PART III FEASIBILITY STUDY OF THE AYALA BRIDGE

12. HISTORICAL BACKGROUND

In 1871, the construction of two bridges was recommended, connecting the two opposite banks of the Pasig River. The first bridge would connect the Arrabal of San Miguel with the Island de Convalecencia, which is located at the center of the Pasig River. The second bridge would connect the Island de Convalecencia with the barrio of Concepcion.

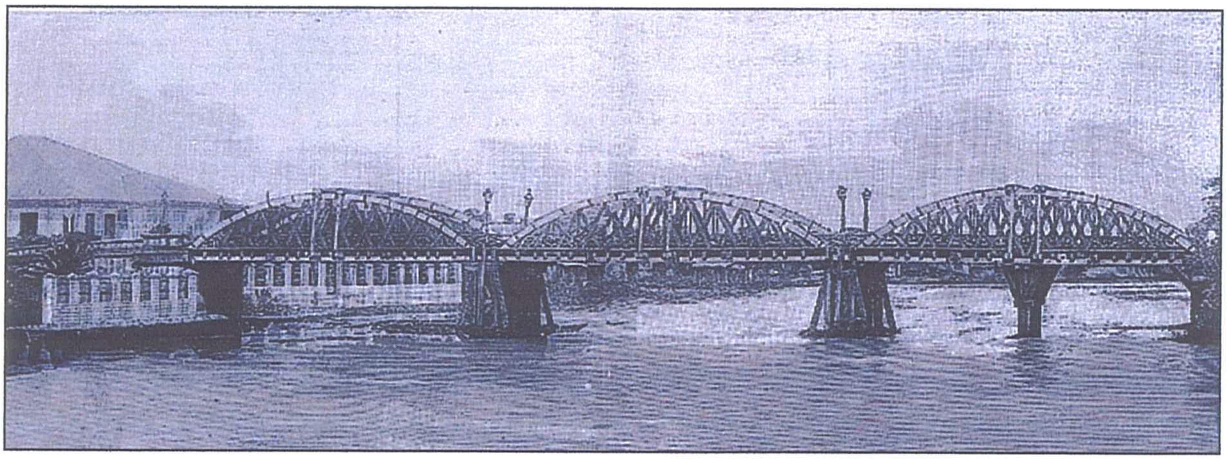
The project began in 1872 and the Ayala Bridge was opened to the public in 1880 and was called as the Puente de Convalecencia. Several years later, it was commonly referred to as the Puentes de Ayala.

When the Ayala Bridge was constructed in 1876, three low arches and a lower platform, all of which were timber-built, formed each of these sections. In 1882, repair works were made in the bridge, and by 1889 the Ayala Bridge was in a dangerous condition.

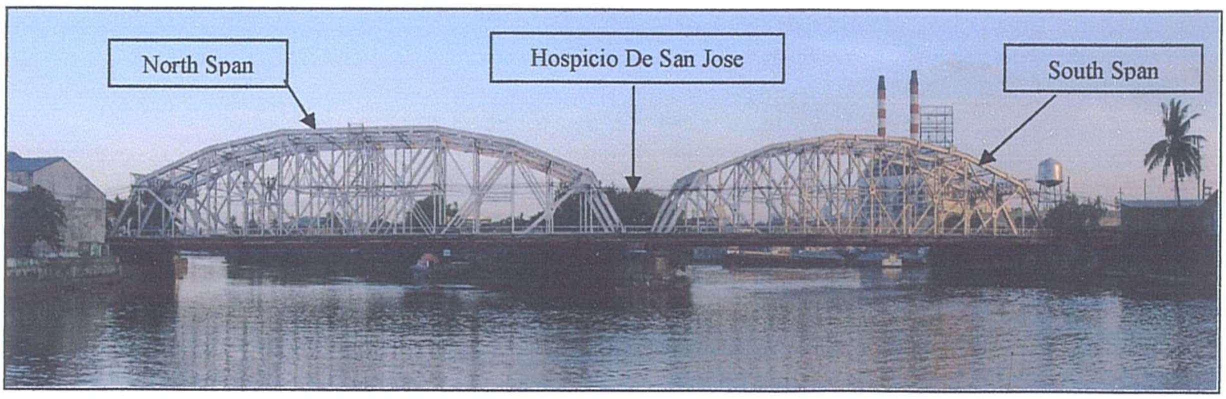
During the early American period, a new proposal to replace the old bridge with a new steel superstructure was made. New construction started in March 1906. The bridge became one continuous riveted structure with pin bearings, made up of two spans of Pratt double type with a curved upper chord. The new bridge was opened to public traffic on August 13, 1906. This new bridge became the original shape of the present Ayala Bridge.

In 1950 after the Second World War, the replacement and additional new bridge construction works were conducted and the Ayala Bridge has been maintained since its 1906 configuration.

The National Historical Institute (NHI), which is one of the government organizations endorsing the issuance of the ECC, has declared the Ayala Bridge as a historical structure of legacy and landmark which should be preserved for posterity.



Old Ayala Bridge (1890) in Spanish Period



Present Ayala Bridge

13. BRIDGE CONDITION SURVEY AND TESTS

CLOSE-UP VISUAL INSPECTIONS

Objective

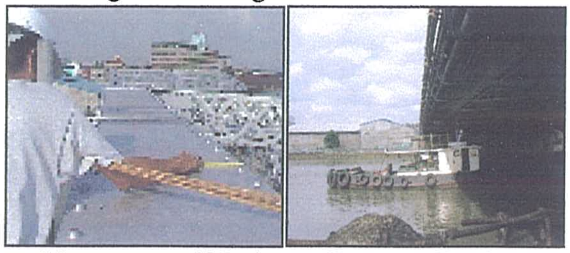
- To find the structural damages and defects,
- To make judgment of damage degrees with damage rating, and
- To make detailed documentation including digital photos and videos.

Inspection Results

- Abnormal deflection during vehicles passing at the north span was observed.
- Serious section loss of bottom chords was found at the connections.
- Cross beams were heavily corroded.
- Stringers of the east side of north span were completely broken near the abutment.
- A sway bracing at the south span and a stringer at the north span were missing.
- Most of joint areas were heavily corroded.
- Steel bearings didn't function because of cracks and heavy corrosion.
- Substructures were mostly sound, while having small cracks.
- The upper chords were mostly sound, while corrosion at joints being found.

SHAPES AND DIMENSION MEASUREMENT

This survey was conducted to provide information on dimensions of bridge members and section properties of members or elements consisting of the bridges.



