CHAPTER 14

COMPARATIVE STUDY ON IMPROVEMENT MEASURES

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COMPARATIVE STUDY ON IMPROVEMENT MEASURES

14.1 POLICY FOR IMPROVEMENT

14.1.1 Selection Process of the Best Improvement Measure

The best scheme of the improvement measures for Ayala Bridge was selected and recommended following the process as shown in **Figure 14.1.1-1.**

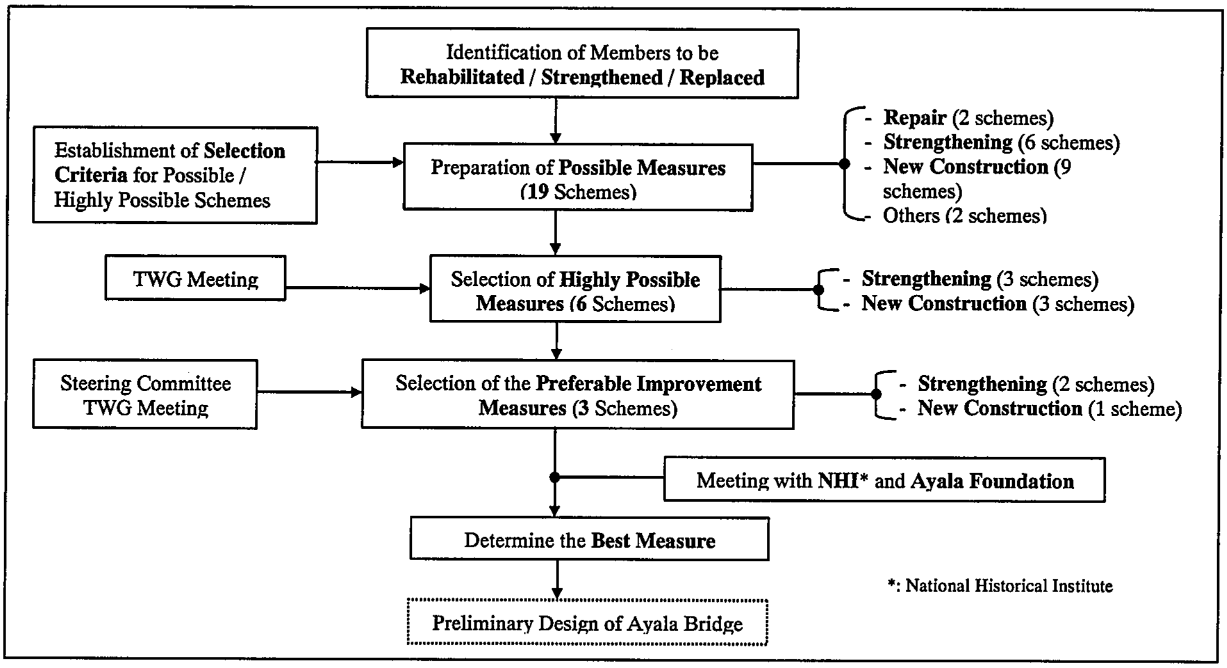


Figure 14.1.1-1 Flow Chart on the Best Improvement Scheme

The reasons for having taken the process above are as follows:

- To propose as many schemes as possible in order to reflect various opinions and ideas in the improvement schemes.
- To make balance among engineering, economic and historical aspects, because the Ayala Bridge has been listed as an important historical structure by NHI.

14.1.2 Minimum Requirements for Improvement

Possible schemes being proposed, the following were agreed as minimum requirements through a series of discussion and meeting with concerned organizations.

Navigation Clearance

- Vertical navigation clearance : 3.75 m (regulatory clearance) or more
- Horizontal navigation clearance (Permanent) : 43 m or more

- Horizontal navigation clearance (Temporary) : 24 m or more (During Construction)

Geometric for Approach Road

- Both intersections : At-grade intersection

Location of Detour Bridge

- Hospicio De San Jose side (Upstream Side)

Traffic Control During Construction

- Maintaining of 4-lane traffic volume.

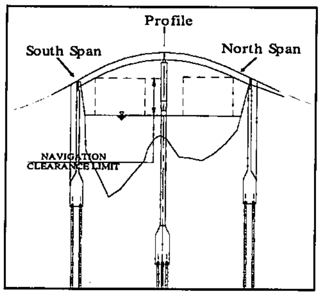
With respect to the vertical alignment of the approach roads, a comparative study on different cases considering navigation clearances of 3.75m (regulatory) and 5.00m (desirable) was carried out. The structural depth ranging from 1.0 to 2.0 meter was used. **Table 14.1.2-1** shows the results of the study. A navigation clearance of 3.75m is applicable for any structural depth without raising the intersection, except the access road going to the Hospicio De San Jose. The structural depth should be made lower as much as possible in order to give better condition for safety driving.

Table 14.1.2-1 Study on Geometric Properties

NAVIGATION CLEARANCE	CASE	Structural Depth (Height from Navigational Clearance Limit) (H)	DESIGN SPEED	MAIN ROAD Grade (%)	MAIN ROAD Grade (Crest)	MAIN ROAD Grade (Sag)	ACCESS ROAD TO HOSPICIO Grade (%)	OVERALL EVALUATION
Existing Clearance (3.5m)	1	0.25M Below the Limit	-	5.3	-	-	4.7	C
			60	O	-	-	O	
			50	O	-	-	O	
			40	O	-	-	O	
Regulatory Clearance (3.75m)	2	1.0m	-	6.0	140m	60m	8.8	A
			60	O	x	O	x	
			50	O	O	O	x	
			40	O	O	O	O	
	3	1.5m	-	6.7	150m	60m	9.1	A
			60	x	x	O	x	
			50	O	O	O	x	
			40	O	O	O	O	
	4	2.0m	-	7.5	160m	60m	10.6	B
			60	x	x	O	x	
			50	x	O	O	x	
			40	O	O	O	x	
Ideal Clearance (5.0m)	5	1.0m	-	7.8	150m	60m	11.1	B
			60	x	x	O	x	
			50	x	O	O	x	
			40	O	O	O	x	
	6	1.5m	-	8.6	160m	60m	16.7	B
			60	x	x	O	x	
			50	x	O	O	x	
			40	O	O	O	x	
	7	2.0m	-	9.3	160m	60m	20.0	B
			60	x	x	O	x	
			50	x	O	O	x	
			40	x	O	O	x	

