Table 15.2 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: : first priority = 35 nos.

: second priority = 35 nos.

: others = 30 nos.

And statistical assessment of all the study bridges is presented in Table 15.3

15.3 Setting Up of Criteria in Selecting Rehabilitation Plan

In the selection of bridge rehabilitation method, the criteria will be set up considering the item below.

(i) Evaluation of structural condition through preliminary (visual) inspection
(ii) Carriageway width determined by the traffic volume
(iii) Possibility of repair and reinforcement by the results of preliminary (visual) inspection
(iv) Capability of adding footway
(v) Existing road alignment condition
(vi) Results of high-water level study(free board)
(vii) Scouring of foundation detected in the preliminary (visual) inspection
(viii) Construction year of the bridge (deterioration by year, loading capacity and design standard)

The bridge rehabilitation methods are classified into 3 categories such as structural aspect, road functional aspect and hydraulic aspect. The structural rehabilitation aims to protect the damaged bridge component and to reinforce the members which have insufficient loading capacity. The functional rehabilitation aims to improve the bridge function by widening of carriageway based on traffic volume capacity, adding footway and alignment improvement, etc. The hydraulic rehabilitation mainly aims to protect river bank and bed around abutments and piers.

Accordingly, the criteria for engineering decision for rehabilitation is classified under 3 categories.

Table 15.3 Summary of Rehabilitation Plan for 100 Bridges

		1st Priority			2nd Priority		Others		Total	
		Reconst I	Reconst II	Reinf & Repair	Reconst	Reinf & Repair	Reconst	Reinf & Repair	Reconst	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.

15.3.1 Selection Criteria for Structural Rehabilitation Methods

The structural rehabilitation methods can be divided into 3 ways such as repair, reinforcement and reconstruction. Each rehabilitation has various methods depending on the types of damage and its range and degree, and also cause of damage. Therefore, preparing the criteria for structural rehabilitation methods shall make engineers to select a particular method against the structural defects easily, such as weal members and structurally insufficient loading capacity.

(1) Repair

The repair is selected to the structures which have enough loading capacities based on the results of structural study for representative 10 bridges. For concrete members, the repair covers non-aggressive cracks due to shrinkage and creep, light deterioration/damage caused by insufficient construction such as honeycomb, scaling and crack. And for steel/iron members, repainting is required. In addition, change of bridge accessories is also applicable. However, redecking with RC slab and change of deck slab type (e.g. from RSJ/BUC to RSJ/RCS) are considered to be reinforcement.

The repair methods are various depending on the types of damage, its range, degree and also the cause of damage. Each type of rehabilitation method applicable in the Study is tabulated in Table 15.4 together with the corresponding application criteria.

Table 15.4 Type of Protection Method and Corresponding Application Criteria

Rehabilitation Plan	Method	Application Criteria
Protection work to * Concrete	- Epoxy injection	- Cracks are not active and surface width is more than 0.2mm, but less than 3.0mm. 1) - Reason for the crack appearance is due to shrinkage or creep of concrete. - No water leakage and no liquid rust. - No carbonation and no chloride attack. 1) : If surface crack width is more than 3.0mm, apply cement paste injection.
*	- Patching	- Defects such as honeycomb, flacking, cavity etc. are not active. - Reason for these effects are mainly due to inferior concrete or poor workmanship. - Minimal carbonation, no chloride attack and no water leakage. - Adequate concrete cover. - Defective area is scattered.
	- Guniting	- Cracks of which surface width is less than 0.20mm are not active. - Concrete is slightly carbonated. - Minimum concrete cover is inadequate. - No water leakage. - Defective area is extensive.

	- Protective Coating	- Cracks are not active and surface width is less than 0.2mm. - No water leakage, no scaling and no flaking. - Minimal carbonation and no chloride attack. - Adequate concrete cover.
	- Waterproof Layer	- Water stain, free lime and other associated defects are observed at slab soffit. - Defects are not active. - Water is penetrating from top of slab through defective concrete or inferior joints between precast members.
	- Concrete Lining (wall)	- Inadequate minimum cover or bricks are exposed. - Abrasion of concrete surface or loss of concrete matrix due to inferior concrete or chemical attack. - Concrete is carbonated.
	- Concrete Lining (piles)	- Minimum concrete cover is inadequate. - Wide longitudinal cracks due to chloride attack or rebar exposure. - Abrasion of concrete surface or loss of concrete matrix due to inferior concrete or chemical attack. - Concrete is carbonated.
Protection works to Steel Member *	- Repainting (superstructure)	- Adequate load carrying capacity. - Non-active corrosion and paint deterioration
*	- Repainting (substructure)	- Steel surface is slightly corroded but load carrying capacity is still adequate. - Bridge is located in a non-severe environmental condition.
	- Concrete Lining	- Steel surface is considerably corroded but load carrying capacity is adequate. - Bridge is located in a severe environmental condition.

Note) * is protection method adopted in the Study.

(2) Reinforcement

The reinforcement is selected to the bridge component which has serious structural damage or insufficient loading capacity determined based on the results of study in Chapter 14.

The serious structural damage which needs reinforcement is the defects such as progressive cracks due to bending or shearing, remarkable settlement and large area of section lack, etc.

The reinforcement methods are also various depending on the types of damage, its range and degree and also the cause of damage. Each type of the rehabilitation method is shown in Table 15.5 together with the corresponding application criteria.

Table 15.5 Type of Reinforcement Method and Corresponding Application Criteria

Rehabilitation Plan	Method	Application Criteria
Reinforcement work to Concrete	- Steel Plate Bonding	- Inadequate load carrying capacity (inadequate amount of reinforcement bar) - No water leakage and no carbonation. - Inadequate for additional stress in beam and slab due to additional dead load. - Active cracks due to bending moment or shear force. - Adequate concrete cover
	- Prepacked Concrete Lining w/ Additional Rebar *	- Inadequate loading capacity. - Various active cracks due to bending moment or shear force. - Inadequate concrete cover. - Suffered mild chloride attach or advanced carbonation. - Defective area is extensive.
	- Guniting w/ Additional Rebar	- Inadequate loading capacity. - Various active cracks due to bending moment or shear force. - Adequate for additional stress in beams and slab due to additional dead load. - Bridge is located in relatively severe chloride environment. - Advance carbonation. - Defective area is extensive.
Reinforcement work to Steel	- Attachment of Steel Plate *	- Inadequate load carrying capacity. - Excess bending stress is less than 20% of allowable stress. - Non-active corrosion, paint deterioration.
	- Concrete Lining w/ Additional Rebar	- Steel surface is considerably corroded and load carrying capacity is inadequate. - Bridge is located at severe environmental condition.

Note) * is reinforcement method adopted in the Study.

(3) Reconstruction

This type of rehabilitation basically shall be selected for bridges of which overall rating is 4.0 and bridges which have inadequate loading capacity. And if the Study result shows that it is difficult to take economical repair/reinforcement, the reconstruction is applicable for the bridge component or whole bridge.

The bridge component which has serious structural or subconscious damage shall be replaced with proper bridge members.

Additionally, where the bridge needs complex reinforcement due to many defects such as functional defects and hydraulic defects with structural damage, it is recommended to reconstruct the bridge.

15.3.2 Selection Criteria for Functional Rehabilitation Methods

The functional rehabilitation can be categorized as widening of carriage way and adding footway.

(1) Widening carriageway

As the necessity of widening of carriageway shall be generally determined by present traffic volume and future traffic volume projection, RDA has own standard on carriageway width. (7.4m is for standard and 6.8m is for less traffic volume bridge on A-route. On B-route, which has less traffic volume, the width is determined considering the existing site conditions.)

(2) Adding footway

The necessity of adding footway is determined based on a situation whether the bridge locates inner-city or near public facilities such as school, hospital and temple, etc. or not.

In the preliminary study, these surrounding conditions were reported in the preliminary environmental examination.

(3) Rising

In the preliminary inspection, some data and information regarding flood level were collected through RDA and interview to resident in the site.

Generally, the bridge height shall be risen in case of which the bridge submerge in the water flow. However, rising of vertical alignment causes adverse effects to upstream side of the bridge, which the approach embankments obstruct flood flow.

Therefore, the rising of vertical alignment will not considered in the Study.

15.3.3 Selection Criteria for Hydraulic Rehabilitation

The hydraulic rehabilitation covers river protection, slope foot protection, river bed consolidation work and river re-alignment work based on the existing condition and range of damage caused by scouring, erosion and flood effect, etc. at the bridge site.

(1) River protection is applicable to protect erosion at river slope around abutment.
(2) Slope foot protection is applicable to protect slope failure caused by river bed scouring at foot of river slope.
(3) River bed consolidation work is applicable to protect scouring around river bed.

(4) River re-alignment work is applicable to protect remarkable erosion caused by irregular flow at upstream side of the bridge.

Hydraulic rehabilitation methods is determined depending on river flow condition, scale of river, flood flow velocity shape of foundation and soil conditions.

Type of rehabilitation method for each plan is shown in Table 15.6 together with the corresponding application criteria.

Table 15.6 Type of Hydraulic Rehabilitation Plan and Corresponding Application Criteria

Rehabilitation Plan	Method	Application Criteria
Slope Protection	- Stone Masonry *	- Slope : 1:0.5 – 1.5 - Height : Less than 5m - Application Small to medium scale river
	- Concrete Block Masonry *	- Slope : 1:0.3 – 1.0 - Height : Less than 3m - Application Rapid stream and small to medium scale river
	- Concrete Block Pitching	- Slope : 1:1.5 – 2.0 - Height : Less than 5m - Application Medium to large scale river
	- Concrete Frame	- Slope : 1:1.5 – 2.0 - Height : Less than 5m - Application Tidal river and bank subjected to wave force
Foot Protection	- Dumped Stone *	- Small to medium scale river and foundation ground is relatively solid
	- Wire Mesh Gabion *	- Small scale river and foundation ground is under soft type.
	- Concrete Block Mattress *	- Medium to large scale river or rapid flow velocity
	- Sheet Piling	- Normal water level at slope toe is more than about 3.0m and it is difficult to provide base concrete under river bed at slope toe.
River Bed Protection	- Wire Mesh Gabion *	- Foundation protection
	- Dumped Stone & Wire Mesh Gabion *	- Local scouring
River Realignment	- Spur Dike by Stone Masonry	- Large scale river
	- Spur Dike by Concrete Pile	- Medium to large scale river

Note) * is rehabilitation plan adopted in the Study.

15.4 Basic Policy of Maintenance and Rehabilitation

15.4.1 Rehabilitation Plan Determined by Bridge Function

(1) Widening Carriageway

1) Method of Widening

There are 3 types of widening methods depending on the horizontal alignment as follows:-

Case – 1 : Strait or large radius curve alignment
Generally, the widening shall be done at both sides of existing bridge except obstacles exist.

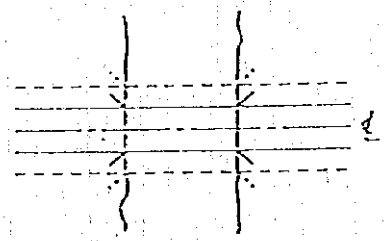


Figure 15.1 Method of Widening 1

Case – 2 : Curve alignment at both side of bridge
The widening shall be done with improvement of alignment because widening without improvement of alignment may cause accident. However, it may exclude the bridge with long length.

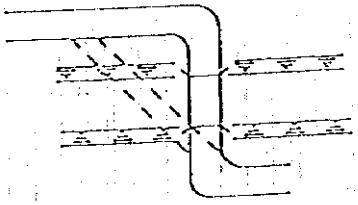


Figure 15.2 Method of widening 2

Case – 3 : U shape alignment
The widening shall be done inside of U alignment considering some improvement.

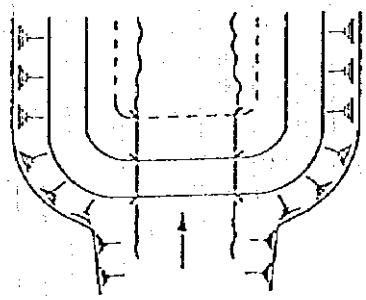


Figure 15.3 Method of widening 3

2) Widening method for each bridge type

Widening method is various depending on the type of structure.

- RSJ/BUC and RSJ/COR
  Major damages of these structure are corrosion of main beam and corrosion of buckle plate and corrugated plate. Main beam shall be covered by R/f concrete and then slab shall be changed to RCS. After that PSC/PRE shall be erected for widening.

- RSJ/RCS
  The damage of this structure is not so serious. The widening shall be done by providing additional beam to the existing structure and PSC/PRE. In case footway only is added, cantilever slab type shall be applicable.

- ST.TR
  The widening shall be done by construction of new bridge adjacent to the existing bridge because of structural difficulty of widening ST.TR. PSC/POS is appropriate type for new bridge. Existing bridge can be used as footway or one lane bridge depending on the width.

- ARCH/BR, ARCH/ST
  There is a difficulty to widen by using the same structural type. The widening shall be done by using other type of beam on both sides of ARCH. Consideration shall be given to its aesthetic point.

- PSC/PRE
  Similar type of beam shall be applied at both side of existing bridge.

- CAUSEWAY
  It is recommended that full scale bridge should be constructed. Otherwise widening shall be done by using the same structural type at both side.

(2) Adding footway

The works shall include the carriageway widening plan considering the surrounding conditions, inner-city area and public facilities near-by.

15.4.2 Rehabilitation plan determined by bridge structure

The rehabilitation plan shall be prepared regarding repair, reinforcement and reconstruction for each representative type. The rehabilitation method should be selected based on the results of preliminary inspection and will be determined after the detailed inspection.