Measurement of Members at Truss Top Chord and with Tugboat

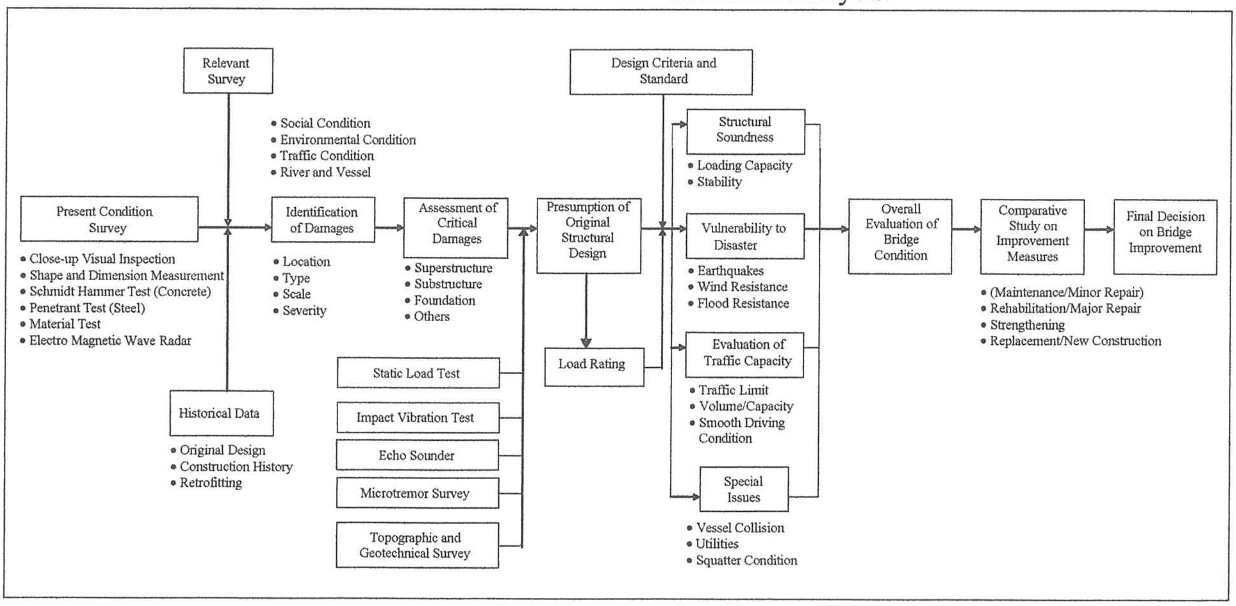
The survey results were used for the presumption of original design and structural analysis.

NON-DESTRUCTIVE TESTS

These tests were conducted to provide information on material properties and any damage that may not be visually observed based on the following tests conducted on steel and concrete members.

- Brinell Hardness Test
- Ultrasonic Flaw Detection Test
- Dye Penetrant Test
- Schmidt Rebound Hammer Test
- Ultrasonic Pulse Velocity Test
- Phenolphthalein Test & Chloride Test

The test results are to be reflected to the structural analysis.



Study Flow of Ayala Bridge

SPECIAL TESTS

Static Load Test

Objectives;

- To measures deflection and strain under the load.
- To compare the test result with structural analysis.

Step Load Pattern of Trucks for Test

- Step Load No. 1 - (12.5 Tons)
- Step Load No. 2 - (25 Tons)
- Step Load No. 3 - (40.7 Tons)

Deflection Survey by Static Load

Maximum deflection at the west truss during step load 3 was 7mm near the middle of the roadway.

Strain Measurement by Static Load

Strains measured by strain gauges were extremely small and ranged from 0.6 $\mu\varepsilon$ to 6.2 $\mu\varepsilon$.

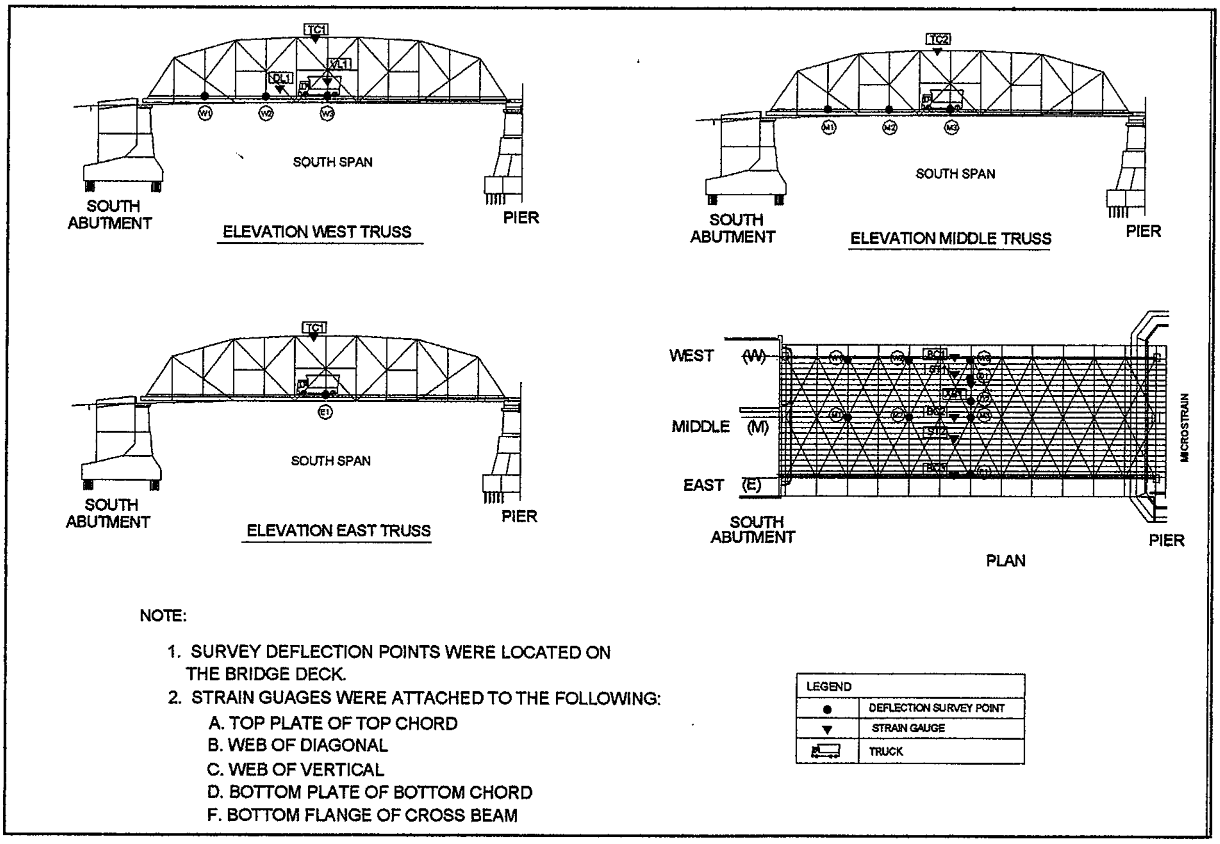
Microtremor Measurement Survey

Objectives;