REMARKS

DESIGN SPEED (kph)	MAX GRADE (%)	MIN. CURVE LENGTH (Crest)	MIN. CURVE LENGTH (Sag)
60	6	180m	60m
50	7	119m	60m
40	9	108m	60m



O : Satisfy AASHTO Requirements
X : Does not Satisfy AASHTO Requirements

A: Satisfies AASHTO Requirements at a Design Speed of 40km/hr

B: Satisfies AASHTO Requirements at a Design Speed of 40km/hr in Except Access Road to Hospicio

C: Does Not Satisfy Regulatory Clearance

14.2 PROPOSITION OF HIGHLY POSSIBLE IMPROVEMENT MEASURES

14.2.1 Possible Improvement Measures

Based on the results of the bridge condition in **Chapter 13**, the Study Team established the following possible schemes considering the following four categories:

- rehabilitation of the existing bridge,
- strengthening of the bridge,
- new bridge construction, and
- others.

Rehabilitation of Existing Bridge

Scheme R1: Rehabilitation of Damaged Joints of Truss Member
Scheme R2: Rehabilitation of Bearing Shoes and Floor System

Strengthening of the Bridge (Conversion from RC deck slab to steel deck slab)

(a) Strengthening of Entire Lower Chords + Replacement of Floor System

Scheme S1: Deck slab conversion only
Scheme S2: Deck slab conversion + New Bridge

(b) Replacement of Lower Chords + Replacement of Floor System

Scheme S3: Deck slab conversion only
Scheme S4: Deck slab conversion + New Bridge

(c) Combination of existing Lower Chord and Steel Through Box Girder

Scheme S5: Deck slab conversion + New Truss Bridge
Scheme S6: Deck slab conversion + New Steel Through Box Girder Bridge

Reconstruction

Scheme N1: 2-Span Continuous PC Rigid Frame
Scheme N2: 2-Span PC Extradosed Bridge
Scheme N3: 2-Span PC Cable Stayed Bridge
Scheme N4: 2-Span Continuous PC Box Girder Bridge
Scheme N5: 2-Span Steel Truss Bridge
Scheme N6: 2-Span Steel Cable Stayed Box Girder
Scheme N7: Simple Through Type Steel Box Girder (2 spans)
Scheme N8: Simple Through Type Steel Arch Bridge (2 spans)
Scheme N9: Simple Through Type Truss Bridge (2 spans)

Others

Scheme O1: Relocation of Existing Bridge + New Bridge Construction
Scheme O2: Converting Existing Bridge to Pedestrian/Light Vehicles Exclusive Use + New Bridge Construction

The result of the comparative study on 19 possible important measures mentioned above were summarized in **Appendix 14.2.1-1 (1/5) ~ (5/5).**

14.2.2 Selection of Highly Possible Improvement Measures

The possible schemes were compared from the following evaluation items:

(1) Structural Aspects
(2) Construction Aspect
(3) Economical Aspect
(4) Geometrical Aspect
(5) Traffic Treatment
(6) Social Environments

Out of 19 possible schemes, six (6) schemes highlighted in **Table 14.2.2-1** were selected as highly possible measures for the comparative study on the improvement alternatives through a series of discussions in TWG meeting and JICA Advisory Committee meeting.

Table 14.2.2-1 Highly Possible Improvement Schemes

	Possible Schemes		Selected Highly Possible Schemes
Rehabilitation of Existing Bridge	R1	Rehabilitation/Strengthening of Damaged Joints of Truss Member	-
	R2	Rehabilitation/Strengthening/Replacement of Bearing Shoes and Floor System	-
Strengthening of Bridge	S1	Strengthening of Entire Lower Chords + Replacement of Floor System (Conversion from RC deck slab to steel deck slab)	-
	S2	Strengthening of Entire Lower Chords + Replacement of Floor System (Conversion from RC deck slab to steel deck slab)+ New Bridge Construction	-
	S3	**Replacement of Lower Chords + Replacement of Floor System (Conversion from RC deck slab to steel deck slab)**	◎
	S4	**Replacement of Lower Chords + Replacement of Floor System (Conversion from RC deck slab to steel deck slab) + New Bridge Construction**	◎
	S5	**Strengthening of Entire Lower Chord + Replacement of Floor System (Conversion from RC deck slab to steel deck slab) + New Bridge Construction**	◎
	S6	Conversion from Existing Lower Chord only to Steel Box Girder (Through Type) + Replacement of Floor System (Conversion from RC deck slab to steel deck slab) + New Bridge Construction	-
New Bridge Construction	N1	2-Span Continuous PC Rigid Frame Bridge	-
	N2	**2-Span PC Extradosed Bridge**	◎
	N3	2-Span PC Cable Stayed Bridge	-
	N4	2-Span Continuous PC Box Girder Bridge	-
	N5	2-Span Steel Truss Bridge	-
	N6	2-Span Steel Cable Stayed Box Girder	-
	N7	**Simple Through Type Steel Box Girder (2 spans)**	◎
	N8	Simple Through Type Steel Arch Bridge (2 spans)	-
	N9	**Simple Through Type Truss Bridge (2 spans)**	◎
Others	O1	Relocation of Existing Bridge + New Bridge Construction	-
	O2	Converting Existing Bridge to Pedestrian/Light Vehicles Exclusive Use + New Bridge Construction	-

◎ : Selected schemes

14.2.3 Evaluation Method and Results

(1) Evaluation Method

The selected six (6) schemes were evaluated by comparing the following items.

- Structural Aspects:
  1) Capacity
  2) Durability
- Economical Aspects:
  1) Construction Cost
  2) Maintenance/Rehabilitation Cost
- Capacity and Geometry:
  1) Capacity
  2) Vertical Alignment
  3) Horizontal Alignment
  4) Access to Hospicio de San Jose
  5) Navigation Clearance
- Traffic Management during Construction:
  1) Temporary Bridge
  2) Affected Land
  3) Affected Houses
- Right of Way Acquisition:
  1) Land
  2) Houses
- Aesthetic Aspects:
  1) Historical Value
  2) New Monument
  3) Civil Design

Each item is rated: A = Excellent, B = Good, C = Reasonable, D = Bad, E = Very Bad

(2) Basic Design

The three (3) improvement measure schemes were developed to the Basic Design in order to approximate dimensions and quantities. Each of these alternatives was studied for construction feasibility. The approximate construction costs for each alternative were estimated using the results of the Basic Design and the study on Construction Method. The study provided 6 general views of the alternatives in order to confirm the geometrical limits of the approach road, navigational clearance, and accessibility to the Hospicio de San Jose.

