0	2.4 to 2.0	under 2.0
1	2	-	7	7	-
2	4	1	7	1	2
3	1	2	8	3	-
4	6	6	8	7	-
5	12	7	4	2	3
other	-	-	-	-	-
sub-total	25	16	34	20	5

Note: [dark shading] : first priority = 35 nos.

[light shading] : second priority = 35 nos.

[no shading] : others = 30 nos.

Table 20.3 Summary of Rehabilitation Plan for 100 Bridges

(in Million Rs. of 1995 Price)

Group	Repair		Reinforcement		Reconstruction		Total
	Nos	Cost	Nos	Cost	Nos	Cost	Cost
1st	8	37.7	11	110.2	16	630.6	778.5
2nd	5	9.6	26	114.7	4	210.5	334.8
3rd	10	4.4	15	122.8	5	119.2	246.4
Total	23	51.7	52	347.7	25	960.3	1359.7

(3) Conceptual Design for Rehabilitation

1) Conceptual Designs

- The conceptual engineering design of rehabilitation of selected 10 bridges were conducted to determine the standard methods of rehabilitation and typical costs which can be used for the cost estimate of similar type of works.

- Furthermore, since it was necessary to define a certain standard in order to diagnose a load carrying capacity of each bridge, analytic assessment applying TL-20 live load was carried out for all steel girder bridges such as RSJ/BUC, RSJ/COR and RSJ/RCS which account for 50 percent of all bridges in the study bridges. The assessment results revealed that among those bridges, all bridges were inadequate to carry TL-20 load and 8 bridges should be replaced by a new bridge.

Table 20.4 Summary of Rehabilitation Plan for 100 Bridges

Bridge type	Span	1st Priority Reconst I	1st Priority Reconst II	1st Priority Reinf & Repair	2nd Priority Reconst	2nd Priority Reinf & Repair	Others Reconst	Others Reinf & Repair	Total Reconst	Total Reinf & Repair
RSJ/BUC RSJ/COR RSJ/RCS RSJ/DEC RSJ/DEC	RSJ/T l= 3.7m ~ l= 10.5m	8 175, 33, 18 38, 144, 31 32, 35	1 119	7 20, 150, 108 78, 70, 68 120	4 77, 148, 44 52	18 40, 195, 17 102, 151, 154, 65 89, 147, 173, 21, 24 55, 56, 74, 127, 133 209	4 36, 131, 25 58	12 106, 138, 211 210, 2, 59, 30, 39 57, 135, 136, 67	17	37
ST. TR/T/RCS ST. TR/T/DEC ST. TR/T/COR ST. TR/D/COR ST. TR. T. BUC	l= 9.3m ~ l= 51.0m	3 122, 33, 72	-	5 66, 80, 128 197, 75	1 77	8 76, 79, 99 93, 34, 42 178, 21	-	5 130, 19 26, 53, 69	4	18
ARCH/S	l= 22.8m	-	-	-	-	1 84	-	-	-	1
BAILEY	l= 18.3m ~ l= 33.5m	-	-	3 208, 202, 61	-	-	-	1 22	-	4
RCB RCS RC/BOX	l= 3.8m ~ l= 9.7m	1 1	-	2 7, 91	-	1 123	-	3 41, 103, 73	1	6
PSC/PRE PSC/POS	l= 4.9m ~ l= 16.2m	-	-	4 7, 86, 212 68	-	1 87	-	1 71	-	5
CAUSEWAY	l= 2.6m ~ l= 3.7m	-	2 62, 63	-	-	-	1 60	-	3	-
ARCH/BR ARCH/CO ARCH/STO	l= 3.6m ~ l= 17.2m	1 129	2 119, 27	-	-	4 85, 47, 209 201	-	3 46, 43, 45	3	7
Total nos. of bridge types (Total nos. of bridges)		13 (12)	5 (4)	21 (19)	5 (4)	33 (31)	5	25	28 (25)	79 (75)

Note: Reconst I means reconstruction which is required by the damages.
Reconst II means reconstruction which is required by the stress check.

- Based on above assessment results as well as the inspection results, all defects observed in each study bridge were judged from viewpoints of material deterioration, load carrying capacity, bridge function and hydraulic adequacy. Thereafter, a suitable rehabilitation plant for each bridge of the 90 bridges was selected.

- The summary of the rehabilitation methods for the 100 bridges is shown in Table 20.4.

2) Cost Estimate

- The summary of the rehabilitation cost for the 10 bridges is shown in Table 20.5.

Table 20.5 Summary of Rehabilitation Cost for the 10 Bridges

	Bridge No.	Financial Cost
Repair	53, 7, 212	32.2
Reinforcement	85, 59, 20, 70, 211	51.7
Reconstruction	77, 33	486.7

(in Million Rs. of 1995 Price)

- The costs studies in the 10 bridges are applied to estimate the rehabilitation costs for 100 bridges which are summarized in Table 20.6 afterward. It shows the total cost of Rs. 1,410 million in 1995 prices.