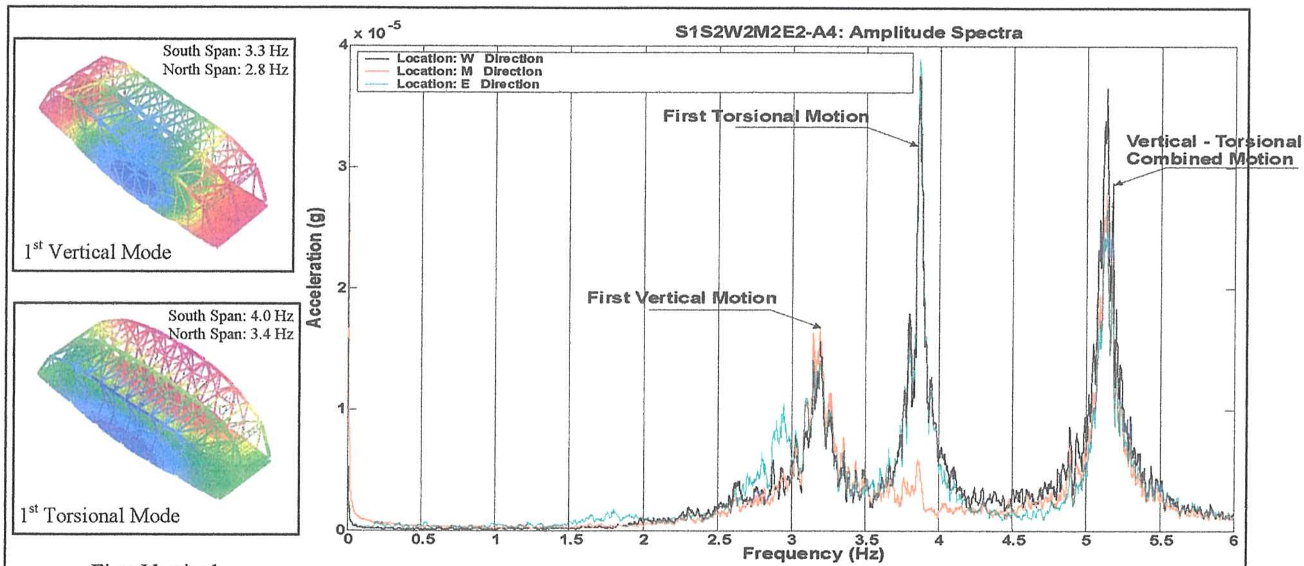
- To identify and confirm the modes relevant to the deformations due to the dead load and governing live load cases (MS 18 lane loadings) considered in Modeling of Structure,
- To confirm that the impact vibration test of substructure are associated with the vertical modes of the superstructure not with the natural frequency of the bridge pier.

Most Probable Natural Frequencies Measured

- For the South Span, the most probable natural frequency of the 1st vertical mode is 3.2Hz, and that of the 1st torsional mode is 3.9Hz.
- For the North Span, the most probable natural frequency of the 1st vertical mode is 2.7Hz, and that of the 1st torsional mode is 3.4Hz
- The analysis model for load rating was modified to fit for these natural frequencies.



Location of Deflection Survey Points and Strain Gauges



First Vertical & Torsional Modes

Amplitude Spectra: Vertical Direction

Mode and Frequency by Microtremor Measurement

Impact Vibration Test of Substructure

Objectives

- To evaluate the substructure soundness by focusing on the natural frequency of the pier.
- To compare the test result with stability analysis.

Impact Pendulum

The pendulum was positioned to impact the centerline of the middle truss of the bridge. The impacting head used had a mass of about 100 kg. The tip of the head was covered with rubber.

Impact Head of Yellow-Painted Pendulum

Judgment of Substructure Soundness

Judgment of the soundness of the pier through comparison on natural frequency between test results and eigenvalue analysis.

Rating Index (k) is defined as the ratio between the Natural Frequency of Test and Natural Frequency of Analysis.

Criteria for Substructure Soundness

Rating Index	Rating		Action
0.7 or Less	A	(A1)	In dangerous condition to abnormal external forces. Improvement work is required.
0.85 or less		(A2)	To conduct follow-up test to check the progress of deterioration.
0.86 or more	B		No problem at present

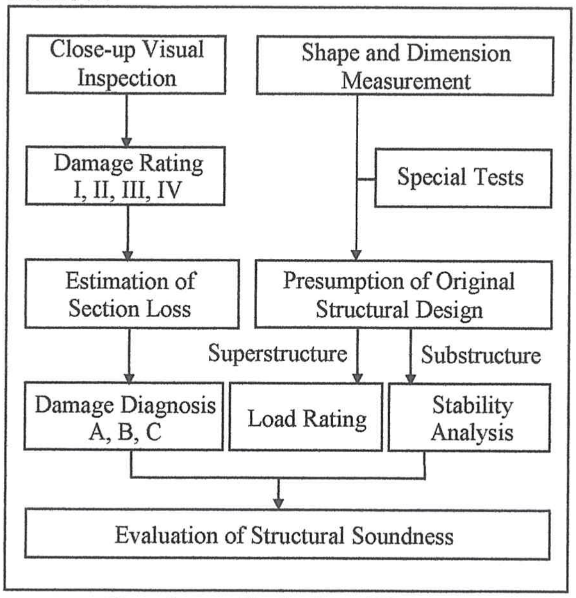
Judgment for Structural Soundness

Natural Frequency		Rating Index	Judgment
Analysis	Test		
15.2 Hz	17 Hz	1.12	B : No Problem at Present

14. ASSESSMENT OF EXISTING CONDITION

DAMAGE RATING AND DIAGNOSIS

Through the close-up visual inspection, each damage was assessed by location (X), depth (Y) and scale (Z), and categorized into damage rating (I, II, III and IV), then diagnosed (A, B and C) with estimation of section loss of member.



Procedure on Evaluation of Damages

Qualitative damage rating method is also adopted to judge the necessity of improvement work.

Classification Criteria for Judgment of Improvement Work for Steel Structure

Category / Survey Items	Improvement work required
Crack of Member	Even for minute cracks
Thickness of Plate (rust and corrosion)	Section loss is over 10% of the thickness of plate.
Coating (conditions / deterioration)	Delamination is observed entirely.
High tension bolt (section loss, looseness)	Over 10 % or 10 bolts at a splice.
Measurement of deformation	Deformation over L/125. L : Length of a member
Close-up visual inspection (joint gap between girders)	Edges of both girders are in contact or possible to be in contact.

The damage diagnosis reveals the fact that the damages have extremely developed, and the qualitative damage rating justifies the urgent need of improvement of the Ayala Bridge.

Damage Type	(1) CORROSION

Corrosion is the representative damage for steel that is easy to be oxidized in the environment. Because being progressive damage but easy to be found, this is one of important damages the progress of which shall be protected by maintenance activities.

		Influence of Damage on Load-Carrying Capacity and Durability	
		High	Low
Location or Pattern (X)	Severeness	-	-
	Sample Description	-	-
Depth (Y)	Severeness	Section Loss	Surface Rust
	Sample Description	Swollenness of steel surface or reduction of cross section area due to missing of corrosion parts.	Dotted surface rust areas.
Expanse (Z)	Severeness	Entire	Local
	Sample Description	Entire expanse of corrosion or rust to members	Local expanse such as leakage area of corrosion or rust.

X	Z	Secondary Members	Main Members
High	High	(I) or II	(I) or II
	Low	III	I or II
Low	High	III	I or II
	Low	IV	III

○: Result of Judgment

An Example of Damage Rating

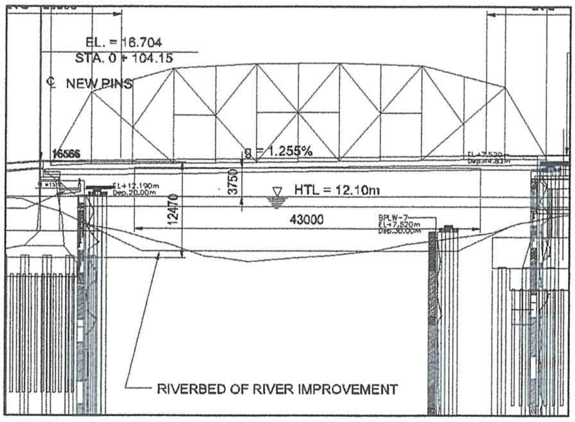
Damage Diagnosis and Section Loss

SOUTH SPAN					
Location	Reference No. of Members	Damage Type	Evaluation Based on Field Survey		Estimated Section
			Damage Rating	Diagnostic of Category	
South Span, West Truss					
Bottom	M109-112	CO	I	A	30%
Chord	M112-115	CO	I	A	30%
	M115-121	CO	I	A	30%
	M124-127	CO	I	A	30%
South Span, Middle Truss					
Bottom	M206-209	CO	I	A	30%
Chord	M209-212	CO	I	A	30%
	M212-215	CO	I	A	30%
	M215-218	CO	I	A	40%
	M218-221	CO	I	A	40%
	M221-224	CO	I	A	30%
South Span, East Truss					
Bottom	M309-312	CO	I	A	30%
Chord	M312-315	CR	I	A	30%
	M315-318	CO	I	A	40%
	M318-321	CR	I	A	40%
	M321-324	CO	I	A	30%
	M324-327	DE	I	A	30%

