3.4 REHABILITATION DESIGN

3.4.1 Reconstruction Design

(1) Scope of Design Work

The purpose of the reconstruction design in the Study is to show examples of basic designs for the eight reconstruction bridges. The bridges were planned based on the topographic maps and the ground conditions surveyed, to select bridge type, size and location, considering function and capacity of bridge, geological and geographical condition, and environmental impacts.

After the bridge plan, the CADD (Computer Aided Design and Drafting) programs developed in the Study was used for design and preparation of drawings. However, for case of San Jose Bridge, the MOP is required to carry out supplemental design besides the design by the CADD to complete it.

(2) Bridge Plan

The reconstruction plans for alignment and location, bridge type, width, high-water-level and freeboard, as well as topographic and soil-boring survey area, had been discussed between the MOP and the Study Team during and after the general inspection. Based on the agreed plan for each bridge site, topographic survey by scale 1/200 and soil-boring survey were carried out (See **Chapter 3.3.1**).

Bridge plan was performed taking account of the following technical points:

1) Span arrangement
   - Span length was in principle selected from the economical span range of 20 to 30 m, bearing in mind the balance of superstructure and substructure costs. If the substructure cost is expected high for piles, a little longer span is considered for economy.
   - For multi-span bridges, a standard beam of same size and span was applied as far as site condition allowed, for easier and economical design and construction.
   - To secure smooth water flow, span arrangement was checked from the total pier widths in waterway not over 5 % of river width.

2) River crossing direction
   - Bridge was planned as far as possible to cross river at right angle toward river flow.

3) Location of pier and abutment
   - Many bridges inspected in Chile have insufficient openings for waterway, so that abutment was planned to be set back from the existing location.
   - Direction of pier and abutment was planned parallel to flow direction.
   - In case that new bridge was constructed parallel and adjacent to the existing bridge, the location of new piers was so determined as to come on the direction of flow from the

existing piers in order not to disturb flow.

4) Type of super- and substructure
   - In selection of superstructure type, the following factors were considered.
     - Span length
     - Availability of beam fabrication yard at site
     - Ground condition
     - Transportation of pre-fabricated beams to site
   - For the span over 30 m and terrain of site was mountainous, steel beam was selected considering easiness of erection work although it was costly compared to PC (prestressed concrete) beam.
   - Pile bent pier was not adopted although it was a economical construction, from the following reasons:
     - Pile bent tends to create turbulence in flow around piles and causes severe local scour, and
     - To catch floating woods debris and that causes narrowing flow area.

5) Freeboard on high-water-level
   - The minimum freeboard of 1.0 m between high-water-level and the lowest point of superstructure was adopted for safe pass of floating debris.

6) Embedding of footing
   - The minimum depth of 2.0 m was taken from river bed down to top of footing, and footing was embedded minimum 1.0 m into hard gravel strata or placed directly onto trimmed level of solid rock or deepened more than the anticipated scouring depth.

(3) Embedding Depth of Footing against Scour

To examine the embedding depth of footing below riverbed, an estimation of scouring depth was tried.

There are three forms of scour in evaluating the safety of bridges, namely general scour, contraction scour and local scour. General scour is the general degradation of riverbed along some considerable length of the river. Contraction scour results from contraction of channel width near the abutment embankment. Local scour is the erosion of material adjacent to abutments and around piers.

The scour to be checked here is only a local scour around a pier. The other general and contraction scours were not considered, because they involve the river hydraulics but which is unfortunately not surveyed in the Study.

The curve presented in **Figure 3.5** (from Iowa Highway Research Board Bulletin No. 4 by Laursen and Toch) shows the predicted local depth of scour for a rectangular pier. For pier shapes other than rectangular, **Table 3.12** gives multiplying factors for relating scour.

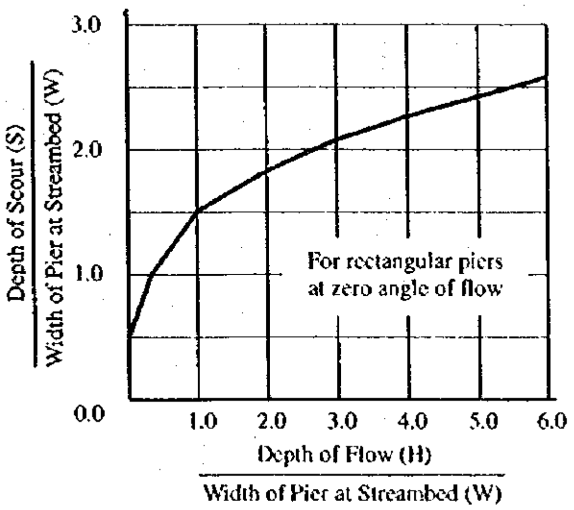


Figure 3.5 Curve for Depth of Scour

Table 3.12 Shape Coefficients K for Nose Forms

(Use only for piers aligned with flow)

Nose form		Coefficients: K
Rectangular		1.00
Semicircular		0.90
Eliptic		0.80

Scour for the reconstruction bridges was estimated with the following assumption:

- Width of pier at stream bed : W = 1.20 m
- Depth of water flow : H = 3.00 m assumed
- $\frac{H}{W} = \frac{3.00}{1.20} = 2.5$

For the pier width to flow depth ratio of $\frac{H}{W}$ = 2.5, the ratio of scour depth (S) to pier width (W) is taken as $\frac{S}{W}$ = 1.9 from the curb of **Figure 3.5**.

The designed pier nose is semicircular, accordingly the shape coefficient is given as K = 0.90 from **Table 3.12**. In result, scour depth is estimated as:

$$S = \frac{S}{W} \text{ x W x K} = 1.9 \text{ x } 1.20 \text{ x } 0.90 = 2.0 \text{ m}$$

Therefore, a minimum 2.0 m of embedding depth was adopted for all the reconstruction bridges. The depth of 2.0 m is a minimum depth of pier foundation given by the Japan's River Act.

(4) Bridge Design

Main features of the bridge designs are summarized in **Table 3.13**.

Table 3.13 Summary of Reconstruction Bridge Designs

No.	Bridge Name	Type of Superstructure	Span & Bridge Length	Bridge Width (Roadway & Sidewalk)	Location of New Bridge
2	David Garcia	Post-tensioned PC beam	4 @ 26 = 104 m	10 + 2 @ 1.5 = 13.0 m	Same location
3	Granallas	Post-tensioned PC beam	2 @ 28 = 56 m	7 + 2 @ 1.2 = 9.4 m	Same location
*5	San Jose	Post-tensioned PC beam	3 @ 28 = 84 m	10 + 2 @ 1.0 = 12.0 m	Down-stream side
6	Puangue	Post-tensioned PC beam	4 @ 30 = 120 m	10 + 2 @ 1.2 = 12.4 m	Up-stream side
7	San Jose de Marchiue	Post-tensioned PC beam	6 @ 27 = 162 m	7 + 2 @ 1.0 = 9.0 m	Up-stream side
8	Antivero No. 2	Post-tensioned PC beam	4 @ 29 = 116 m	9 + 2 @ 1.2 = 11.4 m	Same location
13	Poculon	Pre-tensioned PC beam	2 @ 20 = 40 m	7 + 2 @ 1.0 = 9.0 m	Down-stream side
16	San Juan	Steel plate girder	1 @ 34 = 34 m	8 + 2 @ 1.2 = 10.4 m	Same location

For the new bridges, bridge widths were decided by the MOP taking account of the width of approach roads, the traffic condition, and the future widening plans.

In case of No. 5 San Jose Bridge, the approach road is sharply curved, therefore the bridge has to cross the river curved and skewed. The bridge also needs piles and a circular pier column. Such unusual design can not be handled by the CADD, therefore the design prepared in this Study provides only a basic design with the following features:

- Curved and skewed bridge is designed as a straight and right-angle bridge. It is not a precise analysis but considered enough for small bridges within certain limit of curve and skew.
- Footing with piles and circular pier column can not be designed by the CADD.

(5) Design Conditions

Major design conditions adopted to the design are as follows:

1) Design method: CADD Program (Allowable Stress Method)

2) Design specifications: AASHTO (1992)

3) Dead loads:

- Plain concrete : 2.30 t/m^3
- Reinforced concrete : 2.50 t/m^3
- Steel : 7.85 t/m^3

- Pavement : 2.30 t/m^3
- Soil : 1.80 t/m^3

4) Live loads: HS 20-44 loading

5) Sidewalk load: $Wp = 0.293$ t/m^2 (7.6 m $< L \leqq 30.5$ m)

6) Wind load: $Wv = 0.244$ t/m^2

7) Earthquake load: Acceleration coefficient $A = 0.15$ (Category B by Single Mode Spectral Method)

8) Properties of materials:
- Concrete : H30 and 40, $f_c' = 250$ and 350 kg/cm^2
- Reinforcing bar : A63-42H, $f_y = 4{,}200$ kg/cm^2, $f_s = 6{,}300$ kg/cm^2
- Anchor bar : A44-28H, $f_y = 2{,}800$ kg/cm^2, $f_s = 4{,}400$ kg/cm^2
- Structural steel : A52-34ES, $f_y = 3{,}400$ kg/cm^2, $f_s = 5{,}200$ kg/cm^2
- High-tension bolt : according to ASTM A490.

9) Soil strength parameters of bearing strata: See **Table 3.14**, assumed based on the results of soil-boring survey (See **Soil-boring Report**).

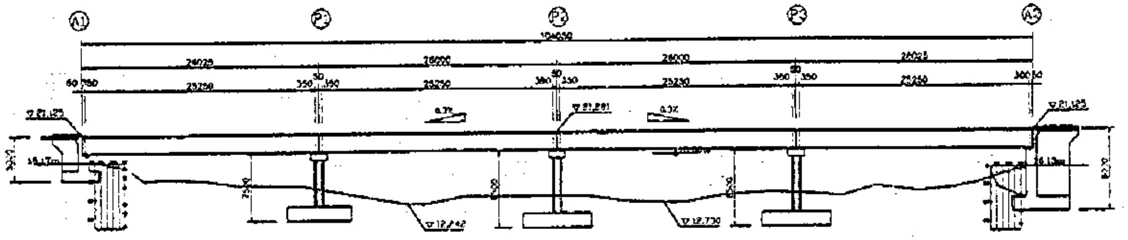
Table 3.14 Soil Strength Parameters

No.	Bridge Name	Unit Weight (t/m^3)	Internal Friction Angle (degree)	Cohesion (t/m^2)
2	David Garcia	2.0	42	0
3	Granallas	2.0	42	0
5	San Jose	1.5	0	13.3
6	Puangue	1.9	42	0
7	San Jose de Marchiue	1.9	42	0
8	Antivero No. 2	2.0	42	0
13	Poculon	1.9	42	0
16	San Juan	1.5	0	6.4

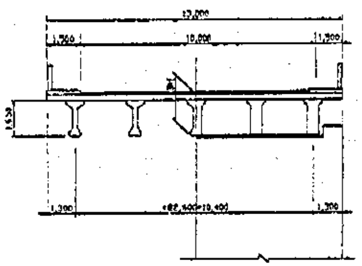
(6) General View Drawings

Based on the data collected and the plans adopted so far, the eight reconstruction bridges were designed by using the CADD programs developed in the Study. Only the general views of them are attached hereto in the following pages, and details are given in **Appendix III (Volume 5/8)**.

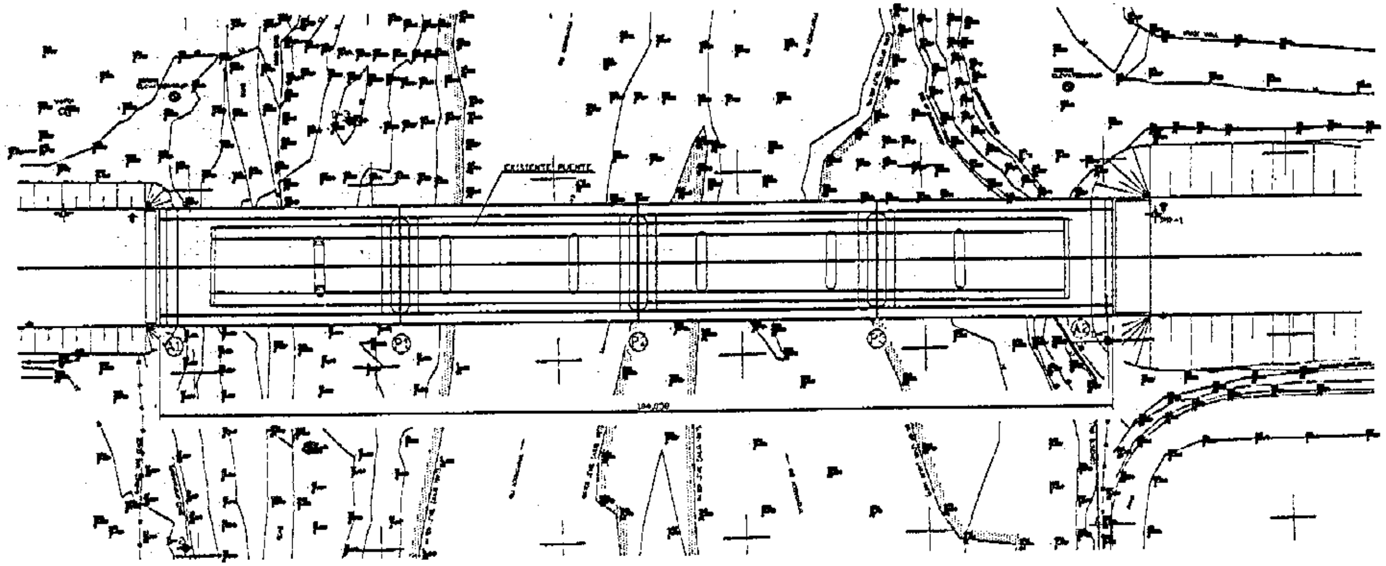
CORTE LONGITUDINAL
ESC.1:250



SECCION DE VIGA
ESC.1:100



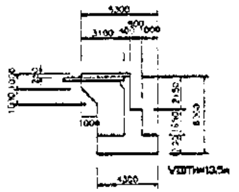
PLANTA
ESC.1:250



DETALLE DE BH

Pavimento	125
Losa	200
Viga	1650
Apoyo	50
Pedestal	100
Total	2125

ESTRIBO A1
ESC.1:150



PILA P2 P3 (P1)
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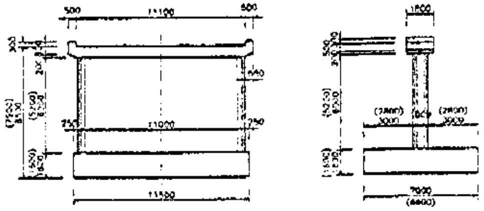

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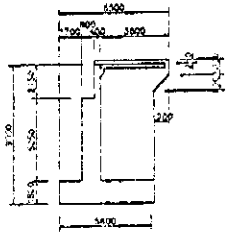
ESC.1:150

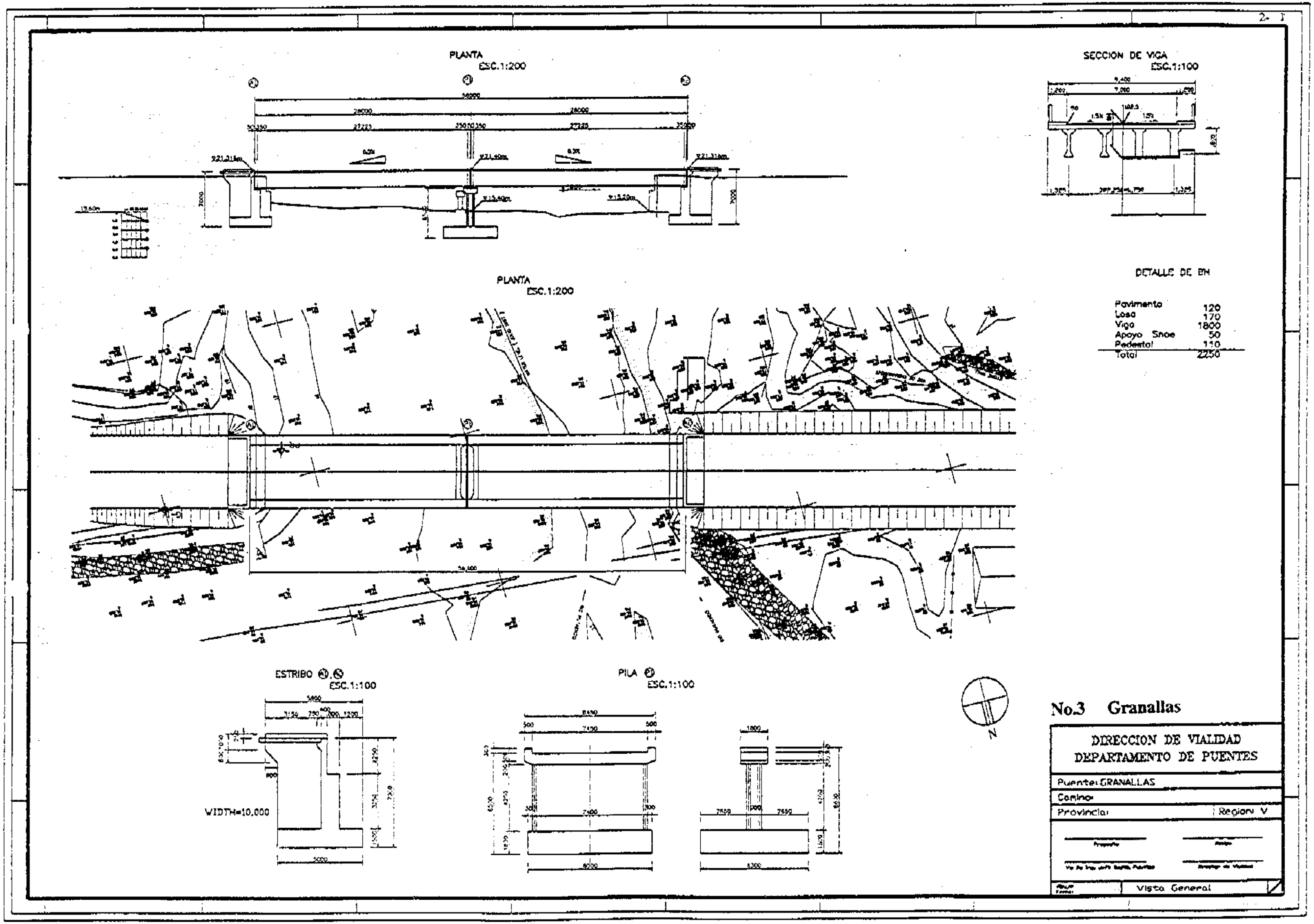


No.2 David Garcia

DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES

Puente: DAVID GARCIA
Camino:
Provincia: | Region: V

Vista General



DETALLE DE BH

Pavimento	120
Losa	170
Viga	1800
Apoyo Shoe	50
Pedestal	110
Total	2250

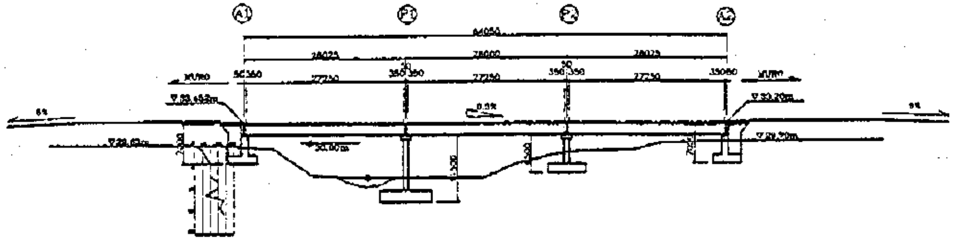
No.3 Granallas

DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES

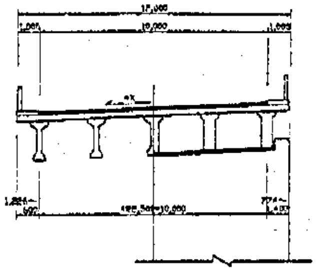
Puente: GRANALLAS
Camino:
Provincia: Region V

Vista General

CORTE LONGITUDINAL
ESC.1:400



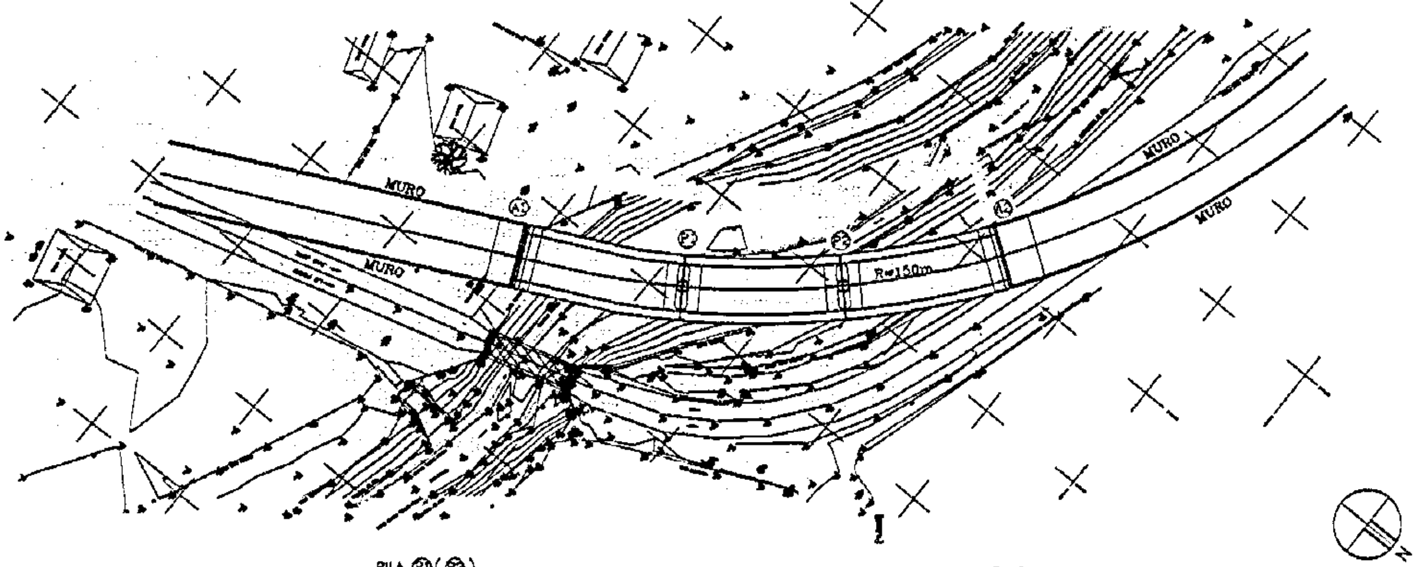
SECCION DE VIGA
ESC.1:100



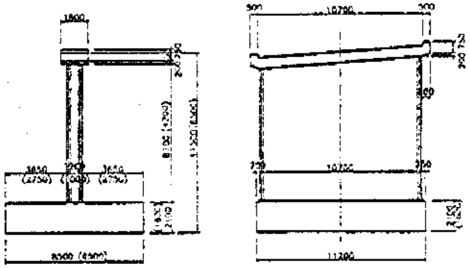
DETALLE DE BH

Pavimento	50
Losa	170
Viga	1850
Apoyo	50
Pedestal	130
Total	2250

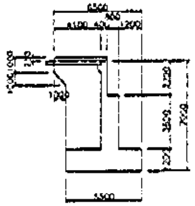
PLANTA
ESC.1:400



PILA P1 (P2)
ESC.1:150



ESTRIBO A1 A2
ESC.1:150



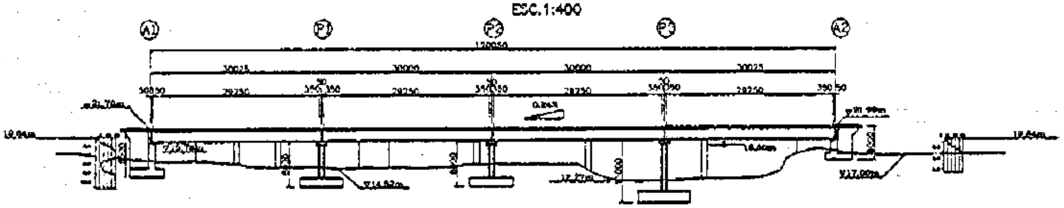
No.5 San Jose

DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES

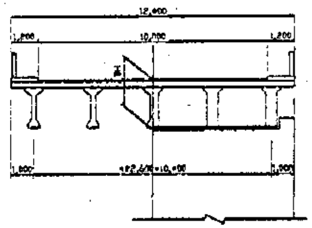
Puente: SAN JOSE
Camino:
Provincia: | Region: RM