(1) RSJ/BUC and RSJ/COR

Repair		
-	Main beam, Cross beam	Repainting
-	Bearing	Replacement with rubber bearing or provision of new bearing
-	Railing	Repainting or replacement
-	Expansion	Provision of new expansion
-	Abutment	Provision of parapet wall
Reinforcement		
-	Main beam	Adding main beams for widening (if necessary) Covered by R/f concrete
-	Deck slab	Redecking by using RCS
-	Substructure	Covered by curtain R/f concrete
Reconstruction		
-	Superstructure	Reconstructed with PSC/PRE
-	Substructure	Reconstructed with RC structure

(2) RSJ/RCS

Repair		
-	Main beam, Cross beam	Repainting
-	Deck slab	Epoxy injection, Water registrant layer on desk

– Bearing	Replacement with rubber bearing or provision of new bearing
– Railing	Repainting or replacement
– Expansion	Provision of new expansion
– Abutment	Provision of parapet wall Reinforcement
Reinforcement	
– Main beam	Adding main beams for widening (if necessary) Covered by R/f concrete
– Deck slab	Additional deck (for widening)
– Substructure	Covered by curtain R/f concrete
Reconstruction	
– Superstructure	Reconstructed with PSC/PRE or PSC/POS
– Substructure	Reconstructed with RC structure

(3) ST.TR/T

Repair	
– Main beam, Cross beam Stringer	Repainting, protect concrete on lower code
– Deck slab	Redecking to RCS Epoxy injection, Water registrant layers on desk(BUC and COR)
– Bearing	Recovering of its function, or provision of new bearing
– Railing	Repainting or replacement
– Expansion	Provision of new expansion
– Abutment	Provision of parapet wall
Reinforcement	
– Main beam	Lower code shall be reinforced by steel plate and protect concrete on it
– Deck slab	Increase of thickness, Steel plate bonding, Adding of stringer
– Substructure	Covered by curtain R/f concrete
Reconstruction	
– Superstructure	Reconstructed with PSC/PRE or PSC/POS
– Substructure	Reconstructed with RC structure

(4) ARCH/BR

Repair	
– Arch(Main structure)	Coating by epoxy, Water registrant layers under pavement
– Railing	Replacement or new railing
Reinforcement	
– Arch(Main structure)	Reconstruction is recommended
Reconstruction	
– Superstructure	Reconstructed with PSC/PRE or PSC/POS
– Substructure	Reconstructed with RC structure

(5) ARCH/ST

Repair	
– Arch(Main structure)	Cement mortal injection, Water registrant layers under pavement
– Railing	Replacement or new railing
Reinforcement	
– Arch(main structure)	Covered by curtain R/f concrete Reconstruction
– Superstructure	Reconstructed with PSC/PRE or PSC/POS
– Substructure	Reconstructed with RC structure

(6) PSC/PRE

Repair	
– Main beam	Epoxy injection to cracks Patching
– Bearing	Provision of rubber bearing
– Railing	Replacement
– Expansion	Replacement, or provision of new expansion
Reinforcement	
– Main beam	---
– Deck slab	---
Reconstruction	Reconstruction by same type

(7) RCB,RCS,CAUSEWAY

Repair	
- Main beam	Epoxy injection to cracks
- Bearing	Replacement with rubber bearing, or provision of new bearing
- Railing	Replacement
- Expansion	Replacement, or provision of new expansion
Reinforcement	
- Main beam, Deck slab	Prepacked concrete
Reconstruction	
- Superstructure	Reconstructed with PSC/PRE
- Substructure	Reconstructed with RC structure

(8) Abutment, Pier

Repair	
- Body	Epoxy or Mortar injection to crack
- Foundation	Protection concrete to scouring
Reinforcement	
- Body	Covered by R/f curtain concrete
- Foundation	Protect concrete
Reconstruction	Reconstructed with RC structure

15.4.3 Rehabilitation Plan Determined by Hydraulic Aspect

- River protection	Stone masonry, Concrete block masonry, and Concrete frame work
- River bed consolidation work	Gabions, Concrete mat, Rabble-mound
- River re-alignment	Gabions, Rabble-mound

15.5 Planning Results of Maintenance and Rehabilitation

Out of the 100 study bridges, 18 bridges were found to be in very bad condition and assessed to be beyond economic repair, hence there bridges are recommended to be totally replaced by constructing a new bridge.

In addition, some of bridges were found to be inadequate in terms of a structural view point from the results of stress check. A list of those two types of bridge which require reconstruction plan is shown Table 15.7.

Table 15.7 List of Study Bridges which Require Reconstruction Work

Based on Damage Condition		Based on Stress Check	
SER No.	Type of Bridge	SER No.	Type of Bridge
1	RCB	44	RSJ/BUC
175	RSJ/COR	36	RSJ/COR
122	ST.TR/T/RCS	52	RSJ/COR
33	ST.TR/T/RCS RSJ/RCS		
129	ARCH/BR	119	RSJ/RCS
83	ST.TR/T/RCS RSJ/RCS	148	RSJ/BUC
18	RSJ/RCS	25	RSJ/RCS
72	ST.TR/T/COR		
38	RSJ/T		
144	RSJ/RCS		
31	RSJ/RCS		
32	RSJ/COR		
35	RSJ/RCS		
62	CAUSEWAY		
63	CAUSEWAY		
27	ARCH/ST		
77	RSJ/BUC ST.TR/T/COR		
131	RSJ/COR		
58	RSJ/RCS		
Total	19	Total	6

And the summary of rehabilitation plan for the 100 bridges is shown in Table 15.8.

Table 15.8 Summary of Rehabilitation Plan for the 100 Bridges

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	Main Frame	Abut.	Pier	Wing Wall	Overall	Rehabilitation Plans from Structural View Point	Work Period (month)
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
175	AB027	1/2M		RSJ/COR	4.40	1	9.70	9.80	3	4	3	-	3	4.0	Reconstruction by RCB	7.0
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
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
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
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
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
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
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
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
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
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
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
202	B 304	14/5K	1993	BAILEY	9.15	1	4.80	-	-	-	(4)	-	(4)	(4.0)	Repair (protection of abutment against scouring)	1.0
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
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
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
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
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
61	B 379	7/6K		BAILEY	33.50	1	4.75	-	(4)	(1)	-	-	-	(3.2)	Repair (redecking by steel plate)	2.0
62	B 423	29/3K		CAUSEWAY	15.02	4	3.66	9.20	-	4	3	2	-	4.0	Reconstruction by PSC/PRE	12.0
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
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
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
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
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

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width		Damage Rating						Rehabilitation Plans from Structural View Point	Work Period (month)
							Exist.	Propd.	Deck	Main Frame	Abut.	Pier	Wing Wall	Overall		
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width		Damage Rating						Rehabilitation Plans from Structural View Point	Work Period (month)
							Exist.	Propd.	Deck	Main Frame	Abut.	Pier	Wing Wall	Overall		
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
93	AA005	21/4K	1926	ST.TR/I/BUC	98.30	2	9.01	-	2	2	2	3	2	3.0	Repair (main frame)	5.0
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width		Damage Rating						Rehabilitation Plans from Structural View Point	Work Period (month)
							Exist.	Propd.	Deck	Main Frame	Abut.	Pier	Wing Wall	Overall		
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
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
41	B 454	15/3K	1924	RCS	10.30	2	3.63	-	-	2	3	2	3	3.0	Repair (hand rail)	1.0
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
69	B 188	5/4K		ST.TR/T/RCS	12.60	1	3.06	-	1	3	2	-	-	3.0	Repair (main frame)	2.5
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
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
84	AA001	110/2K	1933	ARCH/S	68.30	3	7.80	-	3	1	1	1	1	2.4	Rehabilitation (redecking)	12.0
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
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
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
201	B 288	10/5K		ARCH/CO	7.20	2	8.06	-	-	1	2	-	2	2.0	Repair (grouting for wing wall)	1.0
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
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
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
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
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
43	AA004	206/9K		ARCH/BR	39.40	3	4.70	-	-	2	2	1	2	2.0	Repair (cleaning & grouting)	1.0
45	AA004	209/1K		ARCH/CO	28.40	2	4.25	-	-	2	1	1	2	2.0	Repair (cleaning & grouting)	1.0
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
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
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
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
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
46	AA007	73/5K		ARCH/ST	11.70	1	5.80	7.50	-	1	1	-	1	1.0	Rehabilitation (widening)	6.0

SER No.	Route No.	Bridge No.	Year Built	Type of Bridge	Length Exist (m)	Nos. of Span	Overall Width		Damage Rating						Rehabilitation Plans from Structural View Point	Work Period (month)
							Exist.	Propd.	Deck	Main Frame	Abut.	Pier	Wing Wall	Overall		
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
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

CHAPTER 16 ENVIRONMENTAL EXAMINATION

16.1 General

Serious environmental impacts do not occur resulting form the bridge improvements which involve repair, widening or reconstruction.

The bridge improvement project is not subject to Environmental Impact Assessment (EIA) Regulations as it is not in the scope of specified project under the Environmental Act.

Nevertheless on densely populated areas may cause relocation of residents, traffic jam and environmental pollution. The improvements at important locations, e.g., tourist spot, historical sites, or national parks may adversely affect sceneries, social and natural environments.

The preliminary survey report described that the impacts of large-scale work (e.g. reconstruction of a long bridge) on relocation, remains and cultural assets, water rights and rights of common, landscape and scenery should be considered.

Accordingly, the impact of the bridge improvement on environments should be taken into account.

To prevent environments from deteriorating, a preliminary study of measures to counter-act pollution and other factors that may worsen the social environment is important. The absence of environmental consideration can increase a project cost in case the project have caused environmental impacts.

JICA projects are also required to give environmental consideration under the Japanese Environmental Act.

Thus, the study of environmental impacts was conducted together with the master plan study on bridge development.

16.2 Preliminary Environmental Examination

16.2.1 Outline of Preliminary Environmental Examination

This chapter deals with the examination of the environmental considerations which was conducted together with the preliminary bridge inspection. A examination form containing the observed environmental condition in the bridges covered by the study and their surroundings, and the expected environmental impacts was formulated to conduct summary scoping and to collect environmental data on the said areas.

16.2.2 Environmental Considerations for the Selection of the Bridge for Preliminary Inspection

Serious environmental impacts are not expected to result from the bridge improvement works which involve repair, replacement or extensions. Nevertheless, it is important that environmental considerations should be adequately carried out in the following cases:

(1) Densely Populated Areas/Cities

The works are expected to affect densely populated areas/cities which are not only heavily congested with people but with vehicles as well. Accordingly, the impacts of the following on the environment should be considered:

- Resettlement
- Relocation of public, industrial, and religious facilities
- River-use
- Traffic obstruction (vehicles and pedestrians)

(2) Tourist Spots, Cultural and Historic Remains

The impacts of the works on important sites, e.g., tourist spots and historical sites, should be taken into consideration.

(3) National Parks, Sanctuaries

The impacts of the works on the natural environment, such as national parks and sanctuaries, and other areas restricted for development, should be considered.

Efforts were taken to ensure that bridges constructed in the areas above are included in the selection of the bridges for preliminary inspection. The location of the area for environmental consideration was determined from an atlas or any topographic map.

Accordingly, the following bridges were selected based on their significant need for environmental consideration:

1) Bridges where the impacts of works should be particularly considered (bridges in densely populated areas/cities)

SER No. 7, 27, 52, 57, 66,68, 75, 76, 93, 108, 119, 135, 144, 175

2) Bridges where the impacts of works on landscapes and scenic views should be considered (bridges in tourist spots and historical sites)

SER No. 1, 27, 42, 43, 57, 68, 75, 76, 84, 87, 86, 119, 135

3) Bridges where considerations on natural environmental impacts are important (bridges in the peripheries of national parks and sanctuaries)

There are hardly any roads in these areas; the works extend up to surrounding areas exercising natural environmental preservation.

SER No. 89, 91, 106

16.2.3 Preliminary Environmental Examination Results

Three teams organized for the preliminary bridge inspection carried out the Preliminary Environmental Examination. Prior to the commencement of the survey works of these teams, a joint study was carried out on SER No. 75, 76 bridges to confirm the items to be studied and to unify the criteria for examination.

The Preliminary Environmental Examination form used in the study is shown in Table Q.1 (Appendix-Q).

The results of the Preliminary Environmental Examination are summarized separately. Table Q.2 (Appendix-Q), a list of the results of the study on 101 bridges, has been organized to understand the importance of environmental considerations.

To understand the importance of environmental consideration, the assessment of the study items were carried out according to the following 4 steps:

Assessment	Criteria
◎	Environmental consideration is essential
○	Environmental consideration is preferred
△	Environmental consideration is somewhat necessary
×	Environmental consideration is not necessary

Efforts were taken to ensure that bridges thought to be in need of environmental consideration are included in the selection of bridges 10 bridges for detailed inspection. The following bridges for detailed inspection and their environmental considerations are as shown below.

SER No. 85

This bridge is located in a city where traffic volume is large and bustling with pedestrians and bicycles. In view of the fact that the bridge leads to an intersection on the Colombo side, the impact of the bridge improvement works on traffic and safety of pedestrians should be particularly considered. Residents of the area bathe and wash their clothes in the river(Ma Oya).

This bridge is an attractive arc shaped bridge constructed of bricks. Although this is not a tourism area, the bridge could be a potential tourist attraction.