NORTH SPAN					
Location	Reference No. of Members	Damage Type	Evaluation Based on Field Survey		Estimated Section
			Damage Rating	Diagnostic of Category	
North Span, West Truss					
Bottom	M139-142	CO	I	A	30%
Chord	M142-145	CO	I	A	30%
	M154-157	CO	I	A	40%
North Span, Middle Truss					
Bottom	M234-238	CO	I	A	50%
Chord	M238-239	CO	I	A	30%
	M239-242	CO	I	A	30%
	M242-245	CO	I	A	30%
	M245-248	CO	I	A	30%
	M248-251	CO	I	A	30%
	M251-254	CO	I	A	40%
	M254-257	CO	I	A	40%
	M257-260	CO	I	A	30%
	M260-263	CO	I	A	30%
	M263-266	CO	I	A	30%
	M266-269	CO	I	A	10%
	M271-272	CO	I	A	50%
North Span, East Truss					
Bottom	M342-345	CO	II	B	10%
Chord	M351-354	CO	III	B	15%
	M357-360	CO	I	A	30%
	M360-363	CO	II	B	10%

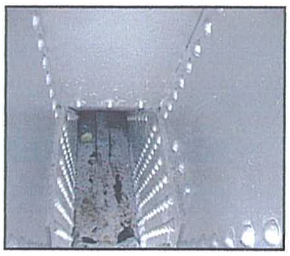
PRESUMPTION OF ORIGINAL STRUCTURE

Based on the shape and dimension measurement, the presumption of original structural plan was made referring to the available as-built drawing. The purpose is to prepare the structural shapes, dimensions and properties for the analysis model of the Load Rating.



Elevation of Ayala Bridge (North Span)

- Inspection results are to be used for visible portions such as superstructure, exposed parts of substructures.
- Shapes and dimensions of the substructures are to be determined from the non-destructive test. For the members for which the non-destructive test was not carried out, the properties are to be estimated based on the relevant materials and as-built drawings if indicated.
- The foundation type and its embedded depth are to be determined from as-built drawings and geotechnical survey results.
- The number of piles are to be fixed from the calculation based on the original design code.



Reduced Cross Section of Bottom Chord due to Corrosion

Fractured Stringer and Heavily Corroded Stringers

Heavily Corroded Stringer at South East

Fractured Stringer at North East Portion

Typical Damages

LOAD RATING

The purpose of this analysis is to evaluate quantitatively the load carrying capacity of primary members of superstructure. Structural data were evaluated and integrated in order to build a complete and realistic structural frame model of the superstructure.

The allowable stress method expressed by the following formula, was used to evaluate the capacity of the members.

$$RF = \frac{R - D}{L(1 + I)}$$

Where : RF = Rating Factor (RF)

R = Allowable stress of member

D = Stress due to Dead Loads

L = Stress due to Live Loads

I = impact factor

The Rating Factor (RF) can be used to determine the Load Rating (LR) of the superstructure members as follows:

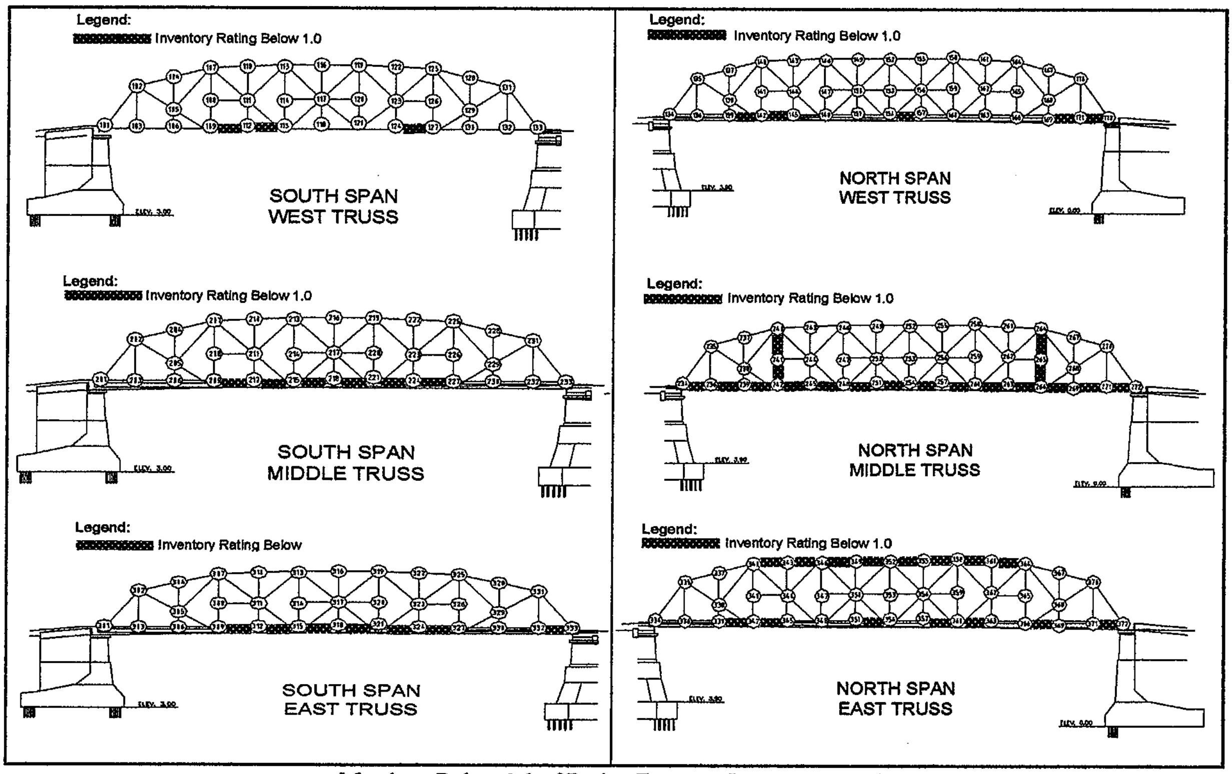
$$LR = RF \cdot W$$

Where : W = Weight of the Rating Vehicle in metric tons

The analysis results suggest the following counter measures shall be undertaken.

- Tightening the regulation on the present vehicle load limits from 5 to 3 tons should be done, if improvement works are not carried out. However, the drastic improvement works of main members shall be required because RF_i of the inventory level is still insufficient for any vehicle.
- The drastic improvement works of the bridge should be conducted as soon as possible in order to secure the safety driving and to prevent the potential fall down of the bridge.
- The planning of the improvement works shall be implemented so as to meet the latest design code requirements with consideration of the present traffic conditions.