Vista General

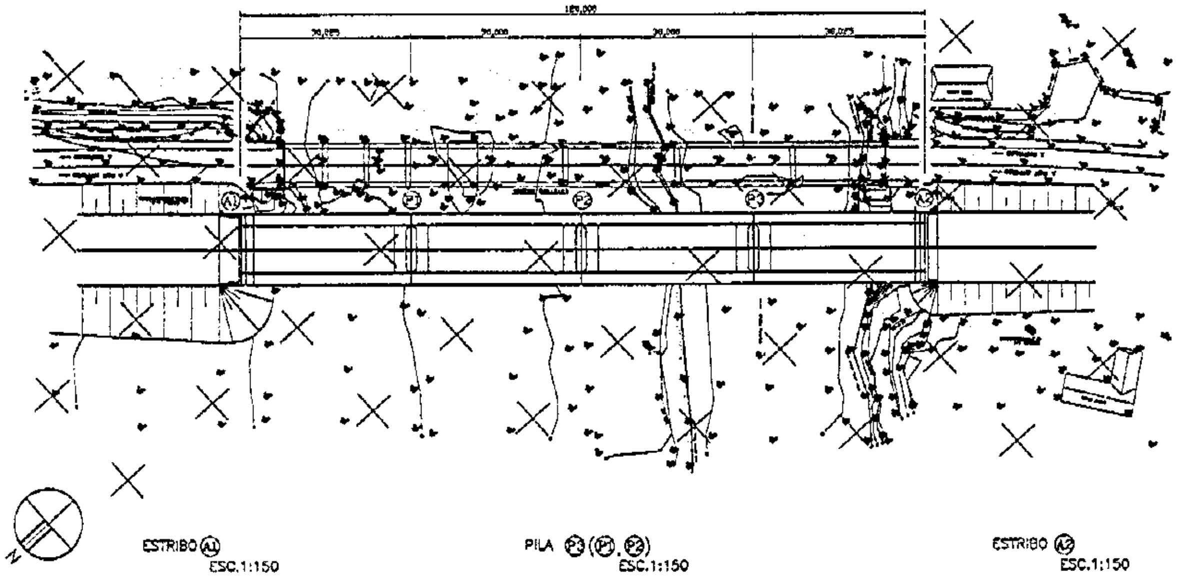
CORTE LOGITUDINAL
ESC.1:400



SECCION DE VIGA
ESC.1:100



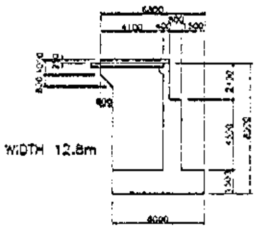
PLANTA
ESC.1:400



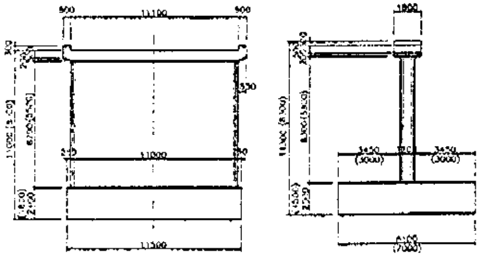
DETALE DE DH

Pavimento	125
Losa	200
Viga	1800
Apoyo	50
Pedestal	75
Total	2150

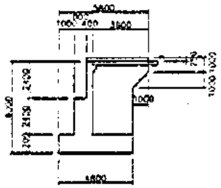
ESTRIBO A1
ESC.1:150



PILA P3 (P1, P2)
ESC.1:150



ESTRIBO A2
ESC.1:150

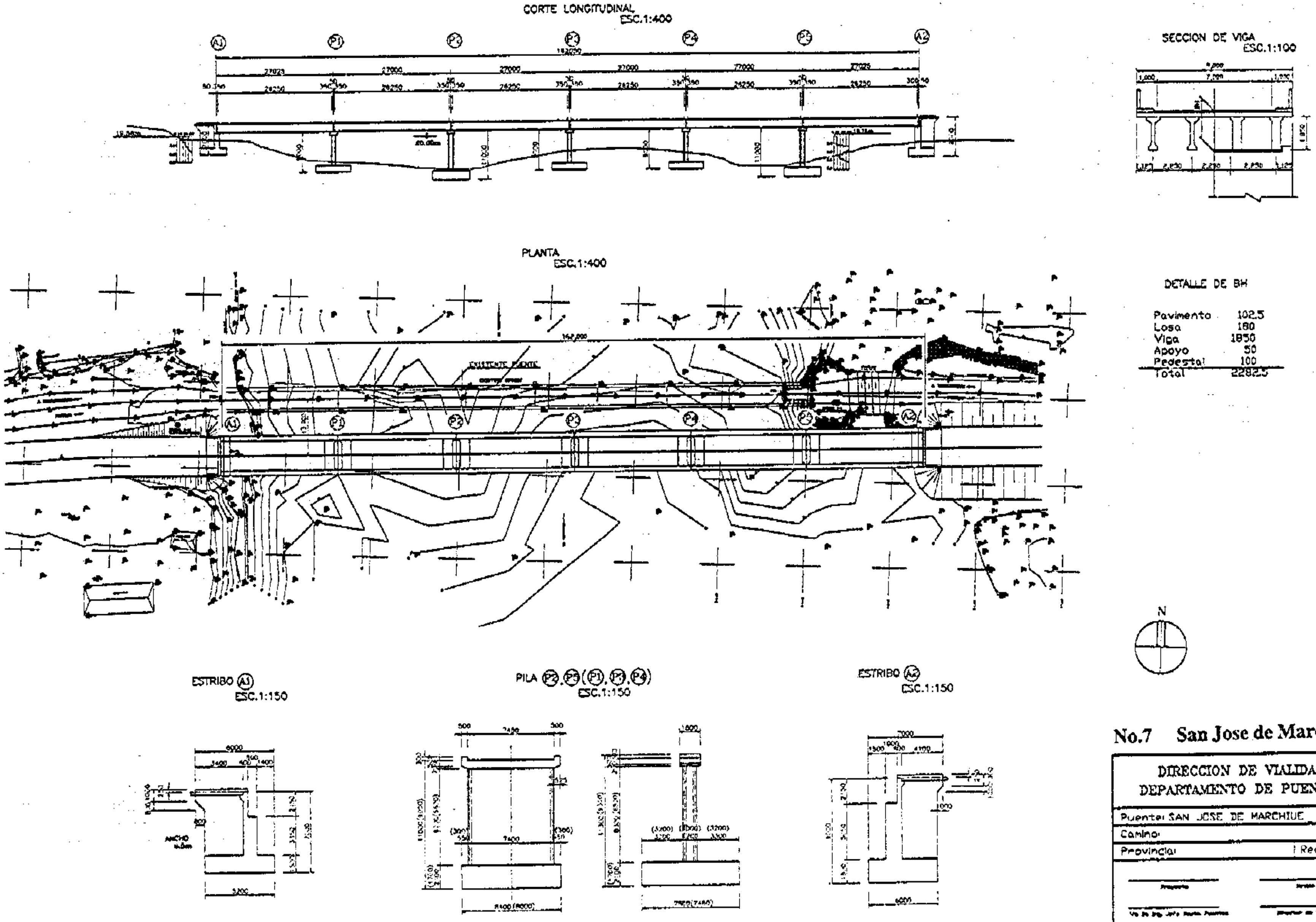


No.6 Puangue

DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES

Puente: PUANGUE
Camino:
Provincia: Region:RM

Vista General



DETALLE DE BH

Pavimento	102.5
Losa	180
Viga	1850
Apoyo	50
Pedestal	100
Total	2282.5

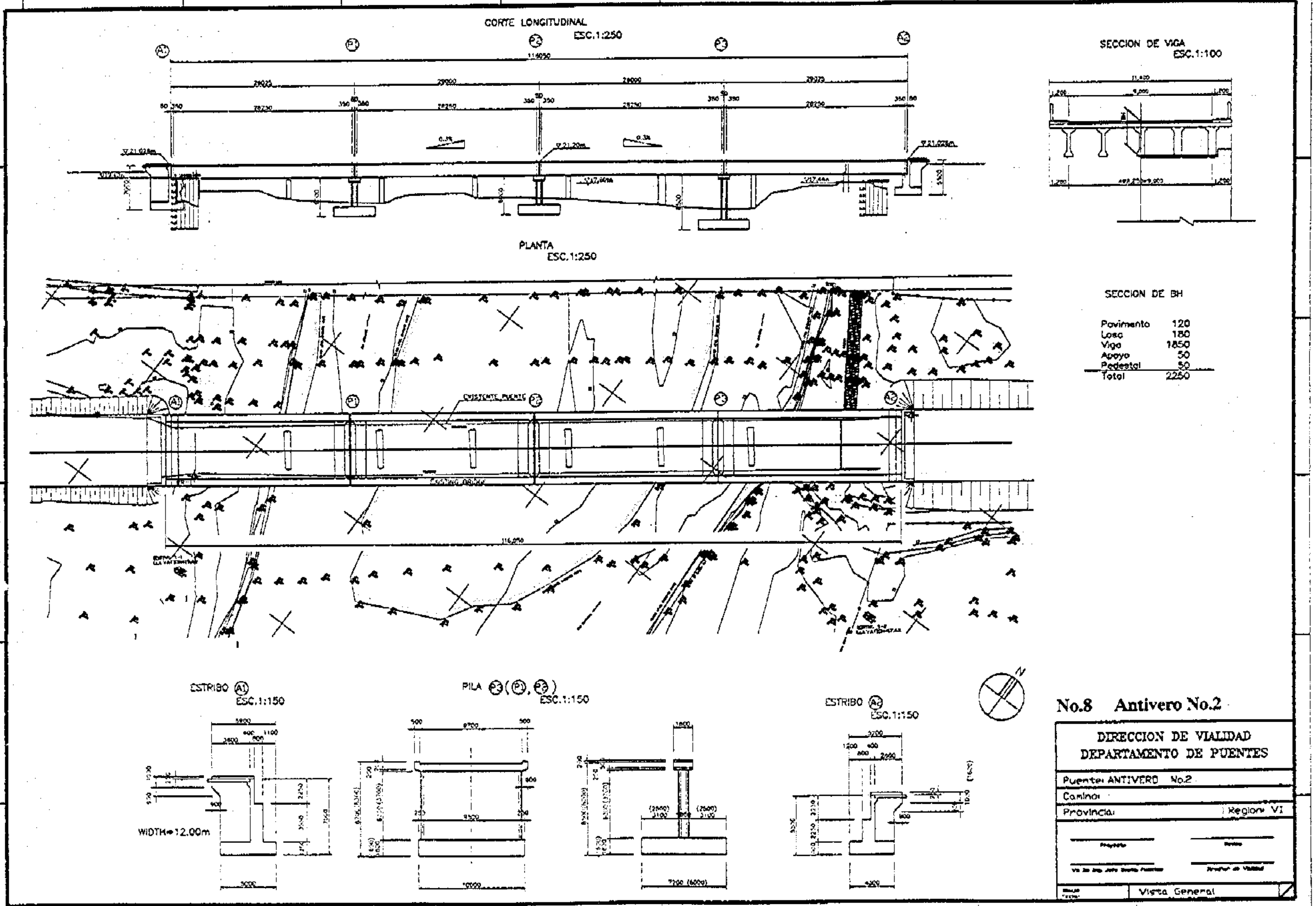
No.7 San Jose de Marchiue

DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES

Puente: SAN JOSE DE MARCHIUE
Camino:
Provincia: | Region: VI

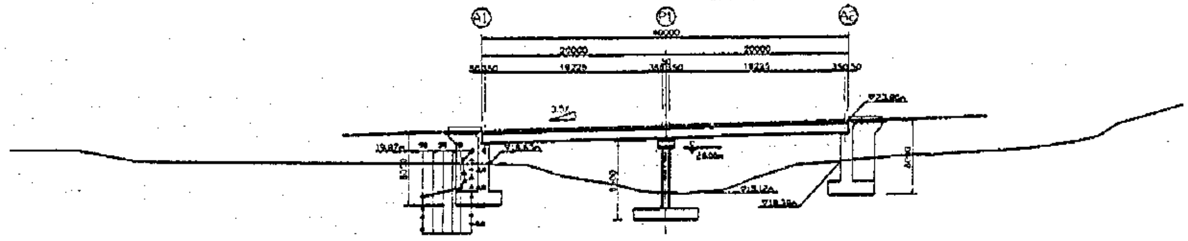
Vista General

No.8 Antivero No.2

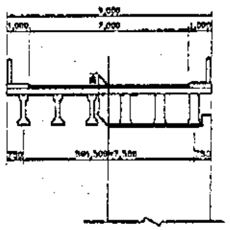


7-

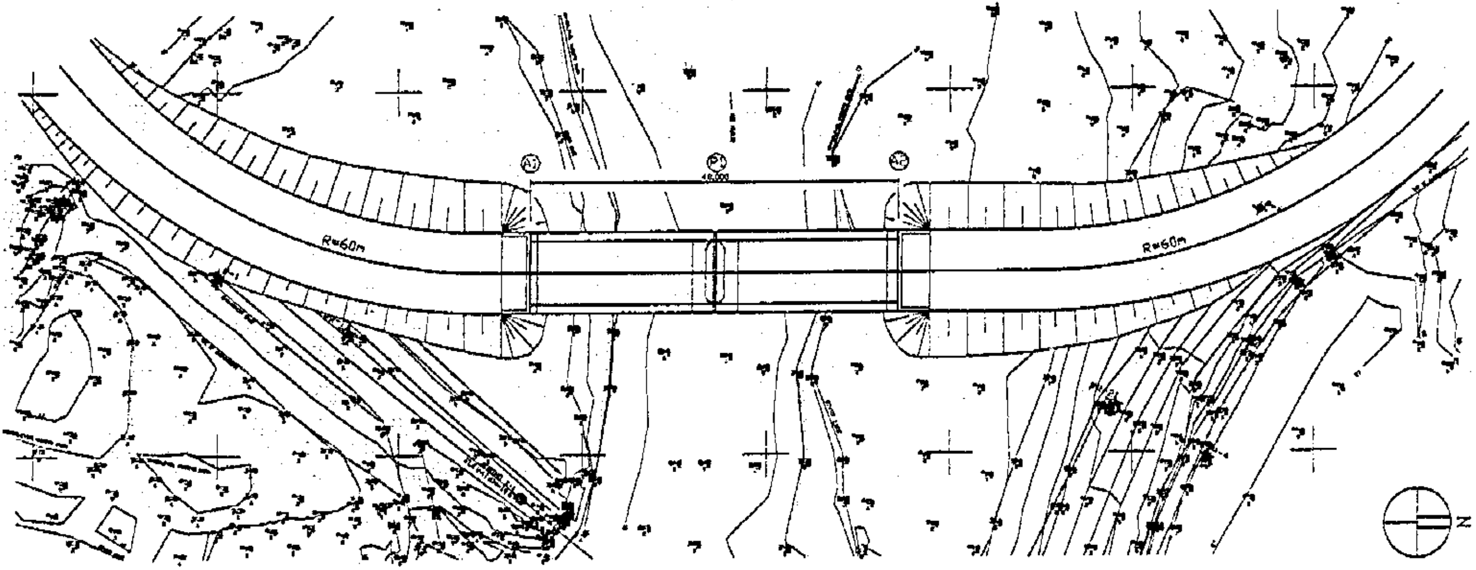
CORTE LONGITUDINAL
ESC.1:250



SECCION DE VIGA
ESC.1:100



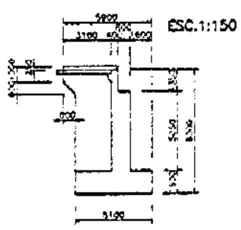
PLANTA
ESC.1:250



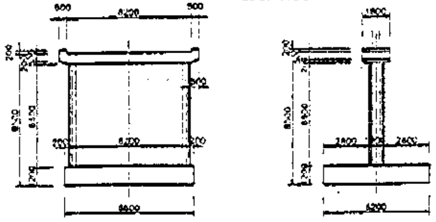
DETALLE DE BH

Pavimento	120
Losa	170
Viga	1000
Apoyo	50
Pedestal	60
Total	1400

ESTRIBO Ⓐ1 Ⓐ2
ESC.1:150



PILA Ⓟ1
ESC.1:150



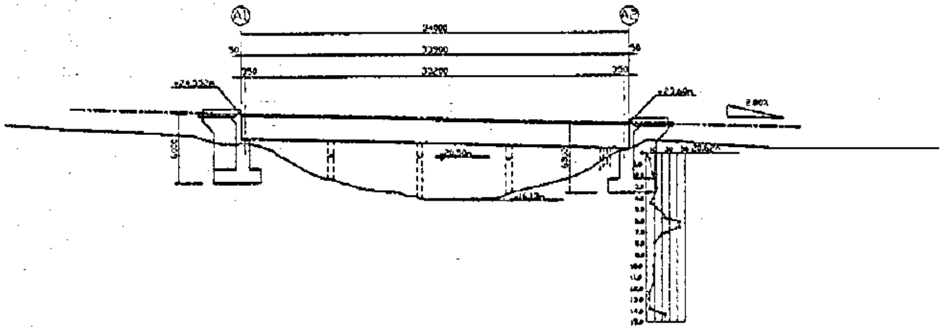
No.13 Poculon

DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES

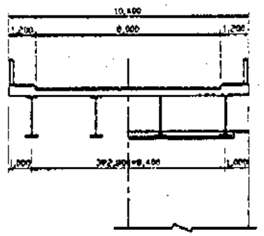
Puente: POCULON
Camino:
Provincia: Region:IX

Vista General

CORTE LONGITUDINAL
ESC.1:200



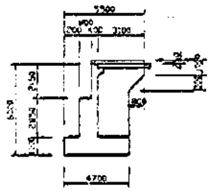
SECCION DE VIGA
ESC.1:100



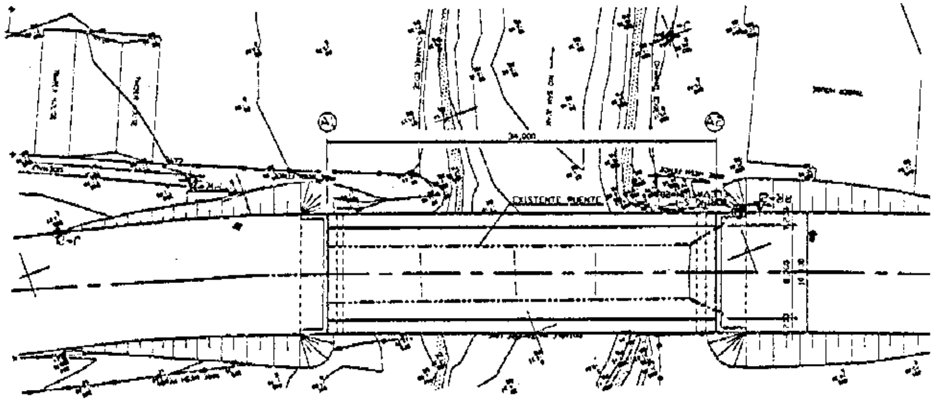
DETALLE DE BH

Pavimento	130
Losa	190
Haunch	100
Web	1600
LowerFl	16
Apoyo	50
Pedestal	64
Total	2150

ESTRIBO Ⓐ1 Ⓐ2
ESC.1:150



PLANTA
ESC.1:200



No.16 San Juan

DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES

Puente: SAN JUAN
Camino:
Provincia: Region: IX

Vista General

3.4.2 Repair Design

(1) Scope of Repair Designs

The purpose of the repair design is to show examples of various repairs for the bridges to be repaired. The repair designs were based on the information of each bridge collected by general inspection and the results of damage inspection. The repair methods were decided in accordance with the repairing scheme studied in **Clause (4) of Chapter 3.2.3.**

As regards the repair of timber structures, the repair method the MOP has taken is replacement of damaged timbers with new ones and that has been practiced by regional MOPs in their maintenance duties. There was no particular techniques in the timber repairs to be interpreted by drawings. Therefore, the repair designs for the following timber-used bridges were omitted:

- No. 9 Los Cardos Bridge

  The bridge consisted of timber slabs, steel beams and concrete piers/abutments. Damages were observed mainly on timber slabs but very few on steel beams and piers. Slight damages were found on abutments, and it was judged that repair was necessary only for replacement of timber slabs.

- No. 12 Quillen and No. 15 Miraflores Bridges

  All members of the two bridges were made of timbers, and some damaged members were required to be replaced.

However, the damages of the above three bridges are presented in **Appendix II-1 (Volume 4/8)**, from which timbers to be replaced can be known.

Therefore, repair designs were prepared for the eleven bridges listed in **Table 3.15**, including No. 2 David Garcia and No. 3 Granallas Bridges. The two bridges were already taken as reconstruction examples but they were considered suitable also for repair examples.

(2) Selection of Repair Method

There are several repair methods applicable to a damage and the most suitable method can be selected by comparing alternative methods from technical and economical points of views. However, this approach is complex and difficult unless by experienced engineers. Therefore, the repair methods employed in the Study are limited to those which are common, simple and often practiced in the MOP. The repair methods employed are listed in **Table 3.16**, and the details of the methods are presented in **Division III of Bridge Manuals (Volume 6/8)**. For the convenience to select repair methods, relation charts of damage types and repairs method are recommended for major damages. The concept of the charts is shown in **Figure 3.6**.

Table 3.15 Bridges for Repair Design

No.	Bridge Name	Bridge Type	Bridge Length (m)	Proposed Major Repairs
1	Confluencia	ST	113.10	• Repair of concrete • Repainting of steel beams
2	David Garcia	RC	93.05	• Repair of concrete
3	Granallas	ST	49.85	• Repair of concrete • Repainting of steel beams
4	Ventanas	RC	30.00	• Repair of concrete • Replacement of expansion joints
10	Cautin	RC	140.00	• Repair of concrete
11	El Indio	ST	21.10	• Repair of concrete
14	Malleco	TM	92.00	• Repair of concrete (abutment only)
17	Medina	ST	170.00	• Repair of concrete (abutment only) • Repainting of steel beams
18	Cautin (88)	ST	39.40	• Repair of concrete (abutment only) • Repainting of steel beams
19	Salva Tu Alma	ST	40.70	• Repair of concrete (abutment only) • Repainting of steel beams and pier column
20	Quinchilca	RC	140.00	• Repair of concrete

Table 3.16 Proposed Repair Methods

Type of Material	Repair Methods
Concrete	Injection, Caulking, Grinding, Coating, Resurfacing, Pre-packing, Dry-packing, Shotcrete/Gunite, Patching, Overlay, Replacement
Steel	Repainting

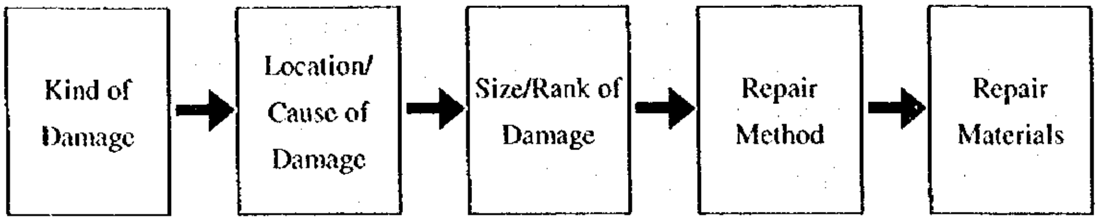


Figure 3.6 Concept of Damage-Repair Method Chart

The damage-repair method charts for major damages are given in **Figure 3.7** from the following page.

In case of the repair for cracks of concrete, to assist the selecting process of method, an additional chart is given in **Figure 3.8**. The chart suggests repair method according to the type and width of cracks.

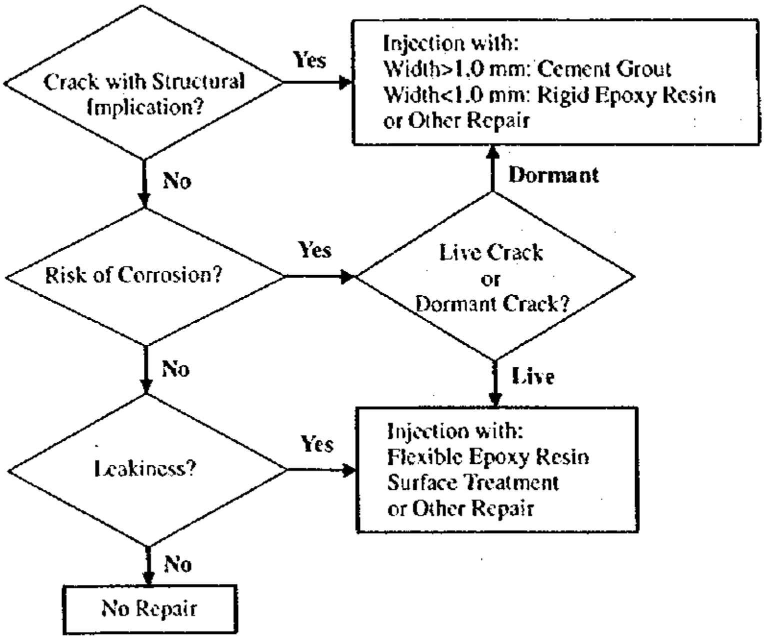


Figure 3.8 Repair Method Chart for Cracks

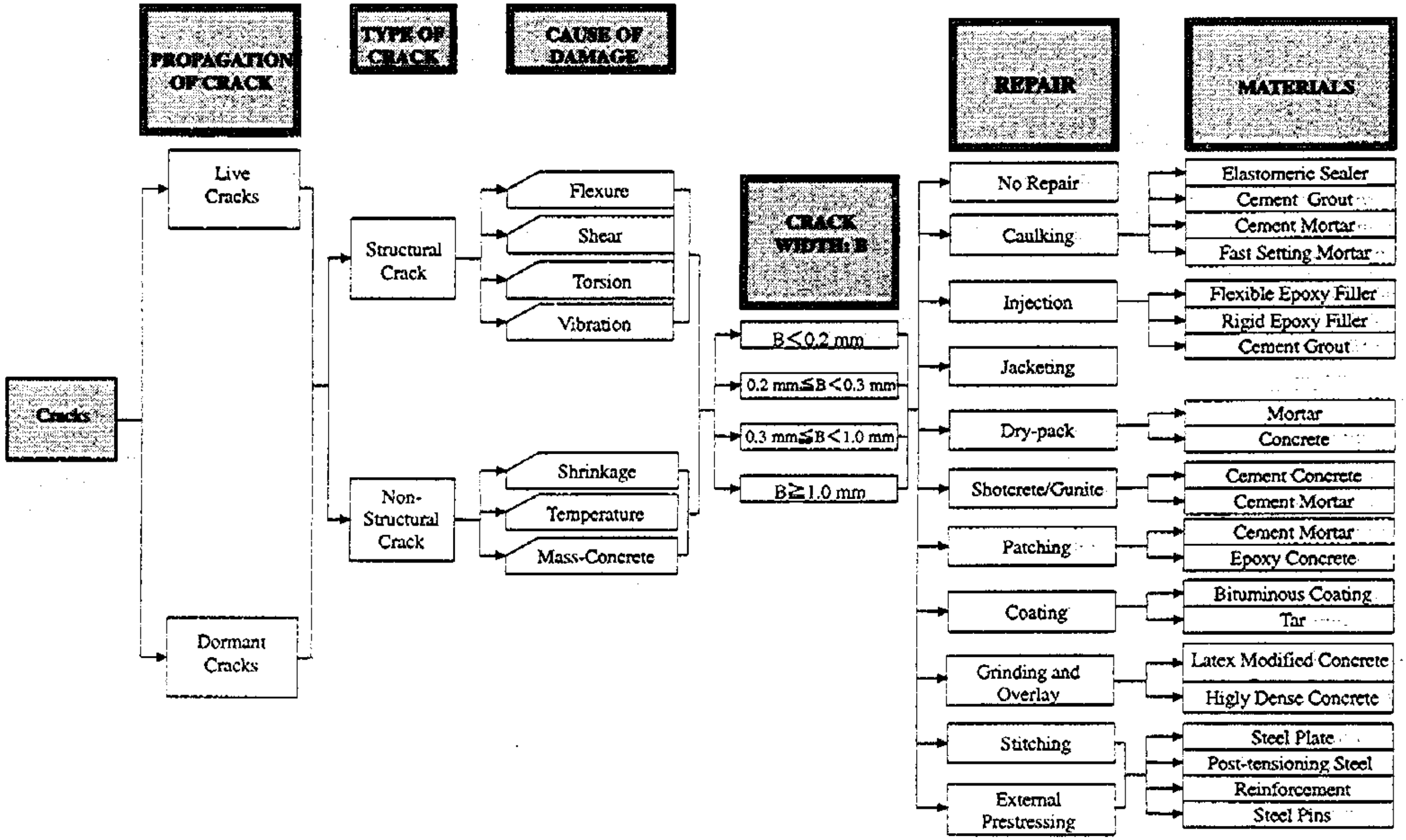


Figure 3.7 Damage-Repair Method Chart (1/7): Cracks on Concrete Structure

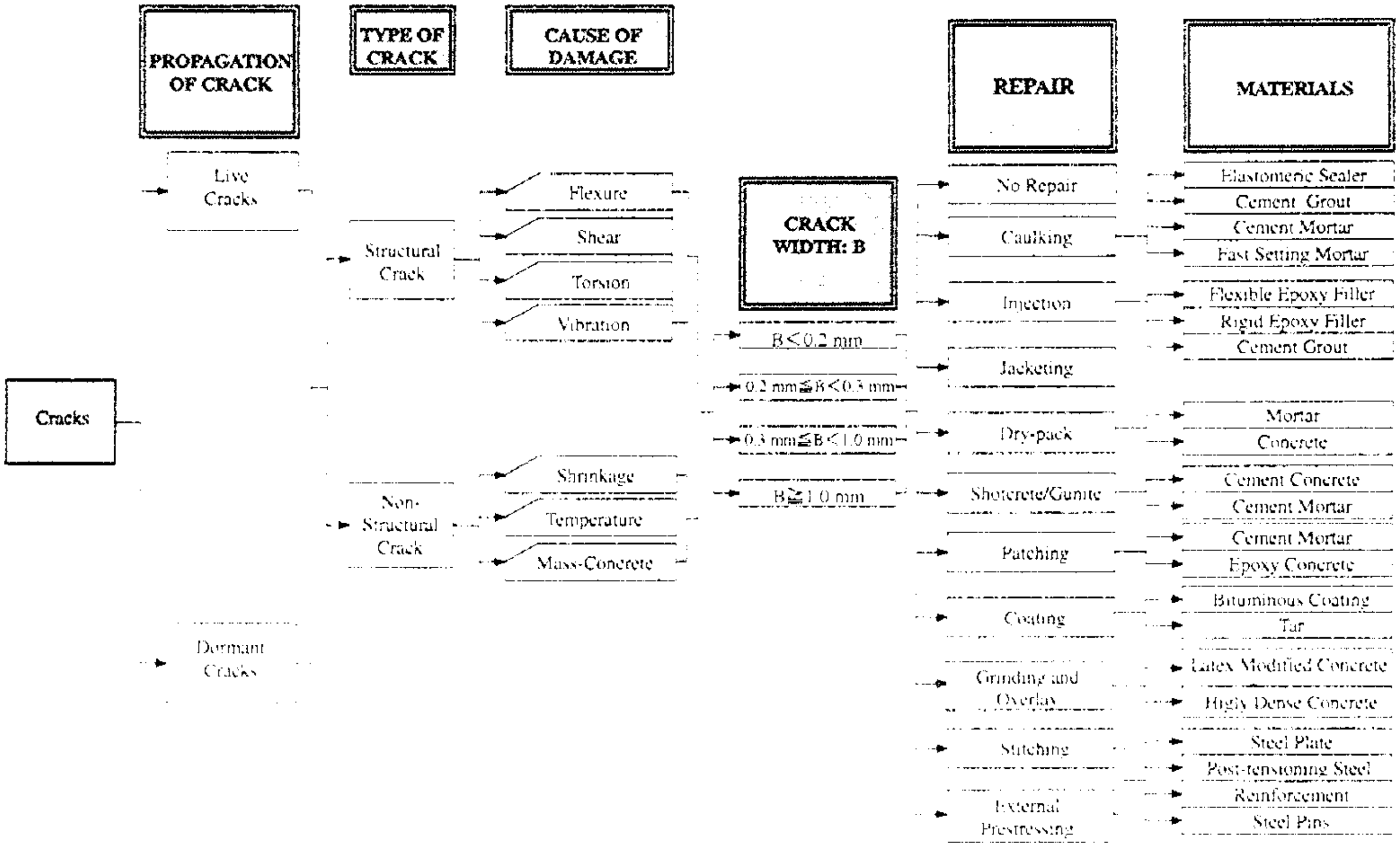


Figure 3.7 Damage-Repair Method Chart (1/7): Cracks on Concrete Structure

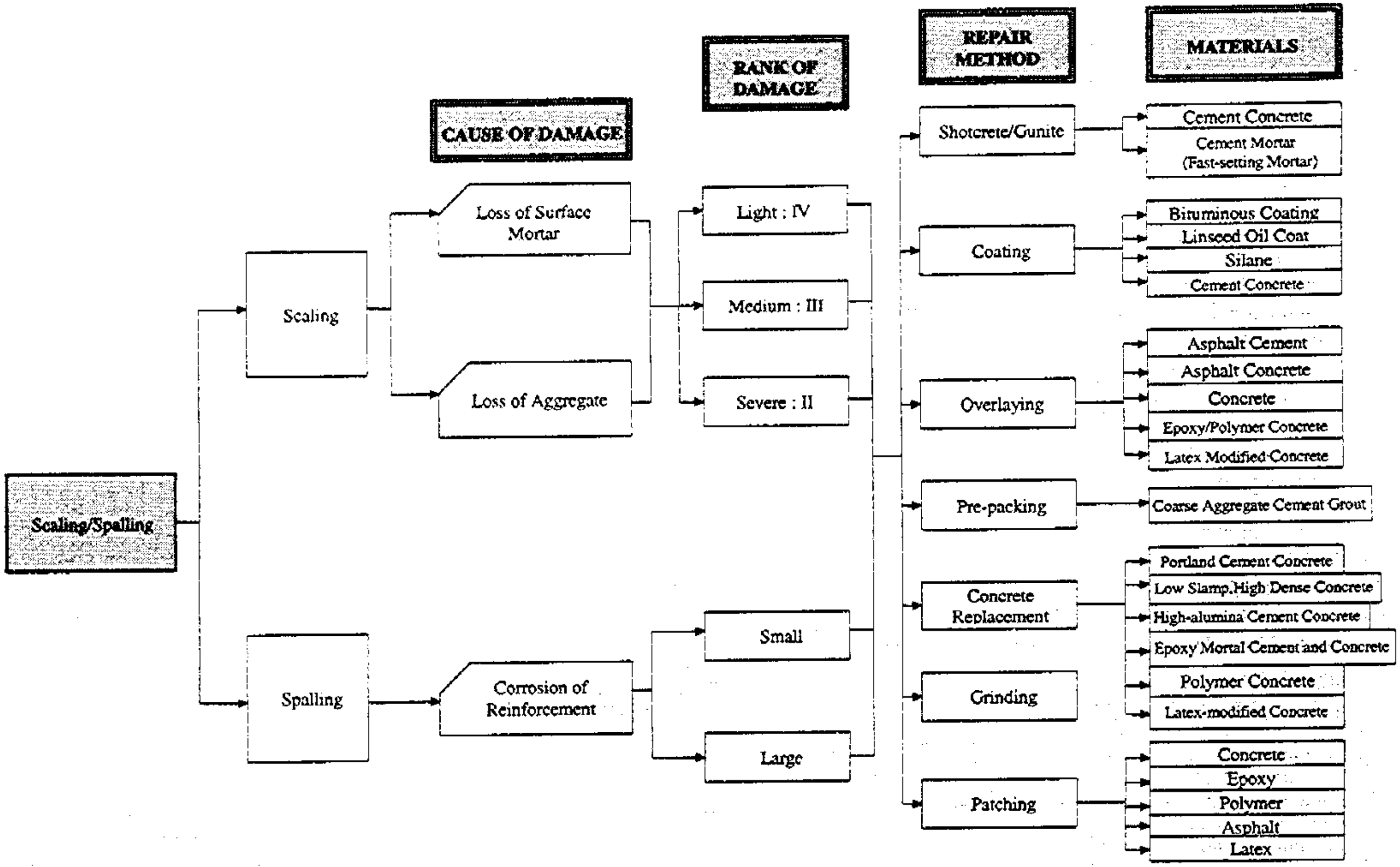


Figure 3.7 Damage-Repair Method Chart (2/7): Scaling/Spalling on Concrete Structure

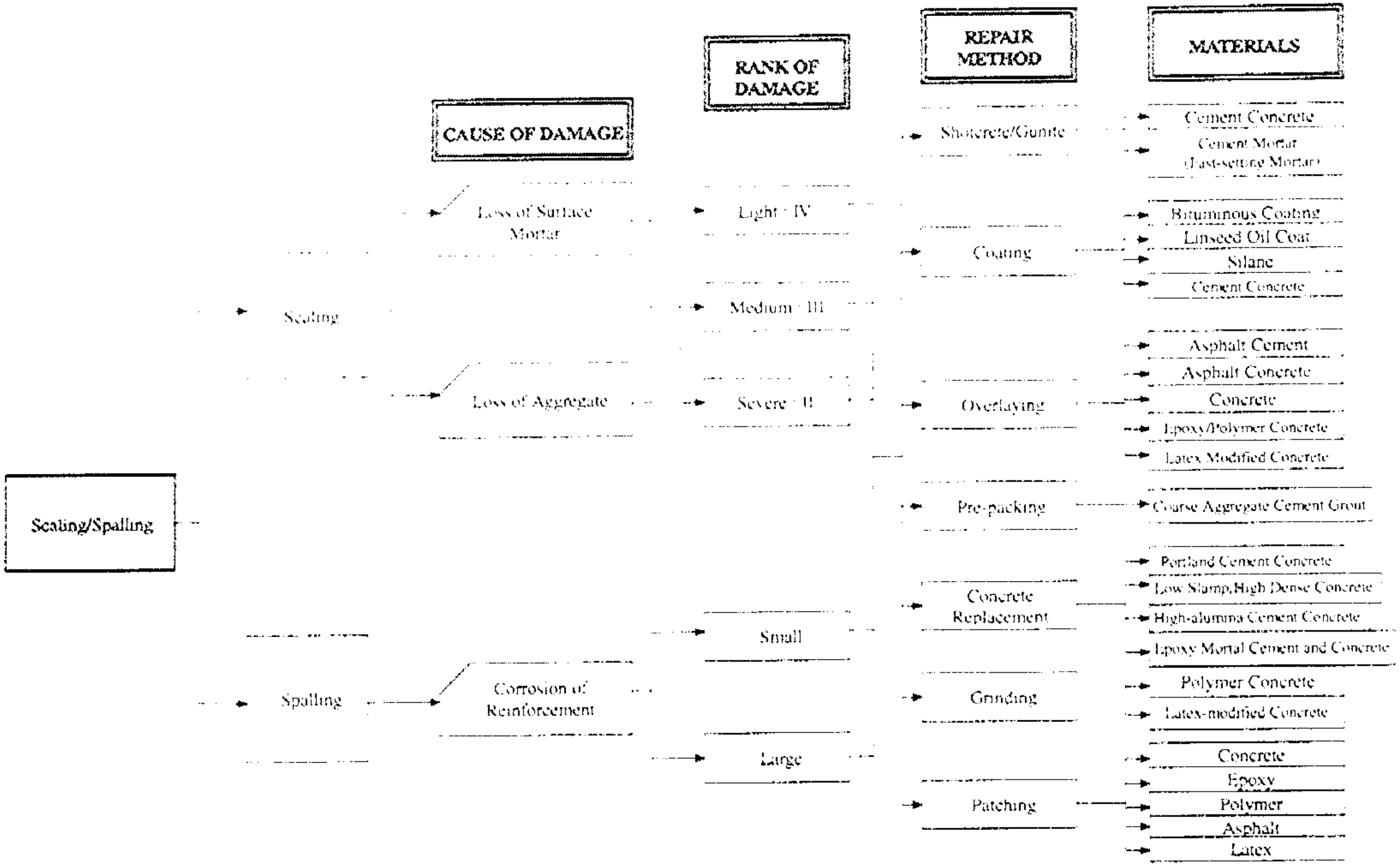


Figure 3.7 Damage-Repair Method Chart (2/7): Scaling/Spalling on Concrete Structure

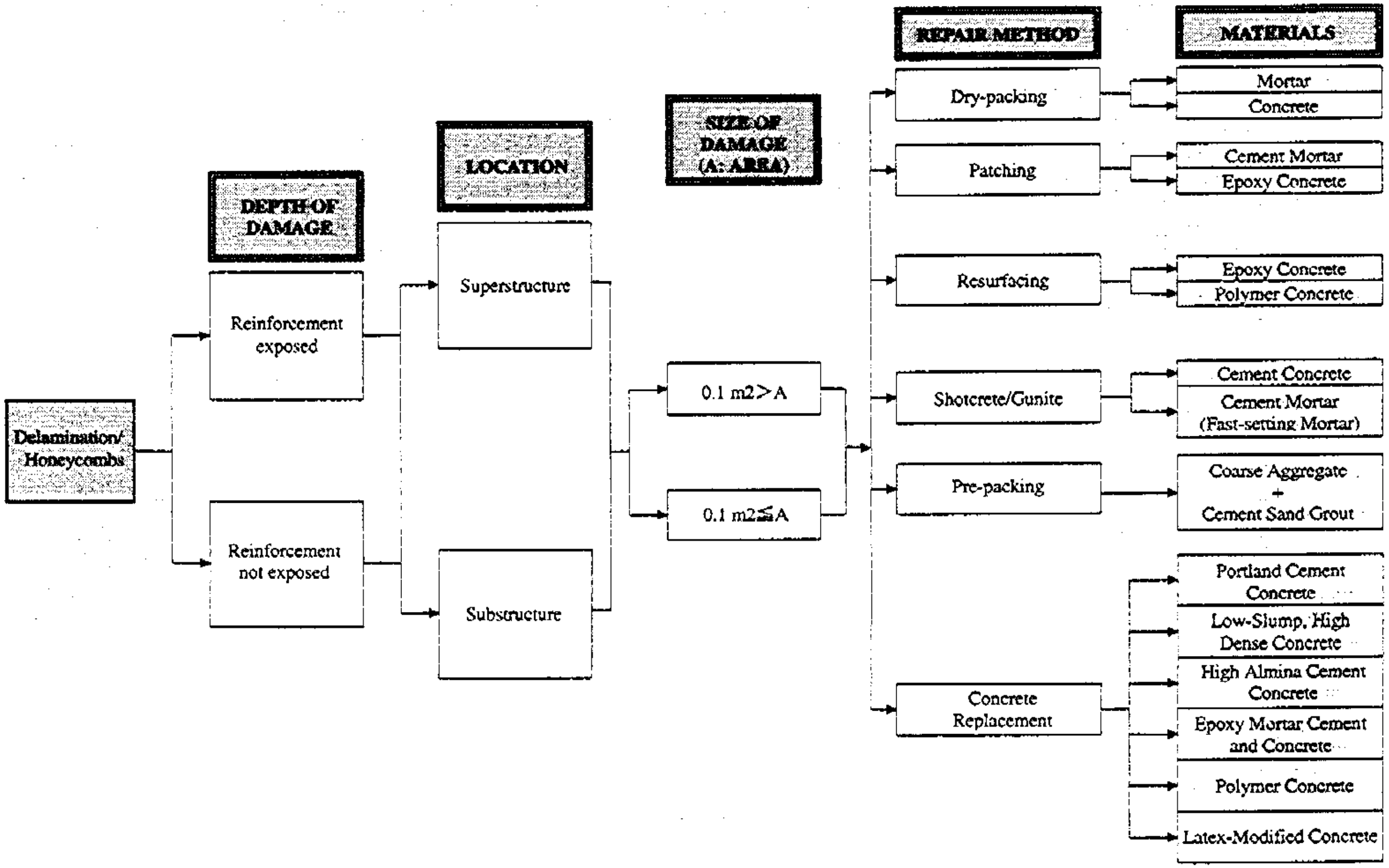


Figure 3.7 Damage-Repair Method Chart (3/7): Delamination and Honeycombs on Concrete Structure