(3) Estimation of Project Cost

Project costs for the comparative study was estimated based on the following:

- The approximate cost rates (unit costs) were estimated based on similar recent bridge contracts in Japan and the Philippine taking into account the differences of price indices between the two countries. Thus the values show the contract price.
- The major construction works fell into superstructure, substructure, removal of existing structure and detour-bridge. These main works were subdivided into the required work items in accordance with the approximate quantities calculated in the basic design. The unit costs of each work are also estimated considering the jobsite conditions.
- Maintenance / rehabilitation costs were broken down into routine maintenance per year, rehabilitation per 20 years and repainting per 40 years.

14.2.4 Result of Evaluation

Table 14.2.4-1 shows the evaluated results with rating for six (6) schemes, which is summarized in **Table 14.2.4-2**. Allocation of the rating score was considered as follows:

A=5, B=4, C=3, D=2, E=1 (The meaning A, B, C, D and E is described in **Section 13.2.2**)

Table 14.2.4-2 Summary of Evaluated Result

	Scheme	Rating	Score	Ranking
Strengthening	S3	2A + B + 2C + E	21	3
	S4	A + B + 2C + 2D	19	4
	S5	2A + B + 2C + D	22	1
New Bridge	N2	A + B + 2C + 2D	19	4
	N7	2B + 3C + D	19	4
	N9	2B + 3C	22	1

The evaluated results are summarized as follows:

- Scheme S5 and N9 has the same rating, followed by Scheme S-3.
- In terms of engineering aspects (Structure, Construction, Traffic/Navigation and Impact to traffic during Construction), Scheme N9 was evaluated as the best scheme.
- However, Scheme S3 was evaluated as the best scheme in due consideration of historical importance and significance of the existing Ayala Bridge.
- Scheme S3 may maintain the exact configuration of the existing bridge and utilize the existing sound members.
- Scheme S3 has a shortcoming in mitigating traffic congestion comparing to the others.

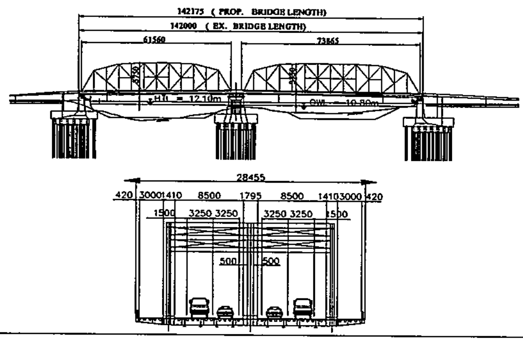
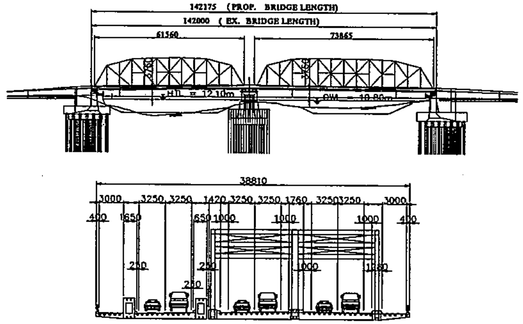
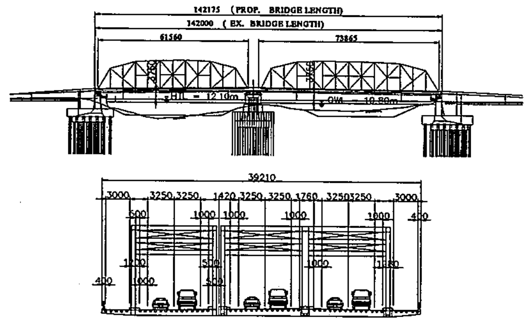
- The second Ayala Bridge is recommended to be provided in order to cope with the future traffic demand on the existing Ayala Bridge, as discussed in **Chapter 19**.

- Traffic congestion on the bridge was observed due to insufficient capacity of both side intersections at both sides of the bridge. In particular, the right/left turn lane lengths including transition lengths were considered to be insufficient. The other schemes are to eliminate this problem by providing six (6) traffic lanes.

- Therefore, improvement of both intersections are included in the Ayala Bridge improvement works.

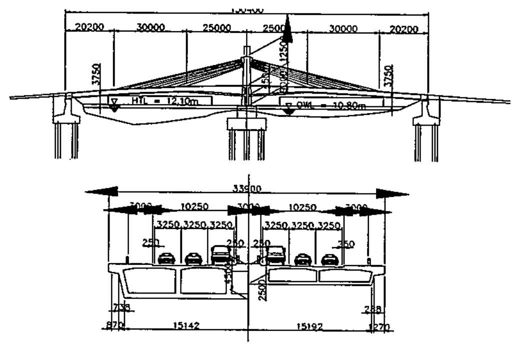
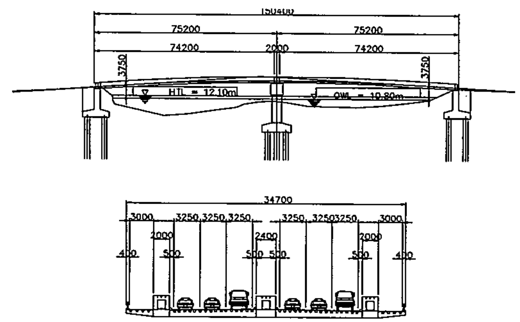
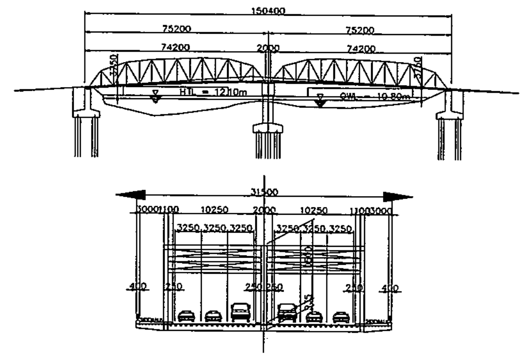
- The other schemes are to eliminate the problem above by providing six (6) traffic lanes.