The figure below shows the members below 1.0 of RF which are highlighted for the Inventory Level. This level generally corresponds to the customary design level of stress but reflect the existing damage and material condition with regard to deterioration and loss of section.



Members Below 1.0 of Rating Factor at Inventory Level

OVERALL ASSESSMENT

The present state of Ayala Bridge was assessed seriously critical, thus requiring the very urgent improvement.

Structural Soundness

Superstructure

- Most of the lower chords show the rating factor, either inventory or operating level, less than 1.0, which means the structural capacity of the bridge is less than 32.7 tons (design load).
- Floor system including cross beams and stringers are heavily corroded or fractured, requiring very urgent replacement.
- The corrosion of members have been heavy due to water from deck slab and aggravated by more number of vehicle and present load of heavy vehicle than expected.

Substructure

- The existing pier is sound to carry original design load, with minor damages.
- However, the stability of pier and abutment are not enough to carry the load of the latest seismic design code with 0.4 ~ 0.7 of capacity/demand ratios (C/D ratio).
- The insufficient stability of substructure is because of the change of design code requirements
- Foundation consists of timber piles, which may not meet the latest seismic code design requirements.

Vulnerability to Disaster

Earthquake

- Ayala Bridge is located 13km from the Marikina Valley Fault System (MVFS) which makes it moderately vulnerable to earthquake.
- The foundation is prone to seismic forces because it was constructed in 1935 where AASHTO have no recommendations with regards to seismic designs and does not meet the latest seismic code requirements.

Wind

The National Structural Code of the Philippines (NSCP 2001) recommends a design basic wind speed of 200 kph. AASHTO recommends only 160 kph. The maximum cyclone center wind velocity of 225 kph passing Metro Manila where the Bridge is located was recorded in 1995 with a gust velocity reaching to 255 kph.

This indicates that the Bridge has been exposed to more than 200 kph basic design wind speed specified in the Philippine Code without any major damage. Therefore Ayala Bridge is not vulnerable to wind forces.

Flood

The pressure from flood water flow is usually quite small comparing to the lateral design force adopted under the earthquake in the Philippines. This means that the earthquake forces dictate the scale and the safety of the substructures.

Traffic Condition

- Insufficient traffic capacity and functionality with load limit of 3.0 tons.
- Level of service of D (v/c=0.70).
- Large deflection of deck slab during passing of vehicles.

Special Issues

Vessel Collision

- The vertical clearance of Ayala Bridge is 3.50 m. which is less than the regulatory clearance of 3.75 m.
- The navigational space between pier and abutment of Ayala Bridge is 60.2 m. which is more than the preferable space of 43 meters.

Utilities

The existing utility lines of the bridge were:

- Two (2) Ø400mm Water Pipes
- Sixteen (16) Electricity Lines
- Eight (8) Telecommunication Lines

Informal Settlers

One informal settler along Ayala Bridge, there are few problems for implementation of the project.

15. PROPOSED IMPROVEMENT MEASURES

POSSIBLE IMPROVEMENT MEASURES

19 possible schemes for preliminary screening of alternatives were prepared from the stand points of four categories: rehabilitation and strengthening of the existing bridge, new bridge construction and others. Among these possible schemes, six (6) schemes were selected as highly possible schemes as shown below.

Selected Highly Possible Schemes

Possible Schemes	
R1	Rehabilitation/Strengthening of Damaged Joints of Truss Members
R2	Rehabilitation/Strengthening/Replacement of Bearing Shoes and Floor System
S1	Strengthening of Entire Lower Chords + Replacement of Floor System (Conversion to steel deck slab from RC deck slab)
S2	Strengthening of Entire Lower Chords + Replacement of Floor System (Conversion to steel deck slab from RC deck slab)+ New Bridge Construction
S3	Replacement of Lower Chords + Replacement of Floor System (Conversion to steel deck slab from RC deck slab)
S4	Replacement of Lower Chords + Replacement of Floor System (Conversion to steel deck slab from RC deck slab) + New Bridge Construction
S5	Strengthening of Lower Chord and Steel whole + Replacement of Floor System (Conversion to steel deck slab from RC deck slab) + New Bridge Construction
S6	Conversion from Existing Lower Chord only to Steel Box Girder (Through Type) + Replacement of Floor System (Conversion to steel deck slab from RC deck slab) + 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)
O1	Relocation of Existing Bridge + New Bridge Construction
O2	Converting Existing Bridge to Pedestrian/Light Vehicles Exclusive Use + New Bridge Construction

Note: (shaded) = Selected Schemes
R = Rehabilitation
S = Strengthening
N = New Bridge
O = Others

EVALUATION METHOD

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

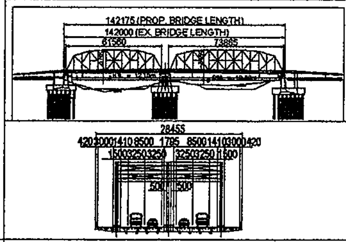
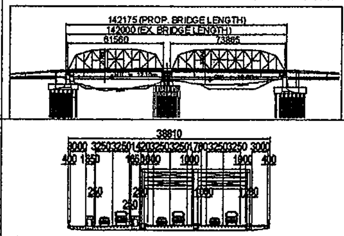
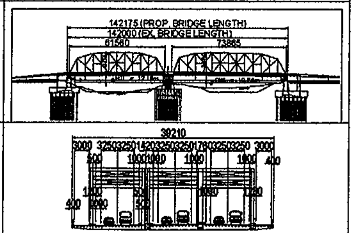
- Structural Aspects
- Economical Aspects
- Capacity and Geometry
- Traffic Management during Construction
- Right of Way Acquisition
- Aesthetic Aspects

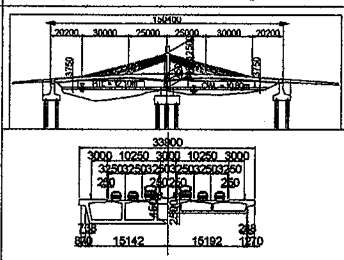
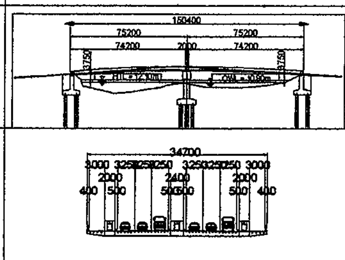
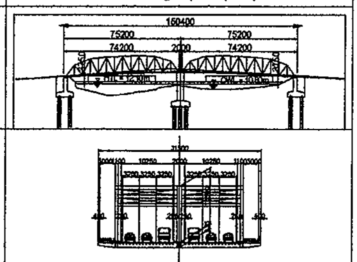
Each item is rated: A = Excellent, B = Good, C = Reasonable, D = Bad, E = Very Bad

RESULT OF EVALUATION

- Scheme S5 and N9 has the same rating, followed by Scheme S3
- 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 preferable scheme in due consideration of historical heritage and significance of the existing Ayala Bridge which was declared as the historical structure to be preserved by NHI.
- Scheme S3 intends to maintain the exact configuration of the existing bridge and utilize the existing sound members.
- Scheme S3 has a shortcoming in mitigation of traffic congestion comparing to N9 and S5.
- Because of the shortcoming of S3, the Second Ayala Bridge was proposed in order to cope with the future traffic demand on the existing Ayala Bridge.
- Traffic congestion on the bridge was observed due to insufficient capacity of both side of intersections of the bridge, in particular, right/left turn lane lengths including transition length were considered insufficient.
- Therefore, improvement of both intersections was included in the Ayala Bridge improvement works.