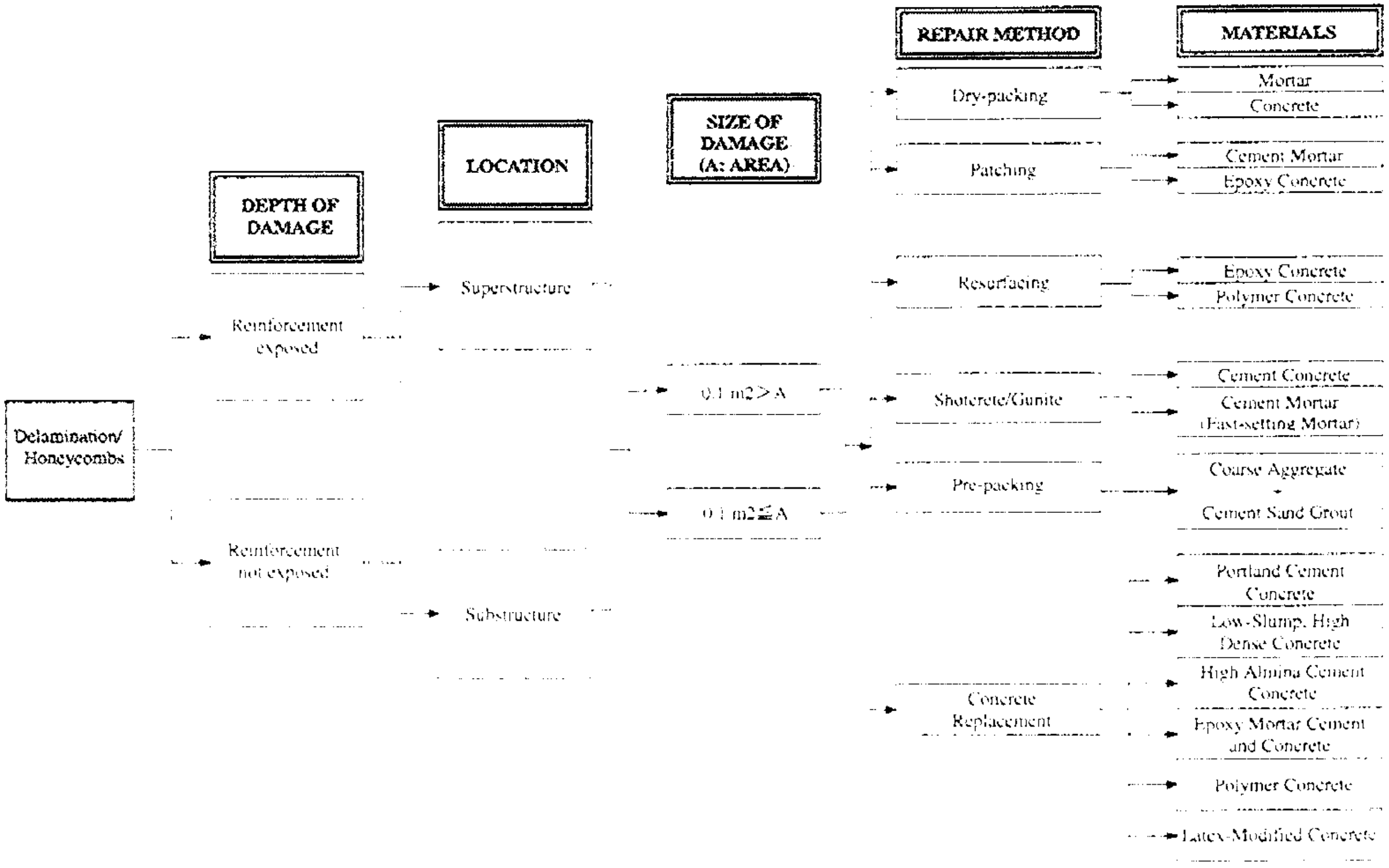


Figure 3.7 Damage-Repair Method Chart (3/7): Delamination and Honeycombs on Concrete Structure

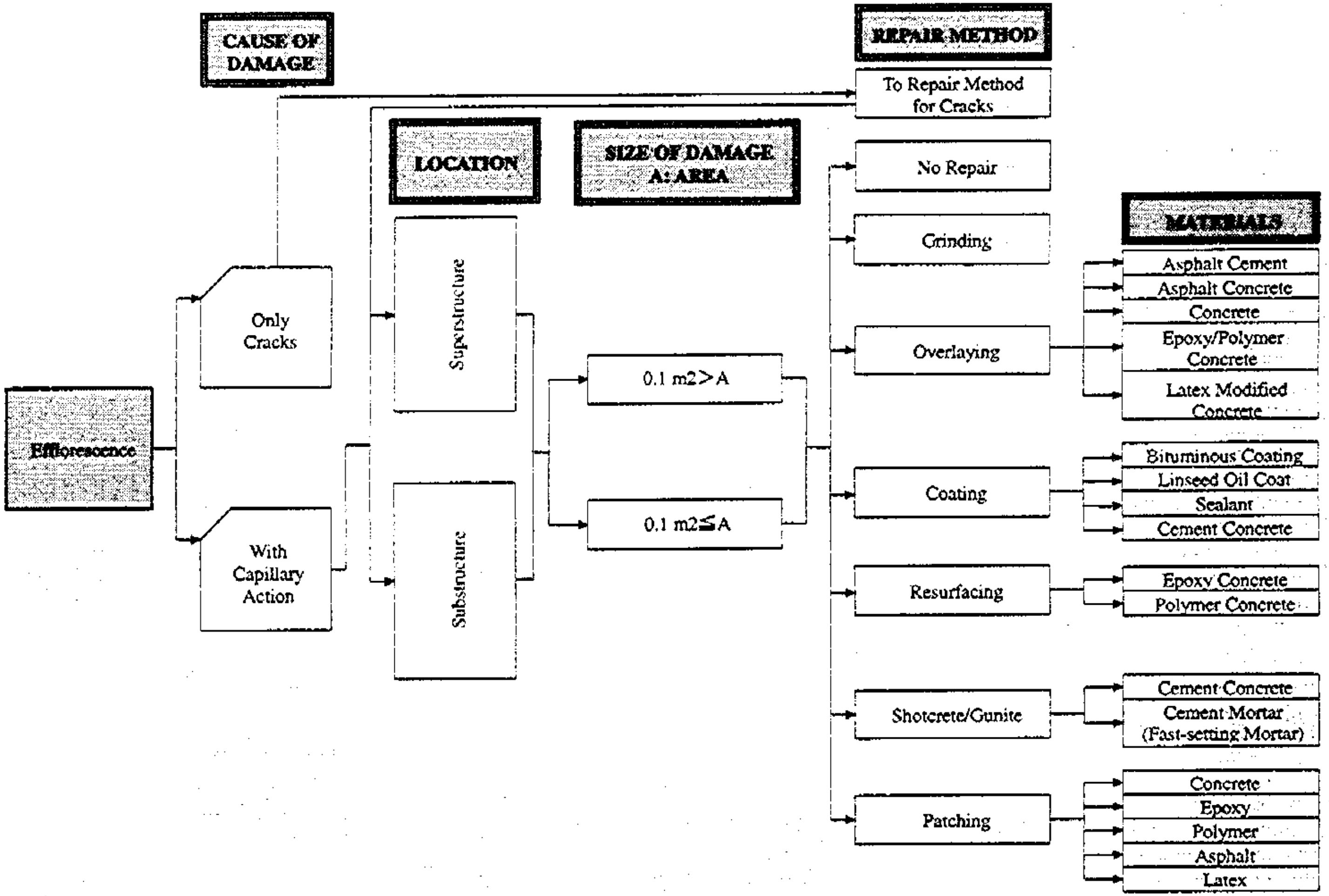


Figure 3.7 Damage-Repair Method Chart (4/7): Efflorescence on Concrete Structure

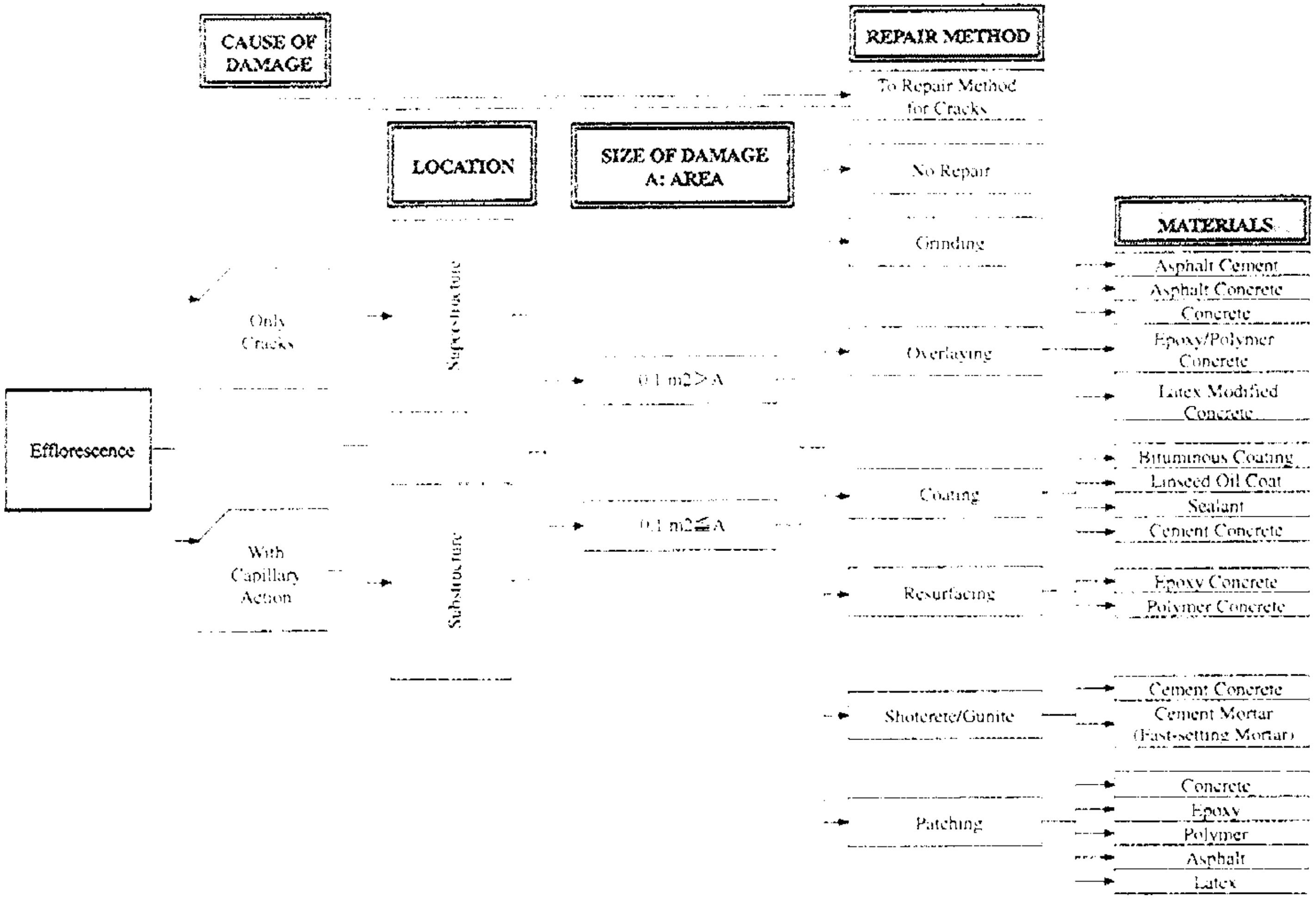


Figure 3.7 Damage-Repair Method Chart (4/7): Efflorescence on Concrete Structure

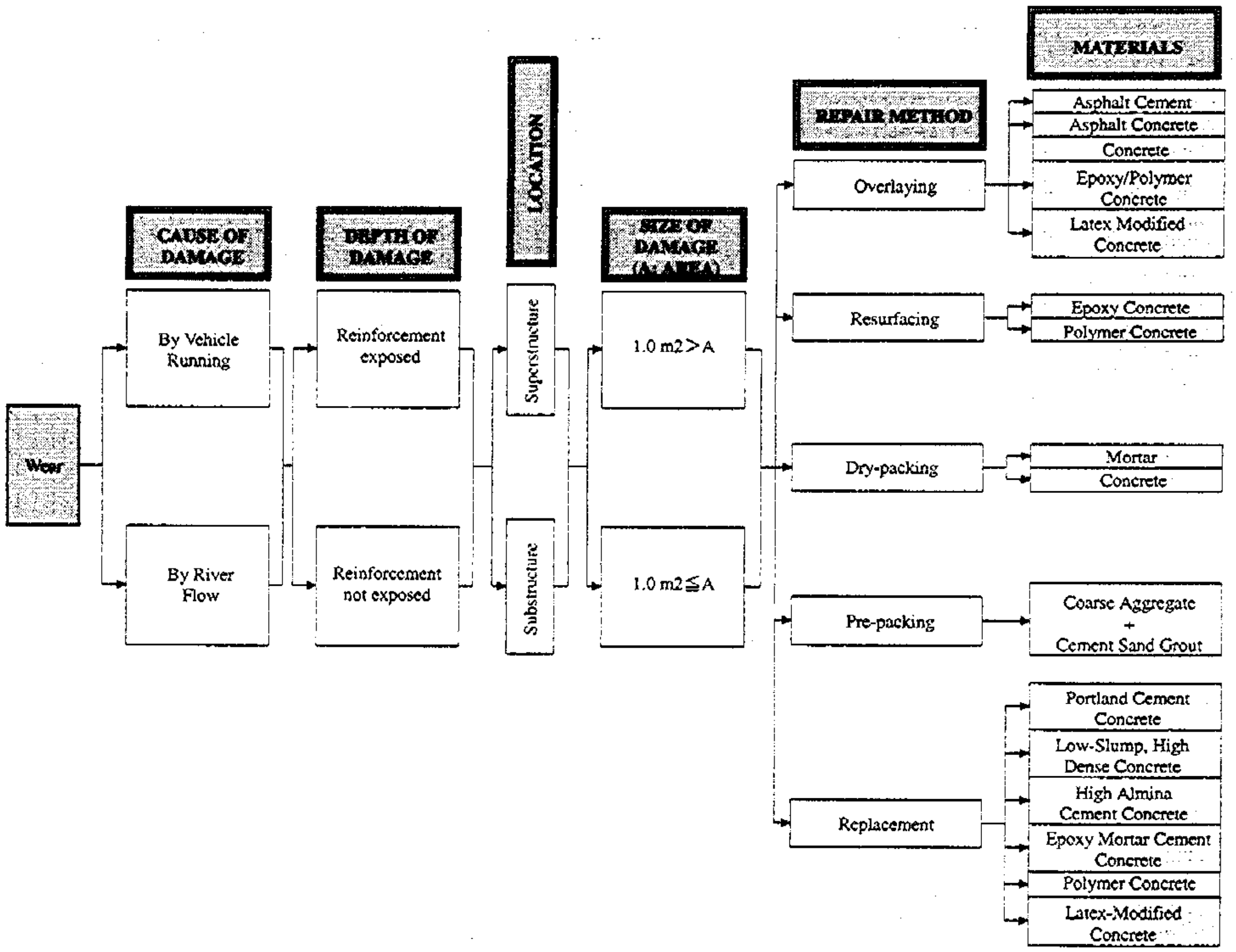


Figure 3.7 Damage-Repair Method Chart (5/7): Wear on Concrete Structure

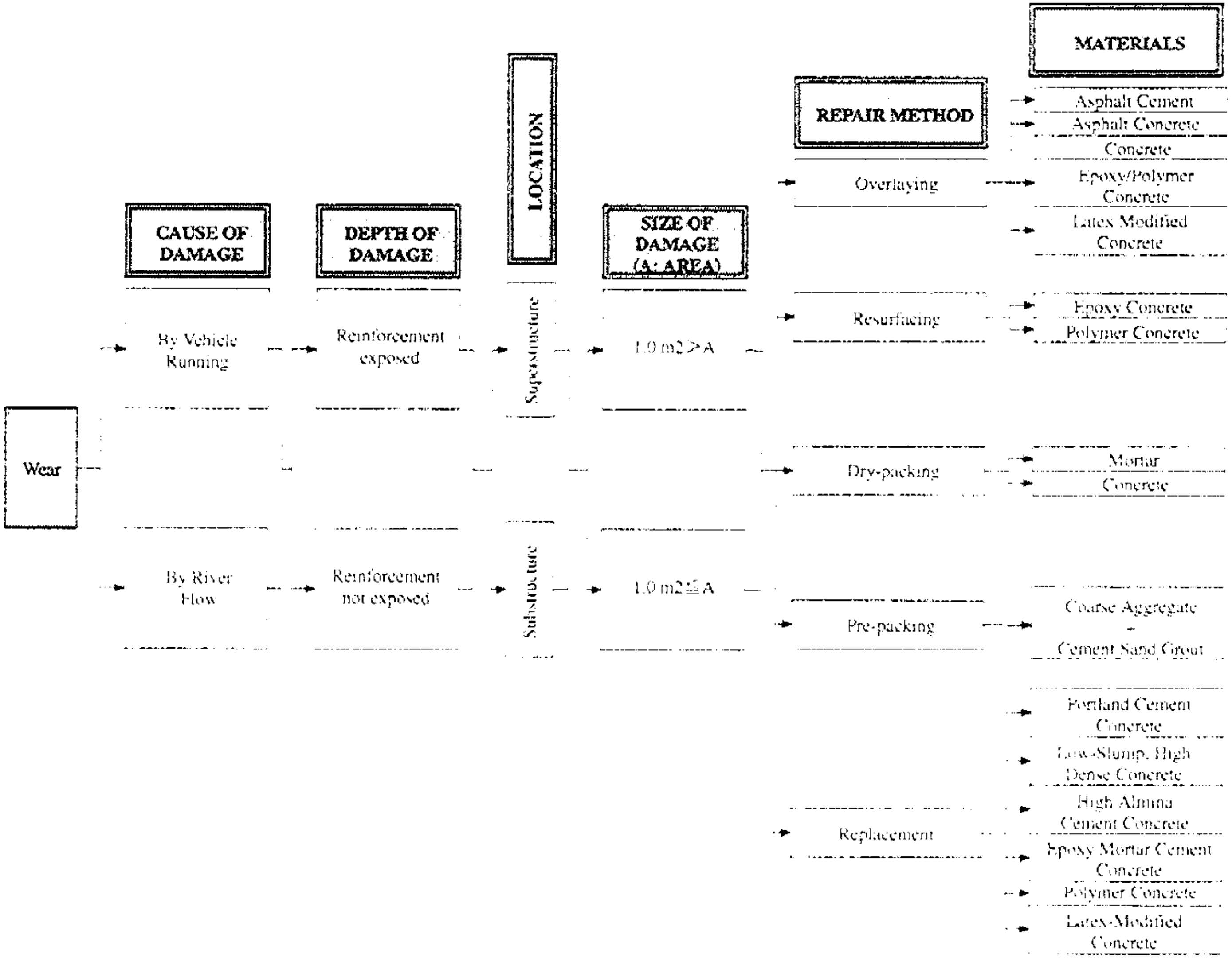


Figure 3.7 Damage-Repair Method Chart (5/7): Wear on Concrete Structure

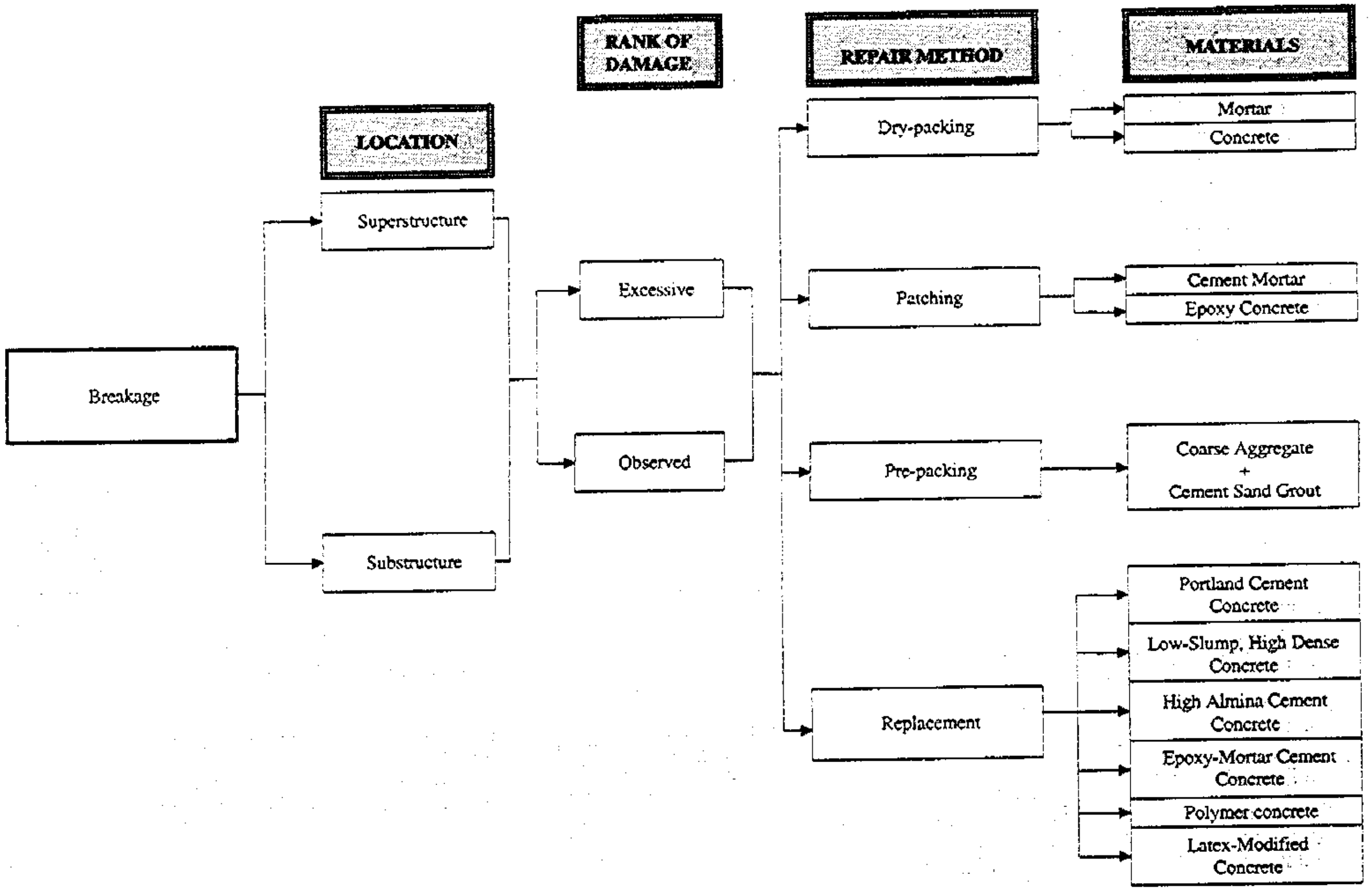


Figure 3.7 Damage-Repair Method Chart (6/7): Breakage on Concrete Structure

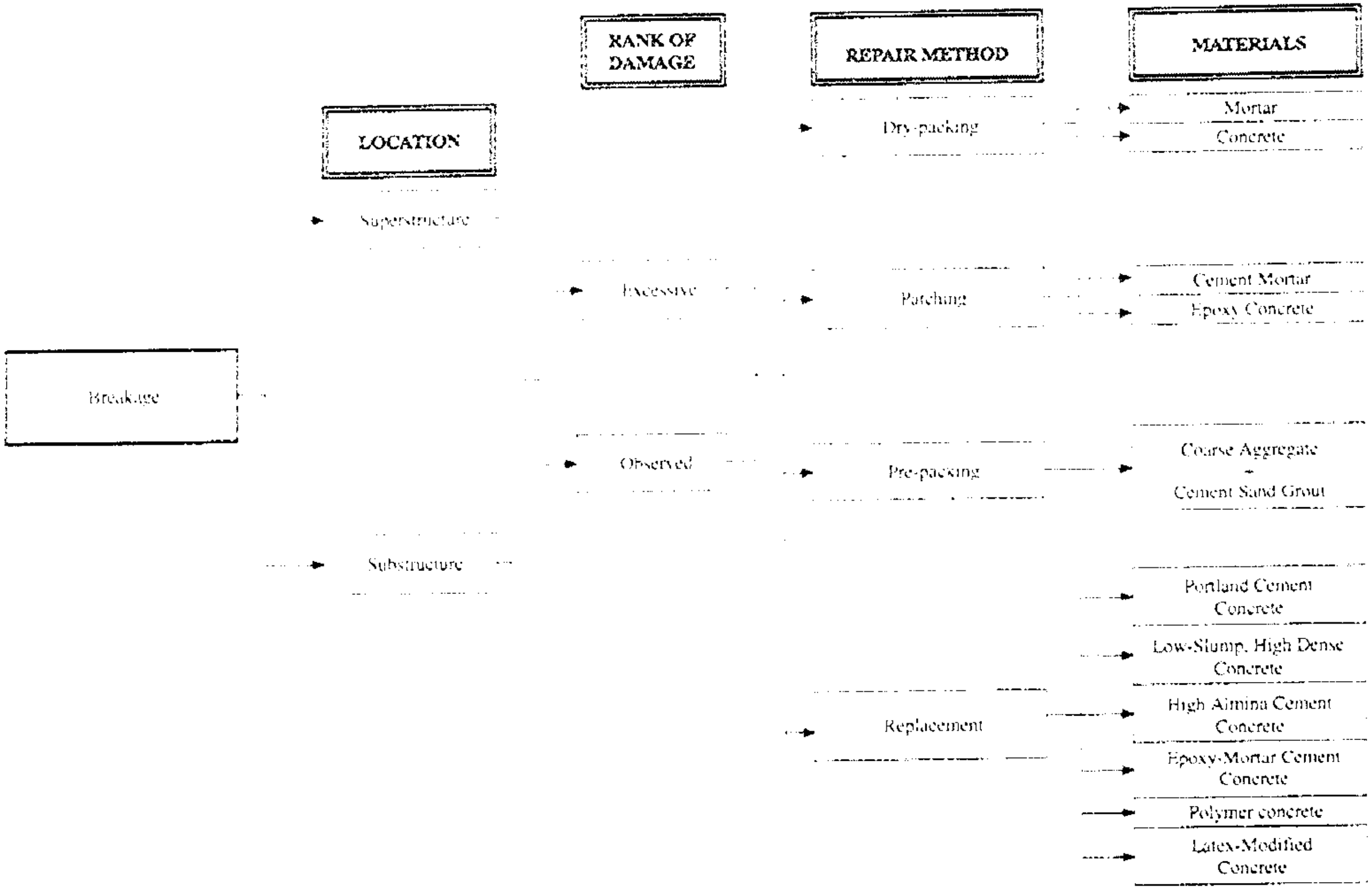


Figure 3.7 Damage-Repair Method Chart (6/7): **Breakage on Concrete Structure**

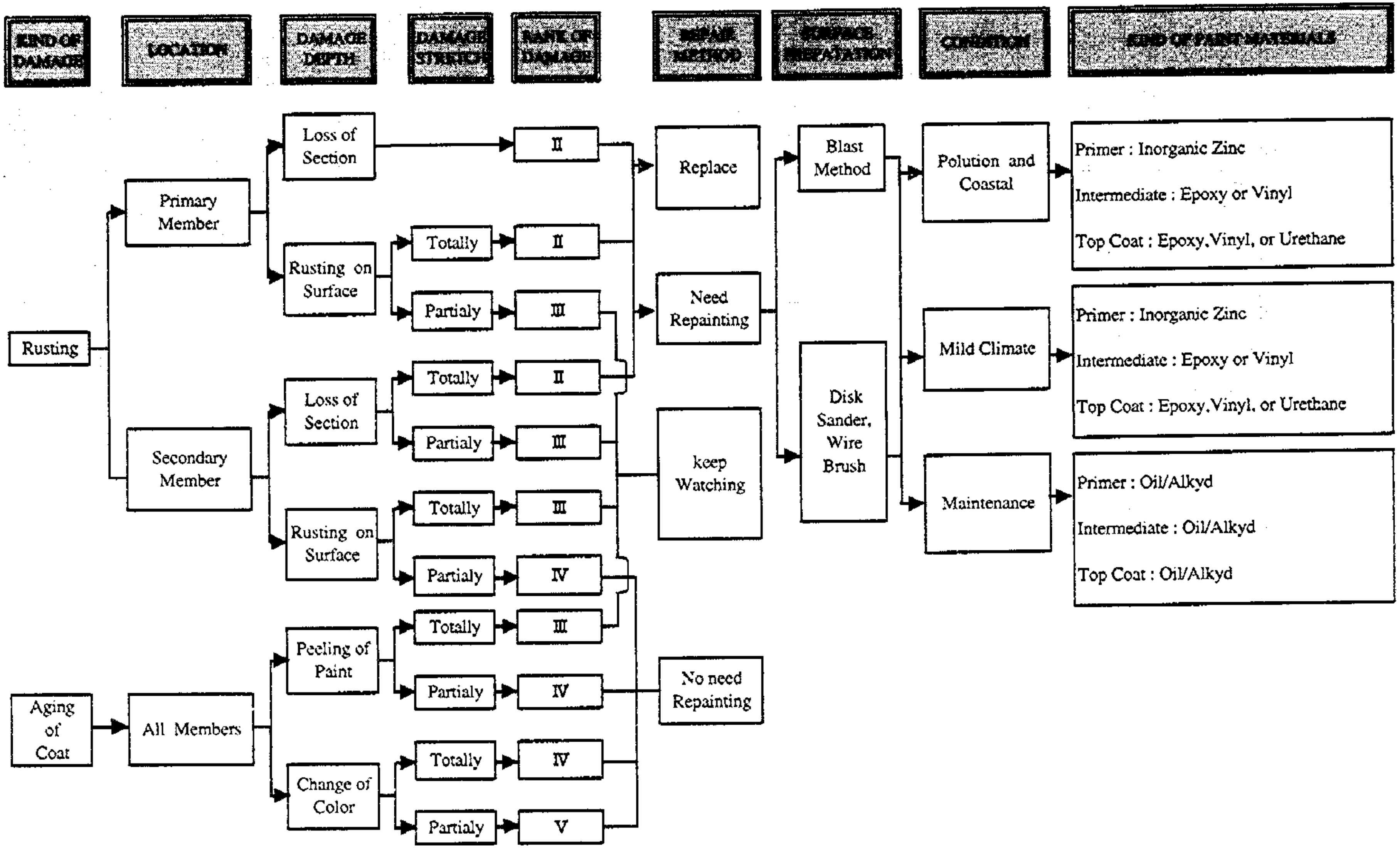


Figure 3.7 Damage-Repair Method Chart (7/7) : Rusting and Aging Coat on Steel Structure

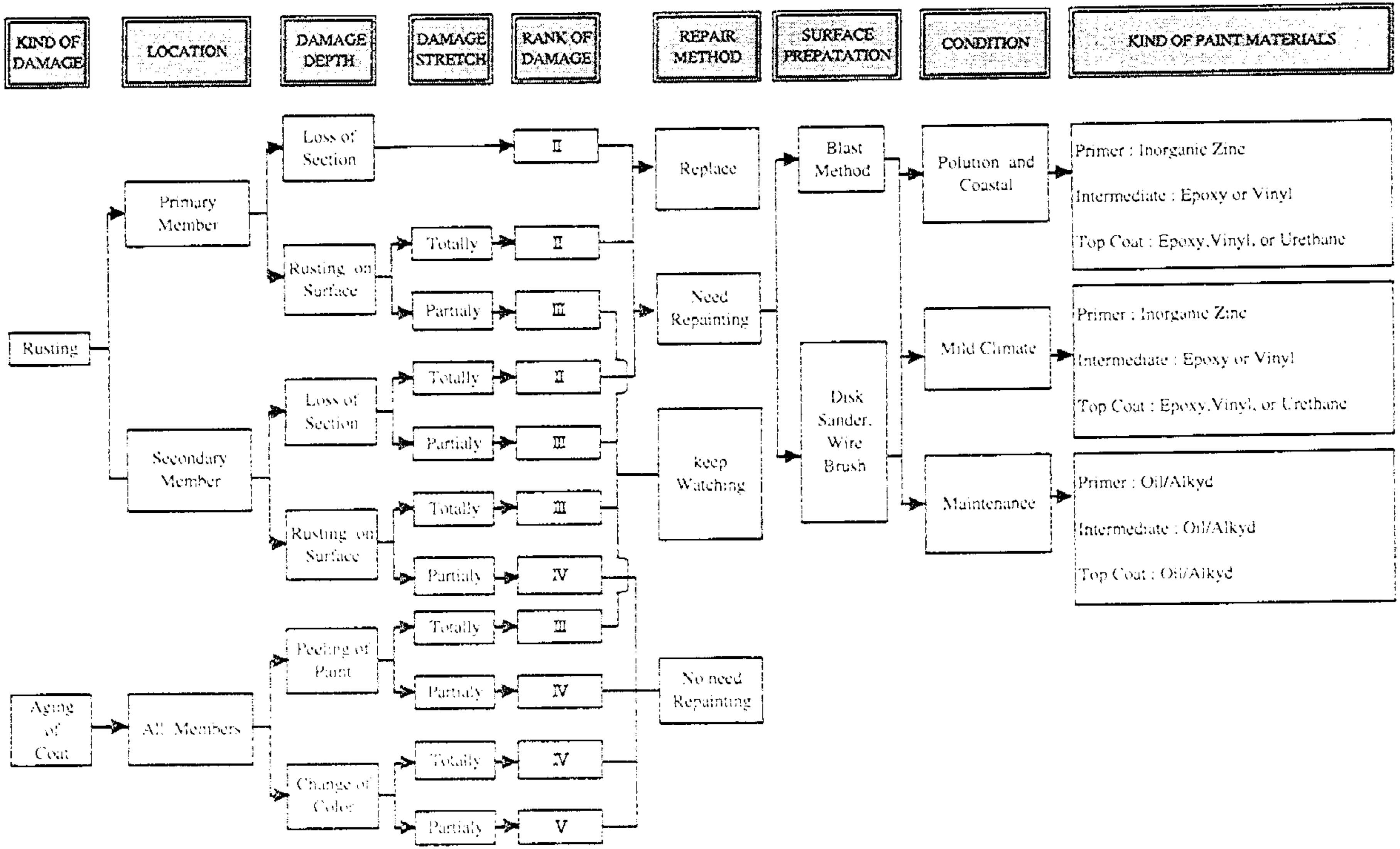


Figure 3.7 Damage-Repair Method Chart (7/7) : Rusting and Aging Coat on Steel Structure

(3) Repair Designs

Based on the data of general and damage inspection, kind and location of damages were selected for repair designing. For each damage and its location selected, a repair method together with materials was decided by the aid of the damage-repair method charts given in the preceding **Clause (2)** of this chapter.