Table 14.2.4-1 Comparative Evaluation of Highly Competitive Scheme for Ayala Bridge (1/2)

Improvement Type		Strengthening of Existing Bridge					
		S3		S4		S5	
Scheme Name		Replacement of Lower Chord		Replacement of Lower Chord + New Steel Bridge		Replacement of Lower Chord + New Truss Bridge	
ELEVATION/SECTION							
Major Works		· Jack - up by 25 cm. · Replacement of lower chord and floor system · Replacement of fatigued members · Strengtening of abutment and pier	Rating	· Jack - up by 25 cm. · Replacement of lower chord and floor system · Replacement of fatigued members · Strengthening of abutment and pier · Construction of additional new through truss bridge	Rating	· Jack - up by 25 cm. · Replacement of lower chord and floor system · Replacement of fatigued members · Strengthening of abutment and pier · Construction of additional new through truss bridge	Rating
Structural Aspects	Capacity	32 Ton , HS - 20	C	32 Ton , HS - 20	C	32 Ton , HS - 20	C
	Durability	Existing steel members may fatigue in shorter period comparing to the new construction.		Existing steel members may fatigue in shorter period comparing to the new construction.		Existing steel members may fatigue in shorter period comparing to the new construction.	
Economical Aspects	Construction Cost	₱1,021.3 M (EUAC = ₱115 M/year)	A	₱1,281.6 M	B	₱1,299.7 M (EUAC = P147M)	B
	Maint./Rehab. Cost	₱2.5 M/Year, ₱48.1 M/20 years (Rehab.), P 37.4 M/40 Years (Paint)		₱3.5 M/Year, ₱47.1 M/20 years(Rehab.), P 51.4 M/40 Years (Paint)		₱3.9 M/Year, ₱47.0 M/20 Years, P 51.1 M/40 Years	
Capacity and Geometry	Capacity	4-Lane with a lane width of 3.25m, which width is for local road. (x)	E	6-Lane with a lane width of 3.25m.	D	6-Lane with a lane width of 3.00m.	D
	Vertical Alignment	Maximum gradient is 7.6 % without raising the existing intersection. A length of 7.6% gradient is 13.7m.		Maximum gradient is 7.6% without raising the existing intersection. A length of 7.6% gradient is 13.7m.		Maximum gradient is 7.6 % without raising the existing intersection. A length of 7.6% gradient is 13.7m.	
	Horizontal Alignment	Relatively sudden change at the south span abutment.		- Relatively sudden change at the south span abutment. - Marking area for channelazation occupies relatively big percentage of the roadway. This conditions cause complicated traffic movement.		- Relatively sudden change at the south span abutment. - Marking area for channelazation occupies relatively big percentage of the roadway. This conditions cause complicated traffic movement.	
	Access to Hospicio de San Jose	Gradient is 5.9 % while maintaining the existing horizontal alignment.		Gradient is 5.8 % while maintaining the existing horizontal alignment.		Gradient is 5.9 % while maintaining the existing horizontal alignment.	
	Navigation Clearance	3.75m		3.75m		3.75m	
Traffic Management During Construction	Temporary Bridge	2-lane temporary bridge 150m of length is required	C	Maintain 4-lane, No temporary bridge is required	A	Maintain 4-lane, No temporary bridge is required	A
	Affected Land (Sq. m.)	3,320 sq. m.		-		-	
	Affected House (Sq. m.)	5 Houses, 1 Water tank		-		-	
R. O. W. Acquisition	Land	300 sq. m.	B	2,400 sq. m.	C	2,400 sq. m.	C
	Houses	0		3 Houses, 1 Water tank		3 Houses, 1 Water tank	
Aesthetic Aspects	Historical Value	Retaining existing landscape	A	Retaining existing landscape	D	Retaining existing landscape in line with NHI position.	A
	New monument	-		-		-	
	Civil Design	Structural permanency, Distinctive quality, Harmony with urban environment.		Damage harmony with urban environment (x)		Disturb urban environment because of complicated structure.	
Overall Evaluation		2A, B, 2C, E, Traffic Capacity is not acceptable	3	A, B, 2C, 2D, Urban environment is not recommendable.	4	2A, B, 2C,D Relatively acceptable in all aspects.	1

NOTE : A = Excelent B = Good C = Reasonable D = Bad E = Very bad

Table 14.2.4-1 Comparative Evaluation of Highly Competitive Scheme for Ayala Bridge (2/2)

Improvement Type		New Construction					
		N2		N7		N9	
Scheme Name		2 - Span PC Extradosed Bridge		Steel Box Girder (2 - Span)		Truss Bridge (2- Span)	
ELEVATION/SECTION							
Major Works		- Removal of existing bridge including abutment and pier - Construction of 2 - span PC extradosed bridge	Rating	- Removal of existing bridge including abutment and pier - Construction of steel box girder (2 -span)	Rating	- Removal of existing bridge including abutment and pier - Construction of steel truss bridge (2 - span)	Rating
Structural Aspects	Capacity	32 Ton , HS - 20	A	32 Ton , HS - 20	B	32 Ton , HS - 20	B
	Durability	Durable with proper and timely maintenance.		Durable with proper and timely maintenance.		Durable with proper and timely maintenance.	
Economical Aspects	Construction Cost	₱1,747.1 M ⓧ	D	₱1,586.7 M	C	₱1,569.0 M (EUAC =₱140M)	C
	Maintenance Cost	₱4.0 M/Year, ₱20.0 M/40 years (Paint)		₱4.0 M/Year, ₱35.7 M/40 Years (Paint)		₱4.0 M/Year, ₱41.5 M/40 Years (Paint)	
Capacity and Geometry	Capacity	6-Lane with a lane width of 3.25 m.	D	6-Lane with a lane width of 3.25 m.	B	6-Lane with a lane width of 3.25 m.	B
	Vertical Alignment	Maximum gradient is 9.0 % and the elevation of the existing intersection has to be raised by 80 cm. A length of 9.0 % gradient is 15.0m. ⓧ		Maximum gradient is 7.2 % without raising the elevation of existing intersection. A length of 7.2 % gradient is 15.0m.		Maximum gradient is 7.2 % without raising the elevation of existing intersection. A length of 7.2 % gradient is 15.0m.	
	Horizontal Alignment	Minimal improvement by rotating the alignment clockwise.		Minimal improvement by rotating the alignment clockwise.		Minimal improvement by rotating the alignment clockwise.	
	Access to Hospicio de San Jose	The gradient of 9.0 % is provided by making the existing road longer with curved alignment and extending it into Hospicio compound.		The gradient is 7.5 % without changing the existing horizontal alignment.		The gradient is 7.5 % without changing the existing horizontal alignment.	
	Navigation Clearance	3.75 M		3.75 M		3.75 M	
Traffic Management During Construction	Temporary Bridge	4-lane temporary bridge is required	C	4-lane temporary bridge is required	C	4-lane temporary bridge is required	C
	Affected Land (Sq. m.)	3,820 sq. m.		3,820 sq. m.		3,820 sq. m.	
	Affected House (Sq. m.)	5 Houses, 1 Water tank		5 Houses, 1 Water tank		5 Houses, 1 Water tank	
R. O. W. Acquisition	Land	1,600 sq. m.	C	1,100 sq. m.	C	530 sq. m.	C
	Houses	3 Houses, 1 Water tank		3 Houses, 1 Water tank		3 Houses, 1 Water tank	
Aesthetic Aspects	Historical Value	-	B	-	D	ECC clearance may be difficult because of NHI position.	B
	New monument	New symbol of urban landscape and technology.		Functional structure		Retainment of historical scenery	
	Civil Design	Excellent structural pemanency.		Simple Functional design		Distinctive urban quality	
Overall Evaluation		A,B, 2C,2D Geometry of approach is not recommended with high initial cost.	4	2B, 3C,D Ordinary design with no special impacts.	4	3B, 3C Acceptable in all aspects including costs, aesthetic aspect, etc.	1
NOTE :		A = Excelent B = Good		C = Reasonable D = Bad		E = Very bad	

