Republic of the Philippines
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

FEASIBILITY STUDY
ON
REHABILITATION AND MAINTENANCE
OF
BRIDGES ALONG ARTERIAL ROADS

FINAL REPORT
VOLUME V
(INSPECTION AND MAINTENANCE REPORT)

JUNE, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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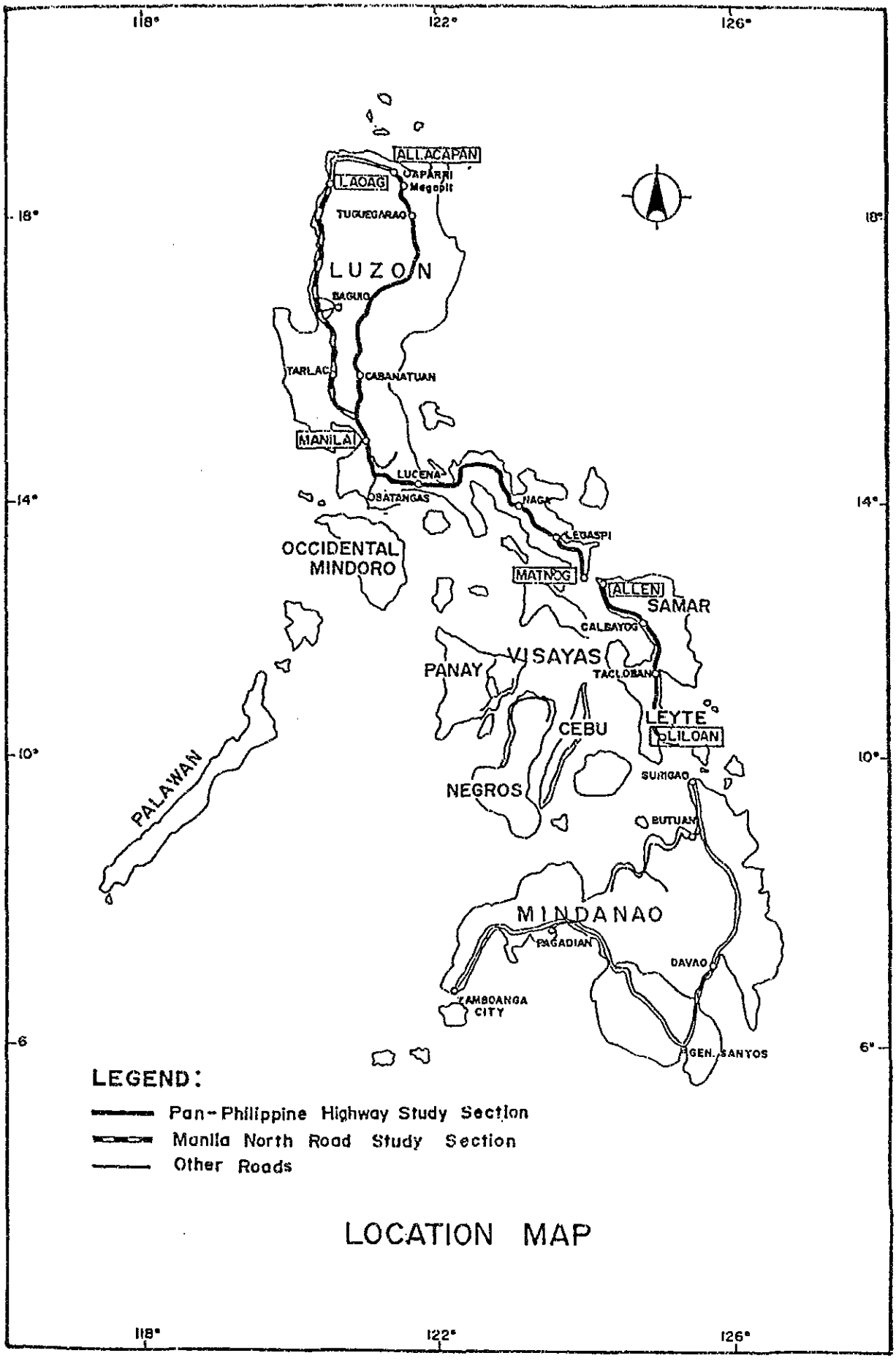
FOREWORD

It is to be desired that bridge inspection and maintenance should be carried out systematically with an appropriate inspection and maintenance guidelines in the Philippines. The DPWH requested to prepare the report presented an approach on bridge inspection and maintenance in the current and the future in the JICA Feasibility Study. Through the Feasibility Study, the study team examined the systematical process of the inspection and maintenance in consideration with the Philippines bridge feature, design standard, and organization of the DPWH etc. The bridge inspection and maintenance report is therefore prepared in a separate volume from the main report, compiling the ideas and method used in visual and detail survey and preliminary design in the Feasibility Study on the Rehabilitation and Maintenance of Bridges along Arterial Roads.