Table 3.17 summarizes the repairs designed for each bridge being classified by the kinds of damages. After the table, the **repair design drawings** for the eleven bridges are attached. On the drawings, the following design data are shown:

① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity

The details of repair methods are presented in **Division III of Bridge Manuals (Volume 6/8)**, and the basis of the quantities are given in **Appendix II-4 (Volume 4/8).**

Table 3.17 Summary of Repair Designs

(1) For Concrete Members

Material Type	Damage	Location	Damage Rank	Repair Method	Materials
Confluencia	Cracks	Deck Slab on Surface	III	• Caulking	• Cement Grout • Cement Mortar
		Sidewalk	III	• Caulking	• Cement Mortar
	Efflorescence	Deck Slab on Cantilever Underside	II	• Injection for Cracks • Grinding and Coating	• Rigid Epoxy Filler • Linseed Oil Coat
		Deck Slab on Cantilever Underside	II	• Injection for Cracks • Grinding and Coating	• Rigid Epoxy Filler • Linseed Oil Coat
		A1-Abutment on Front Wall	II	• Coating	• Cement Mortar
		A2-Abutment on Front Wall	II	• Coating	• Linseed Oil Coat
	Breakage	A1-Abutment on Side Wall	II	• Dry-packing	• Concrete
		Hand Railing	IV	• Replacement	• Concrete
David Garcia	Cracks	Deck Slab on Underside	II	• Injection	• Rigid Epoxy Filler
		A1-Abutment on Side Wall	II	• Injection	• Cement Grout
		A1-Abutment on Front Wall	III	• Caulking	• Elastomeric Sealer
		A2-Abutment on Front Wall	II	• Caulking	• Elastomeric Sealer
		Pier on Cross Beam	II	• Injection	• Rigid Epoxy Filler
		Pier on Side Column	III	• Grinding and Overlay	• Latex Modified Concrete
	Efflorescence	Halving Joint	II	• Resurfacing	• Epoxy Concrete
		A2-Abutment on Side Wall	II	• Coating	• Silane
	Delamination	A2-Abutment on Side Wall	II	• Coating	• Silane
Granallas	Cracks	A1-Abutment on Side Wall	II	• Injection	• Cement Grout
		Pier on Strut Wall	II	• Injection	• Cement Grout
		Pier on Column	II	• Dry-Packing	• Concrete
	Scaling/Spalling	A1-Abutment on Side Wall	III	• Shotcrete/Gunite	• Cement Concrete
	Breakage	A2-Abutment on Side Wall	II	• Replacement	• Concrete
		Pier on Column	II	• Pre-Packing	• Coarse Aggregate • Cement Sand Grout
	Ware	Pier on Foundation	III	• Pre-Packing	• Coarse Aggregate • Cement Sand Grout
Ventanas	Cracks	A1-Abutment on Side Wall	II	• Caulking	• Fast Setting Mortar
		A2-Abutment on Footing	II	• Injection	• Rigid Epoxy Filler
	Efflorescence	Beams at Span 1	II	• Coating	• Linseed Oil Coat
		Beams at Span 2	II	• Grinding • Coating	• Linseed Oil Coat
	Breakage	Beams at Span 1	II	• Pre-Packing	• Coarse Aggregate • Cement Sand Grout
	Scaling/Spalling	Deck Slab on Underside	II	• Coating • Grinding	• Linseed Oil Coat
		A1-Abutment on Front Wall	II	• Coating • Grinding	• Cement Mortar
		Pier on Column	II	• Patching	• Concrete
		Pier on Footing	II	• Pre-Packing	• Coarse Aggregate • Cement Mortar

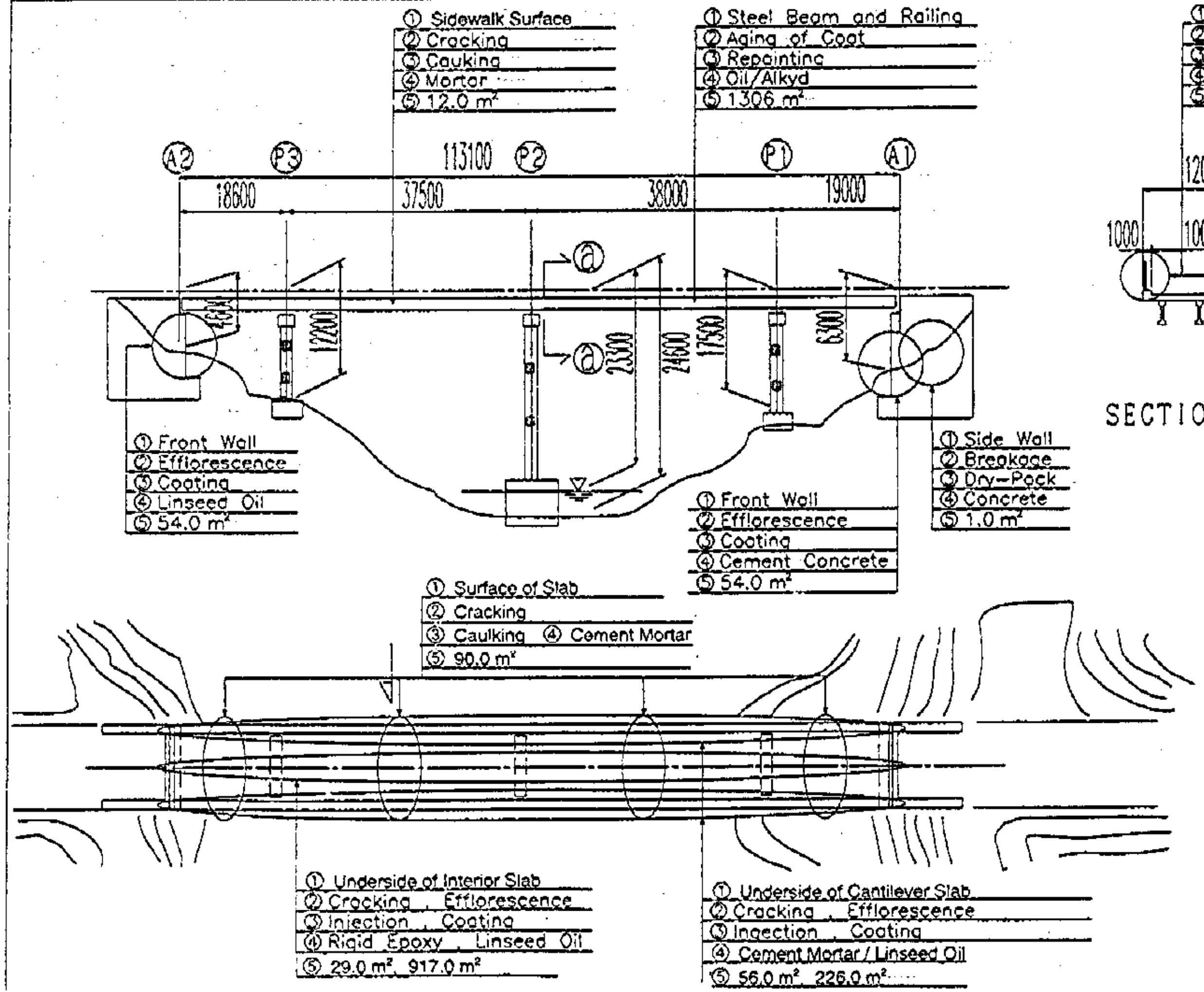
Cautin	Cracks	A1-Abutment on Side Wall	II	• Caulking	• Fast Setting Mortar
		A1-Abutment on Side Wall	II	• Grinding and Overlay	• Highly Dense Concrete
	Efflorescence	Beams	II	• Coating	• Linseed Oil Coat
		Deck Slab on Underside	II	• Injection for Cracks • Coating	• Elastomeric Sealer • Bituminous Coating
	Delamination	Beams	II	• Resurfacing	• Epoxy Concrete
		A2-Abutment on side Wall	II	• Replacement	• Portland Cement Concrete
	Wear	Pier on Footing	III	• Pre-Packing	• Coarse Aggregate • Cement Sand Grout
El Indio	Efflorescence	Deck Slab on Underside	II	• Resurfacing	• Epoxy Concrete
		A1-Abutment on Footing	III	• Grinding • Coating	• Cement Mortar
Malleco	Cracks	A1-Abutment on Side Wall	II	• Caulking	• Fast Setting Mortar
		A1-Abutment on Side Wall	II	• Injection	• Cement Grout
	Scaling/Spalling	A1-Abutment on Front Wall	II	• Patching	• Concrete
Medina	Scaling/Spalling	A1-Abutment on Front Wall	II	• Replacement	• Concrete
	Efflorescence	A1-Abutment on Side Wall	II	• Grinding	
Cautin (88)	Honeycombs	A2-Abutment on Side Wall	III	• Dry-Packing	• Concrete
	Breakage	A2-Abutment on Side Wall	II	• Replacement	• Concrete
Salva Tu alma	Cracks	A1-Abutment on Front Wall	II	• Caulking	• Cement Grout
Quinchilca	Cracks	A1-Abutment on Side Wall	II	• Injection	• Cement Grout
	Scaling/Spalling	Sidewalk	II	• Overlaying	• Concrete
	Delamination	Beams at Support	II	• Pre-Packing	• Coarse Aggregate • Cement Sand Grout

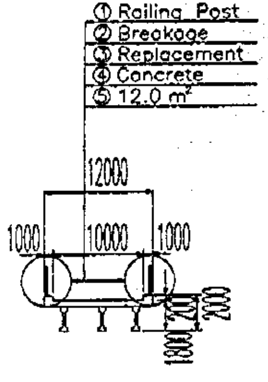
(2) For Steel Members

Material Type	Damage	Location	Damage Rank	Repair Method	Materials
Confluencia	Rusting	Hand Railing	III	• Hand Cleaning	• Oil/Alkyd
David Garcia	Rusting	Hand Railing	III	• Hand Cleaning	• Oil/Alkyd
Granallas	Rusting	Beams	II	• Hand Cleaning	• Oil/Alkyd
Ventanas	Rusting	Hand Railing	III	• Hand Cleaning	• Oil/Alkyd
Cautin (88)	Rusting	Beams	II	• Hand Cleaning	• Oil/Alkyd

REPAIR METHODS AND QUANTITIES			
BRIDGE NUMBER	1	YEAR OF BUILT	
BRIDGE NAME	CONFLUENCIA	BRIDGE LENGTH	113.10m
REGION	Ⅳ	BRIDGE WIDTH	12.000m
ROUTE NAME	D-85	TRAFFIC VOLUME	

Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity





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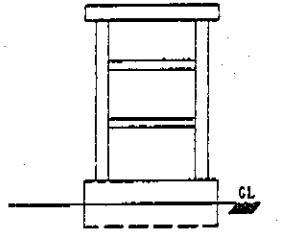

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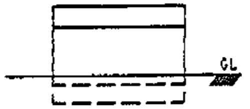
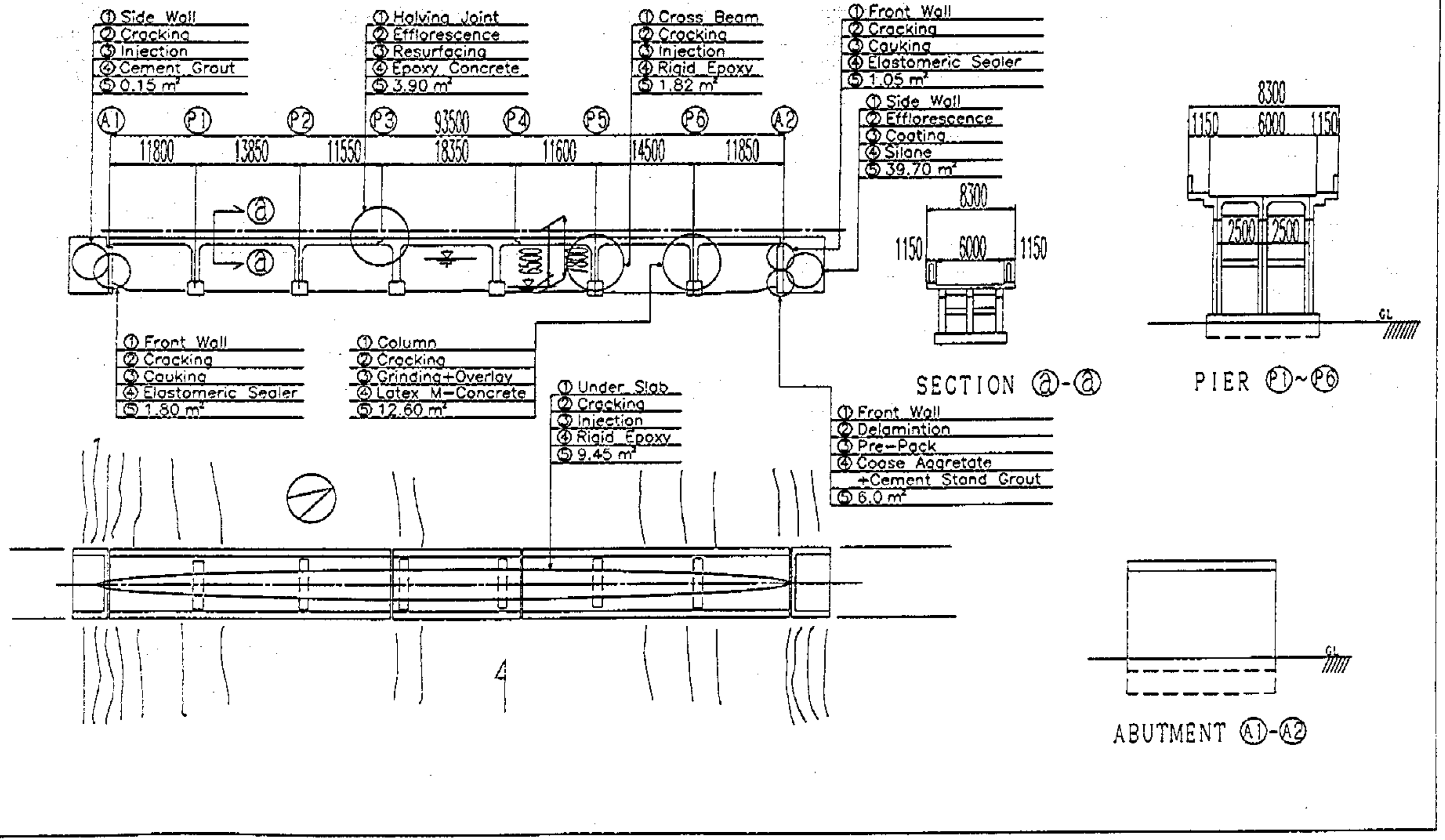


ABUTMENT Ⓐ1-Ⓐ2

REPAIR METHODS AND QUANTITIES			
BRIDGE NUMBER	2	YEAR OF BUILT	
BRIDGE NAME	DAVID GARCIA	BRIDGE LENGTH	93.05 m
REGION	V	BRIDGE WIDTH	8. 30m
ROUTE NAME	E-85	TRAFFIC VOLUME	

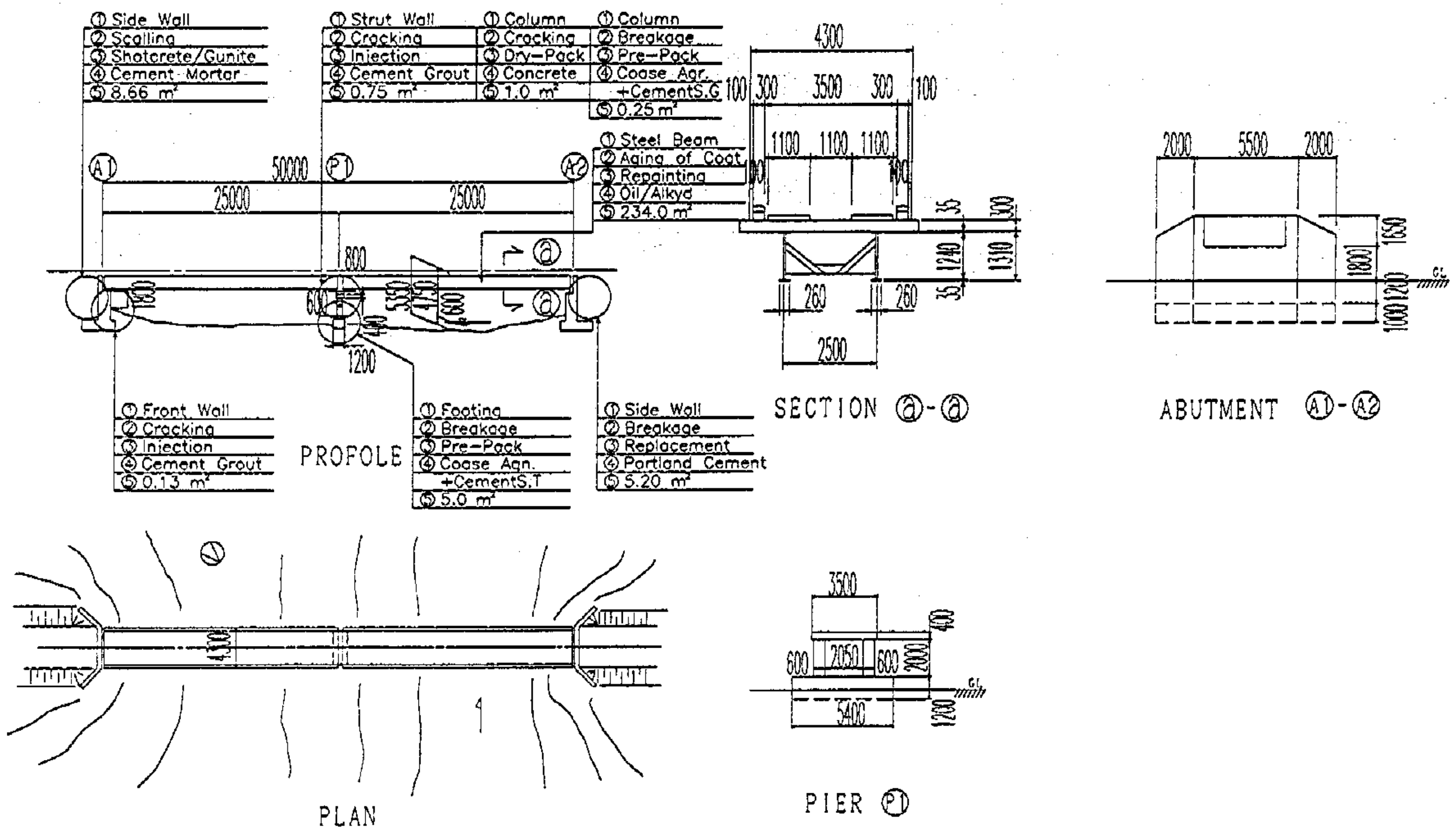
Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity



REPAIR METHODS AND QUANTITIES

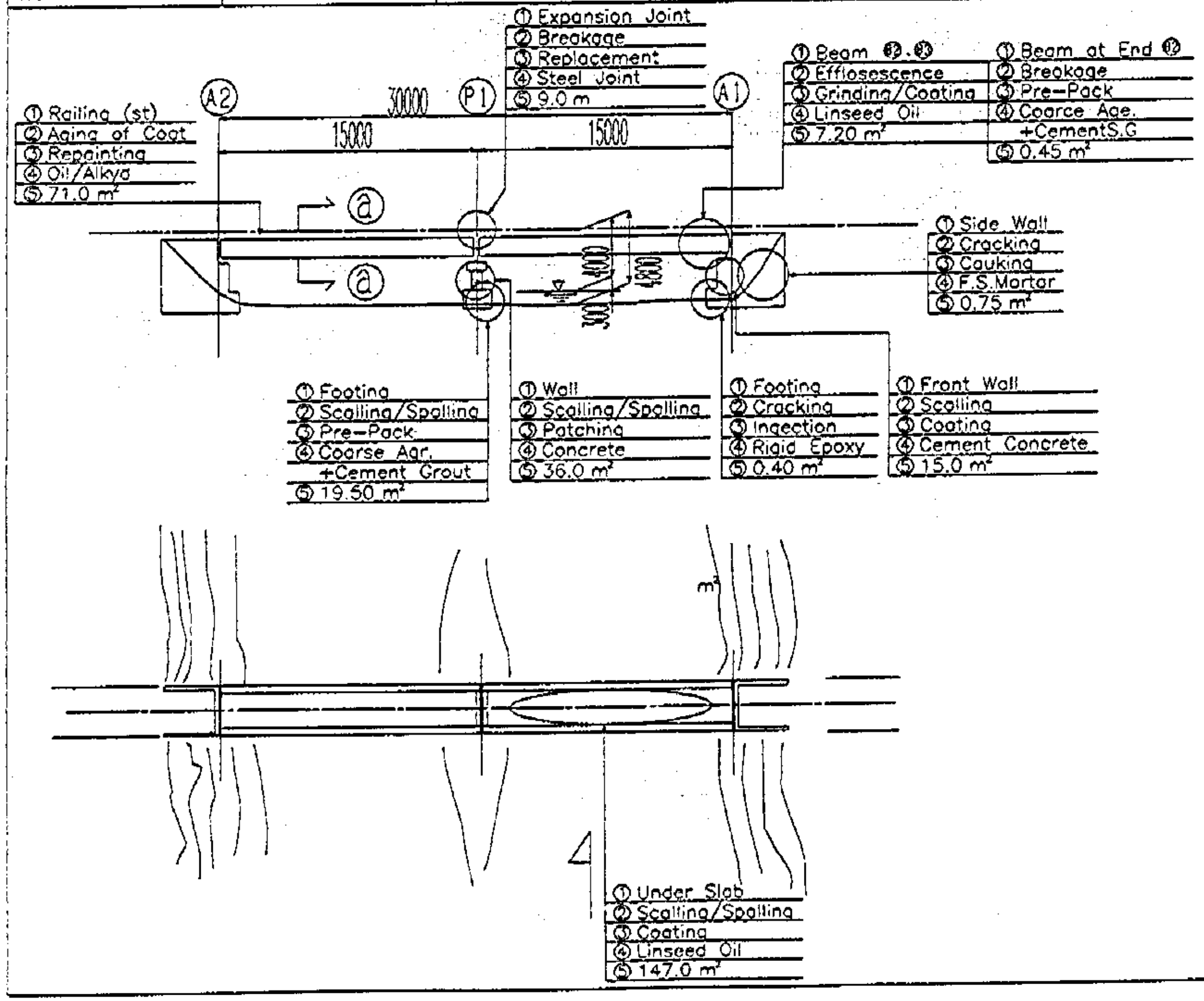
BRIDGE NUMBER	3	YEAR OF BUILT	
BRIDGE NAME	GRANALLAS	BRIDGE LENGTH	50.00m
REGION	V	BRIDGE WIDTH	4.30m
ROUTE NAME	E-533	TRAFFIC VOLUME	

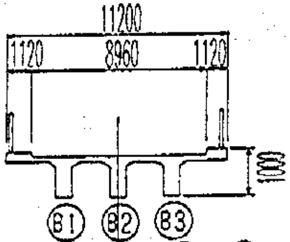
Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity



REPAIR METHODS AND QUANTITIES			
BRIDGE NUMBER	4	YEAR OF BUILT	
BRIDGE NAME	VENTANAS	BRIDGE LENGTH	30.00m
REGION	V	BRIDGE WIDTH	11.20m
ROUTE NAME	F-30-E	TRAFFIC VOLUME	

Legend : ① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity





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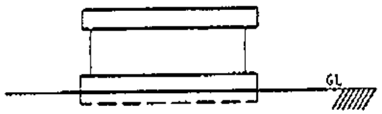

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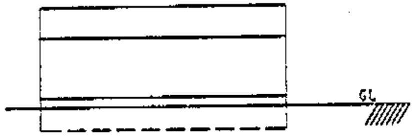
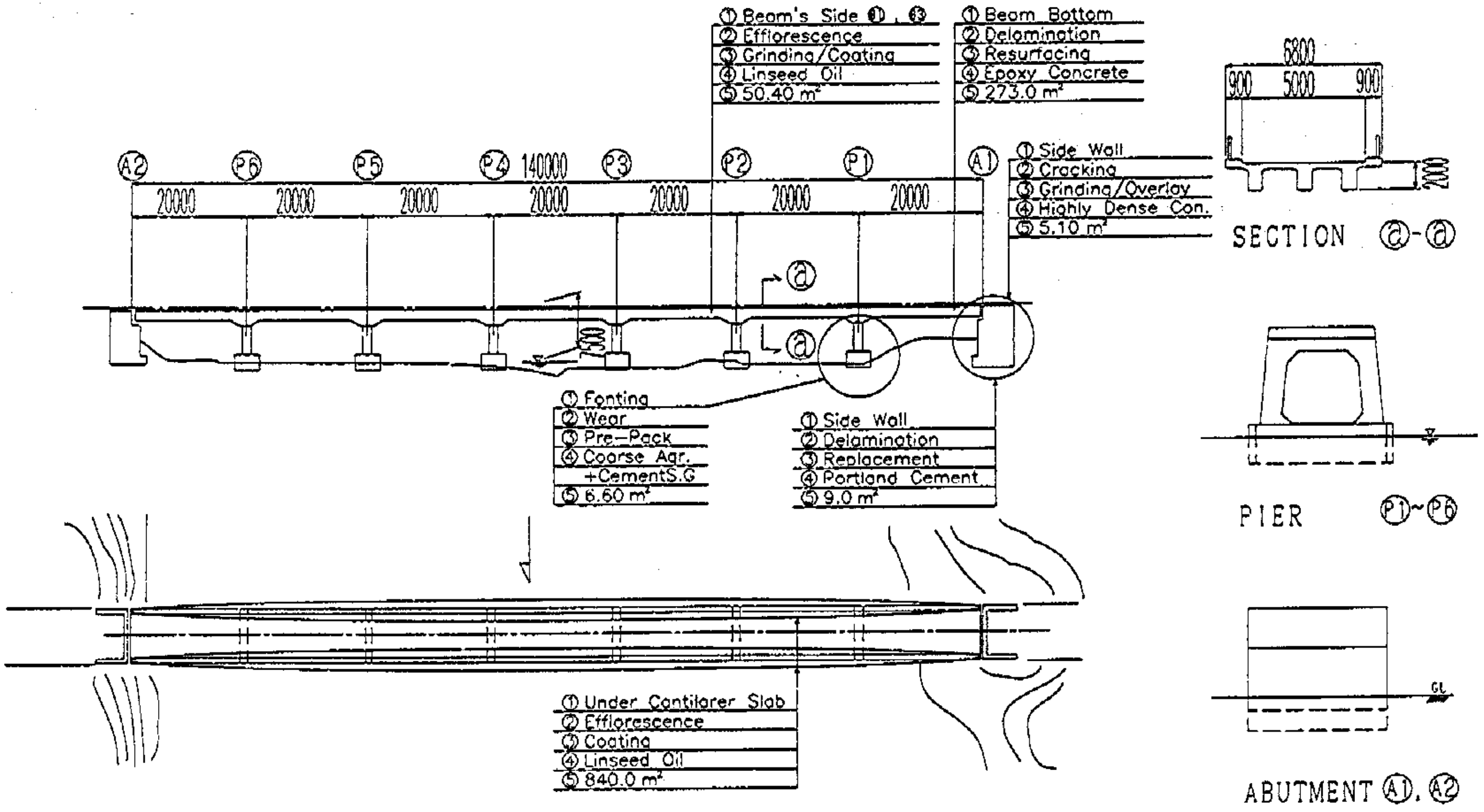


ABUTMENT (A1), (A2)

REPAIR METHODS AND QUANTITIES

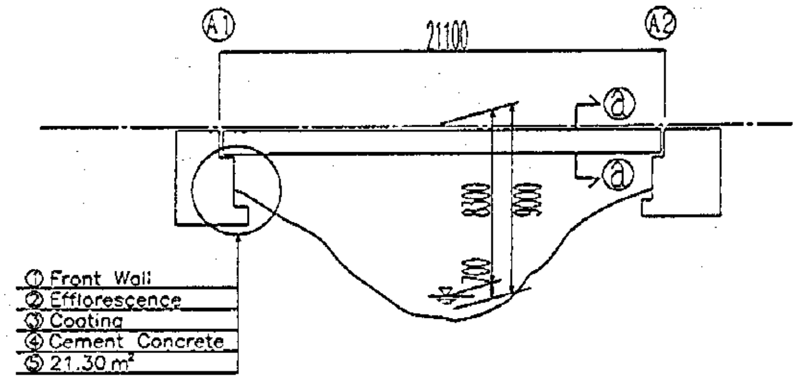
BRIDGE NUMBER	10	YEAR OF BUILT	
BRIDGE NAME	CAUTIN	BRIDGE LENGTH	140.00m
REGION	IX	BRIDGE WIDTH	7.00m
ROUTE NAME		TRAFFIC VOLUME	

Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity

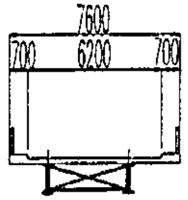


REPAIR METHODS AND QUANTITIES			
BRIDGE NUMBER	11	YEAR OF BUILT	
BRIDGE NAME	EL INDIO	BRIDGE LENGTH	21.10m
REGION	IX	BRIDGE WIDTH	7.60m
ROUTE NAME		TRAFFIC VOLUME	

Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity



① Front Wall
② Efflorescence
③ Coating
④ Cement Concrete
⑤ 21.30 m²



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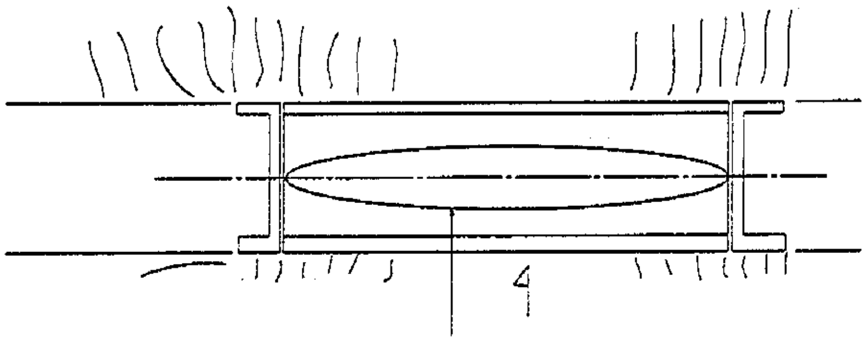
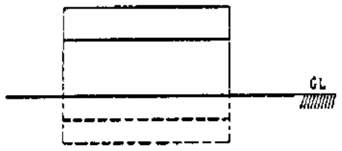


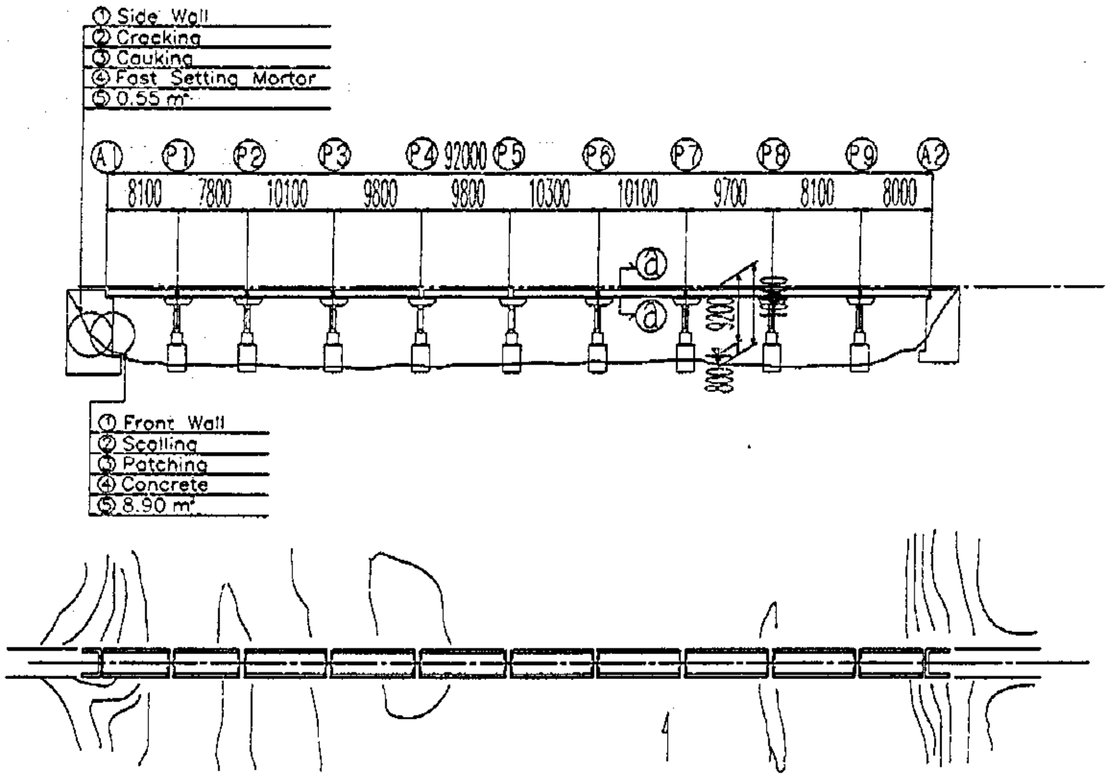
① Under Slab
② Efflorescence
③ Resurfacting
④ Epoxy Concrete
⑤ 101.0 m²

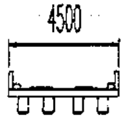


ABUTMENT Ⓐ1, Ⓐ2

REPAIR METHODS AND QUANTITIES			
BRIDGE NUMBER	14	YEAR OF BUILT	
BRIDGE NAME	MALLECO	BRIDGE LENGTH	92.00m
REGION	Ⅸ	BRIDGE WIDTH	4.50m
ROUTE NAME	R-152	TRAFFIC VOLUME	2060/day(1994)

Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity





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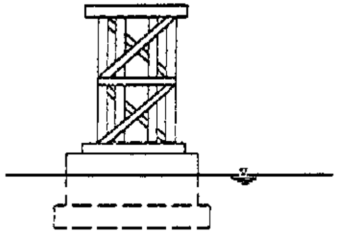
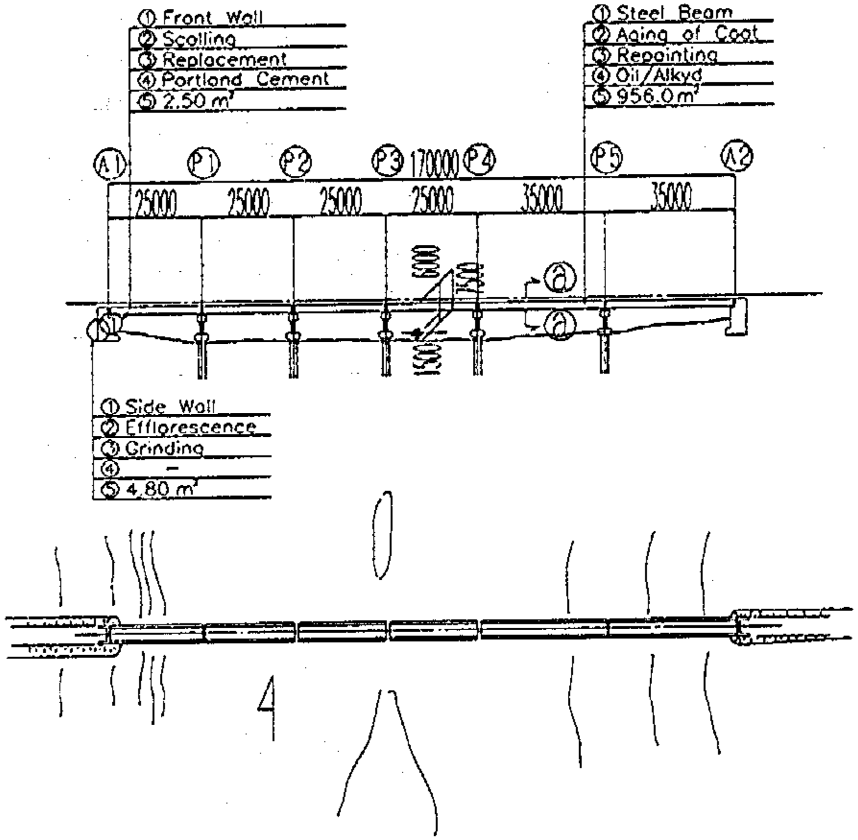


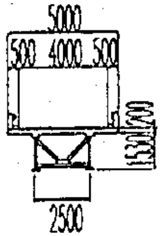
PIER Ⓟ1~Ⓟ9

REPAIR METHODS AND QUANTITIES

BRIDGE NUMBER	17	YEAR OF BUILT	
BRIDGE NAME	MEDINA	BRIDGE LENGTH	170.00m
REGION	IX	BRIDGE WIDTH	4.75m
ROUTE NAME	S-539	TRAFFIC VOLUME	

Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity





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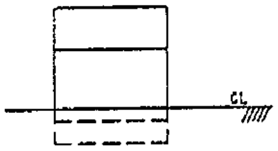

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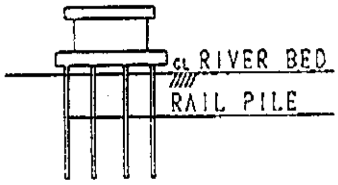


ABUTMENT Ⓟ1 ~ Ⓟ2

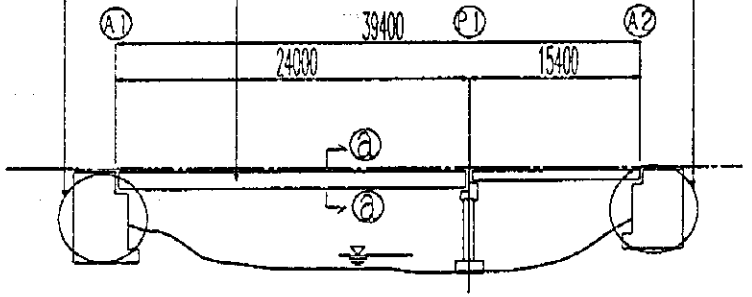
REPAIR METHODS AND QUANTITIES			
BRIDGE NUMBER	18	YEAR OF BUILT	
BRIDGE NAME	CAUTIN 88	BRIDGE LENGTH	39.40m
REGION	IX	BRIDGE WIDTH	3.85m
ROUTE NAME	R-925	TRAFFIC VOLUME	6/day(1996)

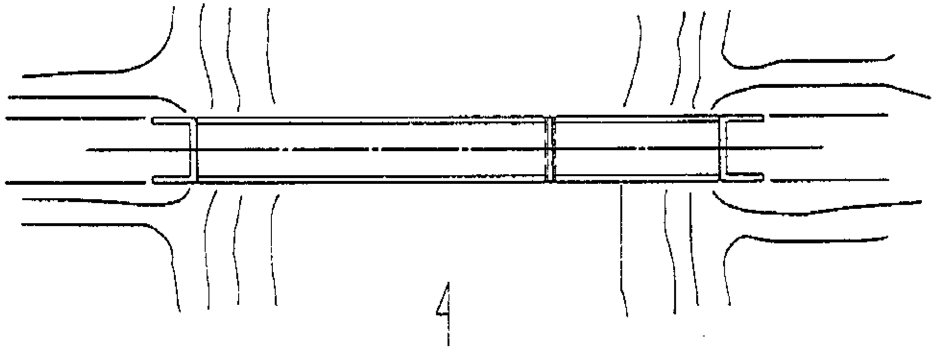
Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity

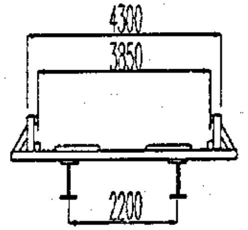
① Side Wall
② Honeycomb
③ Dry-Pack
④ Concrete
⑤ 1.70 m²

① Steel Beam
② Aging of Coat
③ Repainting
④ Oil/Alkyd
⑤ 237.0 m²

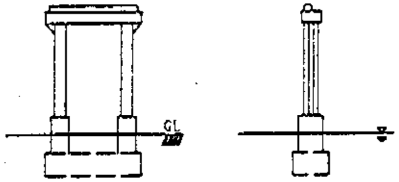
① Side Wall
② Breakage
③ Replacement
④ Portland Cement
⑤ 1.70 m²



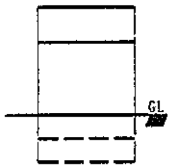




SECTION ⓐ-ⓐ



PIER P1

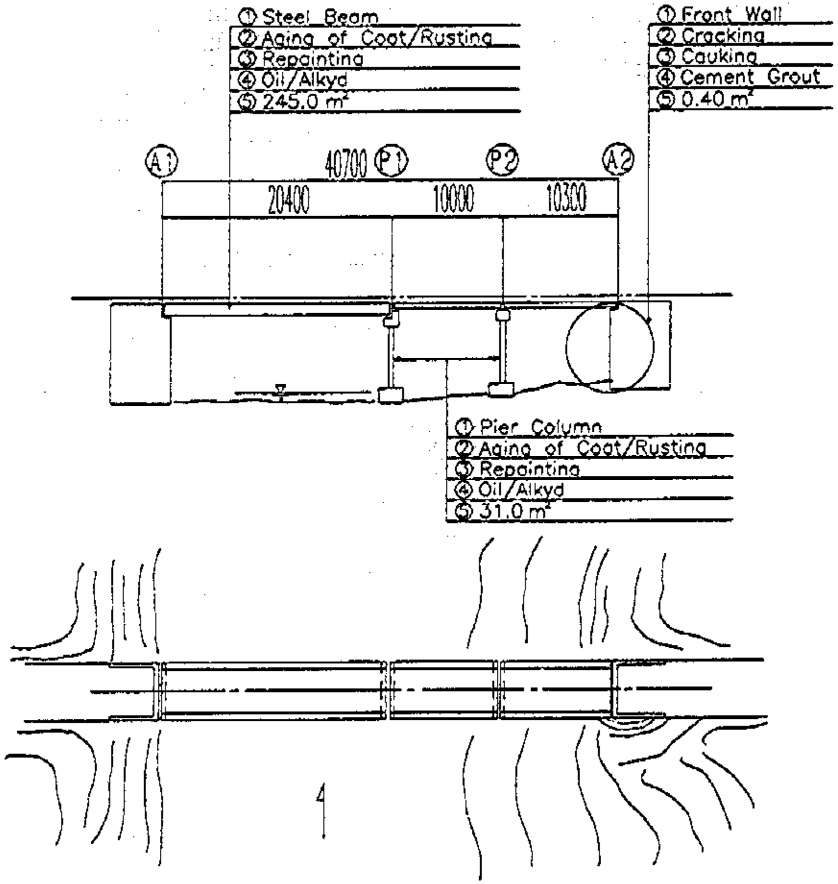


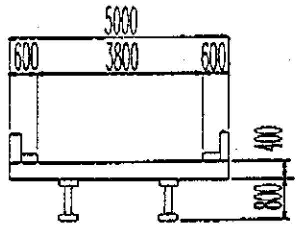
ABUTMENT A1

ABUTMENT A2

REPAIR METHODS AND QUANTITIES			
BRIDGE NUMBER	19	YEAR OF BUILT	
BRIDGE NAME	SALVA TU ALMA	BRIDGE LENGTH	40.70m
REGION	Ⅸ	BRIDGE WIDTH	4.63m
ROUTE NAME	S-553	TRAFFIC VOLUME	76/day(1996)

Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity





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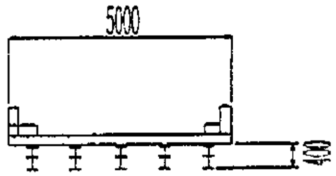

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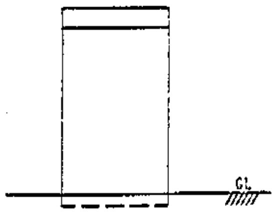

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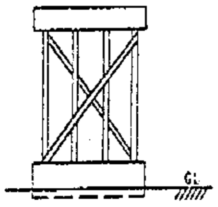
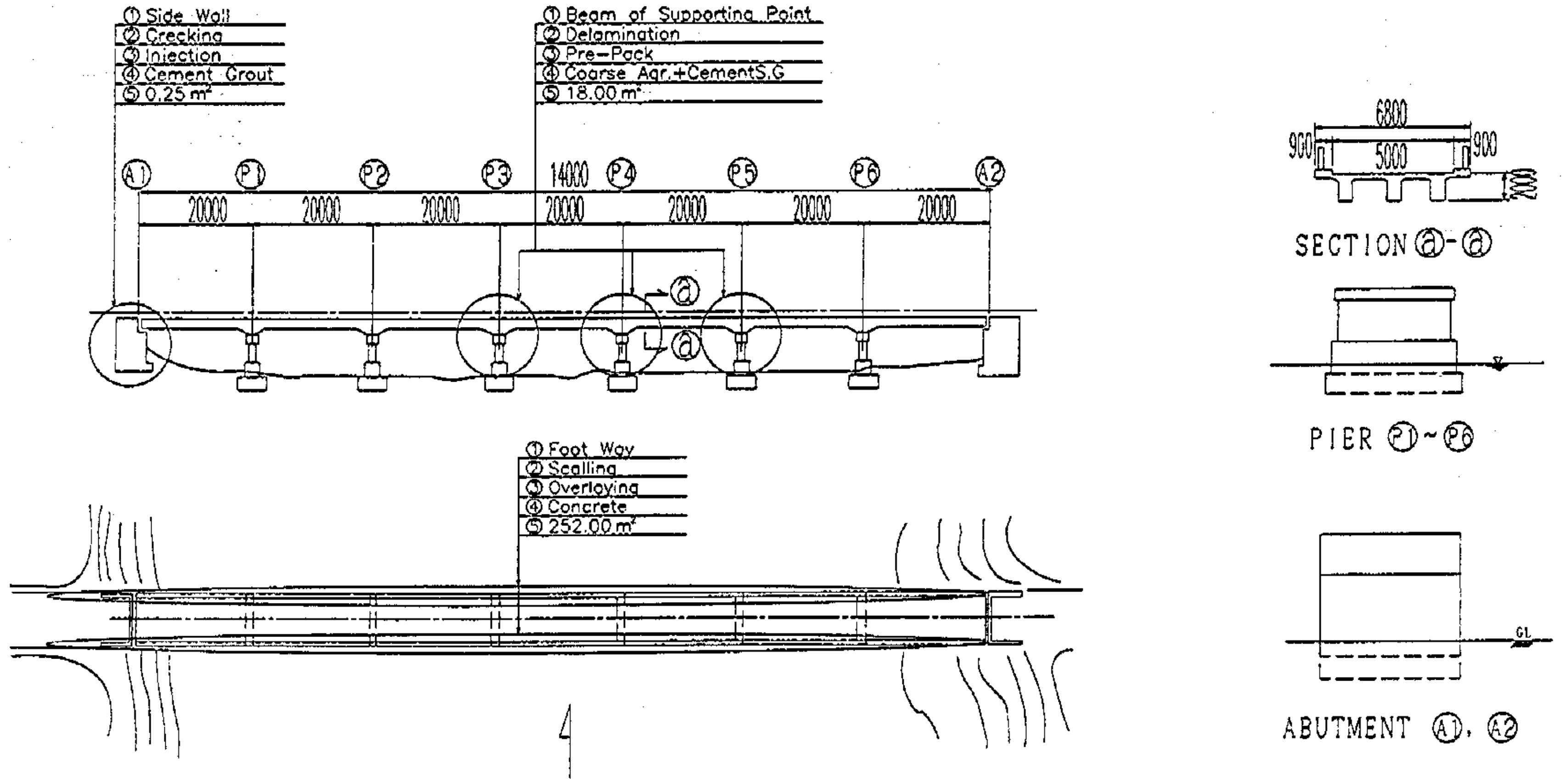


PIER Ⓟ1, Ⓟ2

REPAIR METHODS AND QUANTITIES

BRIDGE NUMBER	20	YEAR OF BUILT	
BRIDGE NAME	QUINCHILCA	BRIDGE LENGTH	140.00m
REGION	X	BRIDGE WIDTH	6.80m
ROUTE NAME		TRAFFIC VOLUME	839/day(1992)

Legend :
① Damage Location
② Kind of Damage
③ Repair Method
④ Material for Repair
⑤ Quantity



3.5 REHABILITATION COST ESTIMATE

3.5.1 Scope of the Cost Estimate

Reconstruction costs for the eight bridges and repair costs for the eleven bridges were estimated based on the designs prepared in **Chapter 3.4**. The estimation was made only for construction cost but did not cover administration and land acquisition costs. The costs estimated here were referred to a basis for the estimation of rehabilitation costs in the rehabilitation plan of **Chapter 2.5**.

3.5.2 Reconstruction Costs

(1) Cost Items

The cost items for reconstruction includes the followings:

- Construction cost for new bridge.
- Construction cost for approach roads, if the new bridge is designed parallel to the existing bridge. In this case, demolition of the existing bridge is not considered.
- Demolition cost for the existing bridge, if the new bridge is designed on the same location.
- Protection costs for local erosion or scouring around the bridge, but levee work or revetment work of river is not considered.

(2) Cost Components

Each cost item is broken down to the following five components:

- Material cost
- Labor cost
- Equipment cost
- Transport cost (assumed for about a distance of 100 km)
- Miscellaneous (assumed 40 % of the total of other cost components, considered to include overhead, taxes, profit, and other indirect costs.)

(3) Cost Data Source

Unit costs were prepared based on the following data sources:

- Actual cost data of bridge rehabilitation projects of the MOP near Santiago in 1996 and 1997
- List of unit costs for bridge works in MOP
- "ONDAC", the manual for the construction in October 1996
- Interview to concrete products suppliers

(4) Reconstruction Costs

Reconstruction cost for each of the eight bridges was estimated in accordance with the above mentioned procedures. The results of the estimation are summarized in **Table 3.18**. The breakdowns of the costs are presented in **Appendix II-5 (Volume 4/8)**.

Table 3.18 Summary of Reconstruction Costs

No.	Bridge Name	Cost (pesos)
2	David Garcia	329.000.000
3	Granallas	212.000.000
5	San Jose	431.000.000
6	Puangue	504.000.000
7	San Jose de Marchiue	432.000.000
8	Antivero No. 2	339.000.000
13	Poculon	263.000.000
16	San Juan	269.000.000

3.5.3 Repair Costs

(1) Cost Items

Repair works are classified into the works for bridge surface, underside of bridge, and pier and abutment. Each work includes the following cost items:

- The work for bridge surface includes repair of hand rails, deck-slab surface, expansion joints, and the traffic management cost during repair work.
- The work for underside of bridge includes repairs of underside of deck-slabs, beams, bearing shoes, and considers false work.
- Pier work considers scaffolding on both sides.
- Abutment work considers scaffolding on the side facing river only.

(2) Cost Components

Repair costs are estimated by assuming the repair unit cost for each type of damage. The following major damages are taken into the cost estimate:

Concrete Structure

- Cracks
- Scaling/Spalling
- Delamination
- Efflorescence
- Honeycombs
- Wear
- Breakage

Steel Structure

- Rusting/Aging of Coat

Unit repair cost of each damage is obtained as the average of costs of various repair methods. The unit repair costs proposed are summarized in **Table 3.19** and their breakdowns are presented in **Appendix II-6 (Volume 4/8).**

Table 3.19 Unit Repair Costs by Damage

(pesos/m^2)

Damage Type	For Underside of Bridge	For Surface of Bridge	For Pier and Abutment
For Concrete Structure			
Cracks	35,700	24,000	24,000
Scaling/Spalling	34,500	24,000	20,800
Delamination	42,000	45,500	31,800
Efflorescence	16,900	10,400	9,100
Honeycombs	42,000	45,500	31,800
Breakage	60,000	65,900	50,000
Wear	45,700	35,700	30,800
For Steel Structure			
Rusting/Aging of Coat	6,300	5,400	5,600

(3) Repair Costs

Repair costs of the eleven bridges were estimated in accordance with the above mentioned procedures. The results of the estimation are summarized in **Table 3.20**, and their breakdowns are given in **Appendix II-6 (Volume 4/8).**

Table 3.20 Summary of Repair Costs

No.	Bridge Name	Cost (pesos)	Recommended Execution Method
1	Confluencia	26,723,000	Contract
2	David Garcia	1,373,000	Direct Force
3	Granallas	748,000	Direct Force
4	Ventanas	6,719,000	Direct Force
10	Cautin	20,029,000	Contract
11	El Indio	1,990,000	Direct Force
14	Malleco	1,990,000	Direct Force
17	Medina	104,000	Direct Force
18	Cautin (88)	135,000	Direct Force
19	Salva Tu Alma	9,000	Direct Force
20	Quinchilca	5,820,000	Direct Force

In the above table, repair cost fluctuates widely by bridge. Only No. 1 Confluencia and No. 10 Cautin Bridges show round amount of costs over twenty million pesos, but others are small. In particular, No. 19 Salua Tu Alma Bridge amounted only the nine thousand pesos, that was why the bridge was designed with a very little repairs and its cost was estimated by unit cost method. For such variation of the repair cots, it is recommended that the bridges with small costs be repaired by the direct force of the MOP as a maintenance work. On the other hand, the bridges with fair amount of costs should be repaired by contracts.

3.6 ENVIRONMENTAL STUDY ON BRIDGE SITE

3.6.1 General

By the passage of the General Fundamental Law of Environment (LEY No.19.300) in March 1994, a series of the following environment-related laws have been enacted in Republic of Chile, such as Modification of Article No.71 of LEY No.19.300 in February 1995, Regulation of Council for National and Regional Consultative Commission for Environment (D.S.No.86) in October 1995, Regulation for the Dictation of Rules of Environmental Quality and Emission (D.S.No.93.) in October 1995, Regulation that fix the Procedure and Stages for Plans Establishment of Prevention and Decontamination (D.S.No.94) October 1995, and Modification of D.S.No.86 (D.S.No.181.) in October 1995. Finally, Regulation System of Environmental Impact Evaluation (D.S.No.30.) has been enacted in April 1997.

The agencies of the MOP are required to assess the environmental impact of their projects. Since bridge rehabilitation is a part of highway projects, which have major impact on land use and community development, LEY requires that social, economic and environmental impacts resulting from existing and proposed projects be formally documented and that appropriate measures be taken to reduce adverse environmental effects.

Meanwhile as a rule, the JICA projects intend to simultaneously attain two goals namely economical development and environmental conservation. For the achievement of the former, various aspects of technical consideration have been already developed in the previous subsections of this report. For the achievement of the latter target, there will be presented a basic consideration in this subsection.

The twenty bridges which are the representative objects for the study of rehabilitation design, have always played more important role as a local road network connecting local major cities, towns and villages. This role will continue to grow in the future.

The main purpose of the Environmental Study is to identify the existing significant environmental elements that would have a high possibility of being affected by implementation of projects and to formulate mitigation measures for adverse impacts. Both of Initial Environmental Examination (IEE) and Preliminary Environmental Impact Assessment (Pre-EIA) should cover pre-construction stage, construction stage and maintenance and operation stage for subjects whatever these are directly or indirectly affected.

3.6.2 Scope of Environmental Study

(1) Process of Environmental Study

The environmental study was carried out by the Study Team in cooperation with the MOP. The study of Initial Environmental Examination (IEE) and Preliminary Environmental Impact Assessment (Preliminary-EIA) for the 20 bridges includes the following activities:

- Investigation of the existing environmental condition,
- Project description and site description,
- IEE (Initial Environmental Examination),
- Pre-EIA (Preliminary Environmental Impact Assessment),
- Pre-EIA matrix, and
- Preparation of environmental assessment manual.

The process of the environmental study is shown in **Figure 3.9**.

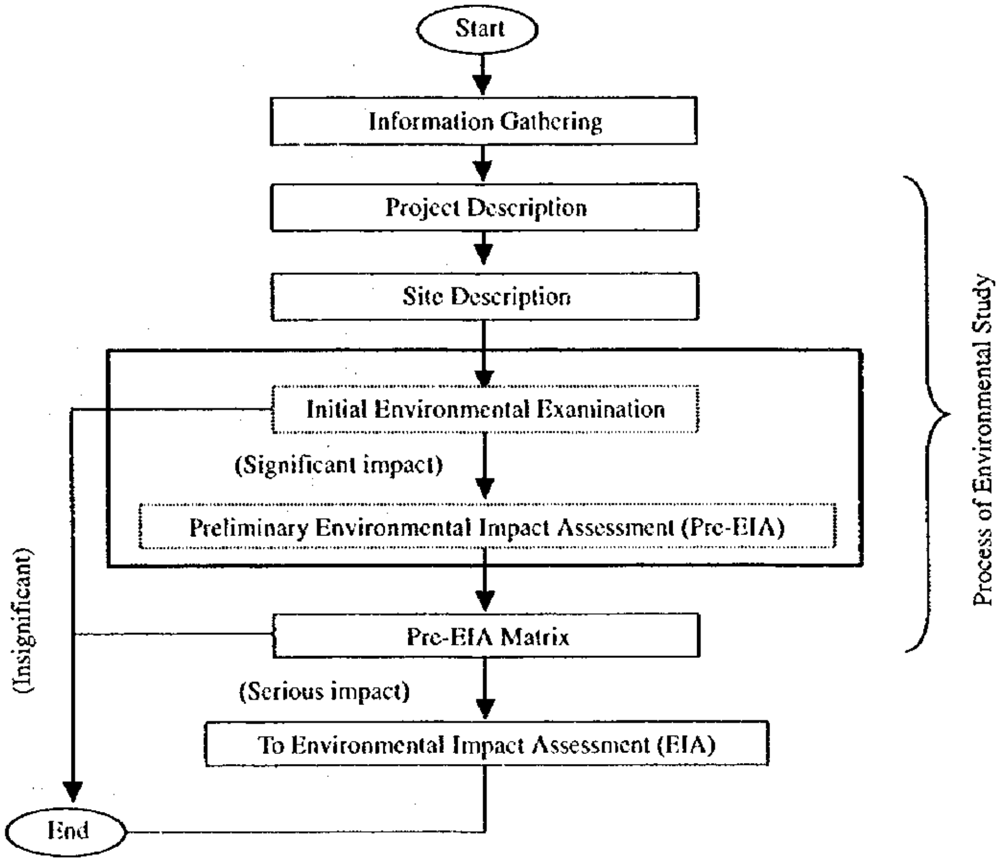


Figure 3.9 Process of Environmental Study

(2) Study Area

The study area covers the existing bridges and adjacent area along their bridges. **Table 3.21** shows the object 20 bridges.

Table 3.21 Bridges for Environmental Study

No.	Bridge Name	Region	Province	Bridge Type	Bridge Length (m)	Rehabilitation Method
1	Confluencia	IV	Choapa	ST	113.10	Repair
2	David Garcia	V	Los Andes	RC	93.05	Reconstruction/Repair
3	Granallas	V	San Fellipe de Aconcagua	ST	49.85	Reconstruction/Repair
4	Ventanas	V	Valparaiso	RC	30.00	Repair
5	San Jose	RM	Chacabuco	RC	16.10	Reconstruction
6	Puangue	RM	Melipilla	RC	105.10	Reconstruction
7	San Jose de Marchiue	VI	Cachapoal	ST	120.00	Reconstruction
8	Antivero No.2	VI	Colchagua	RC	102.90	Reconstruction
9	Los Cardos	VI	Colchagua	ST	73.55	Repair
10	Cautin	IX	Cautin	RC	140.00	Repair
11	El Indio	IX	Malleco	ST	21.10	Repair
12	Quillen	IX	Cautin	TM	25.90	Repair
13	Poculon	IX	Cautin	TM	31.00	Reconstruction
14	Malleco	IX	Malleco	TM	92.00	Repair
15	Miraflores	IX	Malleco	TM	44.40	Repair
16	San Juan	IX	Cautin	TM	31.60	Reconstruction
17	Medina	IX	Cautin	ST	170.00	Repair
18	Cautin (88)	IX	Cautin	ST	39.40	Repair
19	Salva Tu Alma	IX	Cautin	ST	40.70	Repair
20	Quinchilca	X	Valdivia	RC	140.00	Repair

(3) Inspection Items

Many common environmental problems were observed in rural bridges relating to geographical condition and due to construction activity. Therefore, inspection items were standardized for the survey of the 20 bridges. The items were chosen through scoping and screening survey on site.

The items to be inspected are as follows:

Social Environment

Inhabitants:	Residents, indigenous people, their views on the project, and others
Landuse and Facilities:	Urban area, farm land, and others, Historic & cultural site, scenic spot, hospitals, schools and other facilities
Economy:	Commerce, agriculture, forestry, and others
Transport:	Bus terminal, traffic, etc.

Natural Environment

Topography :	Feature of river bank area, steep slopes, soft ground, wetland, etc.
Geology :	Feature of river bank/bed, outcrop, stone, gravel, sand/fault, soil type, etc.
Hydrology:	Feature of river flow, water level, flood level, etc.
Fauna & Flora:	Habitats, rare species /community, etc.

Pollution

Complaints:	Population of the upmost concern
Measures taken:	Institutional measures and compensation

Others

3.6.3 Project and Site Inspection Forms

To conduct the IEE and Preliminary EIA, it is essential at the outset to fully understand the Project Description (PD) and Site Description (SD). The PD includes the contents and features of the projects, such as background, objectives, study area, competent ministry, number of beneficiaries, and type of the project, etc. The SD includes the present conditions of natural and social environment. **Table 3.22** and **Table 3.23** show the standard forms for project description and site description.

Table 3.22 Standard Form for Project Description

Item	Description
Background	
Objectives	
Executing Agency	Ministry of Public Works (MOP)
Beneficiaries	
Project Components	
Existing bridge structure	Slab(Conc.), Beam(Steel), Abutment(Conc.), Pier(Conc.), Foundation(Conc.)
Bridge length, width	Length(m), Width(m)
Other specific features	Carriage way width (m), Side walk width (m)
Project Type	( ) Replacement, (X) Repair
Road Type	( )Urban / (X)Rural area, ( )Plain area /(X)Mountain area (X)Paved / ( )Unpaved
Existing traffic volume	Year 79/6/13(Fri.) (46)Cars/hour, ( )Cars/day
Road width/lanes	Exist Width =(5x2 m) Nos. lanes = (2)
Road structure	( )Embankment / ( )Elevated / (X)Others: Cutting of original ground
Supplemental facilities	
Others	River name:

Table 3.23 Standard Form for Site Description

Item	Description	
Social environment		
Inhabitants: Residents, Indigenous people Their views on the project, Others	Upperstream: Left bank area: Downstream: Left bank area:	Right bank area: Right bank area:
Landuse and facilities: Urban area, Farm land, Others, Historic & cultural site, Scenic spot, Hospitals and other facilities	Upperstream: Left bank area: Downstream: Left bank area:	Right bank area: Right bank area:
Economy: Commerce, Agriculture, Forestry, Others	Upperstream: Left bank area: Downstream: Left bank area:	Right bank area: Right bank area:
Transport: Bus terminal, etc.		
Natural environment		
Topography, (Feature of river bank area) Steep slopes, Soft ground, Wetland	Upperstream: Left bank area: Downstream: Left bank area:	Right bank area: Right bank area:
Geology, (Feature of river bank/bed): Outcrop, stone, Gravel, sand/ Fault, Soil type, etc.	Left bank area:	Right bank area:
Hydrology, (Feature of river flow, Water level, flood level)		
Fauna & Flora / habitats, Rare species /community, etc.,		
Pollution		
Complaints: Population of the upmost concern		
Measures taken: Institutional measures, Compensation		
Others		

3.6.4 Evaluation Forms

All the environmental elements, which would be affected by projects, are listed and discussed in relation to the project activities on a so-called format checklist for the evaluation of IEE and Preliminary EIA. See **Table 3.24**, the standard form proposed for environmental impact consideration. The head line of the table shows Environmental component, Identification of activities, Description of activities, IEE evaluation, Preliminary EIA evaluation and Remarks, while the columns show the environmental components concerned to be affected.

The cause-effect relation will be explained with a mark at each corresponding cell of the checklist. In the IEE evaluation column, 'Yes' means the related project may cause a significant effect on environmental element or negative side, 'No' indicates no influence or positive side, and 'Temporary or Slightly' means either temporary or slightly effect.

When the IEE evaluation becomes positive (No effect) and or temporary/slightly, it is not required to proceed to the Preliminary EIA evaluation. When the IEE evaluation becomes negative (Yes effect), then it is required to proceed to Preliminary EIA evaluation.

In the column of Remarks, reasons of cause-effect relations are required to be filled in corresponding to Yes or Temporary/Slightly effect.

For the Preliminary EIA stage, a standard form of environmental assessment matrix as shown in **Table 3.25** was proposed. The form is divided into pre-construction, construction, and operation and maintenance stages to fill in impact assessment mark for each project activities. Assessment marks are noted below the table.

Table 3.24 Form for Environmental Impact Consideration

David Garcia

No	Environmental component	Identification of activities	Description of activities	IEE evaluation	Preliminary EIA evaluation	Remarks (Reason)
Socio economic Environment						
1	Land and Property	Land aquisition	Transfer of right of land ownership compensation	No		
		Resettlement	Transfer of rights of residence / compensation	No		
2	Economic	Economic activities	Loss of basis of economic activities, such as land, and change of economic structure	No		
		Employment	Increase or decrease of employment opportunity	Increase		Const. Period
3	Traffic and Public facilities	Traffic	Impact on present traffic conditions, increase of traffic congestion	Temporal	Temporal	Use of detour route Safety control
		Public facilities	Impacts on schools, hospitals caused by increase of traffic volume	No		
4	Communities	Disintegration of communities	Community split due to interruption of area traffic	No		
5	Amenity	Amenities	Increase or loss of existing amenities	Increase	Enhance	Aesthetic condition
6	Historical and Cultural	Historical assets	Damage or loss of the value of historic or archaeological remains	No		
		Cultural properties	Damage or loss of the value of cultural assets	No		
7	Vested rights	Water rights and rights of common	Obstruction of fishing rights, water rights, or other rights of common	No		
8	Waste	Waste	Generation of construction and demolition debris	Yes	Temporal	Obligation to the construction side
9	Hazards	Risk and damage	Risk of accidents, traffic damage	Slightly	Temporal	Safety control
Natural Environment						
10	Land	Topographic feature /river bank and bed	Changes of valuable topographic land form condition	No		
		Geological condition	Changes of geological condition	No		
		Land use	Change of original land use	No		Negligible
		Soil erosion	Topsoil erosion by rainfall after earth work and vegetation removal	Slightly	Temporal	Negligible
11	Surface water	Hydrological feature	Changes of flow variation	No		
		Water use	Change of existing water use	No		
		Water quality	Change of water quality	slightly	Temporal	Negligible
		Floating debris	Floating obstacles	No		
		Flood affection	Flood affected area	No		
12	Species and their population, habitat	Terrestrial vegetation /flora	Obstruction of valuable species and their community, habitat	No		
		Terrestrial wildlife /fauna	Obstruction of breeding and extinction of species, communities, habitat	No		
		Aquatic flora	Obstruction of valuable species	No		
		Aquatic fish fauna	Obstruction of breeding and extinction of species, communities , habitat	Slightly	Temporal	Negligible
13	Aesthetics	Landscape	Changes of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structure	No		
Pollution						
15	Atmosphere	Air pollution	Pollution caused by exhaust gas or toxic gas from vehicles	Slightly	Temporal	Control of soil dust
16	Water	Water pollution	Pollution by inflow of silt, sand and effluent into rivers	Slightly	Temporal	Negligible
17	Noise and vibration	Noise and vibration	Generation by construction machinery and traffic vehicles	Slightly	Temporal	Control operation hour.
Overall evaluation		Is Preliminary EIA necessary for the project implementation?		Need of Pre-EIA		

Table 3.25 Form of Environmental Assessment Matrix

David Garcia

			Project activities																																			
			Pre-construction stage										Construction stage																Operation and maintenance stage						Consequent projects			
Environmental component		Identification of activities	Access roads	River crossings	Site surveying	Boring test	Site cleaning /Burning	Earthworks	Equipment	Waste disposal & recover	Land acquisition	Resettlement/compensatio	Access roads	River crossing/deture rool	Earth works	Demolition	Building relocation	Reclamation	Erosion control	Drainage alteration	Piling	Structures	Equipment	Revegetation	Landscaping	Labour force	Utilities	Waste disposal & recovery	Equipment	Transportation / traffic	Pedestrian traffic	Waste disposal & recover	Accidents	Labour force	Amenities	Utilities	Transportation	
Socio economic environment	Land & property	Land aquisition																																				
		Resettlement																																				
	Economic	Economic activities																																				
		Employment																							E												
	Traffic & facility	Transportation / Traffic												P																E	E		E					
		Public facilities																																				
	Community	Disintegration of communities																												E	E							
	Amenity	Amenities																																				
	Historical & cultural	Historic assets																																				
		Cultural properties																																				
	Vested rights	Fishery rights, right of common																																				
	Waste	Generated waste & waste disposal														P												P										
	Hazard	Accidental damages												P																E	E							
Natural environment	Land	Topographic feature/river bank,bed													P																							
		Geological condition																																				
		Land use																																				
		Soil erosion													P																							
	Surface water	Hydrological feature																																				
		Water use																																				
		Water quality													P																							
		Floating debris																																				
		Flood affection																																				
	Species & population	Terrestrial vegetation / Flora																																				
		Terrestrial wildlife / fauna																																				
		Aquatic flora																																				
		Aquatic fish fauna													P																							
	Aesthetic	Landscape																						P										E				
Pollution	Atmosphere	Air pollution													P																							
	Water	Water pollution													P																							
	Noise, vibratio	Noise and vibration																					P															

Impact Assessment Mark:

P : Possibilities of highly negative environmental impact are noted, but a solution has already been found.
A : High possibilities of negative impact, but data obtained to predict the extent is insufficient.
X : Remaining notable negative impact is perceived.
E : Notable improvement of environment is perceived.