SER No. 212

This bridge connects the tourism areas of Galle and Matara. Since traffic is heavy over this bridge, the possibility that the bridge improvement works might obstruct traffic should be taken into consideration. This bridge is located over the Goviyapana Ela River mouth where water is clean.

SER No. 77

The area around this bridge is filled with factories, commercial shops and residences. If the improvement works are to be extensive, resettlement should be considered.

Residents in the area bathe and wash their clothes in the Maha Oya River. Also, river sand is manually mined. The impacts of the construction of the A1 abutment on nearby wells and river use conditions should be taken into consideration. As for improvement works, their impacts on traffic, public safety and life style should be considered.

SER No. 53

The improvement works for this bridge will not have any impact on the houses constructed within the vicinity. Since a bus stop is located nearby the bridge, which is also used by students, the possibility that the improvement works might obstruct pedestrian traffic should be taken into consideration. Manual sand mining is also being carried out at the Delkanda Oya River.

SER No. 211

This bridge was not included in the list of 203 bridges. This bridge is located at a place where traffic is heavy. Since this bridge is considered to be in need of repair, it was chosen for preliminary bridge inspection. The impact of the improvement works on traffic must be considered..

SER No. 33

A rubber factory exists within the surrounding area of the bridge and the housing layout in this area is sporadic. The bridge improvement works would either affect or not affect the area depending on the improvement methods employed. In 1991, traffic volume was low, 750 vehicles/day, but impacts on traffic should be considered if the road that leads to the bridge will be relocated as part of the improvement works. The relocation will affect privately owned lands, thereby requiring further consideration.

SER No. 59

Because paddy fields surround this bridge, the impact of the improvement works on river use should be considered.

SER No. 20

Houses within this area are well spaced and an illegal shop exists near the bridge abutment. A dam is constructed on the Ogodapola Ela River. This is used for irrigation, manual sand mining, bathing, and washing of clothes. The impact of the improvement works on these activities should be considered, as well as the impact on traffic.

SER No. 70

This bridge is located in a densely populated area and its improvement might force the resettlement of residents in areas that will be affected by the works. Traffic over this bridge is heavy, and there are lots of pedestrians and bicycles as well. Further, the beginning of the bridge is located close to a Y-shaped intersection. In view of these conditions, resettlement and traffic obstruction are factors that should be taken into consideration regarding the implementation of the improvement works on this bridge. Considerations should also be given to the traditional fishing activities carried out in Bolgoda Lake.

SER No. 7

This bridge crosses the Negombo Lagoon. The area on the Negombo side is densely built up with houses. The school and harbor of Negombo are located within the scope of the improvement works. Accordingly, the impact of the improvement works on fishing activities should be taken into consideration along with resettlement and traffic obstruction.

16.3 Environmental Examination

16.3.1 Outline of Environmental Examination

(1) Details of Examination

Based on the results of the preliminary environmental examination and the site inspection, an Initial Environmental Examination (IEE) and scoping were carried out.

1) An Initial Environmental Examination (IEE) was carried out on the following 10 bridges due for detailed survey:

SER. No. 85, 212, 77, 53, 211, 33, 59, 20, 70, 7

2) Based on the result of the preliminary environmental examination, scoping was carried out and environmental consideration items were presented in regards to the remaining 91 bridges due for preliminary examination.

The overall flow of the examination is shown in Figure 16.1.

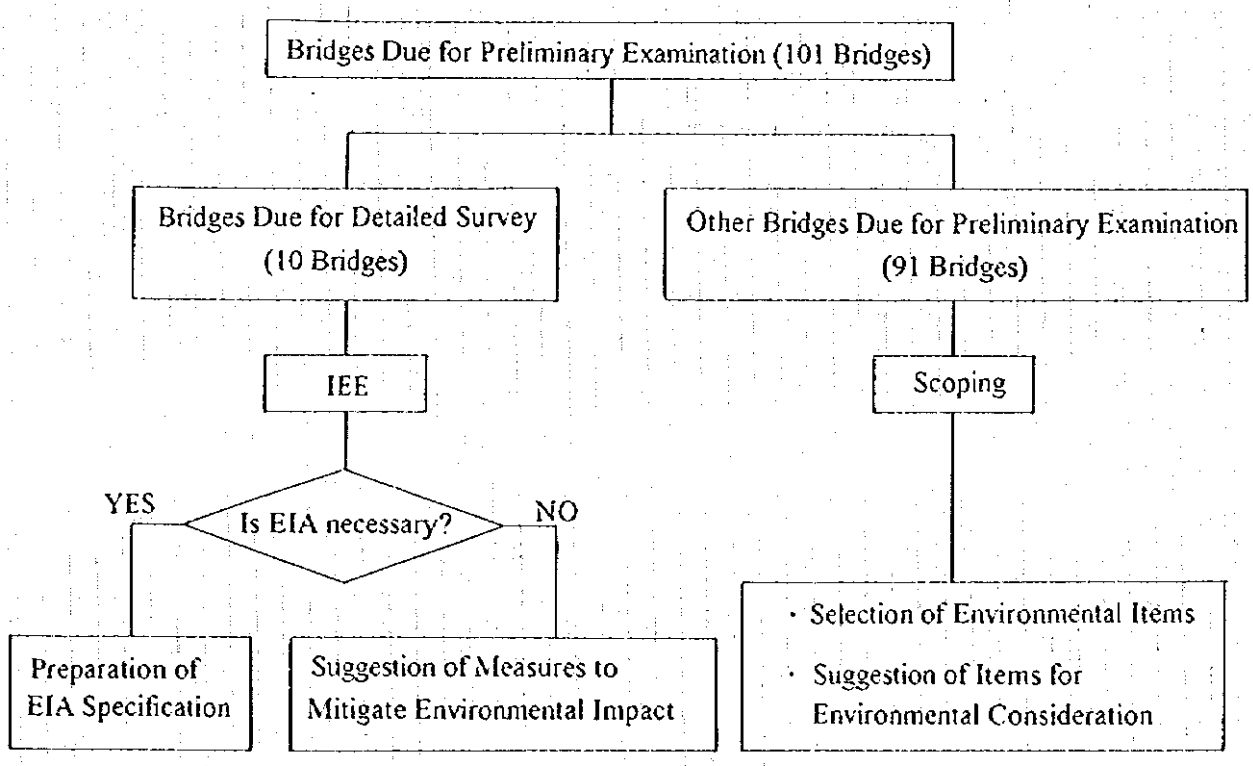


Figure 16.1 Overall Flow of Environmental Examination

(2) Items of Examination

Based on the results of the preliminary survey and the preliminary environmental examination, the following items were selected for the environmental examination.

(i) Relocation of Residents and Rights of Way (Rights of Common)

(ii) Use of river and Water Right

(iii) Traffic Jam (Vehicles and Pedestrians)

(iv) Others (Remains and Cultural Assets, Landscape/Scenery)

(3) Examination Method

1) IEE (Bridges due for Detailed Survey)

The procedure of the IEE shall be as follows:

(I) Outline of Bridge Improvement Plan

The outline of the bridge improvement plan was made from the environmental perspectives.

(ii) General Description of the Overall Environmental Conditions at the Site

The investigation was conducted by using documents such as a land-use map (1:100,000 scale).

(iii) Understanding the Current Environmental Conditions at the Site

A site investigation was conducted to understand the current environmental condition.

(iv) Evaluation of Environmental Impact

Qualitative prediction and evaluation of environmental impacts were carried out.

(v) Examination of Measures to Mitigate the Environmental Impact

Measures to mitigate the environmental impact and environmental protection measures were examined.

(vi) Recommendation of Necessity for EIA

Based on the result of the examinations (i) to (v), if EIA is considered to be necessary, an EIA specification shall be prepared: if not, measures to mitigate the environmental impact shall be proposed.

2) Scoping (Other Bridges Due for Preliminary Survey)

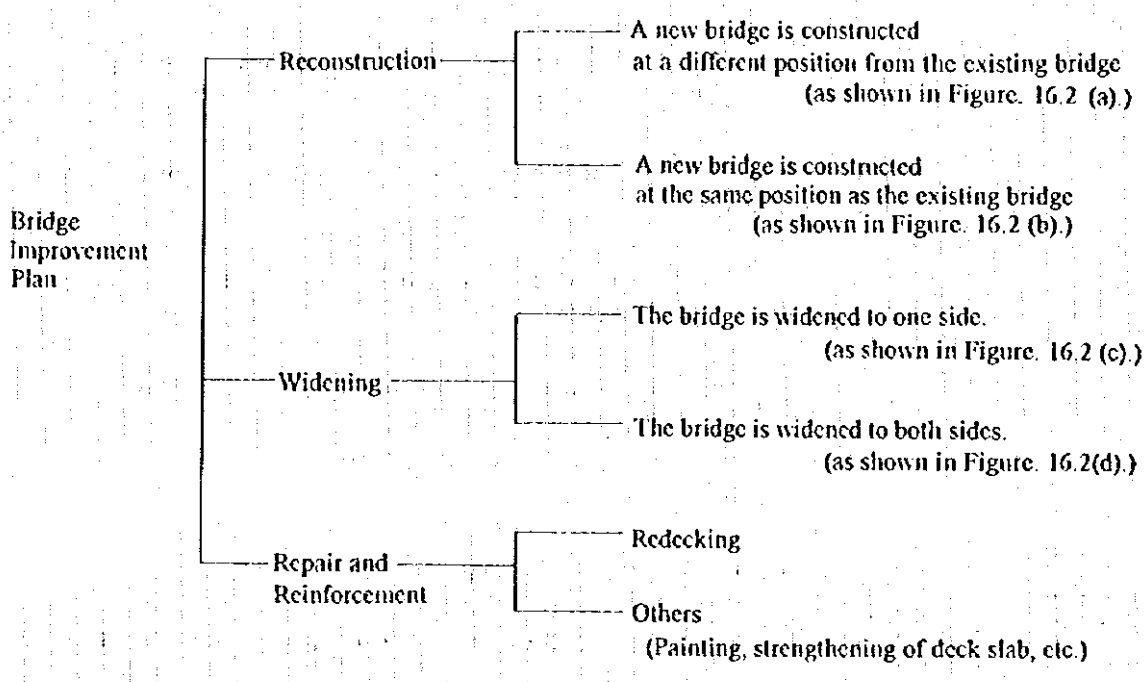
Scoping was conducted in accordance with the JICA guidelines for environmental consideration.
Then environmental examination items were selected and items for environmental consideration were proposed.

16.3.2 IEE results

(1) Outline of Bridge Improvement Plan

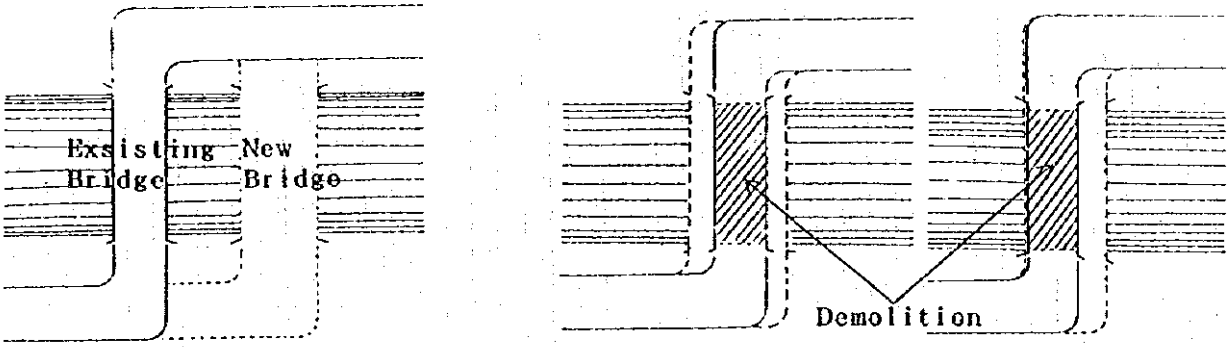
1) Outline of Bridge Improvement Plan

The bridge improvement plans are summarized as below:



(a) Reconstruction (The proposed bridge is constructed at a different position from the existing bridge.)

(b) Reconstruction (A new bridge is constructed at the same position as the existing bridge.)