14.3 LIFECYCLE COST ANALYSIS OF THE AYALA BRIDGE

14.3.1 Procedure

The procedure for the lifecycle cost analysis of Ayala Bridge is illustrated in **Figure 14.3.1-1.**

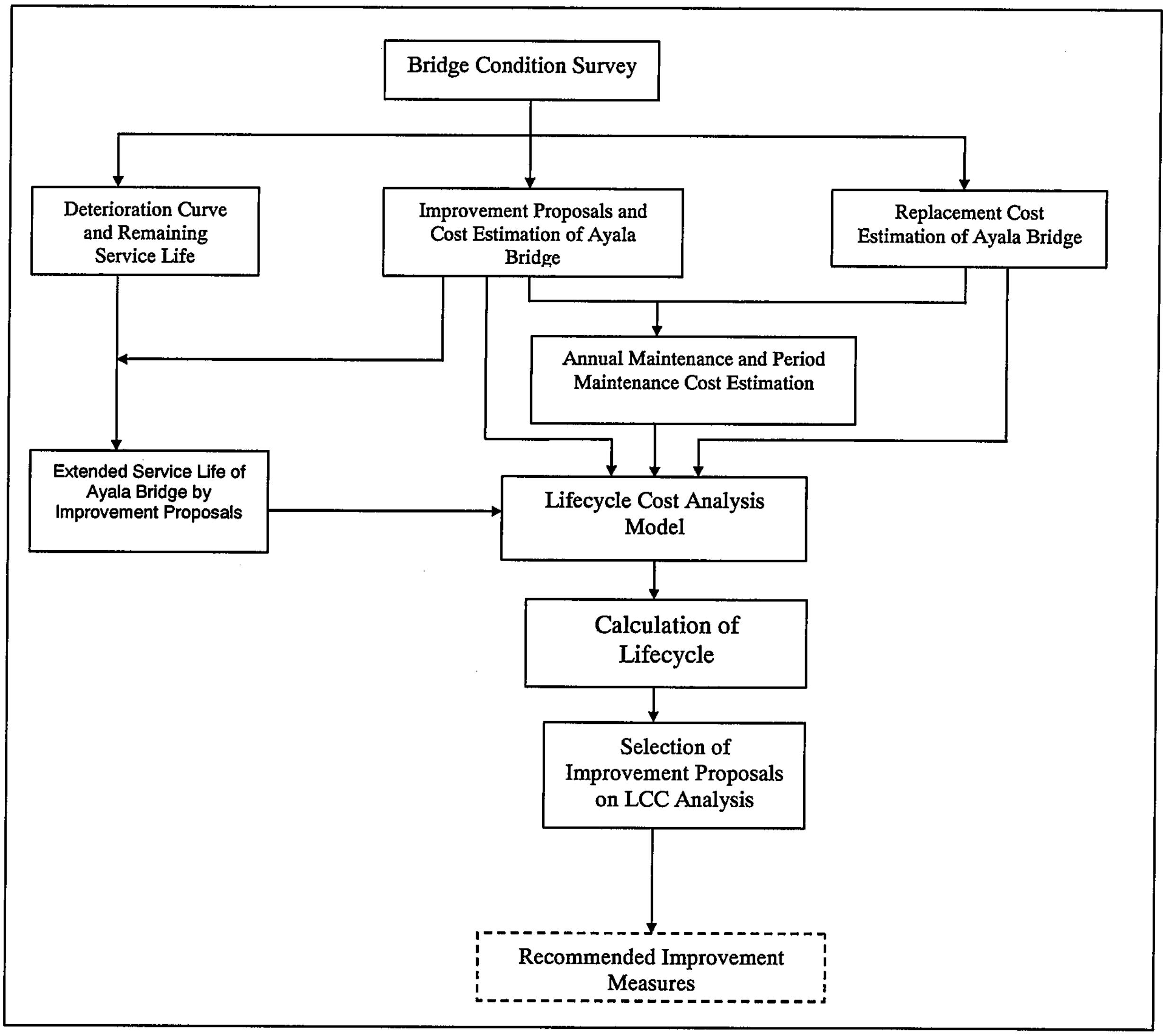


Figure 14.3.1-1 Procedure for Bridge Lifecycle Cost Analysis

14.3.2 Bridge Deterioration Model for Ayala Bridge

(1) Standard Bridge Deterioration

As mentioned in **Chapter 9.3**, the Transportation Systems Center (TSC) Deterioration Study in USA has developed empirical equation of bridge deterioration relating deck, superstructure and substructure condition rating.