3.6.5 Results of the Study

The results of the environmental inspection are presented in **Appendix II-7 (Volume 4/8)** for each of the 20 bridges.

Most of the bridge sites were apart from inhabitant or settlement, and the project activities were not so large. There were generally slight or temporary actions. Existence of historical or cultural assets were unlikely around the bridges. From the view of natural ecosystem, there was no critical place but reveric area, that meant less possibility of the existence of valuable natural flora and fauna resources.

(1) Bridges for Repair

For the bridge sites of repairs among the 20, all activities of environmental components from socioeconomic through pollution were evaluated 'No effect' or positive side, for the project activities were limited to partial work for bridge repairs. At some bridges, there were slightly or temporary effects noted, but they were judged negligible.

(2) Bridges for Reconstruction

For the bridge sites of reconstruction among the 20, some activities of environmental components of socioeconomic, natural environment and pollution were evaluated 'Yes' or negative side, for the projects involved construction of bridges. In this case, one of significant activities might be land acquisition and its related resettlement in the socioeconomic environment, if there were private lands and inhabited within the site of bridge construction. Also, the problem of traffic congestion was considered during construction.

As regards soil erosion, water quality and aquatic fish fauna, there might be considered of temporary affects. Also, air pollution due to dust might be caused by the earthwork in dry summer season. Noise caused by operation of construction equipment might affect cattle ranch if there was any nearby.

3.7 RECOMMENDATION FOR BRIDGE REHABILITATION IN CHILE

3.7.1 Timber Bridges

(1) Cause of Collapse

Timber has been commonly used for short span bridges as temporary on gravel surfaced local roads, which are mainly in Regions VIII, IX, and X of forested area. Urgent problem of timber bridge to be solved is that about 40 to 50 timber bridges have annually collapsed in last 10 years, according to the MOP. Causes of collapse are as follows:

- Heavy loaded vehicles

Heavy vehicles such as dump trucks, semi-trailers loaded with lumber products and road construction equipment are passing on the timber bridges which loads are more than twice of the load limit written on sign boards.

- Deterioration

Lot of timber bridges have already severely deteriorated due to weathering and decay by bacteria, fungi, moss, and insects. Heavy vehicles also cause abnormal deflection and lateral movement which promote more deterioration to mechanically connected portions of the structure.

- Erosion of river bank

Some bridge beams seated directly on a bank without abutment and without proper bank protection (bank seat type) will cause land erosion, settlement and damage to the structure.

- Scouring of foundation

Shallow embedding depth of concrete or rail pile foundation have seriously scoured causing pier column to sink.

(2) Maintenance and Repair

The followings are necessary measures for maintenance and repair.

- Periodical creosote treatment on surface, in cracks and mechanically connected portions every 2 – 4 years after construction.
- Fastening loosed connections of main members and hand railing.
- Strengthening splits of timber columns by steel plate connection.
- Cleaning soil and debris around location of end beams which can easily decayed due to moist of environment.

- Replacement of damaged or weathered longitudinal planks and deck planks.
- River bank protection and river bed protection for the bank seat type and wire mesh gabion or dumped stone for locally scoured pier foundation.

(3) Design and Construction

1) Design

Beams should be designed to satisfy both working stress within allowable stress and beam deflection limitation within 1/300 ratio of span length for enough bending stiffness. Allowable bending stress of wood is as follows:

Kind of tree	Young's modules (kg/cm^2)	Allowable bending stress – parallel to grain (kg/cm^2)	Remarks
COIGUE (Chilean tree)	105,500	96	Santiago university
Needle-leaved tree	100,000	90	Japanese specification for timber bridge (1940)
Broad-leaved tree	100,000	120	

The height of timber beam should be more than 1/18 – 1/20 of span length in order to limit deflection less than 1/300 of span length.

Type of bridge and applicable span length for design load of 9 ton's vehicle are shown below:

Type of Bridges	Span Length (m)				Number of Beam (Nos)	Height of Beam (cm)
	5	10	15	20		
Simple Beam	4 —	— 7			5 – 6	30 – 40
Double Truss and Rigid Frame	6	———	———	15	5 – 6	30 – 40
Fink Type (Reversed queen-post girder)		10	…………	……… 18	5 – 6	30 – 40

Simple beam of 7 m in span length is maximum practical for sawn-timber bridge. Fink type bridge (reversed queen-post girder) has considerably deformed due to elongation of steel bars, loosened nuts and sink of anchor plate into timber, therefore, this type is not recommendable.

If design load over 10 tons is required for timber bridges, the built-up beams (2-beams in layer) is to be applied and designed.

2) Construction

a. Selection of timber

The seasoned (naturally dried) timber, not the green one should be used because of less strength depending on moisture content and possibility of cracks (checks, shakes and splits). The timber which have defects of knots, cracks or decayed spots should not be used.

b. Preservative treatment

Non-pressure treatment with creosote is usually used in Chile. This treatment protect growth of fungus, attack of insects, and also water proofing the timber. Creosote treatment should be carried out two-times on surface, in cracks and mechanically connected portions at construction stage.

c. Bolt connection

A bolt not smaller than 16 mm in diameter should be used for connection of main members. Size of washer should be 3.5 times of bolt diameter and thickness to be at least 1/3 of bolt diameter.

3.7.2 Concrete Bridges

Concrete is a major material commonly used in Chile for bridge construction both of super- and sub-structures. During the bridge inspection work, various damages of concrete were observed namely crack, scaling/spalling, delamination, efflorescence, honeycomb, breakage, leakage, etc., which were detailed in **Chapter 3.2.2.**

The causes of those damages are classified as follows:

- Inadequate Design: may cause shortage of strength and stiffness of bridge structures.
- Poor Construction Workmanship: decreases durability of bridge; such as insufficient compaction of concrete, cold construction joint, shallow concrete cover, etc. deteriorate strength and water-tightness of concrete.
- Poor Quality of Materials: also decreases durability of bridge; such as saltish water and alkaline aggregates for concrete mixture, accelerate corrosion of reinforcement to induce large cracks.
- Environmental Affection: accelerates carbonation of concrete; such as chemical attack by carbon dioxide and other acidic gases in the air and rains, deteriorate concrete seriously.
- Unexpected External Forces: may damage bridge structure decisively; such as over-loaded traffic, big earthquake, and large flood, which bring about excessive stress in structure beyond the design stress level assumed, may sometimes wreck bridges.

Among various causes of damages of concrete bridges as above mentioned, the majors observed were cracking, scaling, spalling, and delamination.

3.7.3 Steel Bridges

(1) General Problems of Steel Bridges

Steel material is utilized not only for main girders, but for bearing shoe, expansion joint, hand rail and so on. Described below are some matters on damages of steel material used as parts of bridges and other matters affecting the damages of steel.

1) Main Structure

a. Welded plate girders, rolled H-shapes or assembled rails are employed as a main girder. Occasionally main girders are modified, transported and reused for the other bridge.

b. Many of steel bridges in Chile have rust on them even under a good atmosphere, supposedly because of leaving it without maintenance for a long period and the lack of maintenance looks to be the biggest cause of the corrosion.

c. As the outer surfaces of web plate of main girders is well ventilated, they rust less than the inner surfaces.

d. Steel girders with timber deck usually rust severely, for the timber deck has gaps between planks and from the gap drop water and mud.

e. Rain water creeping down along the web plate goes to bottom surface of lower flange, and remains there. The water drops hanging down from the flange bottom bring about bad corrosion.

f. Field joints are made not by high tensile grip bolts but by welding. The butt welding are not finished by grinding. The former is nowadays a much easier method of connection than the latter.

g. Most of cross frames are of X-shape composed of rolled angle shapes joined back to back each other, or sometimes steel round bars, which are not strong enough, are used.

h. Each member for lateral bracing is assembled in the same manner as those of the cross frame mentioned above.

i. Because of difficulty of procuring the steel materials and in order to save the materials for the web plates, steel plates are connected by welding side by side and up-and-down to constitute a sheet of plate.

j. Sometimes vertical stiffeners are found attached to the outer side of web plates, and this will cause dust, leaves and then moisture to be accumulated on top of the lower flange. The moisture is, no need to say, the direct cause of rust on steel materials.

2) Bearing Shoe

a. Although the height of bearing is too low to observe the condition of the bearings, the type is supposed to be the one composed of two steel plates, so-called linear bearing type. They are stuffed completely with mud, and supposedly are not functioning as a bearing shoe.

b. As expansion joint is usually not installed , or even in case of having it drainage from deck through a gap of expansion joint is not taken into account, water and mud drop down and accumulated near bearing shoes. This is the main cause to deteriorate bearing shoes.

c. Occasionally main girders are mounted on the top of substructures directly without bearing shoe, and therefore this will do harm to these girders.

d. A bearing shoe is usually equipped with a pair of anchor bolts, but they do not look strong enough to resist horizontal earthquake force. Anti-seismic bars inserted into a cross beam are expected to resist the force.

e. An elastomeric bearing is used, and a bearing which employs lead instead of neoprene also exist.

f. Most bearing shoes seat too close to the edge of bridge seat, which means a danger of shearing fracture of concrete by a heavy reaction force or fall-down of main girders from bridge seat under earthquake force.

3) Deck Slab

a. Timber or reinforced concrete are used as the materials for deck slab. Timber planks are arranged perpendicular to the main girders with proper gaps so that rain water can easily drained away from the deck surface in case of timber bridge. On the other hand for a steel bridge, timber planks are laid on the steel girders so that the longer side of the cross-section of the timber planks stand vertically to make them more rigid by the method so-called "paquete" in Spanish, and in this case the gaps between the floor materials are less narrow or they contact each other.

b. When a deck is made of concrete, then it is usually paved by concrete as well.

4) Expansion Joint

a. In case of a timber deck, generally there's no expansion joint but a gap of several centimeters wide is given between parapet and timber deck. Water and mud fall down from the gap, and they are deposited around the bearing so deeply as to conceal the bearing totally.

b. In case of a concrete deck, generally expansion joints are installed at both ends of the deck, but their purpose is just to cover and protect the edge of the concrete deck, and not to support a wheel load when it is exactly on the gap. The disadvantage of the expansion joints in the latter type is that when the gap is narrow, then mud and stone stay between the gap, and when it is wide, then wheel load gives an impact to the edge of the concrete and does harm.

c. The expansion joints usually are not equipped with gutter which may process water from the deck surface.

d. Many expansion joints were found not functioning normally because they catch heavy mud and many stones in the gap.

e. And also many steel expansion joints are found that the face plates have been worn out or corroded, and in some case part of the face plate are lost.

5) Hand Rail

a. When a deck is made of timber, then the hand rails of the bridge are of timber as well. When a deck is of concrete, then the hand rails are of steel or concrete.

b. Steel hand rails are utilized more than the concrete one these days in order to reduce the dead weight.

c. The materials for the steel hand rails is usually steel flat bars of only 3 to 4 millimeter thick. This type of hand rails is not strong enough to resist a collision load of vehicles, but aims to prevent pedestrians from falling down.

d. Wrong structure of steel hand rail were found sometimes during the detail inspection, that is, a post of hand rail was fixed at an abutment but the next post was fixed at the end of bridge deck, this will result in unnecessary tensioning through the top rail because the rail connects these neighboring posts.

e. It was often found that hand rails were not properly maintained even if they were seriously corroded, or heavily deformed due to collision.

6) Drainage System

a. For a timber deck, there's no need a drainage system at all for the reason described in (3) Deck Slab.

b. For a concrete deck, short pipes of usually 50 cm long with diameter of approximately 5 to 7 cm are set up at both sides of road way penetrating the concrete slab. These pipes work as catch basin and lead water from bridge surface down.

7) Others

a. Corrosion represents most of the damages on steel structure. When rust appears only on the surface of the steel, repainting will be sufficient to protect it against the further corrosion. On the other hand, the corrosion is so deep that the cross-section of the steel member decreases, then the other remedy by which it is compensated like patching of a steel plate.

b. Hand rails are exposed directly to the atmosphere, thus they tends to be corroded severely and quickly. They have to be maintained well, but in case that their damage is so serious they have to be replaced.

c. Expansion joints are exposed not only to the atmosphere but to the rubbing by tires of vehicles. The condition of the expansion joints affect the damage of deck, and so they have to be replaced.

(2) Sample Strengthening Design

As defined before in this report, reconstruction means to replace a whole bridge by a new structure to restore a bridge to the service level. There is a third way of rehabilitation of a bridge, that is strengthening, where the existing load carrying capacity and/or geometry of the bridge are improved. Although strengthening is out of scope of the study, some ideas of how to strengthen a bridge is being described hereafter taking Granallas Bridge as a sample, which consists of two span simply supported steel girders with timber deck. There was no signpost showing the load capacity, and neither the structural analysis nor the drawings of the bridge of those days were found.

The calculation refers briefly to:

- the penetration dye test and measurement of thickness of the existing steel plates of the structural elements conducted at the site of Granallas Bridge,
- analytical estimation of the present load carrying capacity of the bridge based on the data resulted from the measurement as mentioned above, and

- strengthening and improvement by replacing the timber deck by concrete slab deck to compose the steel girders with the concrete deck as a composite girder.

The result of the calculation shows that:

- the bridge has at present the load carrying capacity of equivalent HS10-44 through a simple estimation, and
- in order to replace the timber deck by concrete as shown in **Figure 3.10**, lower flange plates have to be reinforced by thick steel cover plates, because the neutral axis goes up higher and then stronger tension stress works in the lower flange after the two materials are composed.

The calculation process is given in **Appendix II-8 (Volume 4/8)**.

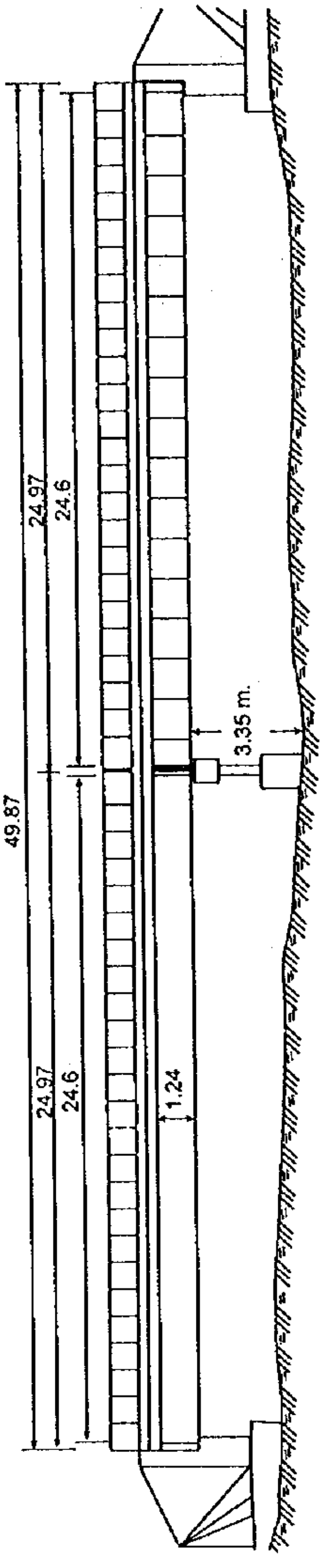
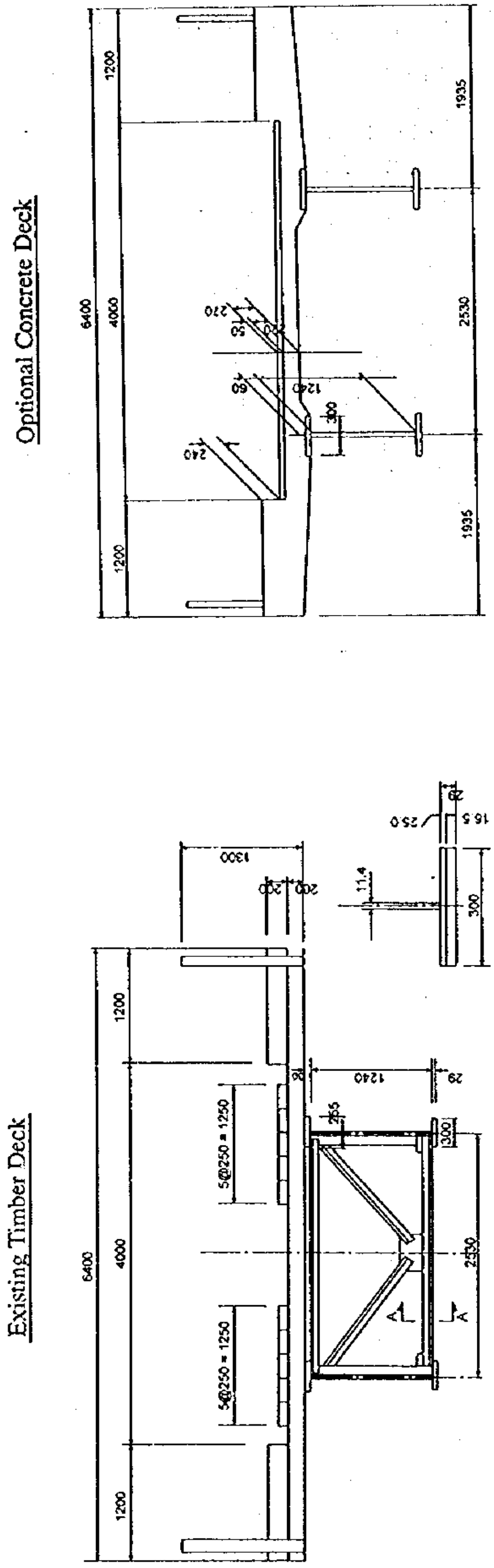


Figure 3.9 Sample Strengthening Design for Granallas Bridge


Optional Concrete Deck

Existing Timber Deck

Figure 3.10 Sample Strengthening Design for Granallas Bridge

CHAPTER 4

STANDARD BRIDGE CADD SYSTEM

CHAPTER 4 STANDARD BRIDGE CADD PROGRAM

4.1 CURRENT COMPUTER USE IN CHILE

In August, 1995, 'Windows 95' was launched in USA and as early as a month later its Spanish version was put on market in Chile. Since then, the combination of the IBM-compatible computers (DOS/V) and the operation system(OS) of Windows 95 has become the standard use of personal computer(PC)s in the world and so in Chile.

In Chile, the DOS/V PCs are dominant: the makers available are IBM, COMPAC, Acer, EPSON, HP, etc. and the most are pre-installed with Windows 95 Spanish version. The Macintosh OS machines are also found in Santiago but very few. The world common application programs such as MS-office and Lotus Super-offices are widely used in Chile, too.

As regards the programming language, on the base of Windows 95, 'Visual Basic 4.0' has begun to be used and take the place of 'Basic' in Chile. For the drawing program, 'Auto-CAD R12 (MS-DOS) for Spanish' and 'R13 (Windows) for English' are popularly used.

4.2 CURRENT BRIDGE DESIGN AND CONSTRUCTION PRACTICES IN CHILE

4.2.1 Design Practice

(1) Design Criteria

1) Design Standards: Fundamentally the MOP designs bridges in accordance with the AASHTO(American Association of State Highway and Transportation Officials) standards.

2) Design Vehicle Load: The MOP applies:

   - 120 % of the AASHTO's HS20-44 load for major highways and trunk roads, and
   - 100 % of the AASHTO's HS20-44 load for rural roads.

3) Earthquake: The MOP applies the earthquake coefficient of 0.15 all over the country.

4) According to an experienced bridge consultant who the Study Team interviewed in Santiago:

   - The other climate-related loads (such as wind load, snow load and temperature change), and river flow pressure are not usually taken account of for design of small-scale rural bridges. These loads are considered individually only for design of large bridges.
   - There is no particular standards for bridge design method in MOP, but service load design method is popular among the bridge engineers of Chile and strength design method is rarely used.

5) For the freeboard of bridge beams above the high-water-level, 1.0 m has been conventionally taken as a minimum value.

6) Footings are usually designed to be embedded not less than 1.0 m deep into the hard riverbed which will not be scoured.

(2) Bridge Types

1) For 10 to 25 m span range; many RC(Reinforced Concrete) cast-insitu beams, applying cantilever method for longer spans, had been constructed before, but nowadays they have been taken the place by pre-cast PC (Prestressed Concrete) beams.

2) Regarding PC beams:

   - PC beams are generally economical compared to steel beams for short to medium span bridges in Chile.

- For 15 to 25 m span range; pre-tensioned PC beams are most often used for advantage in cost and construction.
- For 25 to 35 m span range; post-tensioned PC beams are usually used depending on site condition and for the transportation difficulty of pre-tensioned beams.

3) Regarding steel beams:

- For over 35 up to 50 m span range; welded steel plate girders become competitive to PC beams under certain site condition such as difficult access of heavy equipment.
- Even for the span range less 35 m; steel girders are sometimes used for special reasons such as skewed or curved designs.

4.2.2 Construction Practice

(1) Construction Methods

1) Factory-made bridge members

- Precast concrete members are widely used in Chile for from drain ditches to building members. Pre-tensioned PC members are produced in several factories around Santiago mostly of electric poles and building members but a little of bridge beams.
- Only two or three steel fabricators in Santiago manufactures steel bridge beams on order basis. Because the steel bridge market is so small in Chile, its design and fabrication remain just as they have been: (1) rivets are still used in regions, (2) field welded splices are designed although high strength bolts are available in Chile, (3) they prefer manufacturing steel shapes by welding steel plates rather than using rolled steel shapes.

2) Beam erection work

- For short to medium span bridges if site is accessible, traveling crane is most often used together with temporary stages. The 50 to 80 ton class crane is most available in Chile, but the class over 150 ton is difficult to procure even in Santiago.
- Where access is difficult but having enough space behind abutment, launching girder is used. Post-tensioned PC beams around up to 35 m are usually erected by this method.

(2) Construction Materials

- Cement is produced domestically here and the quantity is enough for domestic use.
- Chile is a treasure house having enough aggregate both in quality and quantity.
- Reinforcing bars are produced domestically except some import products.
- All prestressing steel is imported and structural steel is partially imported.

4.3 STANDARD BRIDGE TYPES AND DESIGN CONDITIONS

4.3.1 Road Hierarchy, Standard Width and Geometry

(1) Road Hierarchy : Rural road.
(2) Geometry : Horizontally straight and Vertically level.
(3) Number of Lanes : One or two lanes with sidewalks both sides.
(4) Standard Width :

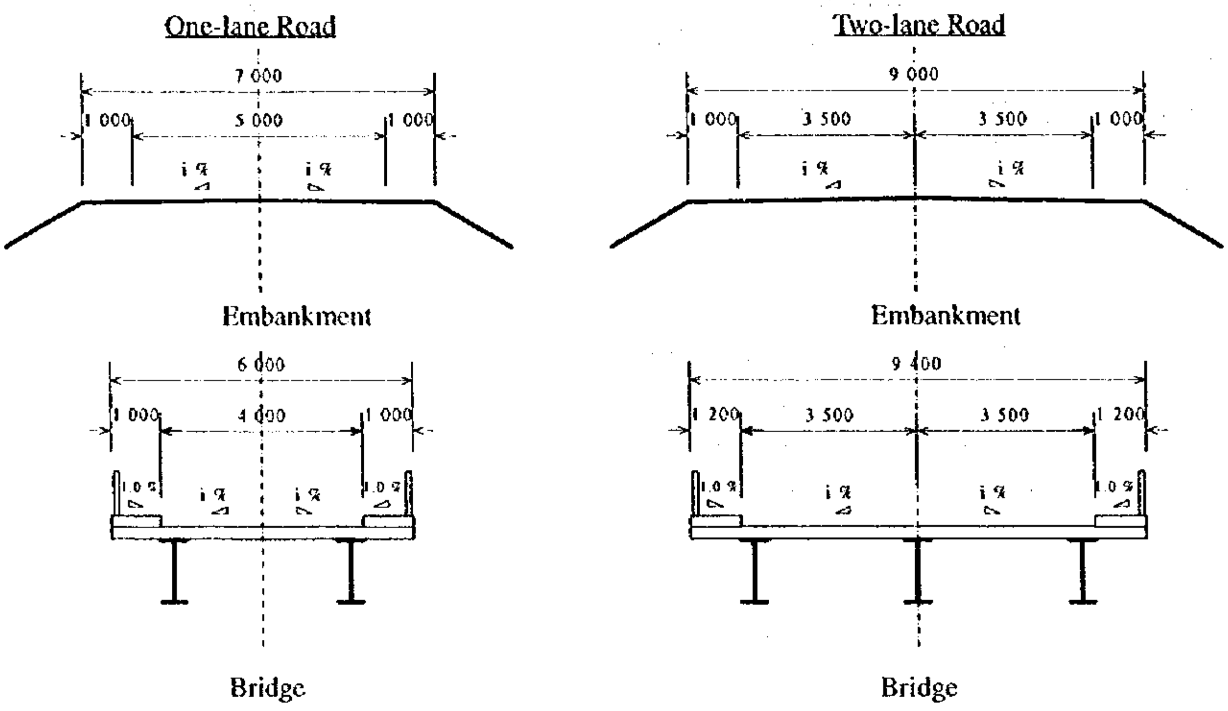


Figure 4.1 Standard Bridge Width

4.3.2 Design Conditions

(1) Design Standards : AASHTO 1992
(2) Design Method : Service load (allowable working stress) design
(3) Design Loads :
- Design Vehicle Load : 100% of HS20-44
- Earthquake : Acceleration coefficient, A = 0.15
- Other Loads : based on AASHTO.

(4) Material Properties:
- Concrete Strength : Reinforced concrete : H-30 $f_c' = 250$ kg/cm^2
  Prestressed concrete : H-40 $f_c' = 350$ kg/cm^2
- Reinforcement : A63-42H fy = 4200 kg/cm^2
  A44-28H fy = 2800 kg/cm^2

- Prestressing Steel : ASTM A416 Stress-relieved Seven-wire Strand.
- Structural Steel : based on ASTM or AASHTO.
- Elastomeric Bearing : based on ASTM or AASHTO.

4.3.3 Standard Bridge Types

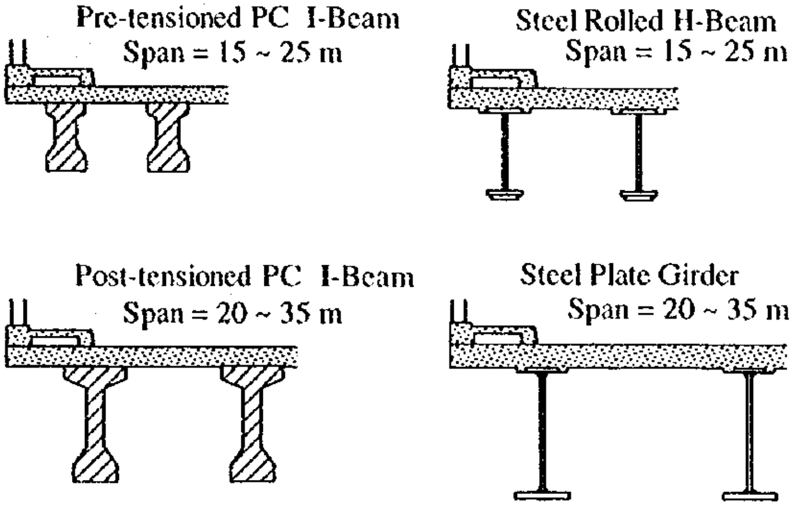


Figure 4.2 Standard Bridge Type (Superstructure)

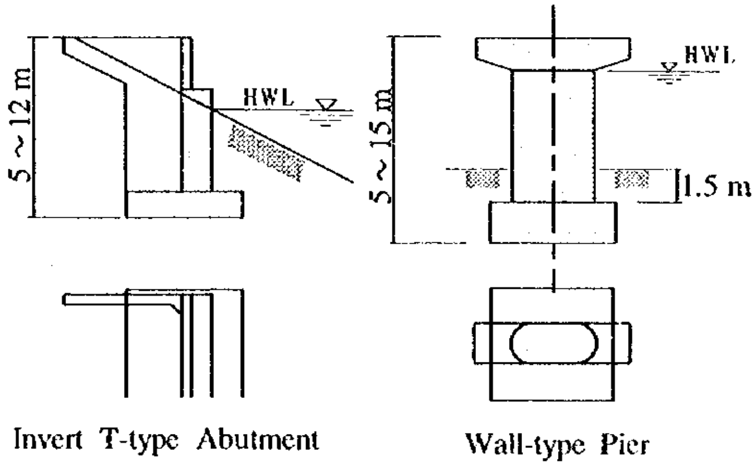


Figure 4.3 Standard Bridge Type (Substructure)

4.4 PROPOSED CADD SYSTEM

4.4.1 Outline of CADD System

The outline of the whole CADD program is illustrated in **Figure 4.4**. The outline of each CADD program for superstructure (steel beam and PC beam) and substructure (abutment and pier) are shown in **Figure 4.5 through Figure 4.8**.