Table 20.6 Project Cost (Million SLR)

Construction Cost		1,044
Engineering Cost	Detailed Design	63
	Supervision	42
Administration		2
Contingency		209
Total		1,360

(in Million Rs. of 1995 Price)

(4) Economic Evaluation and Financial Analysis

The economic evaluation using three economic parameters: EIRR, NPV and BCR was carried out for individual bridge and for the whole project covering 100 study bridges. The project covering 100 bridges was divided into the following three packages in accordance with the priority of rehabilitation plan described in Table 20.2.

First group	:	35 nos. of bridge	1996 - 2000 year
Second group	:	35 nos. of bridge	2001 - 2005 year
Third group	:	30 nos. of bridge	2006 - 2010 year

The summary of economic evaluation is shown in Table 20.7. Although there are some differences amount the values of average internal rate of return for each package, the internal rate of return is about 25% as a whole. A few bridges have shown less than 12% in the return calculation where reasons are small volumes of traffic or larger costs of the rehabilitation plan. However, those can be reviewed in the next feasibility study stage. The grouping can be recommendable from viewpoint of economic evaluation.

Table 20.7 Summary of Economic Evaluation

Group	Nos. of Bridges	Tot. Fin. Cost Rs million	Tot. Econ. Cost Rs million	Averaged EIRR %	Economic NPV 12% Rs million	Economic B/C ratio 12%
1st	35	778.5	576.3	21.46	2.36	1.97
2nd	35	334.8	254.4	35.91	3.08	3.80
3rd	30	246.4	187.3	14.62	-0.01	1.40
Total	100	1359.7	1018.0	24.46	1.72	2.44

(5) Conclusion

- Almost of the study bridges have suffered various distress or damages and some of them are in critical condition.

- Those bridges can be improved mainly by using standard repairing, strengthening works and reconstruction.

- The 100 bridges grouped into 3 packages in priority order are studied in economic analysis and found the grouping is justifiable.

20.1.2 Maintenance System

(1) Organization, etc.

Engineering Services Division in RDA has 4 offices including Bridge Design Section which is responsible for designing new bridges. In the Traffic & Planning Section there are some staff who do review the existing bridges and prepare rehabilitation plans of damaged bridges. They have file records of bridges but not yet completed in covering the whole bridges in RDA.

Implementation of bridge rehabilitation plan is in charge of Maintenance Management and Construction Division who manages field works with local offices.

The expenditures of RDA allocated to bridge investment are found which has increased at a rate more than input on roads. In 1994 the amount was Rs.156 million (6%) while that on roads was Rs. 1,520 million (57%). (The percent is in the RDA's total expenditure). However, the maintenance of roads and bridges are shown not separately. It means bridge maintenance works are mixed in road management in the past.

(2) Establishment of New Section for Bridge Maintenance and Management

A new section should be established which covers inventory filing, plans and designing using standardized methods, cost estimate and related studies for bridges in RDA. The section should be in Engineering Services Division and should gather up all staff related to bridge plan and maintenance programme at the beginning years.

The section will enroll several engineers and several assistants. Specified staff needed in province and local offices should be mobilized from other engineering section as they are necessary. When the work burden becomes heavy, regular local staff should be recruited in each province or regional office.

(3) Guideline

A guideline for Establishment of the Manual for Bridge Inspection, Maintenance and Rehabilitation is prepared in a separate file.

20.1.3 Financial Aspect

(1) 4,430 Bridges Maintenance by RDA

RDA has been carrying out a data base filing of all bridges which RDA administers on A and B routes expected to be completed by March, 1996. Since the results of the above data base could not be used in the Study, the assessment for all 4,430 bridges was made based on the study results of selected 100 bridges.

The grouping of the RDA's overall bridges are in Table 20.8 where the completed bridges in the past years since 1980 are included together with the 100 bridges, 153 bridges and 4,066 bridges. While it is thought majority of those 4,066 bridges are in fair conditions and coverable by routine maintenance, the classification may be restructured when the data base filing is completed.

Table 20.8 Estimation to 4,430 Bridges

Group	First Priority		Second Priority	Third Priority	Sub Total	No Defects	Total
	Reconstr.	Others					
'80	66				66		66
'90	45				45		45
This Study	12	23	35	30	100	3,551	3,651
Not Surveyed	17	34	51	51	153	515	668
Total	86	57	86	81	364	4,066	4,430

Note) '80 means the numbers of bridge which was reconstructed in 1980's
'90 means the numbers of bridge which was reconstructed or will be reconstructed in 1990's.

(2) Estimated Project Cost for 253 Bridges

The master plan in the Study is planned for the 100 study bridges, while the cost of the 153 bridges in North and North-East provinces is approximated by studies over the 100 bridges. Table 20.9 is the summary of 253 bridges.

Table 20.9 Rehabilitation Plan of 253 Bridges

(Cost in Rs million, 1995 Prices)

	Initial 100 Bridges		Secondary 153 Bridges		Total 253 Bridges	
	Nos	Cost	Nos	Using the Av. Cost	Bridges in number	Cost
	a	b	c	d	h	i
1996-00	35	779	51	695	86	1474
2001-05	35	335	51	695	86	1030
2006-10	30	246	51	695	81	941
Total	100	1360	153	2085	253	3445

(3) Budget and Rehabilitation Plan

Budget with sectional distribution of RDA are assumed by using available data in the Study. In which the investment for rehabilitation of bridges can be figured out Rs.4,044 million for the years 1996 - 2010.