Using the equation of bridge condition rating described in **Chapter 9.3**, the developed model for standard deterioration curves of deck-superstructure and substructure can be illustrated in **Figure 14.3.2-1.**

Taking into consideration the bridge condition in the Study Area, the service life of the bridge can be estimated if the Level 2 of condition rating is assumed to be acceptable level.

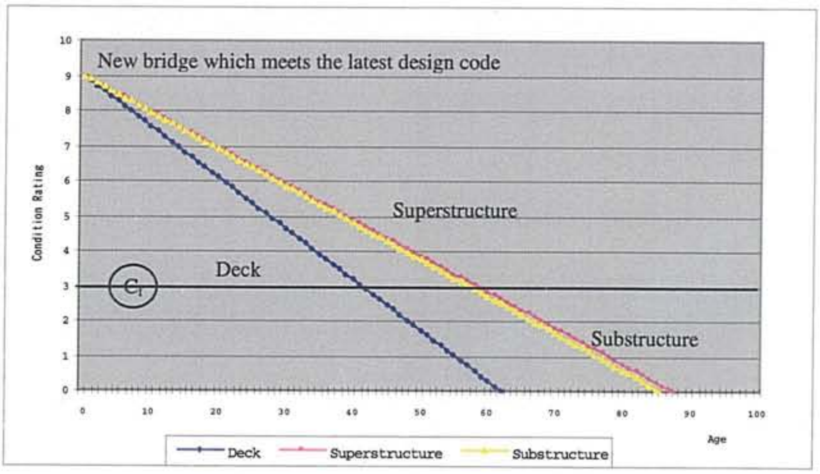


Figure 14.3.2-1 Deterioration Curve by Transportation System Center (TSC)

Unacceptable level (C_f) was considered as follows.

Level 3 :	Meets minimum tolerable limits to be left in place as is.
Level 2 :	Basically intolerable limits requiring high priority of corrective action.
Level 1 :	Basically intolerable limits requiring high priority of major rehabilitation/s or replacement.

In this Study, Level 2 was regarded as the unacceptable level (Cf) considering the present situation of this country as described in **Section 9.3.2**.

Deck: 58 years, Superstructure 67 years, Substructure 87 years

(2) Deterioration Curve of Ayala Bridge

Taking into account the bridge condition survey in this study, the bridge deterioration model mentioned above can be generally applied to the Ayala Bridge. The equation adopted is as follows:

Deck = 9 – 0.119 x (AGE) – 6 x (AGE) x (ADT/10) **(14.3.2-1)**

Superstructure = 9 – 0.183 x (AGE)

Substructure = 9 – 0.08 x (AGE)

According to the historical records of rehabilitation, the rehabilitation for the deck was implemented during 1980's. So the deterioration curve of the Ayala Bridge can be illustrated in **Figure 14.3.2-2**.

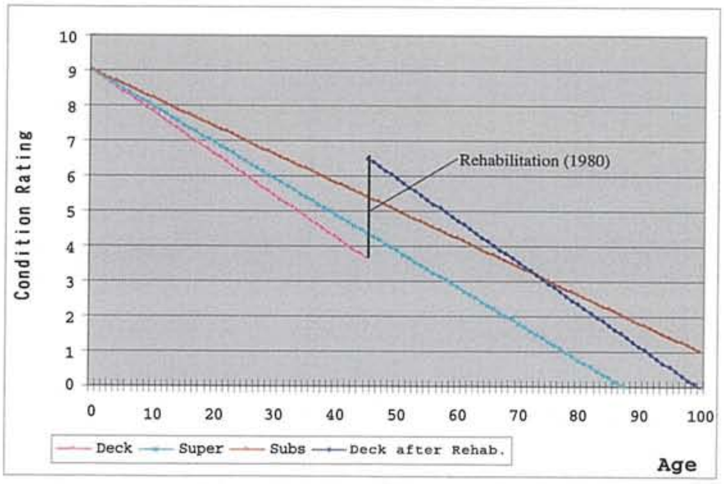


Figure 14.3.2-2 Deterioration Curve of the Ayala Bridge

14.3.3 Improvement Schemes and Cost Estimate

The engineering study proposed the improvement schemes which is shown in **Table 14.4.3-1.**

Table 14.4.3-1 Improved Schemes of Ayala Bridge

Improvement Type	Scheme S3 Replacement of Lower Chord	Scheme S5 Replacement of Lower Chord and New Truss Bridge	Scheme N9 Truss Bridge
Description	- Replacement of lower chord - Replacement of floor system (Conversion from RC deck slab to steel deck slab)	- Combining existing lower chord and steel box girder - Replacement of floor system Additional new through truss bridge	- Removal of existing bridge - Construction of steel truss bridge
Improvement Cost (M Peso)	1,495 (0.70)	1,935 (0.91)	2,121 (1.00)
No. of Lanes	4 –lane	6 – lane	6 -lane
Improvement Cost per Lane (M Peso)	336.4 (0.95)	322.5 (0.91)	353.5 (1.00)

14.3.4 Lifecycle Cost Analysis Model

In the life cycle analysis model, there are principally two (2) cases;

a) Replacement case

b) Strengthening case

The explanation of the lifecycle cost analysis model for these two (2) cases are as follows;

<u>Replacement Case (Scheme N9)</u>

$$LCCp\ (repl.) = A \bullet (pwf''_{SL}) \qquad \textbf{(14.3.4-1)}$$

Where LCCp = lifecycle cost (perpetual service)

A = present worth of the cost of one replacement lifecycle

pwf''_{SL} = perpetual series present worth factor

= $(1 + {}_i/100)^m / [(1 + {}_i/100)^m{}_i - 1]$

i = effective discount rate (%)

m = service life year

This lifecycle cost is in case that the bridge is replaced immediately, as shown in **Figure 14.3.4-1.**

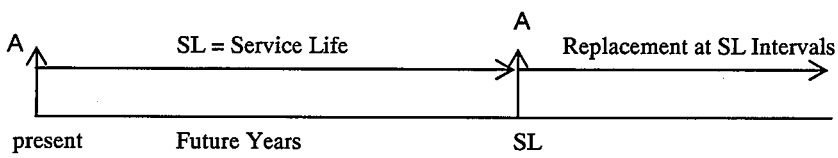


Figure 14.3.4-1 Replacement Case

Rehabilitation Case (Schemes S3 and S5)

LCCP (rehab.) = B + A • (pwf'' SL) • (pwf' e) **(14.3.4-2)**

Where B = present worth of the cost of rehabilitation and maintenance over the remaining life of the existing bridge.

pwf' e = single payment present worth factor

= $1/(1 + i/100)^e$

e = extended service life of the existing bridge through maintenance and rehabilitation (years)

This lifecycle is in case that rehabilitation moves replacement e years into future as shown in **Figure 14.3.4-2**.