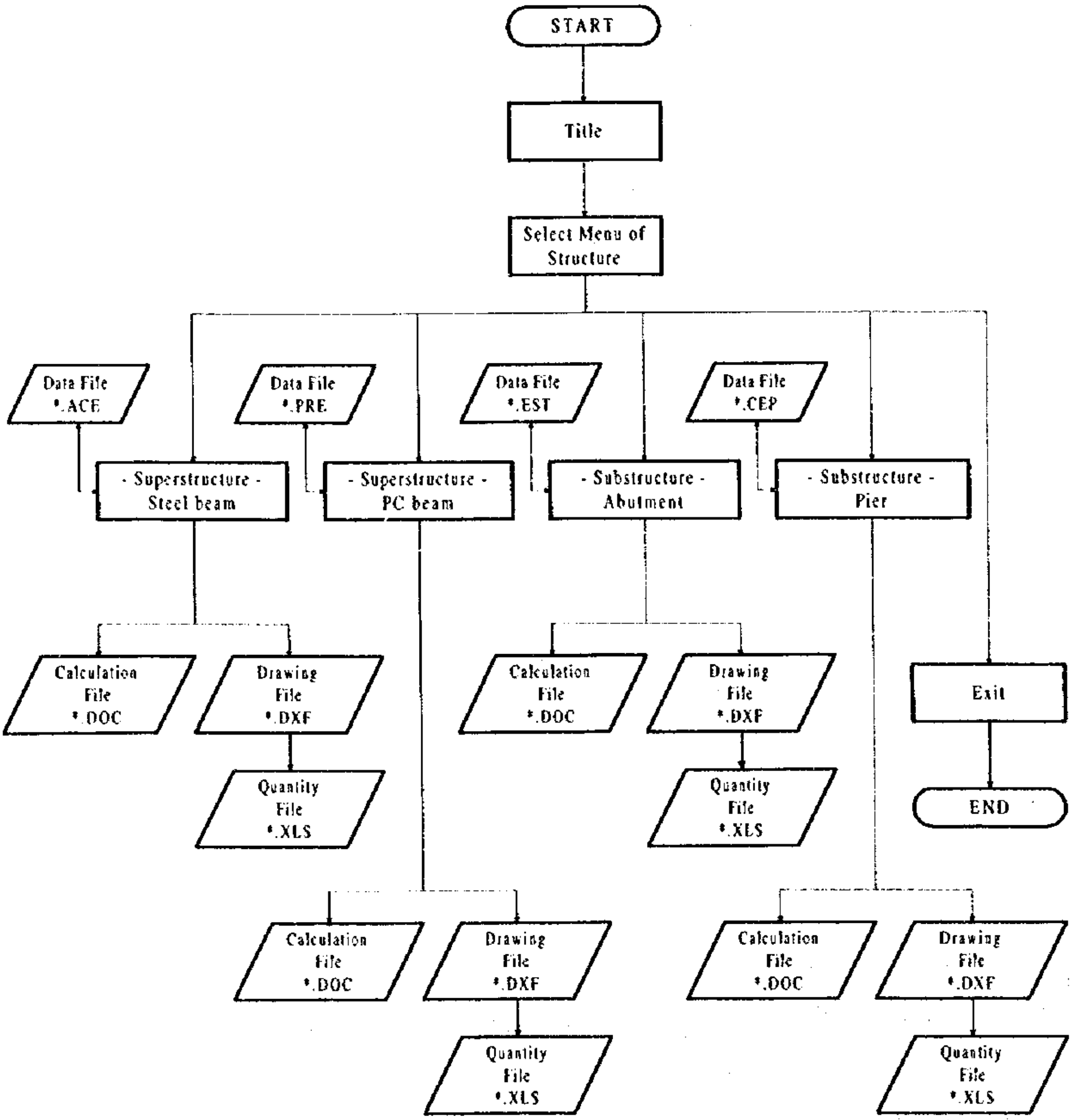


Figure 4.4 Outline of Whole CADD Program

Superstructure - Steel beam

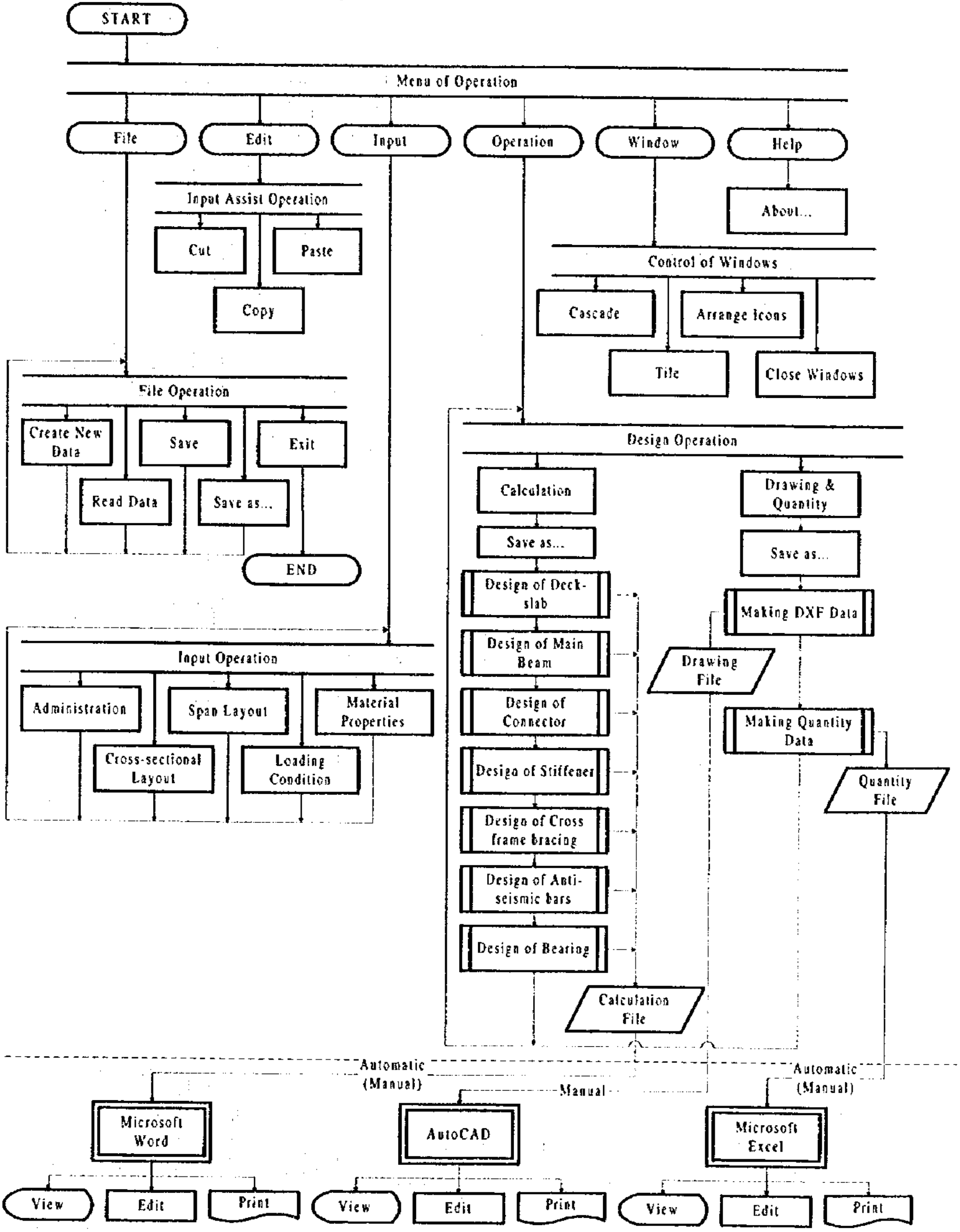


Figure 4.5 Outline of CADD Program (Steel Beam)

Superstructure - PC beam

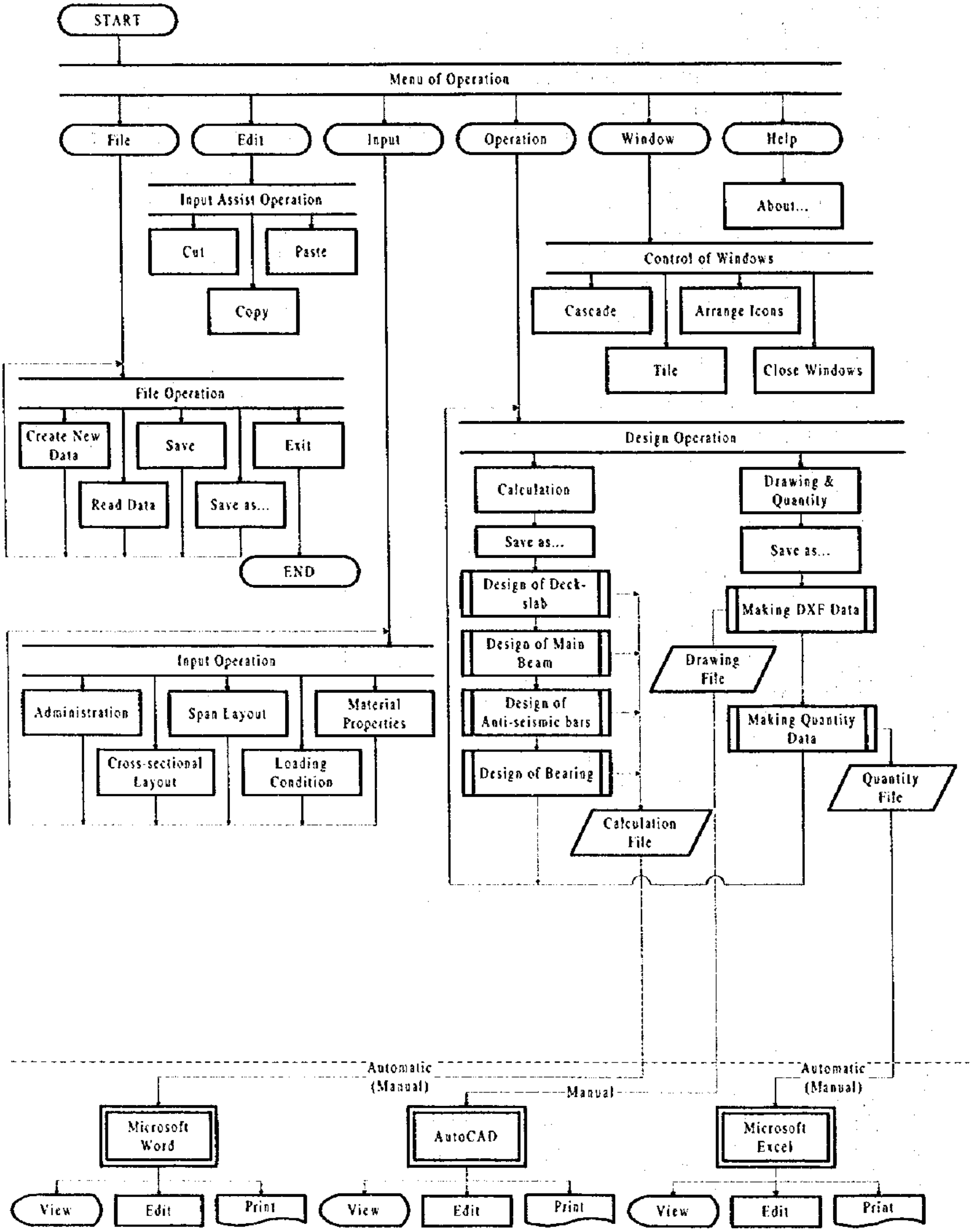


Figure 4.6 Outline of CADD Program (PC Beam)

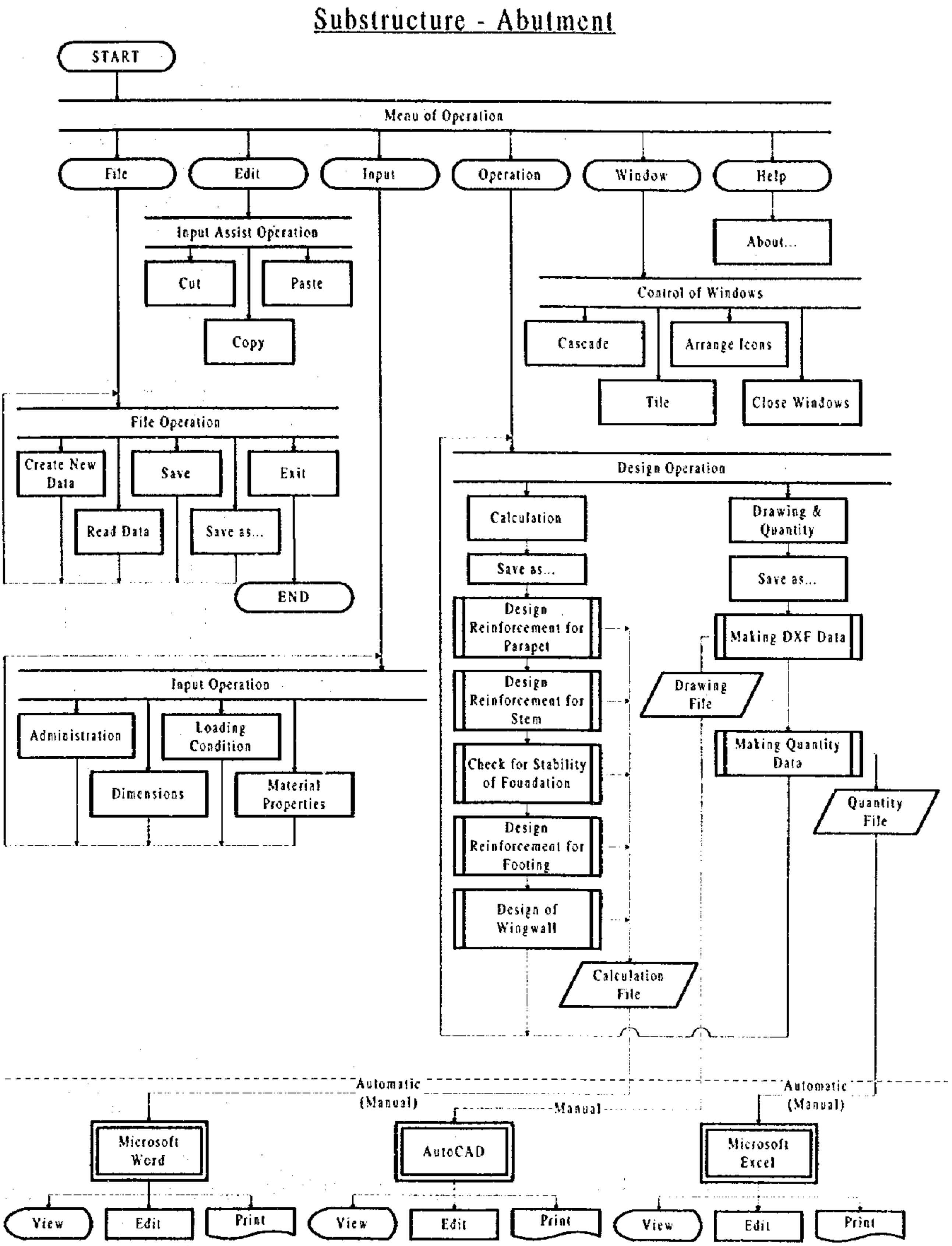


Figure 4.7 Outline of CADD Program (Abutment)

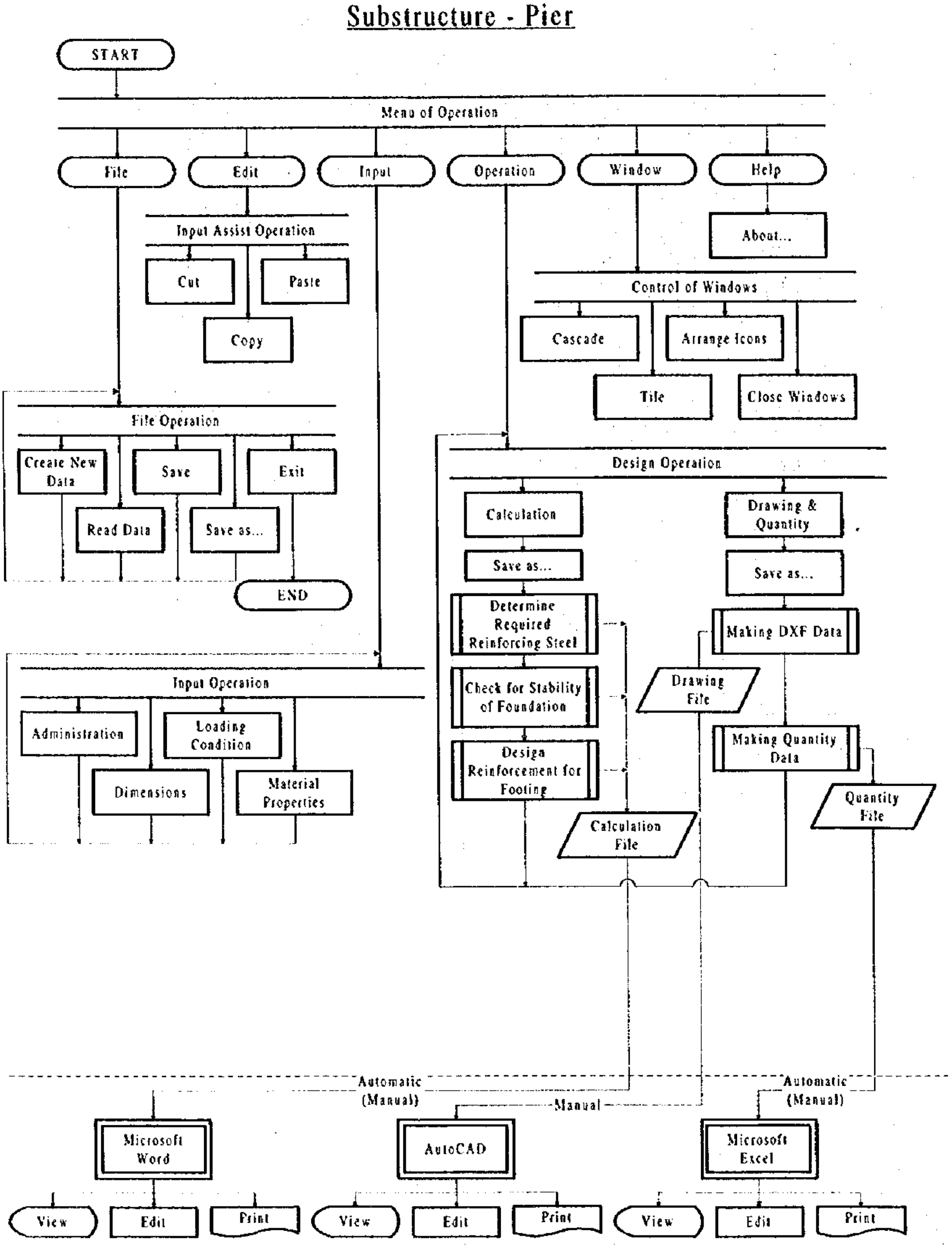


Figure 4.8 Outline of CADD Program (Pier)

4.4.2 Program Development

(1) Scope of CADD Program

The scope and parameters of the CADD program are as follows:

- Bridge types: Superstructure: Steel beam and PC beam.
  Substructure : Abutment and Pier (only direct foundation).
- Number of lanes: One and two lanes.
- Bridge width: 4.0 m for one lane and 7.0 m for two lanes, that can be changed.
- Cross-fall: Footpath: Fixed to 1.0%.
  Roadway: 1.5% or 2.0%.
- Concrete strength: Can be selected H-30 or H-40, but it can be changed.
- Reinforcement: Can be selected A63-42H or A44-28H, but it can be changed.
- Concrete cover: Standard covers are shown but can be changed.
  Superstructure: deck slab: 3 cm, precast beam: 2.5 cm,
  insitu member: 3 cm
  Substructure: members in atmosphere: 4 cm,
  members under earth or water: 7 cm
- Prestressing steel: Only ASTM A416 stress-relieved seven wire strand .
- Structural steel: A52-34ES, A42-27ES, or A37-24ES.
- Geometry: Cross-section of bridge structure shall be symmetrical.
- Span length: 10 to 40 m.
- Number of beams: 2 to 6 beams. Size and spacing of beams shall be uniform.
- End cross-beam: Reinforced concrete.
- Intermediate cross-beam: An intermediate cross beam for PC beam.
- Sway bracing: Spacing shall be less than 6 m for steel beam.
- Bearings: Elastomeric (rubber) bearings.
- Height of substructure: 5 to 15 meters.

(2) Input and Output Language

The language for the CADD program shall be Spanish. The following special Spanish characters can be input through the Japanese keyboard by changing the keyboard property of Windows 95:

Characters	Key Operation
[á , é , ú , í , ó]	[:] + [a , e , u , i ,o]
[Á, É, Ú, Í , Ó]	[:] + [A, E, U, I , O]
[ñ , Ñ]	[;], [Shift] + [;]
[¡ , ¿]	[^], [Shift] + [^]

(3) Utilization of Windows 95's Functions

1) Output by OLE-Function

The OLE (object linking and embedding)-function equipped in 'Visual Basic' was utilized. By this function, the design results(outputs) of the program operation can be displayed and printed out on the form of Word and Excel.

2) Parallel Operation by MDI-Function

The MDI(multi-document interface)-function of Windows 95 allows the parallel operation of several documents on the different windows of display and they are controlled under each home window. With this function, the CADD program is divided into four sub-programs (Steel Beam, PC Beam, Abutment, and Pier) and each is installed in separate home window.

3) File Management by Filename Extension

All input and output files are distinguished by the following extension codes:

· Input Data Files:	Steel Beam	*.ACR
	PC Beam	*.PST
	Abutment	*.EST
	Pier	*.CEP
· Output Data Files:	Design	*.DOC(MS-Word)
	Drawing	*.DXF(Auto-CAD)
	Quantity	*.XLS(MS-Excel)

4.4.3 Input and Output Formats

(1) Design Calculation Formats

The design calculation formats listed below are shown in Program Operation Manual.

- Select Menu of Structure
- Superstructure (Steel beam)
- Superstructure (PC beam)

- Substructure (Abutment)
- Substructure (Pier)

(2) Drawing Formats

The drawing formats listed below are shown in Standard Bridge Drawings.

1) Superstructure(Steel beam)
    - Reinforcement arrangement of deck slab and end cross beam
    - Details of main beam
    - Details of sway bracing and lateral bracing

2) Superstructure(PC beam)
    - Reinforcement arrangement of deck slab and end cross beam
    - Reinforcement arrangement of main beam

3) Substructure(Abutment)
    - Reinforcement arrangement of stem wall and footing
    - Reinforcement arrangement of wing wall

4) Substructure(Pier)
    - Reinforcement arrangement of wall and footing

(3) Summary Tables of Quantities

The summary tables of quantity listed below are shown in Standard Bridge Drawings too.

- Steel beam
- PC beam
- Abutment
- Pier
- Reinforcement table
- Structural steel table

4.4.4 Drawing Specifications

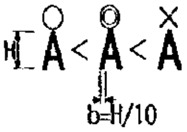
(1) Color and Thickness of Lines and Letters

Shown in the table below are kinds of color and thickness for the lines and letters used in drawings.

Table 4.1 Color and Thickness of Lines and Letters

Color of Line	Thickness of Line (mm)
Red	0.18
Yellow	0.80
Green	0.35
Blue	0.50
White	0.20

Thickness of a letter line shall be less than one tenth of height of a letter.



Types of lines used in drawings are shown in the table below.

Table 4.2 Types of Lines

Type of Line	Sample
Solid line	————————
Dotted line	…………………………
Dash and dotted line	-·-·-·-·-·-·-·-·-

(2) Size of Drawing

Drawing size and a drawing title are shown in **Figure 4.9**.

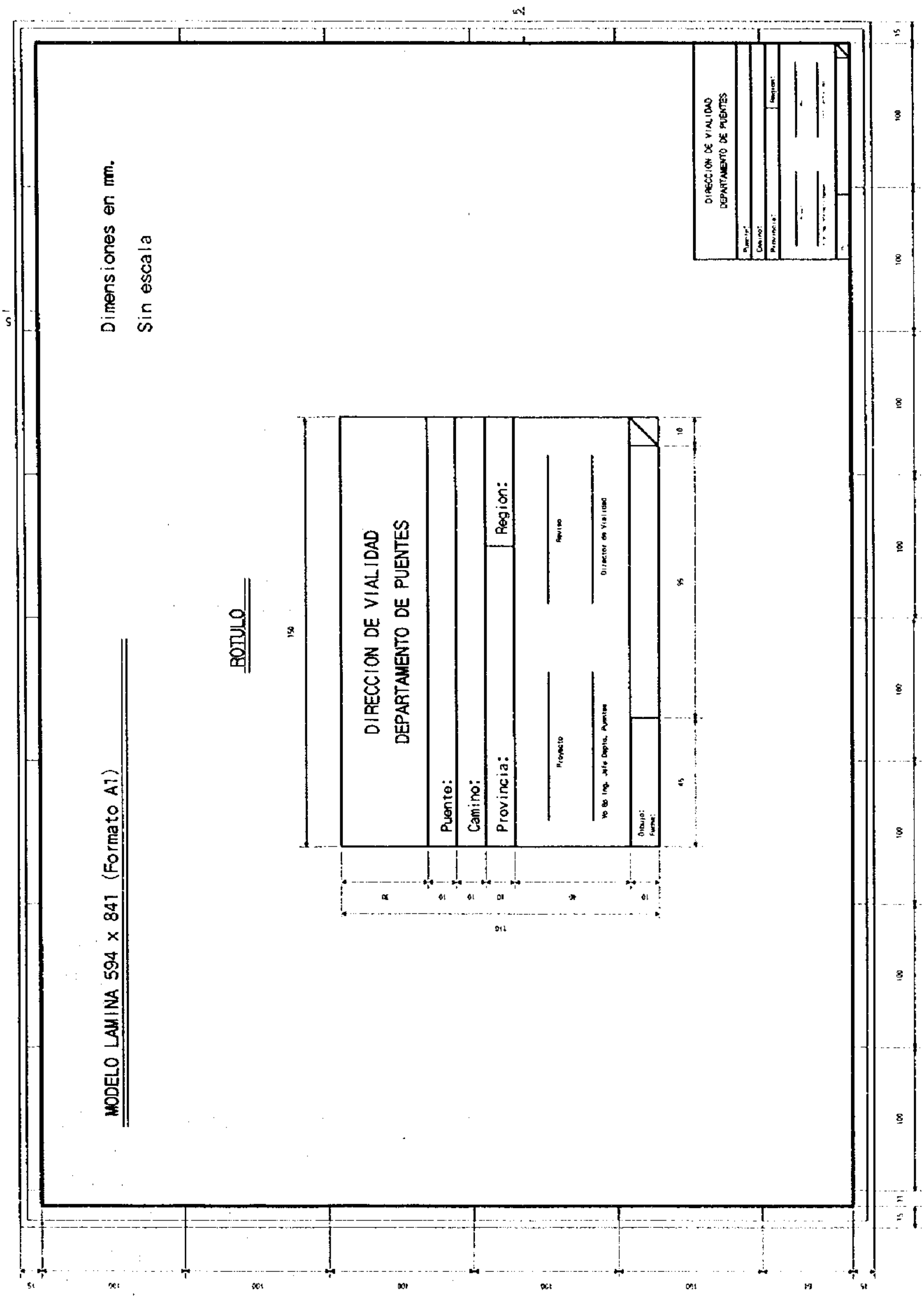
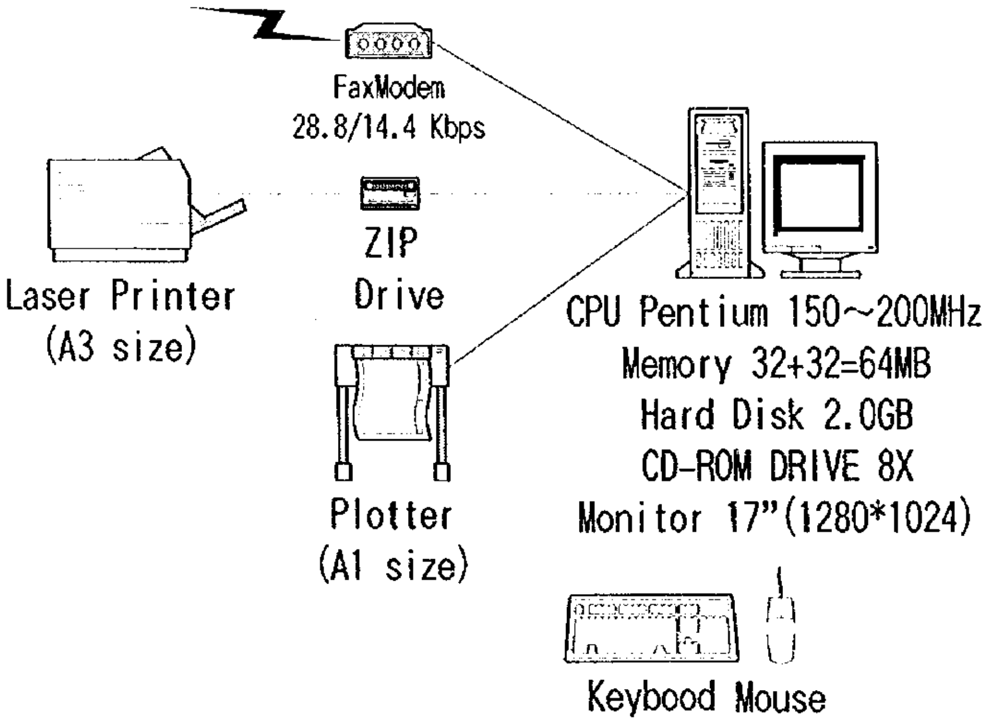


Figure 4.9 Drawing Size and Title Block

4.5 SELECTION OF COMPUTER HARD- AND SOFT-WARE

Hardware



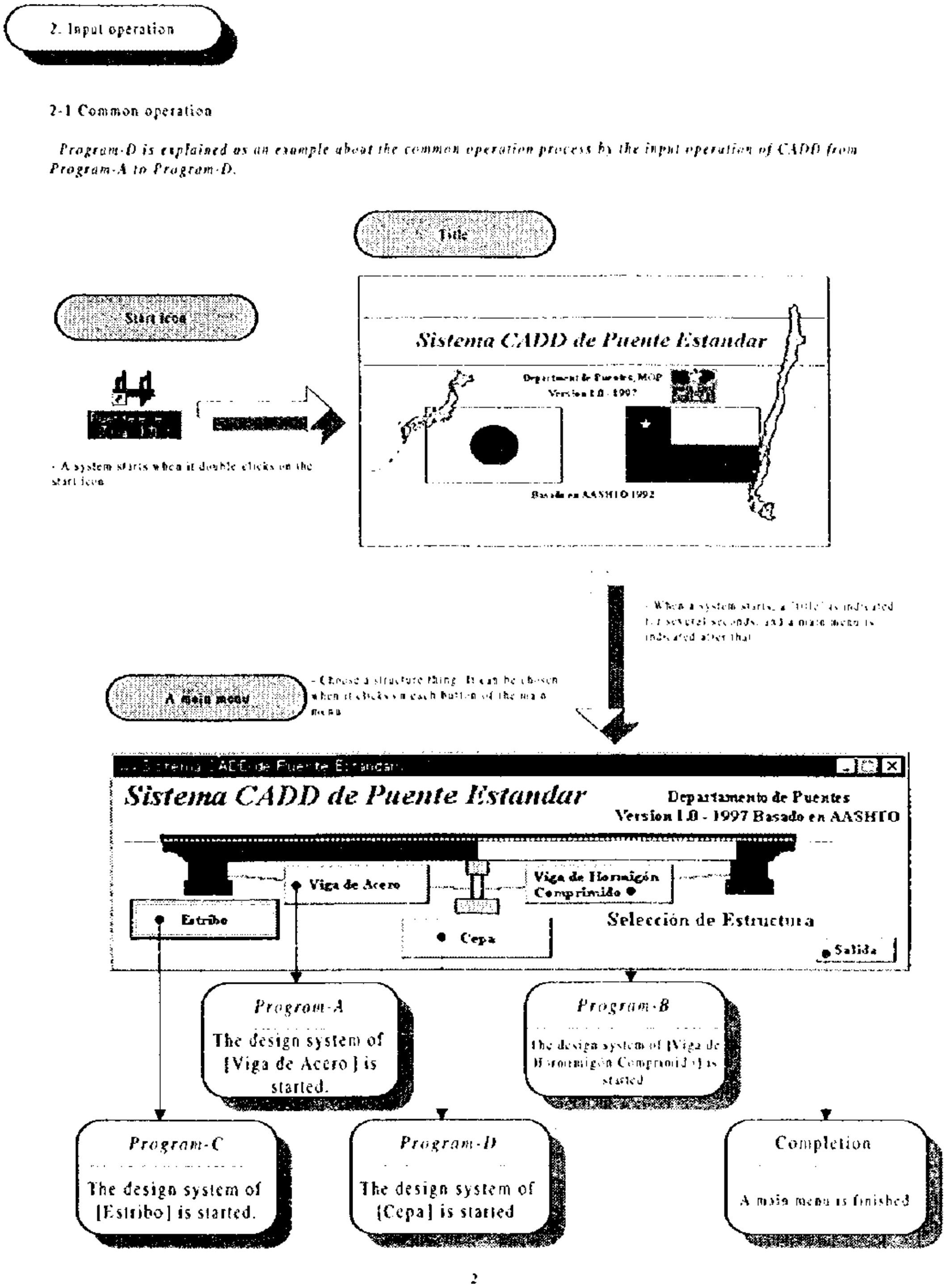
Software

MS-Windows95
MS-Visual Basic4.0 Enterprise Edition for Windows95(CD-ROM)
MS-Office PRO for Windows95(Word,Excel,Access,etc) (CD-ROM)
AutoCAD R13 for Windows95 (CD-ROM)

Figure 4.10 Computer Hard- and Soft-ware for CADD Program

4.6 DEVELOPED CADD PROGRAMS

The details of the developed CADD programs are explained in "CADD Program Operation Manual". A part of input operation is shown in **Figure 4.11**.



2. Input operation

2-1 Common operation

Program-D is explained as an example about the common operation process by the input operation of CADD from Program-A to Program-D.

- A system starts when it double clicks on the start icon.

- When a system starts, a "Title" is indicated for several seconds, and a main menu is indicated after that.

- Choose a structure thing. It can be chosen when it clicks on each button of the main menu.

Program-A
The design system of [Viga de Acero] is started.

Program-B
The design system of [Viga de Hormigón Comprimido] is started.

Program-C
The design system of [Estribo] is started.

Program-D
The design system of [Cepa] is started.

Completion
A main menu is finished.