(c) Widening (to one side)

(d) Widening (to both sides)

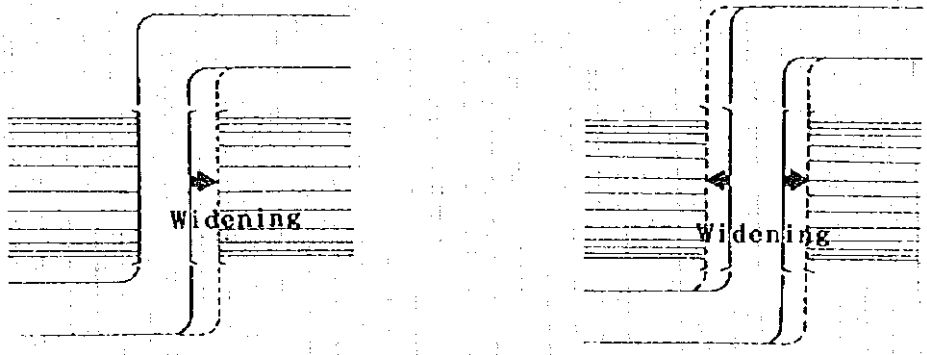
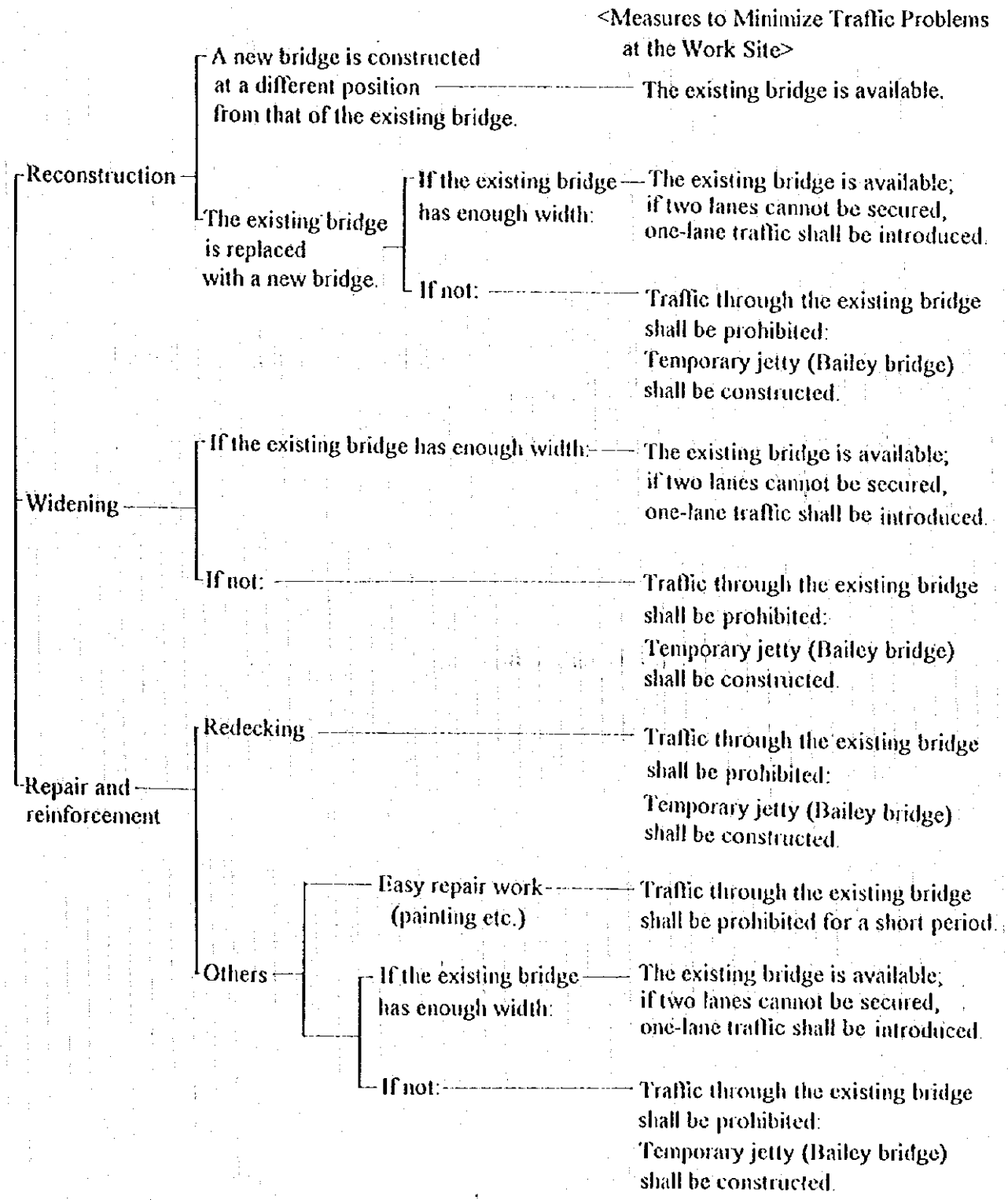


Figure 16.2 Outline of Bridge Improvement Plans

2) Measures against Traffic Jam at the Bridge Improvement Work Site

Measures against possible traffic jam at the bridge improvement work site are described as follows:



3) Summary of Environmental Impact Factors

The environmental impact factors predicted from the bridge improvement plan described in 1) and 2) are as follows:

(i) Reconstruction and Widening

a. To construct a new bridge and approach road, more space needs to be occupied.

b. To construct a temporary jetty, approach roads to the temporary jetty, and construction road, more space needs to be occupied.

c. Traffic problem will occur because of the one-lane traffic at the work site (excluding the case of constructing a temporary jetty).

(ii) Repair and Reinforcement

b. To construct a temporary jetty, approach roads to the temporary jetty, and construction road, more space needs to be occupied.

c. Traffic problem will occur because of the one-lane traffic and traffic prohibition at the work site (excluding the case of constructing a temporary jetty).

Among reconstruction, widening, repair and reinforcement, one or two methods with high feasibility for each bridge were selected and examined. Then an IEE was conducted considering the environmental impact factors a, b, and c.

(2) IEE Results

Based on the results of site inspection and the bridge improvement plan, possible environmental impacts of the bridge improvement were evaluated.

The IEE process and the result of the environmental impact examination are shown in Appendix-Q, Table Q.3. The result of IEE (measures to mitigate the environmental impact, recommendation of necessity for EIA) for each bridge are as follows:

SER No. 85

IEE was conducted assuming the widening.

Possible environmental impacts are: acquisition of private land and impact on the vicinal kindergarten for the construction road; impact on bathing and washing in the river; and traffic problems due to the one-way traffic at the work site.

The measures to mitigate the environmental impact are as follows:

- Acquisition of private land shall be minimized in planning the bridge improvement.
- Parties concerned shall be consulted prior to any land acquisition.
- The bridge improvement projects shall ensure the kindergarteners' safety at the work site.
- The bridge improvement projects shall be carried out so as to avoid flow of a large amount of soil into the river.
- Traffic at the work site shall be controlled by locating sign boards or flagman.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

SER No. 212

IEE was conducted assuming two cases; reconstruction and repair.

Because of sufficient road width, no land acquisition will be required nor any traffic problem will occur if a reconstruction or repair work is carried out.

Therefore, proposal and implementation of measures to mitigate the environmental impact or implementation of Environmental Impact Assessment (EIA) will not be necessary.

SER No. 77

IEE was conducted assuming the reconstruction.

Possible environmental impacts for the construction of temporary jetty and widening of approach road are: relocation of shop; acquisition of private land; and impact on well. Impacts on intake for water service, bathing and washing, and sand mining are also anticipated.

The measures to mitigate the environmental impacts are as follows:

- Acquisition or use of private land shall be minimized in planning the bridge improvement.
- Parties concerned shall be consulted prior to shop relocation or land acquisition.
- Relocation of well or water supply shall be considered if a well is filled.
- The bridge improvement project shall be carried out to avoid flow of a large amount of soil into the river.
- If a water intake may be filled by soil, it shall be relocated.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

SER No. 53

IEE was conducted assuming the reconstruction and repair.
For reconsturuction, acquisition of private land and cutting of coconut trees due to approach road construction, and impacts on bathing, washing and sand mining are foreseen. For repair, impacts on school children are predicted.

The measures to mitigate the environmental impacts are as follows:

- Acquisition of private land shall be minimized in planning the bridge improvement.
- Parties concerned shall be consulted prior to land acquisition.
- Coconut trees which are cut down shall be compensated.
- The bridge improvement projects shall be carried out to avoid flow of a large amount of soil into the river.
- If reconstruction or repair projects are carried out when school children pass by the work site, a flagman or a policeman shall ensure the safety of children.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

SER No. 211

IEE was conducted assuming two cases; widening and reconstruction.

Possible environmental impacts for the construction of temporary jetty are relocation of houses and shops and use of private land. Impacts on bathing and washing are also anticipated.

The measures to mitigate the environmental impact are as follows:

- Relocation of residents of houses and shops shall be avoided in planning the construction of the temporary jetty.
- Use (lease) of private land shall be minimized in planning the bridge improvement projects.
- Parties concerned shall be consulted prior to any use of private land.
- The bridge improvement projects shall be carried out to avoid flow of a large amount of soil into the river.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

SER No. 33

IEE was conducted assuming the case of reconstruction.

Possible environmental impacts are: acquisition of private land for the construction of approach road; and impacts on use of river water intake for industrial purpose (rubber factory), bathing and washing.

The measures to mitigate the environmental impact are as follows:

- Parties concerned shall be consulted prior to any acquisition of private land.
- The bridge improvement projects shall be carried out so as to avoid flow of a large amount of soil and muddy water into the river.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

SER No. 59

IEE was conducted assuming two cases; reconstruction, and repair and widening.

Possible environmental impacts are: use or acquisition of private land (paddies) for the construction of a temporary jetty and widening of the approach road; and poor drainage in areas of fills. It is also anticipated that wastes from upstream attached to the piers, which will hinder the river flow.

The measures to mitigate the environmental impact are as follows:

- Use or acquisition of private land shall be minimized in planning the bridge improvement projects.
- Parties concerned shall be consulted prior to any use or acquisition of the land.
- Poor drainage shall be improved by installing an adequate drainage system or other measures.
- If piers and abutments are constructed, the structures in the river shall be planned not to disturb the river flow.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

SER No. 20

IEE was conducted assuming two cases; reconstruction, and repair and widening.

Possible environmental impacts are relocation of residents of houses and a shops and acquisition of private land for the construction of the temporary jetty and widening of the approach road. Impacts on water intake for agricultural use, bathing and washing, and sand mining are also anticipated.

The measures to mitigate the environmental impact are as follows:

- If the shop (seemingly unauthorized) should be relocated, provision of substitute land or other consideration shall be given.
- Use or acquisition of private land shall be minimized in planning the bridge improvement projects.
- Parties concerned shall be consulted prior to any relocation of the shop or use or acquisition of private land.
- The temporary jetty shall be constructed so as not to disturb the functions of the water intake facility (weir) for agricultural use.
- The bridge improvement projects shall be carried out so as to avoid flow of a large amount of soil into the river.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

SER No. 70

IEE was conducted assuming two cases; reconstruction, and repair and widening.

Possible environmental impacts are relocation of residents of houses and acquisition of private land for widening the approach road. It is also anticipated that water plants cling to the piers, which will hinder the river flow and the traffic of fishing boats. If repair and widening projects are carried out, vehicle traffic and pedestrian safety will be affected by the one lane traffic at the work site.

The measures to mitigate the environmental impact are as follows:

- Acquisition of private land shall be minimized in planning the bridge improvement projects.
- Parties concerned shall be consulted prior to any acquisition of private land or relocation of the unauthorized temporary building.
- If piers and abutments are constructed, the structures in the river shall be planned not to disturb the river flow or traffic of fishing boats.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

SER No. 7

IEE was conducted assuming two cases; reconstruction and repair.

Possible environmental impacts are relocation of residents of houses and shops and impacts on the fishing port. It is also anticipated that traffic of fishing boats will be disturbed due to the construction of temporary jetty and the new bridge.

The measures to mitigate the environmental impact are as follows:

- Relocation of permanent buildings and disturbance to the operation of fishing port shall be avoided in planning the bridge improvement.
- Parties concerned shall be consulted prior any use or acquisition of land or relocation of the unauthorized temporary building.
- Consideration shall be given to any construction of piers for temporary jetty and a new bridge not to disturb the traffic of fishing boats.
- Consideration shall be given to any repair work to ensure the safety traffic of fishing boats.

Environmental impact will be mitigated by implementing the above measures. Therefore, Environmental Impact Assessment (EIA) will not be necessary for the proposed improvement projects on this bridge.

16.3.3 Scoping Results

(1) Summary of Items for Environmental Consideration

According to the results of the IEEs for 10 bridges due for detailed survey and the results of scoping for 91 bridges, the items for environmental consideration required at bridge improvement projects are as summarized in Table 16.1.

Table 16.1 Items for Environmental Consideration at Bridge Improvement Projects

A.	Relocation of Residents and Rights of Way
	A-1 Relocation of permanent buildings shall be avoided in planning the improvement projects. *1
	A-2 Important facilities shall not be disturbed. *2
	A-3 Acquisition or lease of private land shall be minimized.
	A-4 Relocation of residents of unauthorized temporary buildings should be avoided.

A-5 Parties concerned shall be consulted prior to any acquisition or use (lease) of private land or any relocation of residents of unauthorized temporary buildings.

A-6 Consideration shall be given at acquisition of land. For example:
- If valuable trees are cut down (coconut trees etc.), compensation shall be made.
- If a well is filled, compensatory measures such as transfer of the facility shall be provided.
- If unauthorized building is relocated, a substitute land shall be provided.

A-7 Poor drainage in areas of fills shall be improved by installation of drains and other methods.

*1 Project planning of the temporary jetty (Bailey bridge) and safety measures at the work site are included.

*2 Important facilities include: school buildings; hospitals; religious facilities; public facilities; factories; fishing ports; and important trees (e.g. Bo-tree).

B. Use of River

B-1 If water intake (for water supply, agricultural use, and industrial use) is conducted, consideration shall be given to the following points:
- The project shall be carried out so as not to disturb the functions of the water intake facilities.
- If any damage may be given, relocation of the water intake facilities or other measures shall be implemented.
- The bridge improvement projects shall be conducted so as to avoid flow of a large amount of soil and muddy water into the river.

B-2 If bathing, washing, and sand mining are carried out, the bridge improvement projects shall be conducted so as to avoid flow of a large amount of soil into the river.

B-3 If piers and abutments(*3) are constructed, the structures in the river shall be planned not to disturb the river flow and water traffic. If the water traffic is busy at the work site, consideration shall be given to ensure safety of the ships and boats.

*3 Piers and abutments of the temporary jetty are included.