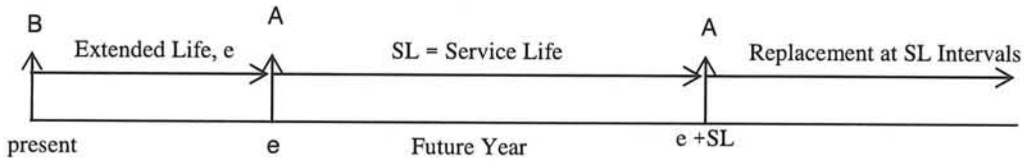


Figure 14.3.4-2 Rehabilitation Case

Let formulas **(14.3.4-1)** and **(14.3.4-2)** be equal in order to obtain the break even point as follows:

A • (pwf'' SL) = B + A • (pwf'' SL) • (pwf' e)

This yield

C = B/A = (1 – pwf' e) • (pwf'' SL) **(14.3.4-3)**

14.3.5 Assumption of Extended Service Life of Improved Bridge

The relationship between improvement cost of the Ayala Bridge and improvement of condition rating is illustrated in **Figure 14.3.5-1**. If the improvement cost is invested to the Ayala Bridge, it is expected to extend the service life of the bridge, as shown in **Figure 14.3.5-2**. The results

Figure 14.3.5-1 Relationship between Investment Cost and Improvement of Condition Rating

of extended service life of the improved bridge are shown in **Table 14.3.5-3**.

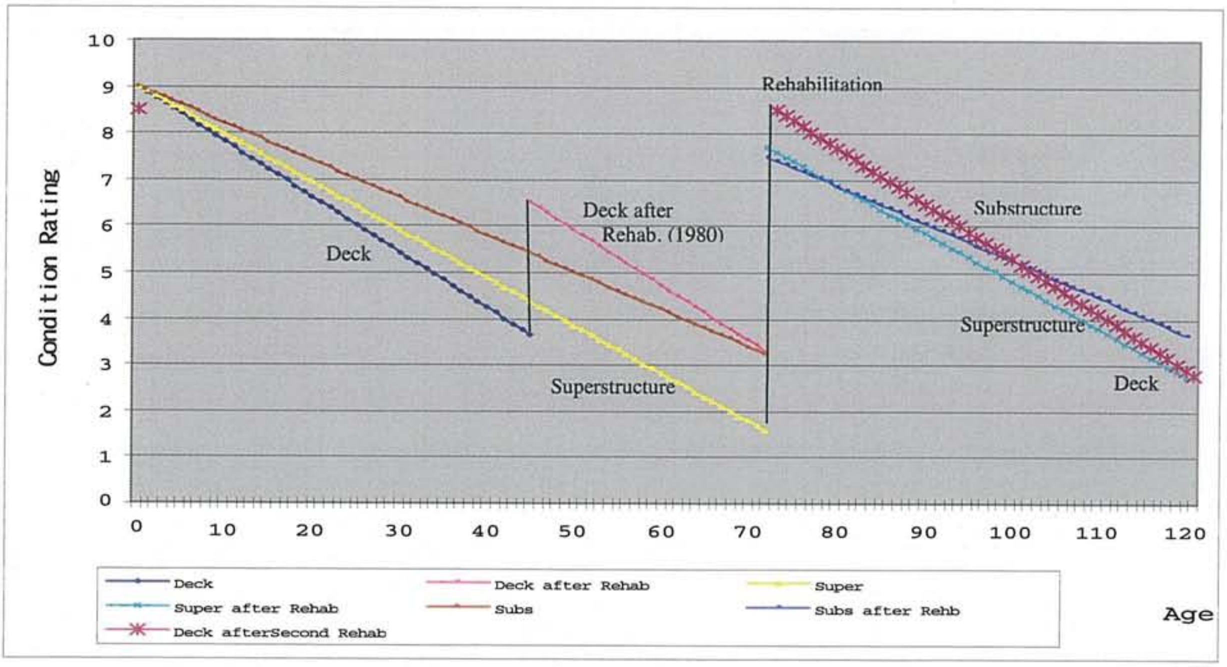
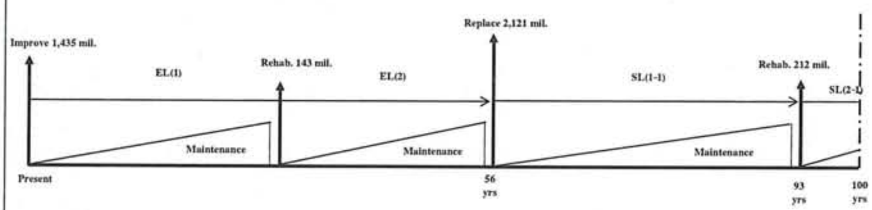
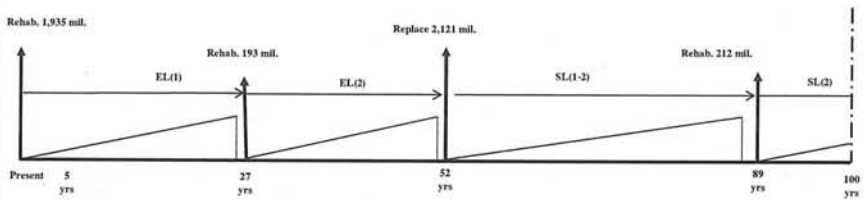
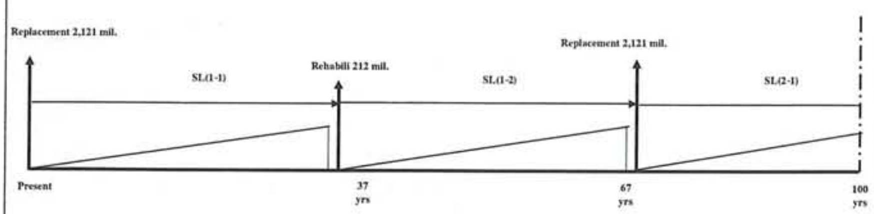