Evaluation of Highly Competitive Scheme for Ayala Bridge

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	
PIER							
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. • Construction of new steel box girder bridge. • Strengtening of abutment and pier.	Rating	• Jack - up by 25 cm. • Replacement of lower chord and floor system. • Replacement of fatigued members. • Construction of additional new through truss bridge. • Strengtening of abutment and pier.	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.), ₱ 37.4 M/40 Years (Paint)		₱ 3.5 M/Year, ₱ 47.1 M/20 years(Rehab.), ₱ 51.4 M/40 Years (Paint)		₱ 3.9 M/Year, ₱ 47.0 M/20 Years, ₱ 51.1 M/40 Years	
Capacity and Geometry	Capacity	4-Lane with a lane width of 3.25m, which width is for local road. ⓧ	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	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	-		-		-	
	Civic Design	Structural permanency, Distinctive quality, Harmony with urban environment.		Damage harmony with urban environment ⓧ		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

Improvement Type		New Construction					
		N2		N7		N9	
Scheme Name		2 - Span PC Extradosed Bridge		Steel Box Girder (2 - Span)		Truss Bridge (2- Span)	
PIER							
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	Will be improved by rotating clockwise a little bit.		Will be improved by rotating clockwise a little bit.		Will be improved by rotating clockwise a little bit.	
	Access to Hospicio	The gradient of 9.0% is provided by making the existing road longer withcurved 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 (m.^{2})	3,820 sq. m.		3,820 sq. m.		3,820 sq. m.	
	Affected House (m.^{2})	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	
	Civic 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

PRELIMINARY DESIGN

Design Policy

Scheme S3, strengthening of the existing Ayala Bridge, was finally selected as improvement measures in line with the policy of the NHI and the DPWH.

The major improvement works include the following;

- Replacement of lower chords with new steel members,
- Replacement of fatigued members,
- Replacement of floor system with steel deck slab systems,
- Reconstruction and strengthening of abutments and pier,
- Jacking-up of superstructure by 25 cm to secure the regulatory navigation clearance, and
- Construction of a detour bridge and road during construction.

The constraints during construction are as follows:

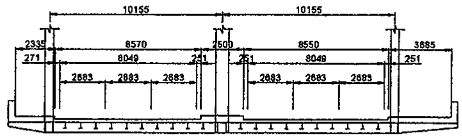
- To maintain the same 4-lane road traffic as the existing bridges,
- To construct a detour bridge at the Hospicio side,
- To maintain vessel navigation, and
- To maintain the existing at-grade intersection, not separated intersection.

Superstructure

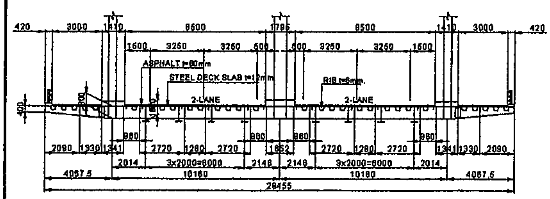
Standard Cross Section
Distance between main trusses was exactly maintained in line with the policy of the improvement scheme. The sidewalk width of downstream side was widened up to 3.0m and that of upstream side reduced to 3.0m.

Steel Plate Deck
The replacement activities of lower chords will necessitate that the steel plate deck is self-supported. The design of floor system was conducted, accordingly, providing that temporary supports act as supporting points.

The newly installed steel plate deck is expected to be continuous structure with the temporary supports during construction. The dimensions of steel plate deck were determined with consideration of construction sequence



a) Before Improvement Works



b) After Improvement works

Standard Section

Cross Beam
Newly installed cross beams were presumed to support the floor system with bearing of main frame trusses, even the floor system is continuously connected to bottom chords. The cross beams are modified as simple span beams with the span length equal to the spacing of main trusses. Dimensions of cross beams are determined by employing allowable stress method.

A cross beam of 800 mm in height was simply determined to accommodate it to a bottom chord 1,000 mm in height.

Bottom Chord
The new bottom chords were designed to secure the safety by installing bottom chords having the total section area equal to or more than that of original bottom chords.

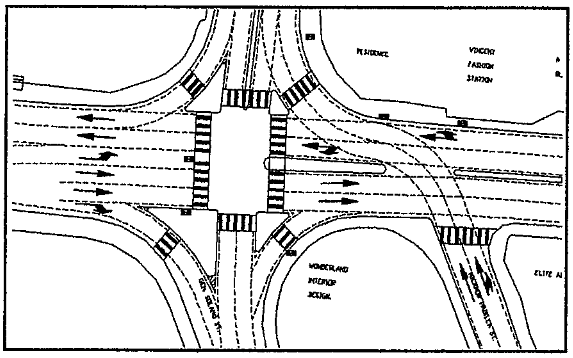
A bottom chord 800 mm in height is equal to the cross beam height. The width of bottom chord is equal to that of existing dimension so that the vertical or diagonal members are connected to the bottom chord with bolts through gusset plates.

Substructure

The abutments are seat type rested on ø1.00m tubular steel pipe pile with fixed connection to the superstructure (hinge support) while pier is on movable connection rested on tubular steel pipe piles.

Intersection

Two (2) intersections (south and north sides) adjacent to the bridge were recommended to be improved to mitigate the traffic congestion.