C. Traffic Problem (Vehicles and Pedestrians)

By implementing measures such as constructing a temporary jetty and securing one lane traffic at the bridge improvement work site, serious traffic jam or adverse effect on the pedestrian safety will be prevented. However, on busy roads such as A1 Road between Colombo and Kandy, A2 Road between Colombo and Galle, or if school children walk to school near the bridge, consideration shall be given to the following cases:

C-1 If traffic jam is anticipated due to large traffic volume and one lane traffic is introduced at the work site, traffic control and pedestrian safety shall be ensured by introducing a sign board or a flagman.

C-2 If there is any danger of traffic accidents at the work site for school children, their safety shall be ensured by introducing a flagman or a policeman.

D. Others

D-1 If any remains or cultural assets are located near the bridge, consideration shall be given not to damage them. Refer to "A. Relocation of Residents and Rights of Way."

-2 If the bridge is a part of a scenery which is widely appreciated, consideration shall be given not to deteriorate the scenery by the bridge improvement.

The relation between environmental impact factors predicted from the bridge improvement plan and items for environmental consideration are shown in Table 16.2.

Table 16.2. Relation Between Environmental Impact Factors and Items for Environmental Consideration

Bridge Improvement Plan			Reconstruction and Widening			Repair and Reinforcement	
Environmental Impact Factors *			a	b	c	b	c
Items Table for Environmental Consideration ** (Refer to 16.1)	A	A-1	O	O		O	
		A-2	O	O		O	
		A-3	O	O		O	
		A-4	O	O		O	
		A-5	O	O		O	
		A-6	O	O		O	
		A-7	O	O		O	
	B	B-1	O	O		O	
		B-2	O	O		O	
		B-3	O	O		O	
	C	C-1			O		O
		C-2			O		O
	D	D-1	O	O		O	
		D-2	O				

Remarks

A: Relocation of Residents and Rights of Way
B: Use of River
C: Traffic Jam
D: Others

a: Construction of New Bridge
b: Construction of temporary Jetty
c: Traffic Jam

* Environmental Impact Factors
  a. To construct a new bridge and approach road, more space is required.
  b. To construct a temporary jetty, approach roads to the temporary jetty, and access roads, more space is required.
  c. Traffic problem will occur because of the one-lane traffic at the work site.

** Items for Environmental Consideration: Refer to Table 16.1 for the definitions of codes.

(2) Scoping Results

Based on preliminary environmental examination and on-site survey (for some sampling of bridges), scoping has been carried out. For improvements of bridges, anticipated environmental problems (impacts) are selected and environmental considerations are suggested.
Scoping results have been shown on Appendix-Q Table Q.4.
Scoping results (anticipated environmental problems and considerations) are shown on Table 16.3.

For all bridges which are subject to scoping, sufficient examinations on improvement methods or traffic problems have not been made. IEE has been done considering all improvements such as reconstruction, widening, repair and reinforcement. Therefore, it is recommended that IEE will be done for 80 bridges (Table 16.3 marked with *) which require environmental considerations after determination of improvement methods and traffic problems.

Table 16.3 Scoping Results

Bridge SER No.	Environmental examination items				Environmental consideration items (Ref Table 16.1)													Necessity of IEE
					A Resettlement / Land Acquisition							B. River-use			C. Traffic obstraction		D: Others	
	(A)	(B)	(C)	(D)	A-1	A-2	A-3	A-4	A-5	A-6	A-7	B-1	B-2	B-3	C-1	C-2	D-1	D-2	
84	O	O	O	O	O		O		O	O			O		O			O	*
1	X	O	O	O										O	O		O	O	*
27	O	O	O	O			O		O	O			O		O			O	*
75	O	O	O	O	O	O	O		O					O	O			O	*
76	O	O	O	O	O	O	O		O					O	O			O	*
86	X	X	X	X															—
87	X	X	X	X															—
79	O	X	O	X			O		O	O					O				*
80	O	O	X	X	O		O		O	O			O						*
43	X	O	X	O									O					O	*
44	X	X	X	X															—
45	X	O	X	X								O							*
89	O	X	X	X			O		O	O									*
91	O	O	X	X			O		O				O						*
178	X	O	X	X								O							*
93	O	O	O	O		O	O		O				O		O			O	*
46	O	X	X	X			O		O	O									*
47	O	O	X	X			O		O	O	O	O	O						*
99	O	O	O	O	O	O	O		O				O		O	O		O	*
2	O	O	X	X			O		O	O			O						*
36	O	O	X	X			O		O				O						*
102	O	O	X	X			O		O	O			O						*
65	X	O	X	X									O						*
103	X	O	X	X									O						*
52	O	X	X	X	O		O		O	O	O								*
106	O	O	X	X	O		O		O	O			O						*
108	O	X	X	X			O		O		O								*
119	O	O	X	X	O	O	O		O			O	O						*
175	O	X	X	X			O		O										*
120	O	O	X	X			O		O	O	O	O							*
30	O	X	X	X			O		O		O								*
122	X	X	X	X															—
123	O	O	X	X			O		O				O						*
55	O	O	X	X	O		O		O	O			O						*
56	O	O	X	X	O		O		O				O						*
127	O	X	X	X			O		O	O									*
128	O	O	X	X			O		O	O		O							*
66	O	X	O	X	O		O		O	O					O				*
31	O	O	X	X			O		O		O		O						*
57	O	X	X	X			O		O		O								*
129	O	O	X	X	O		O		O			O	O						*
130	X	O	X	X									O						*

Table 16.3 Scoping Results

Bridge SER No.	Environmental examination items				Environmental consideration items (Ref Table 16.1)														Necessity of IEE
					A Resettlement / Land Acquisition							B. River-use			C. Traffic obstruction		D: Others		
	(A)	(B)	(C)	(D)	A-1	A-2	A-3	A-4	A-5	A-6	A-7	B-1	B-2	B-3	C-1	C-2	D-1	D-2	
131	O	X	X	X			O		O		O								*
209	O	O	X	X			O		O		O	O							*
210	O	O	X	X			O		O			O							*
58	O	X	X	X			O		O		O								*
67	O	O	X	X	O		O	O	O	O		O	O						*
18	O	O	X	X	O		O		O				O						*
68	O	O	X	X			O		O				O						*
208	O	O	X	X			O		O	O		O							*
69	O	O	X	X			O		O			O							*
133	O	O	X	X			O		O		O		O						*
78	O	O	X	X	O		O		O	O	O	O	O						*
19	X	X	X	X															Δ
71	X	O	X	X									O						*
72	O	X	X	X			O		O	O									*
135	O	X	X	X			O		O										*
34	O	O	X	X			O		O	O			O						*
38	O	O	X	X		O	O		O	O			O						*
136	O	O	X	X			O		O	O		O							*
195	O	O	O	X		O	O	O	O	O	O		O		O				*
197	O	O	O	X		O	O	O	O	O	O		O		O				*
201	O	O	O	X		O	O	O	O	O	O		O		O				*
60	O	X	X	X			O		O	O									*
138	O	X	X	X			O		O	O									*
173	O	O	X	X			O		O			O							*
202	O	O	X	X			O		O				O						*
139	X	X	X	X															Δ
39	X	X	X	X															Δ
61	X	O	X	X									O						*
144	X	X	X	X															Δ
147	X	X	X	X															Δ
148	O	X	X	X			O		O	O	O								*
21	O	O	X	X			O		O				O						*
40	O	O	X	X			O		O		O	O							*
62	X	O	X	X									O						*
63	X	X	X	X															Δ
73	O	O	X	X			O		O				O						*
22	O	O	X	X	O		O		O				O						*
17	O	X	X	X	O		O		O										*
32	O	O	X	X			O		O	O		O							*
150	O	O	X	X			O		O			O	O						*
151	O	O	X	X			O		O		O	O	O						*
154	O	O	X	X			O		O		O	O	O						*

Table 16.3 Scoping Results

Bridge SER No.	Environmental examination items				Environmental consideration items (Ref Table 16.1)													Necessity of IEE
					A Resettlement / Land Acquisition							B. River-use			C. Traffic obstruction		D. Others		
	(A)	(B)	(C)	(D)	A-1	A-2	A-3	A-4	A-5	A-6	A-7	B-1	B-2	B-3	C-1	C-2	D-1	D-2	
24	O	O	X	X			O		O			O	.						*
25	O	O	X	X			O		O	O			O						*
35	O	O	X	X			O		O	O			O						*
41	X	X	X	X															Δ
26	O	O	X	X			O		O	O			O						*
42	O	O	X	X			O		O	O			O						*
74	O	O	X	X			O		O		O	O							*

Legends

O: Selected as an environmental item / Proposed as an item for environmental consideration.

X or a blank: Not selected as an environmental item / Not proposed as an item for environmental consideration.

*: IEE is considered to be necessary.

_: IEE is not considered to be necessary.

(A): Resettlement
(B): River-use
(C): Traffic obstraction
(D): Others

16.3.4 Opinions and Conclusion

(1) IEE of Bridges (10 bridges) for Detailed Survey

For improvements of 10 bridges, the following measures are required to mitigate environmental impacts.

A. Relocation of Residents and Rights of Way

- A plan must be made to prevent relocation of permanent building.
  SER No. 211,7

- A plan must be made not to cause problems at major facilities.
  SER No. 85 (kindergarten), 7 (fishing port)

- A plan must be made to minimize acquisition or use of private lands.
  SER No. 85, 77, 53, 211, 59, 20, 70, 7

- Partiess concerned shall be consulted before acquisition of lands.
  SER No. 85, 77, 53, 211, 33, 59, 20, 70

- Measures such as compensation or replacement must be taken before acquisition of lands.
  SER No. 77 (well), 53 (coconut tress), 20 (unauthorized building)

- Improvement of poor drainage
  SER No. 59

B. River-use

- Consideration for use of tap water
  SER No. 77 (tap water), 33 (industrial water), 20 (agricultural water)

- Consideration for bathing, washing and sand taking
  SER No. 85, 77, 53, 211, 33, 20

- Consideration for river flow and watertraffic
  SER No. 59, 70, 7

C. Traffic Problem and Safety for Pedestrians

- Traffic control and safety for pedestrians
  SER No. 85, 70

- Safety for school children
  SER No. 53

Implementation of the above measures will result in mitigation of environmental impacts. Therefore, implementation of detailed examination (EIA) of environmental impacts on 10 bridges is not required.

(2) Scoping of Preliminary Survey Bridges (91 bridges)

Certain impact will be given to the environment and therefore consideration should be given to the bridge improvement project at 80 bridges out of the 91 (Refer to Table 16.3). The environmental examination items were determined as follows:

A. Relocation of Residents and Rights of Way
B. River-use
C. Traffic Jam (Vehicles and Pedestrians)
D. Others (Remains, Cultural assets, Scenery)

The items for environmental consideration are:

A. Relocation of Residents and Rights of Way
A-1 Avoiding relocation of residents of permanent buildings
A-2 Consideration for important facilities including public, religious and industrial facilities
A-3 Consideration for acquisition or lease of private land
A-4 Consideration for temporary building illegally invaded by squatters
A-5 Discussions with parties concerned in advance
A-6 Compensation or alternative measures at acquisition of land
A-7 Improvement of poor drainage

B. River-use
B-1 Consideration for water intake (for water supply, agricultural use, and industrial use)
B-2 Consideration for bathing, washing, and sand mining
B-3 Consideration for problems against river flow and water traffic

C. Traffic Jam (Vehicles and Pedestrians)
C-1 Traffic control and pedestrian safety
C-2 School children's safety at the bridge improvement work site

D. Others
D-1 Consideration for remains and cultural assets.
D-2 Consideration for landscape

Regarding 80 bridges, it is necessary to examine the improvement plan and traffic control during the improvement project; to carry out an IEE; and to examine the environmental considerations.

(3) Opinion

The following items should be considered for the environment although they are not in scope of this study.

- Smooth traffic flow and/or reduction of environmental pollution such as noise by improvement of the approach road (widening of road or recess of building facing the road).

  SER No. 211, 59

- Traffic jam should be resolved by improving the intersections at both ends of the bridge.

  SER No. 33, 70

- The existing bridge should be reserved and renovated as a tourist attraction.

  SER No. 85

- The elevation of beam sofit should be large enough for the future traffic of larger fishing boats. The project area should be renovated as a tourist attraction.

  SER No.7

If traffic volume increases in the future, traffic jam, noise problem and air pollution may occur on bridges in the densely populated areas. Bridge improvement is not enough to solve these issues; construction of a bypass needs to be considered.

CHAPTER 17 PLANNING OF MAINTENANCE AND MANAGEMENT

17.1 Basic Policy of Planning

Following points have been taken into account for planning of bridge maintenance & management plan of Sri Lanka aiming up to year 2010.

(1) Detailed investigation have been made on RDA of the Sri Lanka government, in particular, the current resources of the Engineering Services Division and the Maintenance Management & Construction Division, including engineers, technical officers, clerks, equipment and materials for inspection, maintenance and rehabilitation, budget and also each provisional offices.

(2) Investigation has been made also on RCDC and other organizations, which are engaged in construction and rehabilitation works, in addition to RDA.

(3) The construction year, present state of soundness of a bridge, future RDA's plan and budget will be studied thoroughly to develop a master plan while considering the present state of bridges in Sri Lanka, particularly 100 bridges for which visual inspection has been made.

(4) The plan to be established must be the one which RDA of Sri Lanka can execute in the future up to year 2010.

(5) After the study on the existing system the improvement plan has been proposed through the basis of experience of the consultant.