Figure 14.3.5-2 Deterioration Curve after Implementing Scheme S3

Scheme	Life Cycle Cost Model	Service Life (Yrs)	LCC (Discounted rate 15 %)
Scheme S3		Type / Year RL 0 EL 56 SL(1) 44 SL(2) 0 Total 100	1,469 million (0.68)
Scheme S5		Year RL 0 EL 52 SL(1) 48 SL(2) 0 Total 100	1,971 million (0.91)
Scheme N9 Replacement		Year RL 0 EL 0 SL(1) 67 SL(2) 33 Total 100	2,173 million (1.00)

Notes: RL: Remaining life
EL: Extended life due to rehabilitation
SL: Bridge cycle life
SL(1): First bridge cycle life
SL(2): Second bridge cycle life
SL(1-1): First bridge cycle life before rehabilitation
SL(1-2): First bridge cycle life after rehabilitation

Figure 14.3.5-3 Life Cycle Analysis of the Ayala Bridge

14.3.6 Calculation of the Lifecycle Cost of the Ayala Bridge

The bridge lifecycle cost of the Ayala Bridge is calculated and shown in **Table 14.3.6-1**.

Table 14.3.6-1 Life Cycle Cost Estimates

Unit: Million Pesos

Scheme	LCC (₱ Million)	Rate	Rating
Scheme S3	1,469	0.68	1
Scheme S5	1,971	0.91	2
Scheme N9 (Replacement)	2,173	1.00	3

Figure 14.3.6-1 shows the life cycle cost evaluation of the Ayala Bridge.

As revealed in **Table 14.3.6-1** and **Figure 14.3.6-1**, the Scheme S3 is the most cost effective scheme among the alternative schemes.

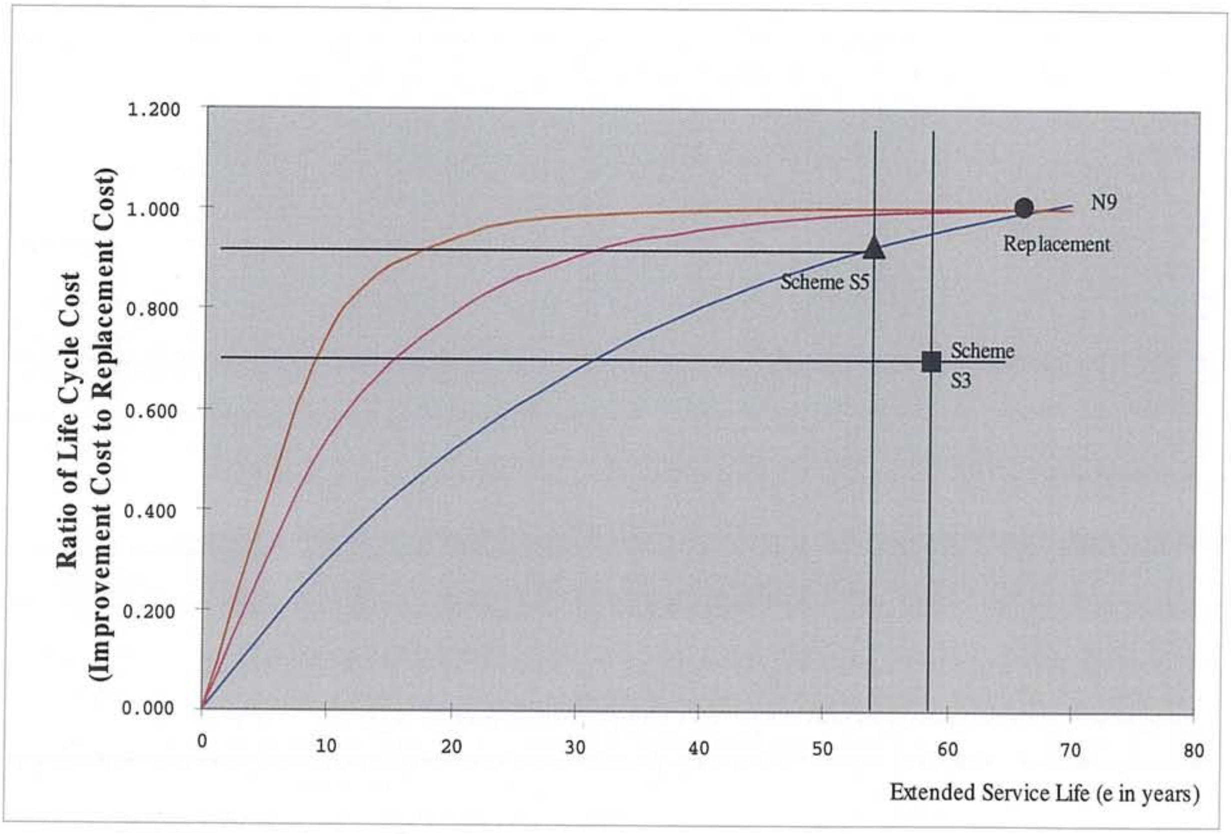


Figure 14.3.6-1 Life Cycle Cost Evaluation on Alternative Improvement Scheme for the Ayala Bridge

14.4 RECOMMENDATION

Originally, Scheme N9 was selected as the best scheme with emphasis on the benefits of engineering aspects. However, the DPWH Steering Committee eventually selected **Scheme S3** as the best improvement measure for Ayala Bridge because of the following reasons.

- The Ayala Bridge has been listed as a historical structure by the NHI (National Historical Institute), which is one of government organizations endorsing the issuance of the ECC (Environmental Compliance Certificate).
- The NHI strongly called for the preservation of the bridge as mentioned in **Section 13.1.3.**
- Through a series of consultations and discussions with concerned organizations, the DPWH has decided to undertake improvement works that will maintain its existing configuration as it is and make the most of existing sound members of its superstructure.
- That is, to replace the heavily damaged lower chords including floor system, to replace some superstructure members with insufficient capacity, and to strengthen the substructures, based on the in-depth survey.
- In addition, from the viewpoint of the life-cycle-cost analysis Scheme 3 is also taken as the most preferable. According to the analysis results, the service life extended by the improvement of Scheme 3 is expected to be 62 years.
- However, the selected improvement works will require sophisticated and state-of-the-art technology because there is a strong possibility that any slight imbalance or mistake during replacement works will cause the bridge to fall-down.