Proposed North Intersection Improvement
for North Side

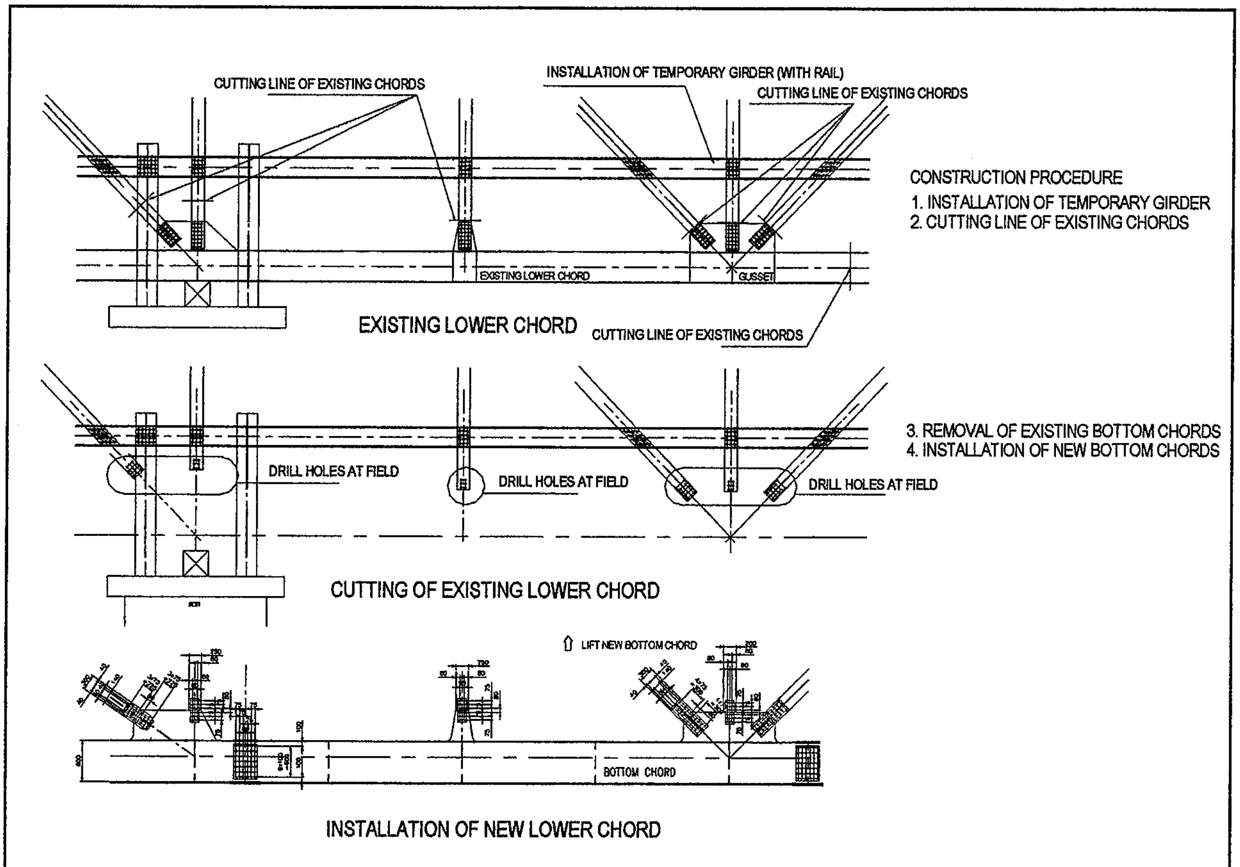
PROJECT COST

The total project cost consists of construction, land acquisition and engineering costs.

Summary of Estimated Project Cost

June, 2003 Prices

Items		Cost (Million Pesos)
Construction Cost	Foreign	781.10
	Local	128.40
	Tax	161.80
	Subtotal	1,071.30
Engineering Cost	Foreign	67.40
	Local	42.90
	Tax	12.30
	Subtotal	122.60
Land Acquisition Cost	Foreign	-
	Local	56.60
	Tax	6.40
	Subtotal	63.00
Grand Total	Foreign	848.50
	Local	227.90
	Tax	180.50
Grand Total		**1,256.90**



Strengthening of Lower Chords

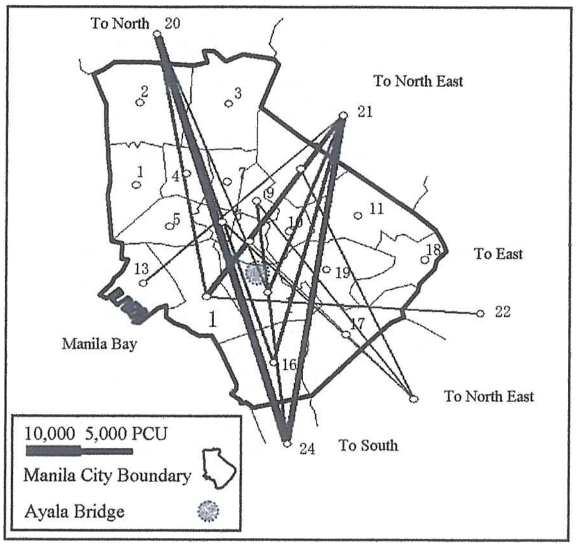
16. TRAFFIC ANALYSIS AND ECONOMIC EVALUATION

TRAFFIC ANALYSIS

The traffic demand on the Ayala Bridge was forecasted on the basis of assumed Bridge Plans as a presumption of the economic analysis

TRAFFIC VOLUME

The traffic volume on the Ayala Bridge will be 33,000 PCU in 2010 and 51,000 PCU in 2020 under "do something case".



Desired Line of Traffic

TRAFFIC IMPACTS OF THE OTHER BRIDGES

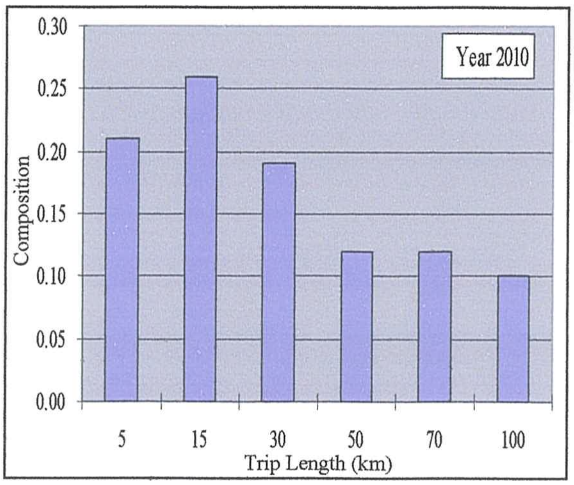
If the Ayala Bridge will not be improved, this bridge may be presumed to be closed sometime in 2008. The traffic demand forecast under this situation (do nothing case) was made.

- In 2010, the traffic volume on the Ayala Bridge will be diverted mainly to Quezon and Second Ayala Bridge.
- However, due to the traffic congestion on Quezon Bridge being over saturated, the traffic volume on Quezon Bridge will reroute again to Delpan and Jones Bridge. This is because the Ayala Bridge forms a part of major arterial road.

TRAFFIC CHARACTERISTICS

Trip length distribution and OD pattern of traffic using the Ayala Bridge is illustrated below.

- Trip length of traffic passing through the Ayala Bridge is about 35km/trips since road network linking with the Ayala Bridge is defined as major arterial.
- The Ayala Bridge has a wide influence area due to the same reason mentioned above.



Trip Length of Ayala Bridge

Traffic Demand Forecast

Unit: PCU/day

No.	Bridge Name	2010		2020	
		Case 1 (Do Nothing)	Case 2 (Do Something)	Case 1 (Do Nothing)	Case 2 (Do Something)
1	Delpan Bridge	73,600	69,500	88,700	88,300
2	Jones Bridge	66,600	58,600	70,900	64,000
3	McArthur Bridge	61,800	67,300	87,300	74,600
4	Quezon Bridge	84,000	72,900	110,300	86,300
5-1	Ayala Bridge	0	33,000	0	51,000
5-2	Second Ayala Bridge	35,300	22,600	53,800	33,900
Total		321,300	323,900	411,000	398,100

ECONOMIC EVALUATION

Methodology

Cost-benefit analysis was used to evaluate the economics of the Ayala Bridge improvement project. Benefit is defined as the savings in the vehicle operation cost (VOC), the fixed cost and the travel time cost (TTC) accrued by the project. The economic project life is taken as 30 years and the economic discount rate is used as 15%.

Impact on Traffic

In 2005, the vehicle-kilometer for the trips assigned on the road network in the influence areas in case of no improvement the Ayala Bridge will be 2,767,363. The vehicle-kilometer will be reduced by the project to 2,681,563. On the other hand, the vehicle-hour of the former case will be 157,087 while the vehicle-hour of the later case will be reduced to 145,444.

Vehicle-Kilometer with and without the Project

Year	W/O Project	W/ Project	W/O – W/
2010	2,767,363	2,681,563	85,800
2020	3,553.544	3,436,236	117,308

Vehicle-Hour with and without the Project

Year	W/O Project	W/ Project	W/O – W/
2010	157,087	145,444	11,643
2020	246,266	223,361	22,905

Economic Cost

The financial cost was converted to the economic cost by deducting tax. Total financial cost of 1,263 million pesos is equivalent to 1,095 million pesos in economic cost. The ratio of economic to financial cost is 86.7%.