(6) Once this study is over, Sri Lanka engineers shall conduct the bridge maintenance and management using the budget of Sri Lanka. Recognizing this, recommendations of this Study must be the one which would contribute to improve the overall road system enabling the work appropriate to the actual state of Sri Lanka.

Prior to establishment of this plan the Study Team has investigated thoroughly the actual condition of RDA's maintenance and management of bridges, collected available data and information and conducted interview with wide a number of people.

17.2 Existing System of Bridge Maintenance and Management

17.2.1 Organization of RDA

Road Development Authority (RDA) are administrating National Highways A and B of 3,726km and 7,405 km and 1,713 bridges on National Highway A and 2,717bridges on that B respectively.

The recent RDA's Overall Organization Chart is shown in Figure 17.1.

Organizational divisions related to maintenance and management of bridges include Engineering Services, Maintenance Management & Construction and Finance.

17.2.2 Organization related to Bridge Maintenance and Management

The organizations of specific governmental offices concerning design, construction, maintenance, rehabilitation and management for roads and bridges in Sri Lanka is shown below.

(1) Organization of Engineering Services Division

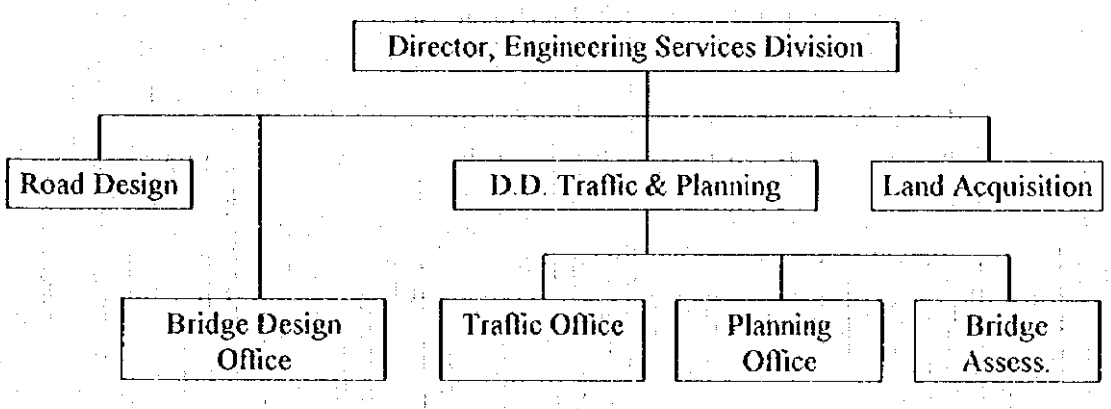
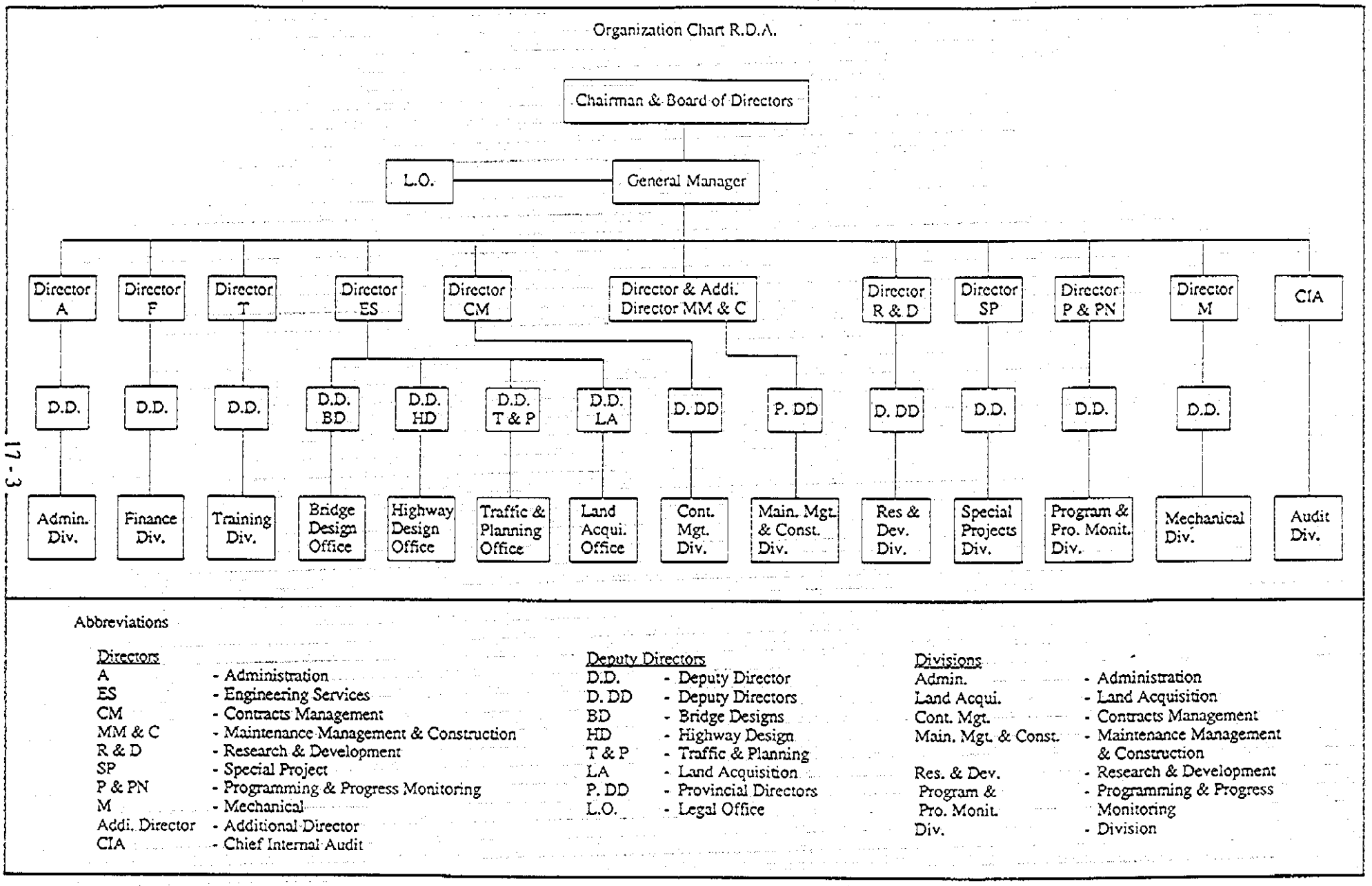


Figure 17.2 Organization of Engineering Services Division

Mainly Traffic and Planning Office is in charge of bridge inventory preparation and filing. Organization of this office is shown in Figure 17.3.

(2) Maintenance Management & Construction Division (MMC)

This division carries out maintenance and management and construction of the project of local funds and loans from OECF, ADB and WB, while Contract Management Division takes the projects of the foreign grant aid.



Abbreviations

Directors

A	- Administration
ES	- Engineering Services
CM	- Contracts Management
MM & C	- Maintenance Management & Construction
R & D	- Research & Development
SP	- Special Project
P & PN	- Programming & Progress Monitoring
M	- Mechanical
Addi. Director	- Additional Director
CIA	- Chief Internal Audit

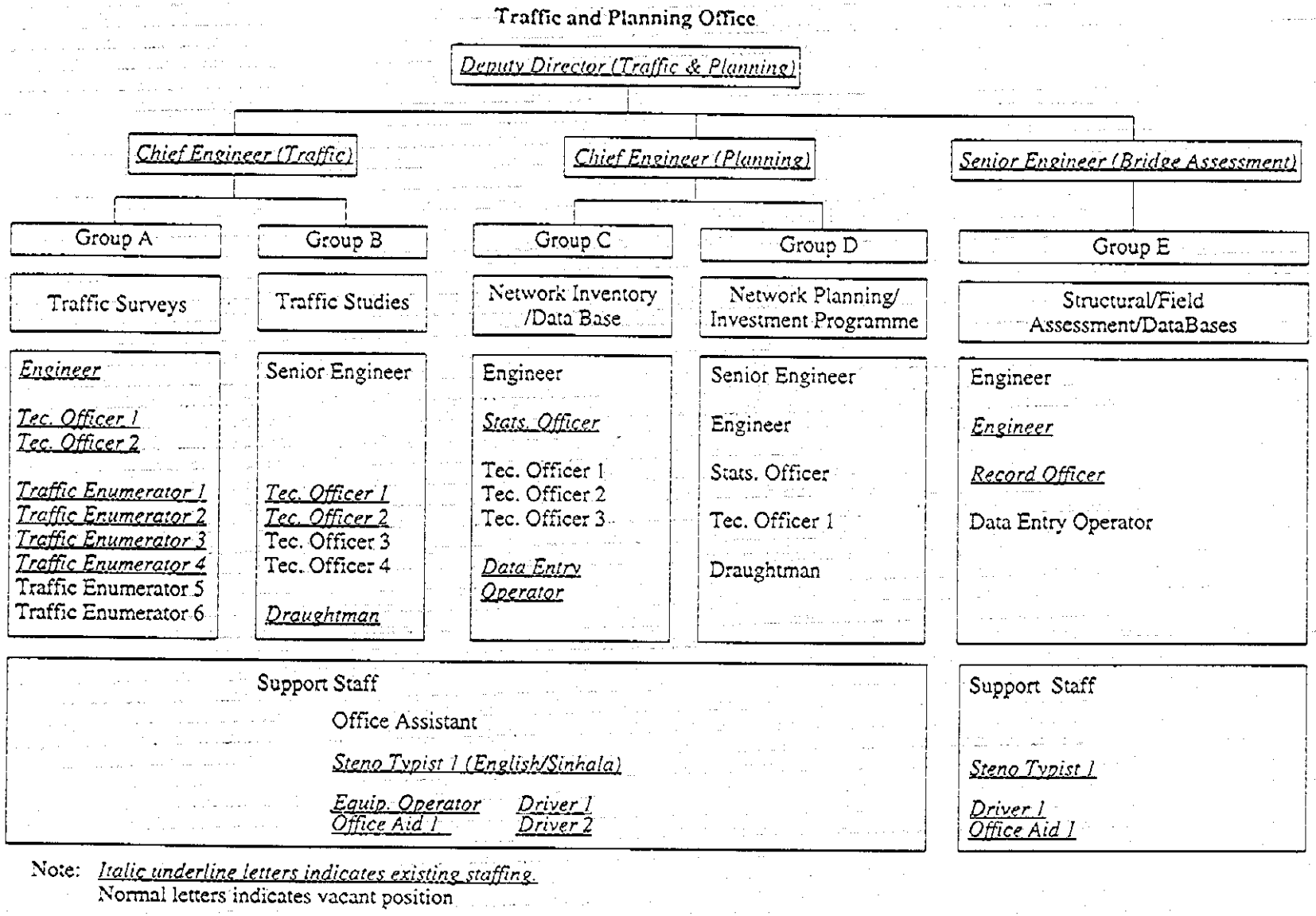
Deputy Directors

D.D.	- Deputy Director
D. DD	- Deputy Directors
BD	- Bridge Designs
HD	- Highway Design
T & P	- Traffic & Planning
LA	- Land Acquisition
P. DD	- Provincial Directors
L.O.	- Legal Office

Divisions

Admin.	- Administration
Land Acqui.	- Land Acquisition
Cont. Mgt.	- Contracts Management
Main. Mgt. & Const.	- Maintenance Management & Construction
Res. & Dev.	- Research & Development
Program & Pro. Monit.	- Programming & Progress Monitoring
Div.	- Division

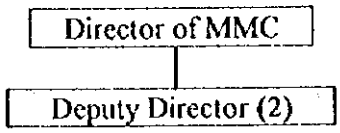
Figure 17.1 Organization Chart of R.D.A



Note: *Italic underline letters indicates existing staffing.*
Normal letters indicates vacant position

Figure 17.3 Organization of Traffic and Planning Office

The organization of the Maintenance Management & Construction Division is shown in Figure 17.4.



Chief Engineer	(3)
Engineer	(1)
Secretary	(1)
Clerk	(1)
Typist (English)	(2)
Typist (Sinhala)	(1)

Figure 17.4 Organization of MMC

(3) Provincial Offices

There are 9 Provincial Offices under the Maintenance Management & Construction Division in each province. Typical organization of Provincial Office is shown in Figure 17.5.

Provincial Office

Provincial Director	(1)
Chief Engineer	(2 or 3)
Executive Engineer	(2 or 3)
Project Engineer	(8) in case of Colombo
Technical Officer	(4)
Clerk and Others	(5)

Figure 17.5 Organization of Provincial Office

Figure 17.6 shows the organization of each province, region and division. Regional offices and divisional offices are small in facilities and staff. When need arises on roads and bridges to restore the normal functions, those local offices work jointly with Province office or RDA Head office. Currently no major works for bridge maintenance by those offices are found during this study.