2

Figure 4.11 Input Operation of CADD Program

4.7 PREPARATION OF STANDARD BRIDGE DRAWINGS

4.7.1 Design Conditions

(1) Design Method: Allowable Stress

(2) Loads

1) Dead Loads
Plane Concrete : $W_c = 2.30$ t/m^3
Reinforced Concrete : $\gamma_C = 2.50$ t/m^3
Steel : $\gamma = 7.85$ t/m^3
Pavement : $\gamma = 2.30$ t/m^3
Soil : $\gamma_S = 1.80$ t/m^3

2) Horizontal Force of Railing : $W_B = 0.050$ t/m, $W_L = 0.020$ t/m, h = 1.100 m

3) Sidewalk Live Load

$Lc \leq 7.6$ m → $W_P = 0.415$ t/m^2 Where → Lc = Span Length
7.6 m $< Lc \leq 30.5$m → $W_P = 0.293$ t/m^2 30.5 m $< Lc$

$$Wp = \left(147 + \frac{4464}{Lc}\right) \times \left(\frac{16.76 - (Sw - 0.25)}{15.24}\right) \times \frac{1}{1000}$$

※ In case of $W_p > 0.293$ → $W_P = 0.293$ t/m^2 Where → Sw = Sidewalk width

4) Live Load : HS20-44(100%)
5) Wind : $W_V = 0.244$ t/m^2
6) Earthquake : A = 0.15 , Category B by Single Mode Spectral Method

(3) Materials

Slab Concrete : H-30, $f_c' = 250$ kg/cm^2, $E_c = 2.50 \times 10^5$ kg/cm^2
Beam Concrete : H-40, $f_c' = 350$ kg/cm^2, $E_c = 3.01 \times 10^5$ kg/cm^2
Reinforcing Bar : A63-42H, $f_y = 4200$ kg/cm^2, $f_{sa} = 1690$ kg/cm^2, $E_s = 2.10 \times 10^6$ kg/cm^2
Concrete Cover : 3.0 cm (Lateral Beam 2.5cm)
Anchor Bar : A44-28H , $f_y = 2800$ kg/cm^2, $f_s = 1400$ kg/cm^2
Steel : A52-34ES, $f_y = 3400$ kg/cm^2, $f_{sa} = 1870$ kg/cm^2
Bolt : ASTM A490, $f_{sa} = 1400$ kg/cm^2, ϕ =22mm
PC Cable : 1-12.7 (Pre-tensioned) , 7-12.7 (Post-tensioned)
$f_{pu} = 18980$ kg/cm^2, $f_{py} = 16100$ kg/cm^2, $E_s = 1.97 \times 10^5$ kg/cm^2

4.7.2 Design Parameters for Standard Bridges

The following design parameters are attached:

Table 4.3	For steel beam – one lane
Table 4.4	For steel beam – two lanes
Table 4.5	For PC beam – one lane
Table 4.6	For PC beam – two lanes

After the tables, some samples of standard bridge drawings are presented. The full set of the standard drawings are in **Volume 8/8.**

Table 4.3 Design Parameter of Steel Beam for 1-Lane

(1-Lane)

INDEX	L_V(m)	L_C(m)	H / D	t_w	Ls	b_l	t_l	b_h	t_h	b_r	t_r	R. Bar	Main Gird		H. Stiff.	Splice $n_W \times m_W$	$n_U \times m_U$ $n_L \times m_L$	x(stud)	Pe	Pc	S. Bracing	A.S.B.	Area	Vc	S. Weight	W_R	W/A W_R/V_C	Rd(t) RL(t)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1-SRH-L14_n3	14.500	14.000	0.800	14	14.800	300	16	300	16			φ16@150	3	2.400				4.000	150	300	C300×100×10	φ22n2	87.00		7904.71		90.86	13.521
												φ12@125												30.91		6181.61	199.99	18.956
1-SRH-L16_n3	16.500	16.000	0.800	14	10.600	300	16	300	16	250	10	φ16@150	3	2.400				4.700	150	300	C300×100×10	φ22n2	99.00		9487.37		95.83	15.421
					3.100	300	16	300	16			φ12@125												34.72		6938.31	199.84	19.396
1-SRH-L18_n3	18.500	18.000	0.800	14	12.000	300	16	300	16	250	13	φ16@150	3	2.400				5.100	150	300	C300×100×10	φ22n2	111.00		10740.35		96.76	17.233
					3.400	300	16	300	16			φ12@125												38.58		7695.02	199.46	19.707
1-SRH-L20_n3	20.600	20.000	0.900	16	13.200	350	18	350	18	300	10	φ16@150	3	2.400				7.800	200	400	C300×100×10	φ22n2	123.60		15116.53		122.30	19.670
					3.800	350	18	350	18			φ12@125												42.94		8524.36	198.52	19.929
1-SRH-L22_n3	22.600	22.000	0.900	16	14.600	350	18	350	18	300	14	φ16@150	3	2.400				8.600	200	400	C300×100×10	φ22n2	135.60		16872.61		124.43	21.585
					4.100	350	18	350	18			φ12@125												46.81		9324.24	199.19	20.089
1-SRH-L24_n3	24.600	24.000	1.000	18	15.800	350	20	350	20	300	12	φ16@150	3	2.400				8.600	200	400	C300×100×10	φ22n2	147.60		20862.36		141.34	23.930
					4.500	350	20	350	20			φ12@125												50.89		10094.09	198.35	20.206
1-SBI-L26_n2	26.600	26.000		10	17.200	360	12	440	36			φ16@125	2	3.000		5.850	2×2	8.000	200	400	L-80×80×8	φ25n4	159.60		14865.92		93.14	37.404
			1.300		4.800	360	10	360	16			φ16@175					6×2							55.87		12841.33	229.84	23.715
1-SBI-L28_n2	28.600	28.000		10	18.400	360	14	460	30			φ16@125	2	3.000		6.300	2×2	5.800	200	400	L-80×80×8	φ25n4	171.60		15955.00		92.98	40.183
			1.400		5.200	360	10	360	18			φ16@175				2×14	6×2							59.98		13772.99	229.63	23.784
1-SBI-L30_n2	30.700	30.000		10	19.800	360	15	500	29			φ16@125	2	3.000	300	6.750	3×2	6.400	200	400	L-80×80×8	φ25n4	184.20		18799.32		102.06	43.379
			1.500		5.500	360	10	360	19			φ16@175			120×16	2×15	7×2							64.31		14751.41	229.38	23.831
1-SBI-L32_n2	32.700	32.000		10	17.400	360	17	520	30			φ16@125	2	3.000	320	8.575	3×2	7.000	200	400	L-80×80×8	φ25n4	196.20		20816.80		106.10	46.570
			1.600		3.800	360	10	440	23						120×16	2×17												
					3.900	360	10	360	10			φ16@175					7×2							68.45		15676.01	229.01	23.862
1-SBI-L34_n2	34.700	34.000		10	18.400	360	19	560	29			φ16@125	2	3.000	340	9.163	3×2	7.000	200	400	L-80×80×8	φ28n4	208.20		23203.12		111.45	49.742
			1.700		4.100	360	10	460	23						120×16	2×18												
					4.100	360	10	360	10			φ16@175					7×2							72.56		16633.84	229.24	23.880
1-SBI-L36_n2	36.700	36.000		10	19.400	380	20	580	29			φ16@125	2	3.000	360	9.750	4×2	4.200	200	400	L-80×80×8	φ28n4	220.20		25507.09		115.84	52.948
			1.800		4.300	360	10	480	24						120×16	2×18												
					4.400	360	10	360	11			φ16@175					9×2							76.71		17559.16	228.90	23.888

Table 4.4 Design Parameter of Steel Beam for 2-Lanes

(2-Lane)

INDEX	L_V(m)	L_C(m)	H / D	t_w	Ls	b_f	t_f	b_h	t_h	b_c	t_c	R. Bar	Main Gird.		H. Stiff.	Splice $n_W \times m_W$	$n_U \times m_U$ $n_L \times m_L$	x(stud)	Pe	Pc	S. Bracing	A.S.B.	Area	Vc	S. Weight	W_R	W/A W_R/Vc	Rd(t) RL(t)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
2-SRH-L14-n4	14.500	14.000	0.800	14	14.800	300	16	300	16			φ16@150	4	2.400				5.500	140	300	C300×100×10	φ22n2	131.60		10664.04		81.03	15.243
												φ12@125												47.36		9001.63	190.07	24.033
2-SRH-L16-n4	16.500	16.000	0.800	14	10.600	300	16	300	16	250	10	φ16@150	4	2.400				6.500	140	300	C300×100×10	φ22n2	150.40		12774.26		84.94	17.364
					3.100	300	16	300	16			φ12@125												53.21		10098.13	189.78	24.592
2-SRH-L18-n4	18.500	18.000	0.800	14	12.000	300	16	300	16	250	18	φ16@150	4	2.400				7.350	130	300	C300×100×10	φ22n2	169.20		14915.87		88.16	19.489
					3.400	300	16	300	16			φ12@125												59.12		11194.62	189.35	24.985
2-SRH-L20-n4	20.600	20.000	0.900	16	13.200	350	18	350	18	300	10	φ16@150	4	2.400				7.450	150	300	C300×100×10	φ22n2	188.00		20343.79		108.21	22.082
					3.800	350	18	350	18			φ12@125												65.78		12398.03	188.48	25.267
2-SRH-L22-n4	22.600	22.000	0.900	16	14.600	350	18	350	18	300	19	φ16@150	4	2.400				8.450	150	300	C300×100×10	φ22n2	206.80		23372.89		113.02	24.353
					4.100	350	18	350	18			φ12@125												71.70		13556.74	189.08	25.471
2-SRH-L24-n4	24.600	24.000	1.000	18	15.800	350	20	350	20	300	17	φ16@150	4	2.400				8.250	150	300	C300×100×10	φ22n2	225.60		28750.83		127.44	26.945
					4.500	350	20	350	20			φ12@125												77.95		14672.94	188.24	25.618
2-SBI-L26-n3	26.600	26.000		10	17.200	400	20	440	36			φ16@125	3	3.200		5.850	3×2	8.500	160	300	L-80×80×8	φ25n4	244.40		25109.78		102.74	38.883
			1.300		4.800	360	10	380	20			φ16@175				2×12	7×2							87.10		19245.02	220.95	34.298
2-SBI-L28-n3	28.600	28.000		10	18.400	400	20	460	36			φ16@125	3	3.200		6.300	4×2	8.000	170	300	L-80×80×8	φ25n4	263.20		27884.87		105.95	42.003
			1.400		5.200	360	10	400	20			φ16@175				2×13	7×2							93.55		20639.53	220.63	34.398
2-SBI-L30-n3	30.700	30.000		10	19.800	400	20	500	35			φ16@125	3	3.200		6.750	4×2	7.650	180	300	L-80×80×8	φ25n4	282.00		31044.12		110.09	45.316
			1.500		5.500	360	10	400	21			φ16@175				2×13	7×2							100.32		22098.84	220.28	34.467
2-SBI-L32-n3	32.700	32.000		10	17.400	400	20	520	35			φ16@125	3	3.200	320	8.575	4×2	7.450	180	300	L-80×80×8	φ25n4	300.80		34936.01		116.14	48.490
			1.600		3.800	360	10	480	25						120×16	2×17												
					3.900	360	10	360	13			φ16@175					8×2							106.81		23478.19	219.81	34.511
2-SBI-L34-n3	34.700	34.000		10	18.400	400	20	560	34			φ16@125	3	3.200	340	9.163	4×2	7.250	190	300	L-80×80×8	φ25n4	319.60		38272.60		119.75	51.710
			1.700		4.100	360	10	500	26						120×16	2×17												
					4.100	360	10	360	13			φ16@175					8×2							113.27		24872.60	219.59	34.538
2-SBI-L36-n3	36.700	36.000		10	19.400	400	21	600	33			φ16@125	3	3.200	360	9.750	4×2	6.000	200	300	L-80×80×8	φ25n4	338.40		41836.87		123.63	55.005
			1.800		4.300	360	11	520	26						120×16	2×18												
					4.400	360	10	360	14			φ16@175					6×3							119.70		26251.84	219.31	34.549

Table 4.5 Design Parameter of PC Beam for 1-Lane Bridge

1-Lane																																			
INDEX	L_C(m)	L_V(m)	EL	R. Bar	Main Gird		H(m)	bt	tt	th	bw	hh	tb	bb	N_T	ST	Nd	XB	NB	N1	N5	N6	N7	CS	RB3	RB4	RB6	A.S.B.	Vc	Wc	Wc/Vc	V_B	W_R	W_R/V_B	Rd(t) RL(t)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	24	22	23	24	25	26	27	28	29	30	31	32	33
1-PRE-L14_n4	14.000	14.600	170	φ12@125	4	1.500	0.700	400	150	110	180	185	150	550	1	7.000	17	2.100	9	2	0	8	7	70	φ12	φ22	φ12n2	φ22n2	29.1	4444	152.9	15.2	1935	127.1	13.422
		0.300		φ12@175															7														769	50.5	15.021
1-PRE-L16_n4	16.000	16.600	170	φ12@125	4	1.500	0.800	400	150	110	180	185	150	550	1	8.000	19	2.800	11	2	2	8	7	70	φ12	φ22	φ12n2	φ22n2	33.0	4995	151.6	18.5	2202	119.0	15.626
		0.300		φ12@175															8														978	52.8	15.370
1-PRE-L18_n4	18.000	18.600	170	φ12@125	4	1.500	0.900	400	150	110	180	185	150	550	1	9.000	21	3.500	13	2	4	8	7	70	φ12	φ22	φ12n3	φ22n2	36.8	5563	151.0	22.1	2631	119.2	17.921
		0.300		φ12@175															9														1211	54.8	15.616
1-PRE-L20_n4	20.000	20.700	170	φ12@125	4	1.500	1.000	400	150	110	180	185	150	550	1	10.000	23	4.100	13	2	6	8	7	70	φ12	φ22	φ12n3	φ22n2	40.9	6146	150.2	26.1	2949	113.1	20.305
		0.350		φ12@175															10														1476	56.6	15.792
1-PRE-L22_n4	22.000	22.700	170	φ12@125	4	1.500	1.100	400	150	110	180	185	150	550	1	11.000	23	4.600	13	2	6	8	7	70	φ12	φ22	φ12n4	φ22n2	44.8	6714	149.8	30.2	3436	113.7	22.779
		0.350		φ12@175															10														1619	53.6	15.919
1-PRE-L24_n4	24.000	24.700	170	φ12@125	4	1.500	1.200	400	150	110	180	185	150	550	1	12.000	25	5.100	13	2	8	8	7	70	φ12	φ22	φ12n4	φ22n2	52.7	9833	186.4	32.3	3136	97.0	25.344
		0.350		φ12@175															11														152	4.7	16.011
1-PST-L24_n2	24.000	24.700	200	φ16@150	2	3.000	1.600	1000	150	150	200	250	250	500	1	12.000	4							140	φ12	φ22	φ12n5	φ25n5	48.7	7264	149.2	34.7	3760	108.5	50.149
		0.350		φ12@125																													1914	55.2	23.617
1-PST-L26_n2	26.000	26.700	200	φ16@150	2	3.000	1.700	1000	150	150	200	250	250	500	2	8.667	5							140	φ12	φ22	φ12n5	φ25n5	57.8	10704	185.1	36.1	3425	95.0	55.152
		0.350		φ12@125																													1444	40.0	23.715
1-PST-L28_n2	28.000	28.700	200	φ16@150	2	3.000	1.800	1000	150	150	200	250	250	500	2	9.333	5							140	φ12	φ22	φ12n6	φ25n5	62.0	11459	184.7	39.9	3827	95.8	59.977
		0.350		φ12@125																													1552	38.9	23.784
1-PST-L30_n2	30.000	30.800	200	φ16@150	2	3.000	2.000	1000	150	150	200	250	250	500	2	10.000	5							140	φ12	φ22	φ12n7	φ28n5	66.7	12315	184.5	45.6	4300	94.3	65.767
		0.400		φ12@125																													1667	36.6	23.831
1-PST-L32_n2	32.000	32.800	200	φ16@150	2	3.000	2.100	1000	150	150	200	250	250	500	2	10.666	6							140	φ12	φ22	φ12n7	φ28n5	70.9	13094	184.6	49.9	4588	92.0	70.842
		0.400		φ12@125																													2131	42.7	23.862
1-PST-L34_n2	34.000	34.800	200	φ16@150	2	3.000	2.200	1000	150	150	200	250	250	500	2	11.333	6							140	φ12	φ22	φ12n8	φ28n5	75.2	13851	184.3	54.3	5038	92.7	76.017
		0.400		φ12@125																													2262	41.6	23.880
1-PST-L36_n2	36.000	36.800	200	φ16@150	2	3.000	2.400	1000	150	150	200	250	250	500	2	12.000	7							140	φ12	φ22	φ12n9	φ32n5	79.6	14684	184.4	60.6	5547	91.5	82.816
		0.400		φ12@125																													2792	46.0	23.888

PRE : Pre-tensioned

PST : Post-tensioned

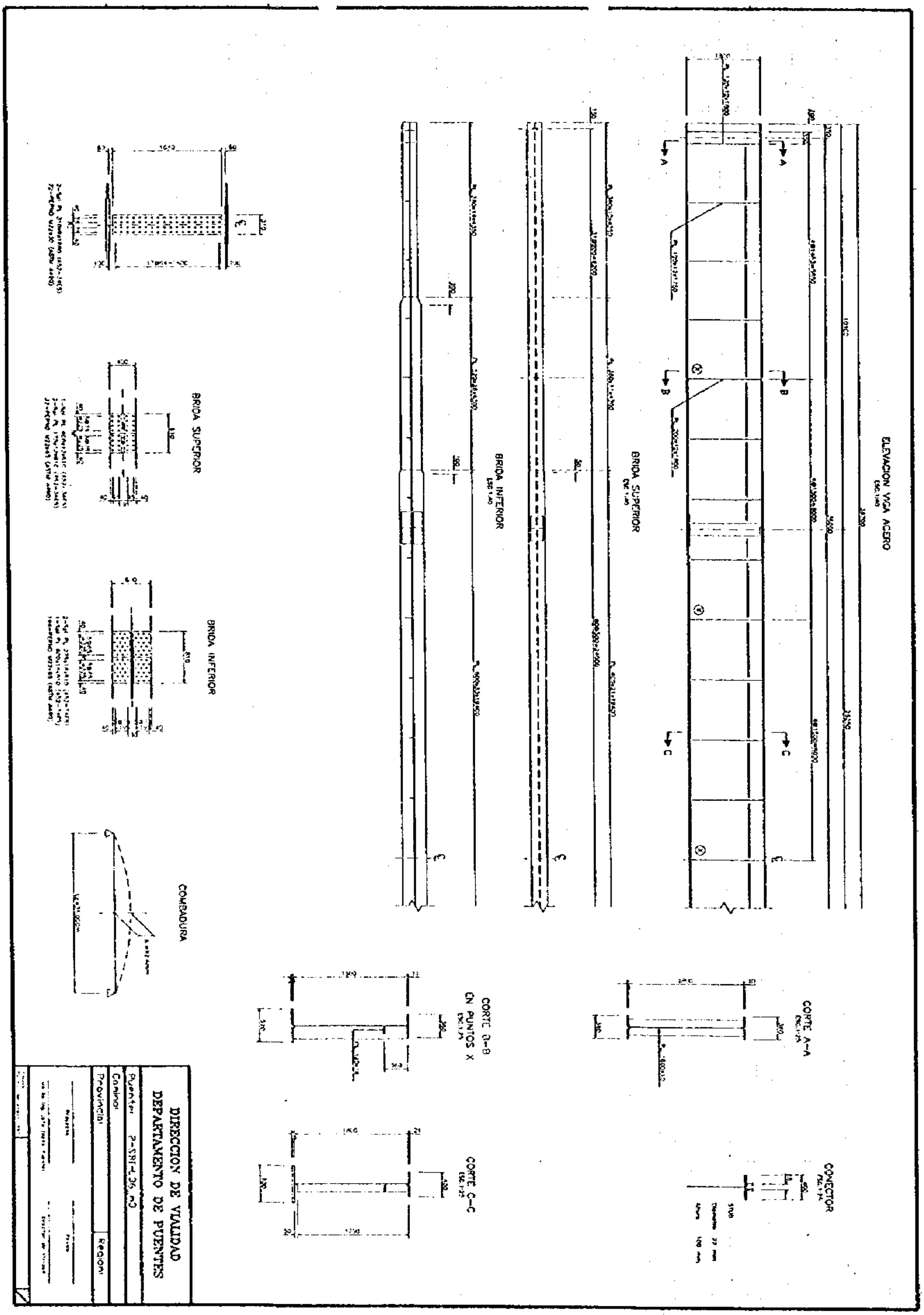
Table 4.6 Design Parameter of PC Beam for 2-Lane Bridge

2-Lane

INDEX	L_C(m)	L_V(m)	EL	R. Bar	Main Gird		H(m)	bt	tt	th	bw	hh	tb	bb	N_T	ST	Nd	XB	NB	N1	N2	N4	N5	N6	N7	CS	RB3	RB4	RB6	A.S.B.	Vc	Wc	Wc/Vc	V_B	W_K W_P	W_K/V_B W_P/V_B	Rd(t) RL(t)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	21			22	23	24	25	26	27	28	29	30	31	32	33
2-PRE-L14_n6	14.000	14.600	170	φ12@125	6	1.500	0.700	400	150	110	180	185	150	550	1	7.000	17	2.100	9	2			0	8	7	70	φ18	φ25	φ12n2	φ22n2	44.9	6752	150.4	22.9	3215	140.7	13.550
		0.300		φ12@175															7																1154	50.5	15.021
2-PRE-L16_n6	16.000	16.600	170	φ12@125	6	1.500	0.800	400	150	110	180	185	150	550	1	8.000	19	3.100	11	2			2	8	7	70	φ16	φ25	φ12n2	φ22n2	50.9	7530	148.0	27.8	3532	127.2	15.773
		0.300		φ12@175															8																1467	52.8	15.370
2-PRE-L18_n6	18.000	18.600	170	φ12@125	6	1.500	0.900	400	150	110	180	185	150	550	1	9.000	21	4.100	13	2			4	8	7	70	φ16	φ25	φ12n3	φ22n2	56.9	8397	147.5	33.1	4222	127.4	18.086
		0.300		φ12@175															9																1816	54.8	15.616
2-PRE-L20_n6	20.000	20.700	170	φ12@125	6	1.500	1.000	400	150	110	180	185	150	550	1	10.000	23	5.100	13	2			6	8	7	70	φ16	φ22	φ12n3	φ22n2	63.2	9230	146.0	39.1	4614	118.0	20.490
		0.350		φ12@175															10																2214	56.6	15.792
2-PRE-L22_n6	22.000	22.700	170	φ12@125	6	1.500	1.100	400	150	110	180	185	150	550	1	11.000	25	5.600	13	2			8	8	7	70	φ16	φ22	φ12n4	φ22n2	69.2	10097	145.9	45.3	5391	118.9	22.983
		0.350		φ12@175															11																2639	58.2	15.919
2-PRE-L24_n6	24.000	24.700	170	φ12@125	6	1.500	1.200	400	150	110	180	185	150	550	1	12.000	27	6.300	15	2			8	8	7	70	φ16	φ22	φ12n4	φ22n2	75.2	10912	145.1	52.0	5877	113.0	25.556
		0.350		φ12@175															12																3101	59.6	16.011
2-PST-L24_n4	24.000	24.700	170	φ16@150	4	2.250	1.600	1000	150	150	200	250	250	500	1	12.000	4									140	φ12	φ22	φ12n5	φ25n3	75.6	14907	197.2	64.6	6298	97.5	41.944
		0.350		φ12@125																															2136	33.0	24.017
2-PST-L26_n4	26.000	26.700	170	φ16@150	4	2.250	1.700	1000	150	150	200	250	250	500	2	8.667	4									140	φ12	φ22	φ12n5	φ25n3	83.6	16276	194.7	72.1	6898	95.7	46.623
		0.350		φ12@125																															2310	32.0	24.116
2-PST-L28_n4	28.000	28.700	170	φ16@150	4	2.250	1.800	1000	150	150	200	250	250	500	2	9.333	4									140	φ12	φ22	φ12n6	φ25n3	90.0	17442	193.9	81.3	7741	95.3	50.802
		0.350		φ12@125																															2484	30.6	24.186
2-PST-L30_n4	30.000	30.800	170	φ16@150	4	2.250	2.000	1000	150	150	200	250	250	500	2	10.000	5									140	φ12	φ22	φ12n7	φ28n3	96.6	18748	194.0	91.2	8659	95.0	56.064
		0.400		φ12@125																															3335	36.6	24.234
2-PST-L32_n4	32.000	32.800	170	φ16@150	4	2.250	2.100	1000	150	150	200	250	250	500	2	10.666	5									140	φ12	φ22	φ12n7	φ28n4	102.7	19926	194.0	99.8	9231	92.5	60.494
		0.400		φ12@125																															3552	35.6	24.266
2-PST-L34_n4	34.000	34.800	170	φ16@150	4	2.250	2.200	1000	150	150	200	250	250	500	2	11.333	5									140	φ12	φ22	φ12n8	φ28n5	108.8	21080	193.8	108.7	10135	93.3	65.023
		0.400		φ12@125																															3770	34.7	24.284
2-PST-L36_n4	36.000	36.800	170	φ16@150	4	2.250	2.300	1000	150	150	200	250	250	500	2	12.000	6									140	φ12	φ22	φ12n8	φ32n3	114.9	22305	194.2	117.9	10736	91.1	70.785
		0.400		φ12@125																															4785	40.6	24.292

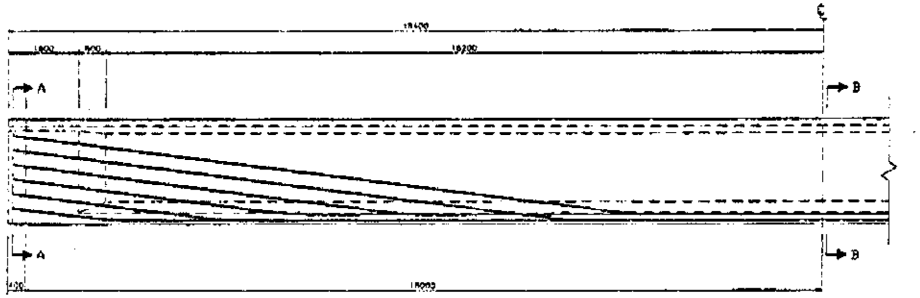
PRE : Pre-tensioned

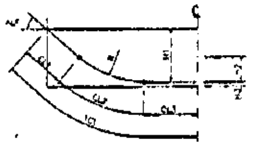
PST : Post-tensioned


ELEVACION VIGA ACERO
BRIDA SUPERIOR
BRIDA INFERIOR
CORTE A-A
CORTE B-B EN PUNTOS X
CORTE C-C
CONECTOR
BRIDA SUPERIOR
BRIDA INFERIOR
COMBADURA
DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES
Puente: P-SRI-L36 n3
Camino:
Provincia:
Region:

1/2 ELEVACION DE VIGA POSTENSADO

ESC.1:50

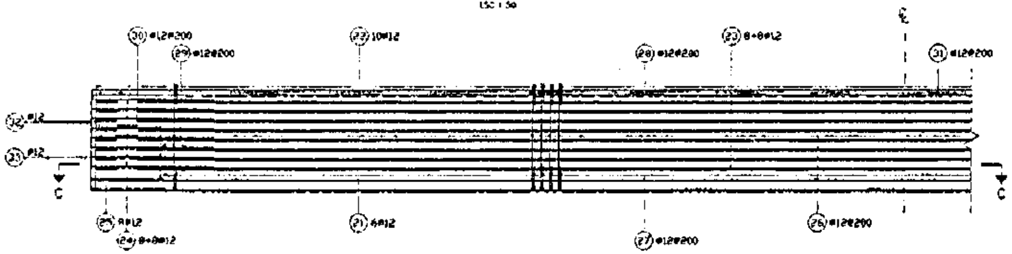




	N°	ø	H1	H2	H3	CL1	CL2	CL3	TC
D1	7	10	1740	75	210	13666	1222	3017	18405
D2	7	10	1440	75	90	12075	1222	5146	18393
D3	7	10	1100	75	210	8414	1222	8730	18366
D4	7	10	780	75	210	5789	1222	11338	18346
D5	7	10	500	75	90	4146	1222	12985	18324
D6	7	10	260	75	90	1922	1222	15171	18314

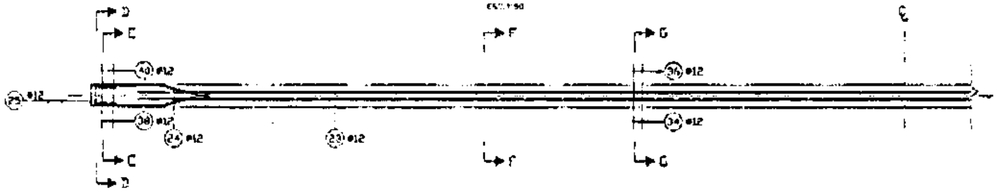
1/2 ENFIERRADURA VIGA POSTENSADO

ESC.1:50



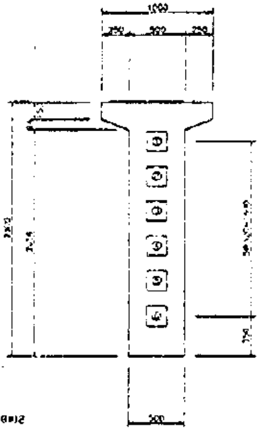
CORTE C–C

ESC.1:50



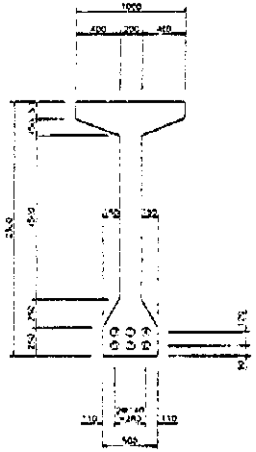
CORTE A–A

ESC.1:20



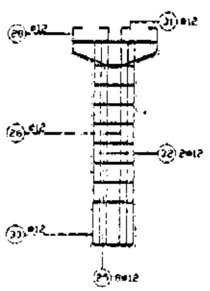
CORTE B–B

ESC.1:20



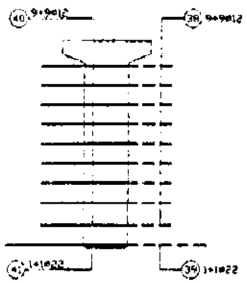
CORTE D–D

ESC.1:25



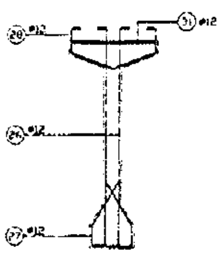
CORTE E–E

ESC.1:25



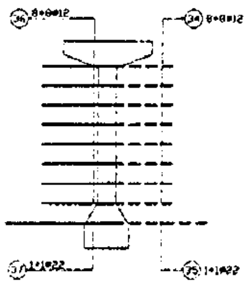
CORTE F–F

ESC.1:25



CORTE G–G

ESC.1:25



DIRECCION DE VIALIDAD
DEPARTAMENTO DE PUENTES

Puente: 2-PST-L36_n4
Camino:
Provincia: Region:

CHAPTER 5

CONLUSION AND RECOMMENDATION

CHAPTER 5 CONCLUSION AND RECOMMENDATION

The objective of the Study is to assist Chile technologically in rehabilitating rural bridges distributed throughout the country.

Conclusions and recommendations for the three main subjects of the Study are described below.

- Establishment of bridge rehabilitation plan method
- Preparation of sample bridge rehabilitation designs
- Development of standard bridge CADD programs and design drawings

5.1 BRIDGE REHABILITATION PLAN

The bridge rehabilitation plan is composed of three systems, namely the bridge inventory system, rehabilitation cost estimation system, and rehabilitation priority system. The rehabilitation project investment plan was prepared through the information collected from the three systems.

(1) Bridge inventory system

Conclusion

A computerized bridge inventory system was proposed as it was necessary to grasp the present situation of existing bridges, especially the inventory data held by the MOP. The inventory data includes location, structural type, dimensions, etc., of bridges, and is essential as fundamental data for rehabilitation. Besides the bridge inventory data, such data as population, income and traffic volume were collected as indices by which necessity of a bridge can be measured, and may be defined as parts of bridge inventory in a wider sense.

Recommendation

The bridge inventory system was developed as a universal system that can be applied to all types of bridges and not merely a data tool to apply to the bridge rehabilitation plan in this Study. One advantage of utilizing the system is that once a network system linking regional organizations is constructed and the central MOP office centralizes the bridge inventory data, maintenance work of bridges may then be carried out effectively and the rehabilitation plan may be prepared or changed promptly.

(2) Cost estimation of rehabilitation

Conclusion

Rehabilitation method (to be repaired or reconstructed) was judged from the data combined of structural bridge type, scale (width and load carrying capacity), and rank of damage which came from the inventory data. The cost of bridge rehabilitation was calculated according to the selected rehabilitation method.

Recommendation

The elements which are considered in the Study for the cost estimation of each bridge are the width and the length of a bridge, although the average construction cost was set in order to process many bridge data. Therefore, data such as the location for reconstruction, type of bridge, span length and information of piles, etc., which effect cost but cannot be known until the bridge is planned, are not included. As primary data for bridge rehabilitation (horizontal topography of river crossing, geological quality of riverbed, etc.) are included in the inventory data, though not in such detail, more precise estimation may be possible, if other data such as the location for reconstruction, type of bridge, span length and information of piles are added to the width and bridge length. Other types of data that maybe needed will be recommended by the MOP.

(3) Judgement of priority for rehabilitation

Conclusion

In order to establish the system for judging the priority of rehabilitation, three indices were defined; those being economy index (traffic volume/rehabilitation cost), safety index (degree of bridge damage), and social index (income differential). First of all, these three indices were calculated, and then total index value was worked out by adding the three weighted indices. Next, bridges were allocated into each 'road link', and the maximum total index value of all bridges belonging to a link represents the link. A list of rehabilitation cost was prepared by arranging the link in the order of the higher index value for each region.

Recommendation

The three evaluation indices mentioned above were recommended based on the fundamental concept that safety and socioeconomic considerations must be made in public investments not placing priority only on economic feasibility, especially when considering the many bridges in rural areas where there may be low returns of investment. This recommendation is in conjunction with the MOP policy. In cases where there is a change in the situation of regional bridges, or where applied to a typical bridge, the MOP must make corrections.

(4) Rehabilitation project investment plan

Conclusion

Road links (bridges) are allocated into the scheduled rehabilitation program of each fiscal year in order of priority on the rehabilitation cost table. The allocation was made in such a manner that the total rehabilitation cost is approximately the same every year.

Recommendation

The project rehabilitation period is supposed as 10 years (first phase 5 years and second phase 5 years). The rehabilitation period was so established that the MOP could complete the rehabilitation project for each year within their budget and organization. It was judged from the conjectured volume of the rehabilitation for all regions based on the data collected at the model survey (IX) region that 10 years would be sufficient for the rehabilitation period. It is recommended that after the first 5-year period, that the plan review the whole rehabilitation plan including the rehabilitation principle on the analysis of the achieved rehabilitation thus far, as 10 years is a long period, and during that time the economical situation and traffic demand in rural roads would change.

5.2 BRIDGE REHABILITATION DESIGN

Conclusion

The bridge rehabilitation design was prepared in order to show an actual technological example which would be useful for the MOP to decide rehabilitation method based on actual inspection results. The Study Team selected twenty bridges with the MOP counterparts and conducted inspection and analysis of amount of damage as well as designs for rehabilitation method.

Besides the inspection of bridge itself, an environmental study was conducted to estimate the effect which rehabilitation of bridges may have on its surroundings. A standardized and simplified method of the environmental study was recommended consequently after exchange of opinions with the staff of the Department of Environment in the MOP over the necessity and procedure of the environmental study for small-scale rural bridges.

Recommendation

To date there do not seem to be many bridges having been inspected and strengthened on a large scale in Chile. Furthermore, more money and effort has been spent on reconstruction rather than repair. Thus, many bridges have not been recognized in the inventory nor maintained over a long period. In order to maintain bridges systematically, it is most important to discover damage as early as possible and to make appropriate repairs without delay. It is therefore recommended to intentionally and actively maintain and repair damaged bridges by efficient use of the inspection method proposed by the Study.

Although the MOP intends to replace timber bridges with more permanent structures such as concrete or steel, the element of time must be considered. To construct a new timber bridge is difficult nowadays from economical and environmental aspects, but on the other hand there is still the advantage of easy repair; therefore the MOP must maintain their technology of timber bridges and not discard it.

Regarding the quality of concrete, it is proposed that the MOP makes effort to improve the quality of concrete implementation. The problem of the quality of concrete is not merely a construction-site issue. If the problem is not properly addressed, Chile will end up with many concrete bridges of poor quality, consequently bringing about the risk of deterioration of rural bridges in general. At the beginning of the rehabilitation plan, there is thus a chance to present bridges of high quality for future users.

In order to extract environmental problems accompanying bridge rehabilitation, it is recommended to start with the Project Description and the Site Description. Following scoping and screening, the initial environmental examination (IEE) is carried out using inspection forms for environmental considerations. In case that an obvious environmental impact is recognized, preliminary environmental impact assessment (Pre-EIA) is carried out. In the Pre-EIA, mitigation methods of remarkable negative impacts caused by the rehabilitation are considered. By proceeding with the study in the order described above, it is easier to grasp the existence of the little-understood environmental problems of the small bridges and measures for overcoming them.

5.3 STANDARD BRIDGE CADD PROGRAM

Conclusion

The bridge CADD program developed in the Study is based on the specifications of AASHTO which are usually adopted by the MOP. The representative bridge types to be developed as well as computer hardware and software were selected according to the investigation results of bridge design, bridge construction, and computer use in Chile.

The programs developed are as follows:

Superstructure
- Pre-tensioned PC beam
- Post-tensioned PC beam
- Steel rolled H beam
- Steel plate girder

All the beams and girders above are composite types with concrete deck.

Substructure

- Inverted T abutment with spread foundation
- Wall-type pier with spread foundation

The standard drawings were prepared by using the CADD program for the bridges both of one and two lanes with span length between 14 and 36 m.

The CADD program and the standard drawings can be applied to typical bridges with a straight alignment and a symmetric transverse cross section, but not to a skewed or curved bridge.

Recommendation

Verification and examination of the CADD program output as well as decision-making is the user's responsibility. Therefore, the program was developed so that the user can compile the output according to his/her purpose. It is possible to use the program out of the scope of its original specifications to some extent depending upon the user's creative capacity.

On developing such a program it is not necessarily advantageous to develop every detail by oneself in such an age when computer technology progresses quickly, therefore existing application software were implemented. In order to maintain the best status for the computer at all times, regular renewal of software and hardware versions must be kept in mind. At the same time, the program itself must be maintained and improved to keep up with the latest version of design standards.

It is recommended that the program be widely used in the country. For the technical staff of the MOP in charge of bridge planning, the basic use of the program is recommended for the estimation of approximate size of planned bridge. While, for the bridge designers both in the MOP and in private firms, the program would be used more in professional application to the identification of suitable design parameters and to the preparation of structural design drawings within the capacity of the program.