Annual maintenance cost was assumed to be 1.0% of the improvement cost.

Economic Benefit

The economic benefit of the project was estimated at 512 million in 2010 and will increase to 925 million with an average annual growth rate of 6.1%.

Total economic benefits during the economic project life period was estimated at 28,457 million.

Estimation Benefits Unit: Million/Year

Year	Saving in VOC	Saving in Fixed Cost	Saving in Time Cost	Total Saving
2010	138	102	271	512
2020	189	201	533	925
2007-2036	5,680	6,247	16,531	28,457

Benefit Cost Analysis

The results of the economic analysis show that Net Present Value (NPV) is ₱1,999 million and BCR is 3.25 over 30 years life of the Bridge using a discount rate of 15% which is designated by the NEDA. The Economic Internal Rate of Return (EIRR) was compiled at 34.3%.

Economic Indicators of Benefit Cost Analysis

Net Present Value	1,999,853
Benefit Cost Ratio (BCR)	3.249
Economic Internal Rate of Return (EIRR)	34.3 %

Sensitivity Analysis

The sensitivity analysis was conducted under a worse case scenario incorporating increase and/or decrease of the estimation of costs and benefits.

Sensitivity Analysis regarding Costs and Benefits Unit: %

		Benefits				
		20% down	10% down	Base Case	10% up	20% up
Costs	20% down	34.3	37.1	39.7	42.3	44.7
	10% down	31.7	34.3	36.8	39.1	41.4
	Base Case	29.5	32.0	34.3	36.5	38.7
	10% up	27.7	30.0	32.2	34.3	36.3
	20% up	26.1	28.3	30.4	32.4	34.3

Note: Project life of the project is assumed to be 30 years

Conclusion

The implementation of the Ayala Bridge improvement project can be justified from the national economic view point since the economic indicators of all cases are more than the cut-off level which can be considered as 15% of EIRR in the Philippines.

17. ENVIRONMENTAL IMPACT ASSESSMENT

BASIS FOR ASSESSMENT

The assessment of environmental impacts of the proposed project is based on the existing conditions in the study area classified in two types:

- Direct Impact Area (DIA) are areas that will be directly affected by the proposed undertaking, and will entail physical displacement of houses and improvements due to the construction of a temporary detour bridge on the east side of Ayala Bridge
- Indirect Impact Area (IIA) refer to those that will be indirectly affected by the possible increase in noise levels, TSP levels and other gaseous pollutants such as SO_X and NO_X due to the operation of various equipment and machinery during the construction phase of the project.

IDENTIFIED IMPACTS

Predicted Impacts

- Adverse impacts such as the possible increase in noise levels, TSP levels and other air pollutants such as SO_X and NO_X due to the operation of various equipment and machinery, and turbidity of river water are expected to be minimal and during the construction period only.

Perceived Impacts

- Perceived positive impact is the increase in job opportunities and benefits of small enterprises during the rehabilitation/ construction period.
- Perceived negative impact is traffic congestion during construction. As in any other construction activities, these adverse impacts are inevitable, but are short term.

SOCIAL ACCEPTABILITY

- Based on interview surveys, a very high 100% of the Project Affected-Families (PAFs) and 95.8% of the other stakeholders expressed full support to the proposed improvement of the Ayala Bridge. Only 4.2% expressed disapproval over the proposed undertaking

- When asked why they are in-favor of the Project, the top two (2) answers are because (i) it is for the safety of the motorists (51.8%), and (ii) it will enhance traffic flow (12.5%). The results are very encouraging because even the PAFs who will actually be displaced to give way to the construction of the detour bridge, are in full support to the improvement works on the Bridge.

Consultation Meetings with Community Leaders

Consultation Meetings with Project Affected Families

RESETTLEMENT PLAN FOR AFFECTED PEOPLE

- Due to the nature of the improvement works to be done, adverse social impacts are expected to be minimal. The only activity that would entail the displacement of people would be the construction of the temporary detour bridge on the eastern side of the Bridge. The said displacement would involve only four (4) families, three of which are tenants on private land staying inside the Hospicio de San Jose Compound, and one (1) informal settler under the west portion of the bridge near its approach.
- To ensure that these PAFs are not worsened-off as a result of the project activities, a comprehensive and workable Resettlement Action Plan (RAP) has to be prepared and implemented for these people. To accomplish this, close coordination between the DPWH, the City Government of Manila, and the housing agencies would be extremely necessary.

18. IMPLEMENTATION

IMPLEMENTATION POLICY

Basic Policy

The need for the implementation of improvement measures of the Ayala Bridge is very urgent considering its damage conditions. Therefore, the implementation plan was scheduled based on the following policies:

- The detailed design shall start immediately after this Study,
- Considering the importance of the Ayala Bridge for socio-economic activities, the implementation period is to be shortened to the possible extent, and
- Load limitation plan shall be studied taking the implementation delay into account due to the recent budget of GOP for road and bridge investments.

Implementation Schedule

The percent share of this project to total investment budget is only 2.02 % as a maximum year. Therefore, the budget for implementing the Ayala Bridge Improvement Project can be secured.

Comparison on Road/Bridge Budget and Annual Investment Requirement

Year	(1)	(2)	(2)/(1) (%)
2004	26,970.0	20.5	0.08
2005	28,370.0	29.7	0.10
2006	29,850.0	603.4	2.02
2007	31,400.0	603.3	1.92

(1) Road and Bridge Investment Budget (Million Pesos)
(2) Annual Investment Requirement for Ayala (Million Pesos)

MAINTENANCE

The main objectives of bridge maintenance are:

- To provide comfortable, safe, efficient and reliable facilities to users, and
- To prevent premature deterioration and prolong the life of road structures, thus protecting road facilities from costly rehabilitation/reconstruction.

Budgetary Consideration

The allocation of the budget for NCR in CY 2002 is very limited, thus recommended to be increased.

EMK for roads & bridges = ₱ 2,598.334 EMK
Basic Cost = ₱ 60,644 / EMK
Estimated budget allocation= ₱ 157,575,000
Estimated maintenance cost for the Ayala Bridge = ₱ 4,550,000
Ratio of maintenance cost for the Ayala Bridge to estimated budget allocation = 0.03

Recommendation

- To allocate budget for Ayala Bridge as a historical structure and the possible tourist–attraction area.
- To expect such company as Ayala Foundation to burden or donate a part of maintenance cost.
- To incorporate maintenance activities for Ayala Bridge into that for the linear park being conducted by PRRC, or to share the cost between the DPWH and PRRC.
- Beauty and aesthetic of the bridge are determined not only from the design but from adequate routine and periodical maintenance activities. It is vital for maintaining historical value and beauty of the Ayala Bridge that adequate maintenance activities shall be certainly conducted.

Implementation Schedule

Unit: Million Pesos

Construction Stage		2004				2005				2006				2007			
1. Implementation Schedule	Detailed Design			▬	▬	▬	▬										
	ROW Acquisition						▬										
	Tender							▪▪▪	▪▪▪								
	Construction									▬	▬	▬	▬	▬	▬	▬	▬

Construction Stage		2004	2005	2006	2007
2. Annual Fund Requirement (Million Pesos at 2003 price)	Detailed Design	20.5	20.4	-	-
	ROW Acquisition/Rental	-	9.3	26.9	26.8
	Construction	-	-	535.6	535.7
	Construction Supervision	-	-	40.9	40.8
	Total	20.5	29.7	603.4	603.3