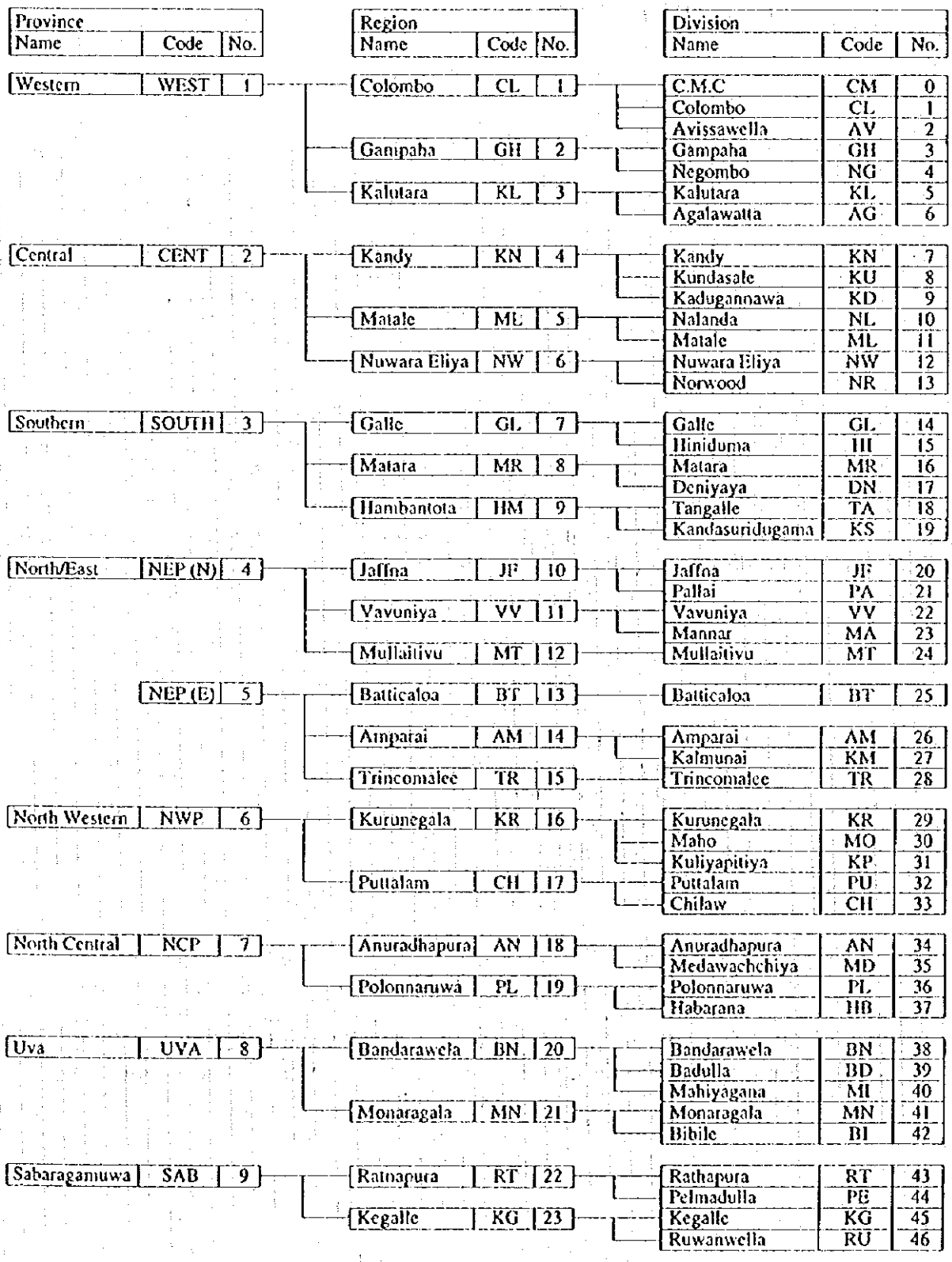


Figure 17.6 Structure of Administrative Divisions-R.D.A.

(4) Regional Office

As shown in Figure 17.6 under Provincial Offices, there are Regional and Divisional Offices.

As a example Western Province and its Colombo Regional Office are shown in Figure 17.7 and Figure 17.8.

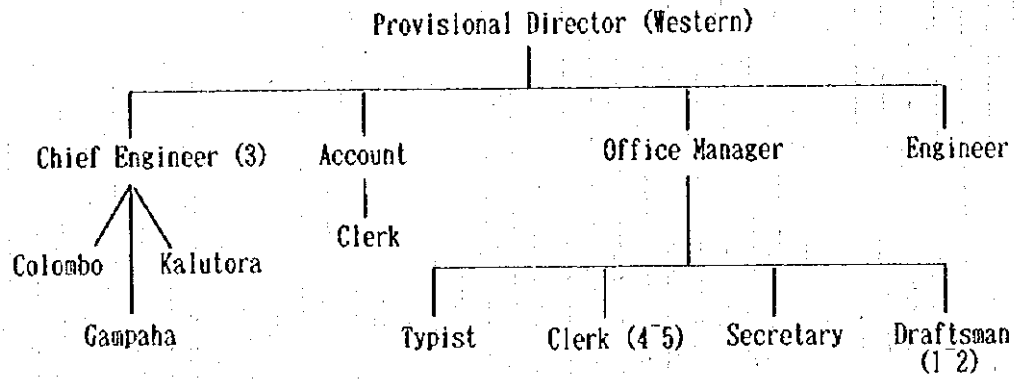


Figure 17.7 Organization of Western Provincial Office

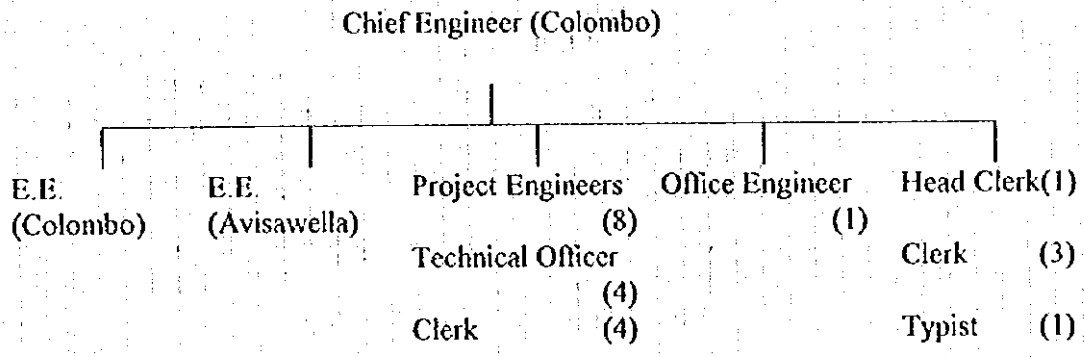


Figure 17.8 Organization of Colombo Regional Office under Western Province

17.2.3 Status of Bridge Maintenance and Management

(1) Engineering Services Division (E.S.D.)

This division is taking the part of design, planning and management for roads and bridges together. As to the business of the bridge maintenance and management the following offices are concerned with this division.

Visual inspection----------	Engineering Services division with each Provincial Offices
Inventory & Inspection Form -----	Engineering Services Division, Traffic & Planning Office
Maintenance & Management------	Engineering Services Division with Maintenance Management and Construction Division.

In the stage of actual maintenance works, the following two divisions take part in.

Rehabilitation ----------	Maintenance Management and Construction Division with Contractors

(2) Current Bridge Maintenance Management System

The Traffic and Planning Office has played the role of planning of Bridge Maintenance & Management while collecting the inventory data to some extent. The reason why is the following.

1) The project of WB's bridge maintenance and management

This project with WB fund was performed by the UK consultant, Rendel Palmer and Tritton between years 1990 to 1991. For this project 2 British engineers had been sent to Sri Lanka and worked with only 1 Sri Lanka engineer. Originally about 4,400 bridges on A and B National Highways were targeted for the inventory.

However too many inputs were required to the computerized database, they did for only about 500 bridges has been data-based and seized. Another reason of failing was a personnel arrangement of 1 Sri Lankan to 2 Britishs.

Computer: IBM Personal System/2, Model 70386
Printer: EPSON Fx 1050

2) RDA own work for Inventory

After the unsatisfactory result of WB's project, RDA prepared and collected the bridge inventory of about 1,300 bridges on A national highways.

3) RDA then collected the data (dimension with defect) of about 2,000 bridges on B national highways.

4) The 206 bridges inventory was once proposed for master plan subject,

however, SW agreed to survey 100 bridges in selected from the above inventory.

(3) Materials and Equipment

At present the following inspection tools are kept by the Bridge Assessment section under Traffic & Planning office.

(i) For Visual Inspection

1.	Plumb Bob	-3 Nos.
2.	Wire Brush with Scraper	-2 Nos.
3.	Hammer Head 2.5 Lbs	-1 No.
4.	Hammer 2.5 Lbs	-2 Nos.
5.	Anival Small	-1 No.
6.	Leather Gloves (Pairs)	-2 Nos.
7.	Aluminium Adjustable Ladder 30' - 0"	-1 No.
8.	Aluminium Adjustable Ladder 20' - 0"	-1 No.
9.	Aluminium Adjustable Ladder 5' x 2'	-1 No.
10.	Sign Boards with Stands	-4 Nos.
11.	Hand Axe	-1 No.
12.	Masons Trowel	-2 Nos.
13.	Hammer 14 Lbs Head only	-2 Nos.
14.	Hammer Head 2 Lbs	-2 Nos.
15.	Safety Helmet	-15 Nos.
16.	Club Hammer 1 kg	-2 Nos.
17.	Wire Brush	-2 Nos.
18.	Plumb Bob Brass Sets	-2 Nos. Sets.
19.	Rubber Groves (Pairs)	-4 Nos.
20.	Sprit Level Aluminium (1 Meter)	-1 No.
21.	Clip Board	-4 Nos.
22.	Nylon String No. 3	-1 Roll.
23.	Goggles	-14 Nos.
24.	Polipopline Rope 12 mm Dia.	-1 Roll.
25.	Life Jacket	-2 Nos.
26.	Elastic Tie Wire with Hooked End	-10 Nos.
27.	Jackets used for Bridge Inspection	-10 Nos.
28.	Chain Lock 1 Meter	-2 Nos.
29.	Binoculaler	-3 Nos.
30.	Inflammable Boat & Ores	-1 No.
31.	SLR Camera K300 Zoom Lens Sigma Vivita Flash Model 283	-2 Nos. Sets in Box
32.	Tripod for Camera	-1 No.
33.	Imported Nylon Rope 9 mm	-1 No. Roll

(ii) For Detailed Inspection

1.	Micrometer Caliper Set (5 Pieces)	-1 No.
2.	Micrometer Caliper	-1 No.
3.	Radius Curve with Parallel Ruler	-1 No.
4.	Clenometer Bar	-1 No.
5.	Micrometer	-1 No.
6.	Caliper	-2 Nos.
7.	Auger	-2 Nos.
8.	Chisel Varius Size	-8 Nos.
9.	Long Handle Knife Bill Book	-1 No.
10.	Hand Knife	-1 No.
11.	8" x 1" Cold Chistles	-8 Nos. (3 Nos. Unserviceable)
12.	Micro Cover Meter	-2 Nos.
13.	Ultrasonic Steel Thickness Meter	-1 No.
14.	Crack Measuring Rulers	-4 Nos.
15.	Magnifying Crack Microscope	-2 Nos.
16.	Schmidt Hammer	-2 Nos.
17.	Geological Hammer	-4 Nos.
18.	Cupling Agent for Ultrasonic Steel Thickness Meter	-5 Nos. Cans

17.2.4 Budget

(1) Existing Budget Allocation

Table 17.1 shows the budget allocation of years 1990 to 1994.

Table 17.1 Budget Allocation

(Unit : Million Rs.)

Year	Investment			Maintenance	Admini.	Grand Total
	Road	Bridge	Total			
1990	877	10	877	177	91	1,155
1991	1,210	36	1,246	201	111	1,558
1992	1,150	86	1,236	170	117	1,523
1993	2,345	152	2,497	181	182	2,860
1994	1,520	156	1,676	717	258	2,651

(2) Budget for Bridge Maintenance and Management

Budget and expenditures on bridges are shown in Table 17.1. In RDA, the major rehabilitation and replacement are recorded separately, but routine maintenance is shown together.

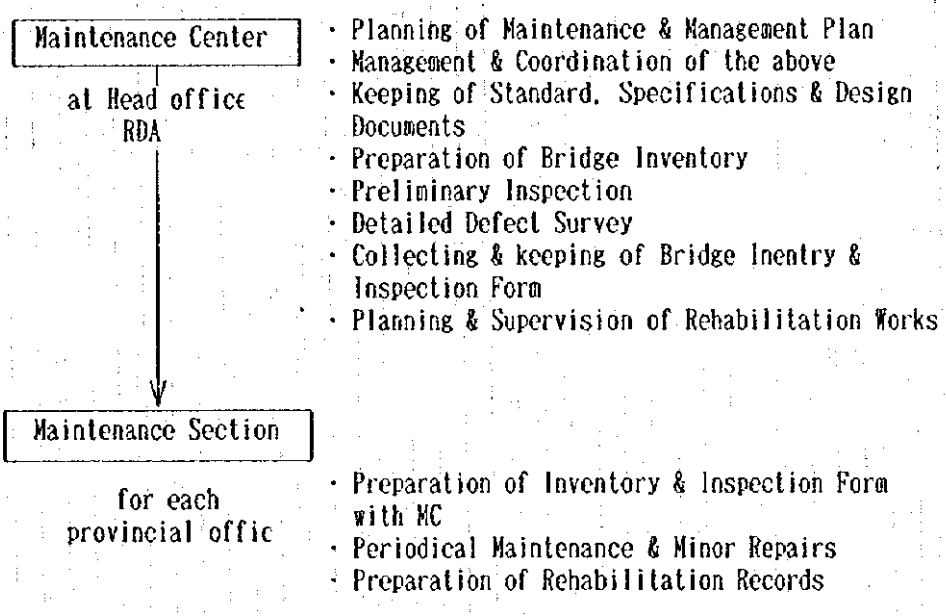
17.3 Basic Plan of Proposed Bridge Maintenance and Management

New organization responsible for maintenance and management of bridges shall be established separately from those for roads under the same Engineering Services Division, since so far no active operation has not been made for bridges under current organization.