If the bridge rehabilitation cost of Rs.3,445 million is compared to this budgetary scale estimated, it appears a shortage of Rs.276 million in the first period while the surplus of Rs.875 million is calculated for the remaining periods, being shown in Table 20.10. It should be noted there remain 4,066 bridges which are waiting for thorough investigation in the similar way done for the 100 bridges. The rehabilitation cost depends on the result of thorough investigation which should be better conducted urgently by RDA.

Table 20.10 Budget Estimate and Rehabilitation of 253 Bridges

(Rs million in 95 prices)

Year	Estimated Budget for Bridges	Bridge Rehabilitation Cost			Surplus or Shortage
		Initial 100 Br.	Secondary 153 Br.	Total 253 Bri.	
	a	b	c	d=c+b	e=a-d
1996-00	1198	779	695	1474	-276
2001-05	1353	335	695	1030	323
2006-10	1493	246	695	941	552
Total	4044	1360	2085	3445	599

(4) Other 4,066 Bridges

The remaining 4,066 bridges are thought in fair conditions manageable by routine maintenance. The budget for routine maintenance for bridges is assumed at 2% of total budget for RDA in this Study. However, it should be noted that conditions of those 4,066 bridges change every year which may need to revise the budget scale and sectional allocation of RDA. If the ongoing data base filing of bridges by RDA is completed, it will affect the budget scale and allocation additionally.

20.2 Recommendations

(1) Need to Prepare Bridge Inventory Rapidly and to Plan Maintenance and Rehabilitation Programme

At present stage, there are many points which are uncertain regarding the background of this master plan. However, at first bridge inventory study which can give a clear technical interpretation for the defects of each bridge should be completed. And all the inspection results and maintenance and rehabilitation records should be centralized in the Engineering Services in RDA Headquarters. From a practical point of view, the most important question is apparent; how to select a suitable rehabilitation method for each bridge. In order to implement the above works, "the Guide Line for Bridge Inspection, Maintenance and Rehabilitation" will be a great help. As for its application and correct method of usage, a professional training should be carried out periodically.

And it is evident that the method, which is suggested in the Study, is only preliminary and refinement of it should be achieved in the subsequent stage in the feasibility studies, designs and implementation. Together with these experiences, a comprehensive manual should be edited and utilized by RDA.

(2) Need to Prepare Own Manual for Bridge Inspection, Maintenance and Rehabilitation

To maintain bridges in sound state, early detection and rehabilitation of damage to bridges are essential. Overlooking any abnormality or damage in the early stage will allow such damage to grow further to result in accidents.

To prevent this, it is necessary to inspect the bridges' present state correctly according to the established inspection procedure and to prepare and to assess the inspection result on the basis of recognition of the characteristics and deformation of the structure. In order to implement the works systematically by themselves, it is recommended that their own manual be prepared based on the "Guideline for Bridge Inspection, Maintenance and Rehabilitation".

(3) Need to Establish a Solid Organization and Manpower for Bridge Management

In order to implement systematic bridge inspection, maintenance and rehabilitation, it is necessary for RDA to establish a solid organization for bridge management. Because those activities will, to a considerable extent, rely on the progress in organizational, managerial and training development. Therefore, the following aspects are recommended:

- The Engineering Services in RDA Headquarters should be responsible for bridge management.

- The Engineering Services in RDA Headquarters should establish bridge inspection and maintenance teams, and frequent personal turnovers must be avoided to keep a certain technical level on the bridge management.

- The above teams should have the authority to give a professional training to engineers of each regional office of RDA on the job.

- The trainee shall become "manpower" to deal with the actual periodical inspection, and proper filing of bridge inventory and rehabilitation record. Therefore, the training shall aim them to understand the necessity and importance of the bridge management.

(4) Need to Allocate Budget for Bridge Management

The cost needed for the bridge maintenance and management is estimated at Rs. 14.9 million per year.

The cost consists of the expense of personnel, plant, equipment and office maintenance, etc., to manage the Maintenance Center which is to be established in the Engineering Services and the Maintenance Section in each province of RDA.

The cost is well within the budget, which is 28% of the budget for bridge maintenance in the amount of Rs. 53 million (estimated) for the year in 1995.

(5) Need to Adjust Relations between Road Network Development Plans

In general, economic evaluation for bridge rehabilitation project should be carried out following to road network development plans, while the road improvement projects are still ongoing in Sri Lanka. Considering these circumstances, bridge rehabilitation plans were prepared separately from road rehabilitation plans. However, it might cause an untimely implementation of the plan. To have rational and effective development plans to be realized, each plan has to be made, checked and altered considering other development plans including national plans for development to have a balance.

In this sense, it is necessary to continue look after the progress of road improvement projects. In the meantime, a long-term development plans must be determined simultaneously covering both of roads and bridges rehabilitation plans.

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