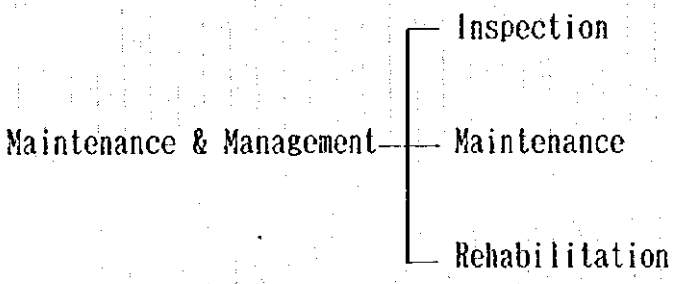
17.3.1 System of Proposed Bridge Maintenance and Management Activities

It is recommended to organize newly a Maintenance Center in the Engineering Services Division and a Maintenance Center at each Provincial Office.

1) Duties and Responsibilities



2) Systems and Work Items of Maintenance & Management



		Numbers
1)	Inspection	
	(a) Preliminary Inspection (Visual Inspection) with preparation of Bridge Inventory and Inspection Form (w/Photos)	4,430 Bridges

(b) Detailed Inspection — As required
More careful inspection of specific members of bridges

(c) Detailed Survey (same as done in Oct. & Nov.) — approx. 440 Bridges

Inspection Flow is shown on Figure 17.9.

2) Maintenance

Periodical or daily maintenance work including minor repair.

- Cleaning---------- Road surface, Drainage, Pier and Abutment top around bearings grasses on Main girders, grasses in water course etc.
- Pavement---------- Potholes patching, pavement replacement
- Minor repair ------ Replacement of damaged railing, expansion joints Patch paint or re-painting

3) Rehabilitation (to be executed as contract base)

Major repair (Remedy)

Strengthening

Functional improvement ---- Widening carriageway, sidewalk adding

Rehabilitation Flow is shown on Figure 17.10.

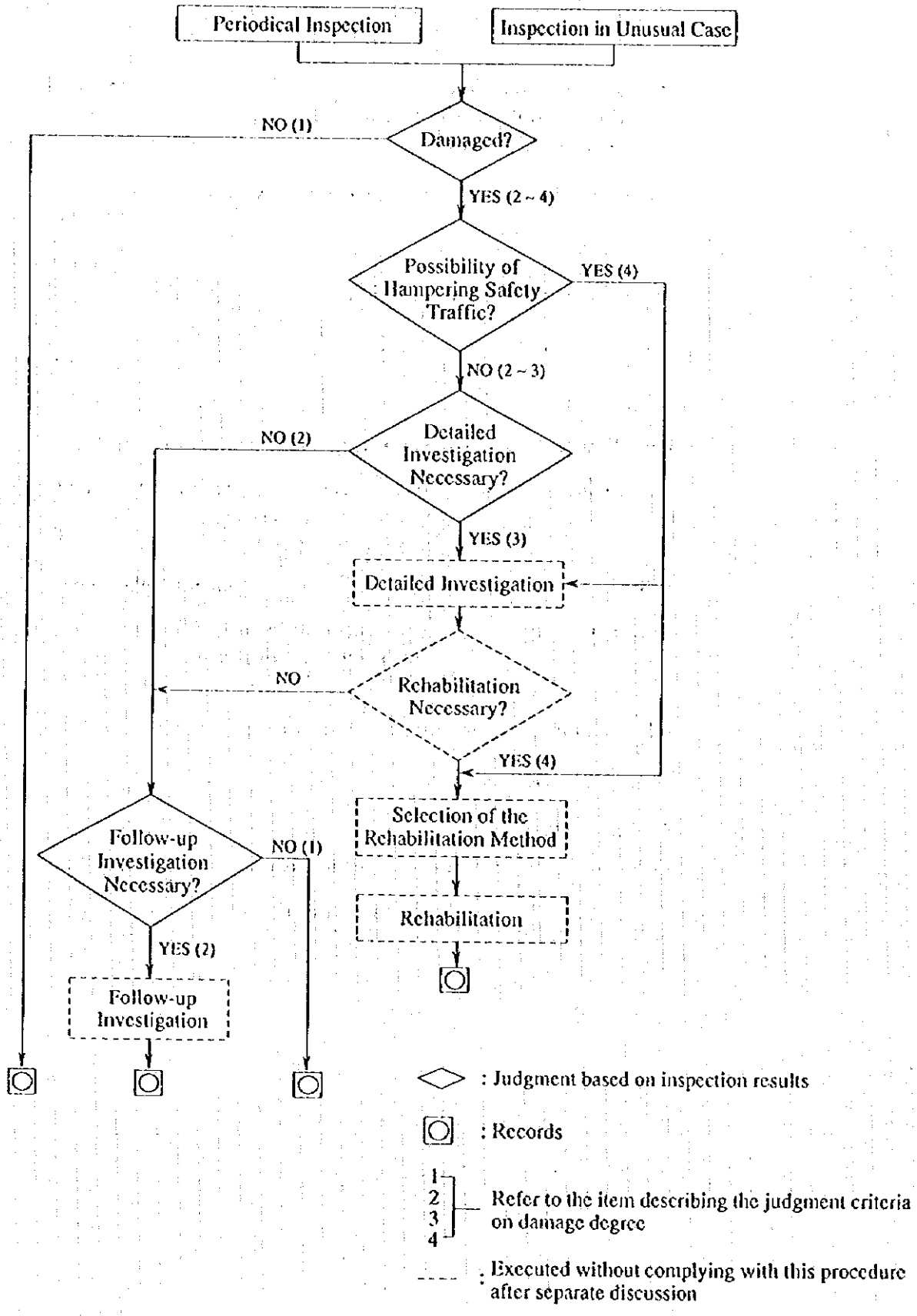


Figure 17.9 Inspection Flow

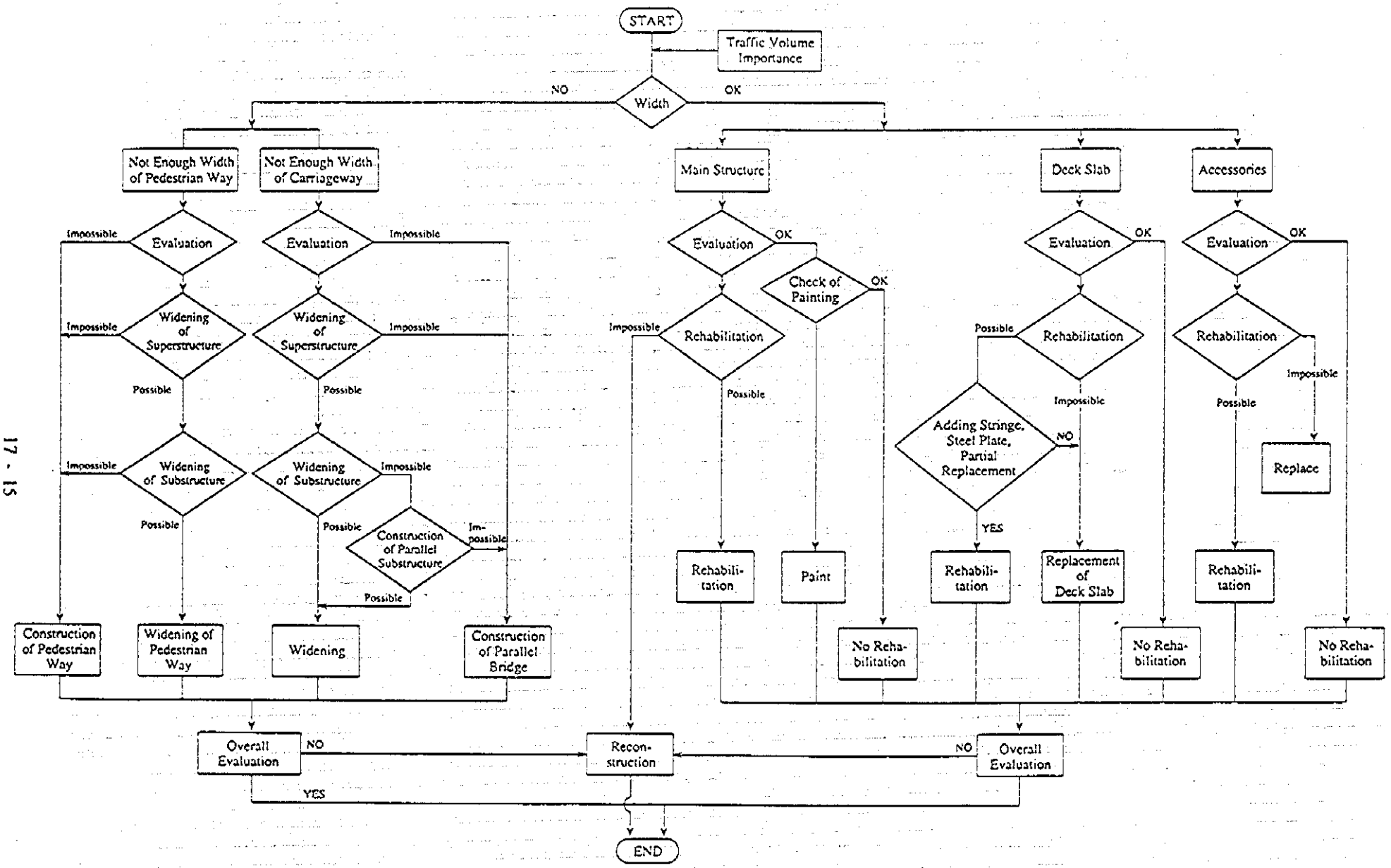


Figure 17.10 Flowchart of Selection of Rehabilitation Methods (Reinforcement Rehabilitation)

Rehabilitation Method

On the basis of the preliminary inspection on 100 bridges, the following rehabilitation types can be shown. For each rehabilitation type, a standardized approach in planning, budget process, cost and design, bidding, etc. should be prepared.

Table 17.2 Rehabilitation Method

Rehabilitation Plan	Member	Rehabilitation Method
Repair	Concrete	Coating
		Injection of resin
		Patching
	Steel	Repainting
		Addition of cover plate
		Weep hole in lower chord member
	Expansion joint	Replacement of members
	Substructure	River bed protection
		Filling of void in stone pier and abutment
	Revetment	Slope protection
Strengthening	Concrete	Pressure bonding of steel plates
		Additional stressing
		Prepacked concrete lining with additional reinforcing bar
	Steel	Concrete lining of steel girders
		Addition of longitudinal girders
	Slabs	Replacement to concrete slabs
	Bearing	Replacement to rubber bearing
	Expansion joint	Replacement of joint
	Drainage	Larger drain pipe size
	Substructure	Concrete lining
		Increase in the number of piles and pile cap
		New construction of abutment parapet
Functional improvement	Superstructure & Substructure	Widening of sidewalk
		Addition of sidewalk
Reference		Guniting
		Waterproofing of concrete slabs
		Guniting with additional reinforcing bars

17.3.2 Organization and Materials and Equipment for Proposed Bridge Maintenance and Management

As mentioned above the Study Team recommended the new organization for the bridge maintenance and rehabilitation. The detailed numbers for personnel and plants, equipment and tools are shown below.

	Maintenance Center at Head Office	Maintenance Section at 9 Provincial Offices
Personnel		
Chief Engineer	1	-
Engineer	2	9
Technical Officer	3	9
Draftsman	1	-
Clerk	1	-
Operator	1	-
Record Keeper	1	-
Total	10	18
Plant, Equipment & Tool		
Bridge Inspection Vehicle	1	-
Ultrasonic Steel Thickness Meter	1	-
Ultrasonic Hardness Meter	1	-
Schmidt Hammer	2	-
Sedan	1	-
Van	1	-
Total	7	0
Office Space w/running cost	10 x 10 m	-
Total	10 x 10 m	0

Materials

Epoxy resin, coal tar epoxy or coal tar paint

17.4 Cost Estimate

For the proposed maintenance and management system, and proposed target the following cost estimate has been made.

(1) Visual Inspection, Bridge Inventory and Inspection Forms

New established the Maintenance Center at RDA Head Office is proposed to be responsible for this task.

Table 17.3 Cost of Bridge Inspection and Inventory

(per year) (Unit: Mil. Rs)

	Maintenance Center	Maintenance Section	Total
Personnel	2.0	4.0	6.0
Plant, Equip., Tool	3.6	1.0	4.6
Office etc.	1.2	0.6	1.8
Contingency	0.4	0.6	1.0
Total	7.2	6.2	13.4

Notes 1. Depreciation of plant, equipment and tool are estimated for the duration of 15 years.
2. Repair fee is estimated by 20 %.

(2) Routine Bridge Maintenance including minor repair

Since the accounting method of routine maintenance is not shown separately for bridges and roads, it is hard to determine the routine bridge maintenance cost. However the following cost for routine bridge maintenance including minor repair shall be suggested.

Rs. 1.5 million/year

(3) Total cost of inspection and maintenance

Therefore Rs.14.9 million (=13.4+1.5) shall be required. As discussed in Chapter 19, the cost would be about Rs. 53 million for the case in 1995. The above cost seems manageable within the 1995 estimate.

17.5 Manual for Bridge Inspection, Maintenance and Rehabilitation

A guideline has been prepared by the JICA Study Team, so that RDA will be able to establish the manual of Bridge Inspection and Maintenance for their own use.