It is hoped that this report will be of value to all personnel concerned with bridge management and contribute to the establishment of a systematical bridge inspection and maintenance organization.

During the preparation of the report, technical assistance and valuable comments provided by personnel of the Bureau of Maintenance of the Department of Public and Highways are greatfully acknowledged.



LOCATION MAP

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ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation
DPWH	-	Department of Public Works and Highways
GOJ	-	Government of Japan
GOP	-	Government of the Philippines
JICA	-	Japan International Cooperation Agency
JIS	-	Japan Industrial Standard
NSCP	-	National Structural Code of the Philippines
PMO-FS	-	Project Management Office - Feasibility Study
PALS	-	Philippine Axle Load Study
MNR	-	Manila North Road
PPH	-	Pan-Philippine Highway
PPH-N	-	Pan-Philippine Highway - North
PPH-S	-	Pan-Philippine Highway - South
DL	-	Dead Load
LL	-	Live Load
RC	-	Reinforced Concrete
RCDG	-	Reinforced Concrete Deck Girder
PCDG	-	Prestressed Concrete Deck Girder
SIB	-	Steel-I-Beam
P.C.	-	Prestressed Concrete
CPU	-	Central Processing Unit
BRIDAMAS	-	Bridge Management System
H.T.B.	-	High Tension Bolt

ABBREVIATIONS FOR MEASUREMENTS

mm	- millimeter
cm	- centimeter
m	- meter
km	- kilometer
cm^2	- square centimeter
m^2	- square centimeter
m^2	- square meter
m^3	- cubic meter
km^2	- square kilometer
kg	- kilogram
ton	- metric ton
N	- newton (9.80665 N = 1 kgf)
KN	- kilo newton
KGF/CM^2	- kilogram (force) per square centimeter ($1\ kgf/cm^2 = 10{,}000\ Pa = 10\ KPa$)
KN/cm^2	- newton per square centimeter ($1\ N/cm^2 = 10{,}000\ Pa = 10\ MPa$)
Pa	- pascal ($1\ Pa = 1\ N/m^2$)
KPa	- kilo pascal
MPa	- mega pascal ($1\ MPa = 10.197\ kgf/cm^2$)
V	- velocity
A	- area
L	- length
r	- radius of gyration
psi	- pounds per square inch
^oc	- centigrade
%	- percent
m^3/s	- cubic meter per second
sec	- second
EL	- elevation

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 General

Bridges as a part of the road network are very important structures because of their strategic location and of the unfavorable traffic interruption that arise when they collapse or when their capacity is impaired. Bridge management, therefore, encompasses all of the operations designed to ensure appropriate serviceability, guarantee or satisfactory level of safety, ensure optimum traffic capacity and maintain the bridges in operational state. Bridge management then constitute the following.

1. Inspection and bridge data base,
2. Evaluation and classification of damages,
3. Selection of rehabilitation method,
4. Maintenance works (improvement, remedy and temporary repair) and
5. Rehabilitation works (reconstruction, replacement of superstructure, and repair).

Maintenance and rehabilitation, which are reactive work originated from the inspection, have been severely neglected in the past. The Department of Public Works and Highways (DPWH) has recognized the importance of bridge rehabilitation from traffic interruption recently occured on the arterial roads due to failures. These failures were due to some of the following reasons.

a) Settlement of pier due to scouring action,
b) Settlement of concrete deck slab due to advance erosion of cross-beams,
c) Washout of bridge approach due to bank erosion and
d) Collapse of bearing due to movement of pier.

The DPWH, therefore, has given high priority in the refinement of the presnet system being used in bridge maintenance and rehabilitation with a systematic inspection system and bridge data base. The JICA feasibility study team carried out the inspection of bridges along arterial roads, compiled the relevant data, made an assessment of the

damages and deterioration and recommended maintenance and rehabilitation methods. The process of inspection and maintenance carried out during the feasibility sutdy is diagrammed in Fig. 1.1.

1.2 Objectives and Scope of the Report

The results of the JICA feasibility study are reported that: Bridge inspection and maintenance have not been carried out systematically on the arterial roads, maintenance have developed as an emergency stop-gap measure in the repair or rehabilitation of damaged bridges and information on inspection and maintenance techniques has not been widely disseminated. It is therefore essential to make known widely current bridge information regarding bridge maintenance and rehabilitation.

The objective of this report was not to introduce of new set of ideas, but rather to compile the ideas and methods used by the JICA study team during previous activities in consideration of the present system and condition of the DPWH. Within the above-mentioned objectives, the scope of the report as prepared by the JICA Study Team are as follows.

1. Methodology for the utilization of data provided by bridge inspection, relating to the computer-used data base.

2. Strategy for systematic inspection.

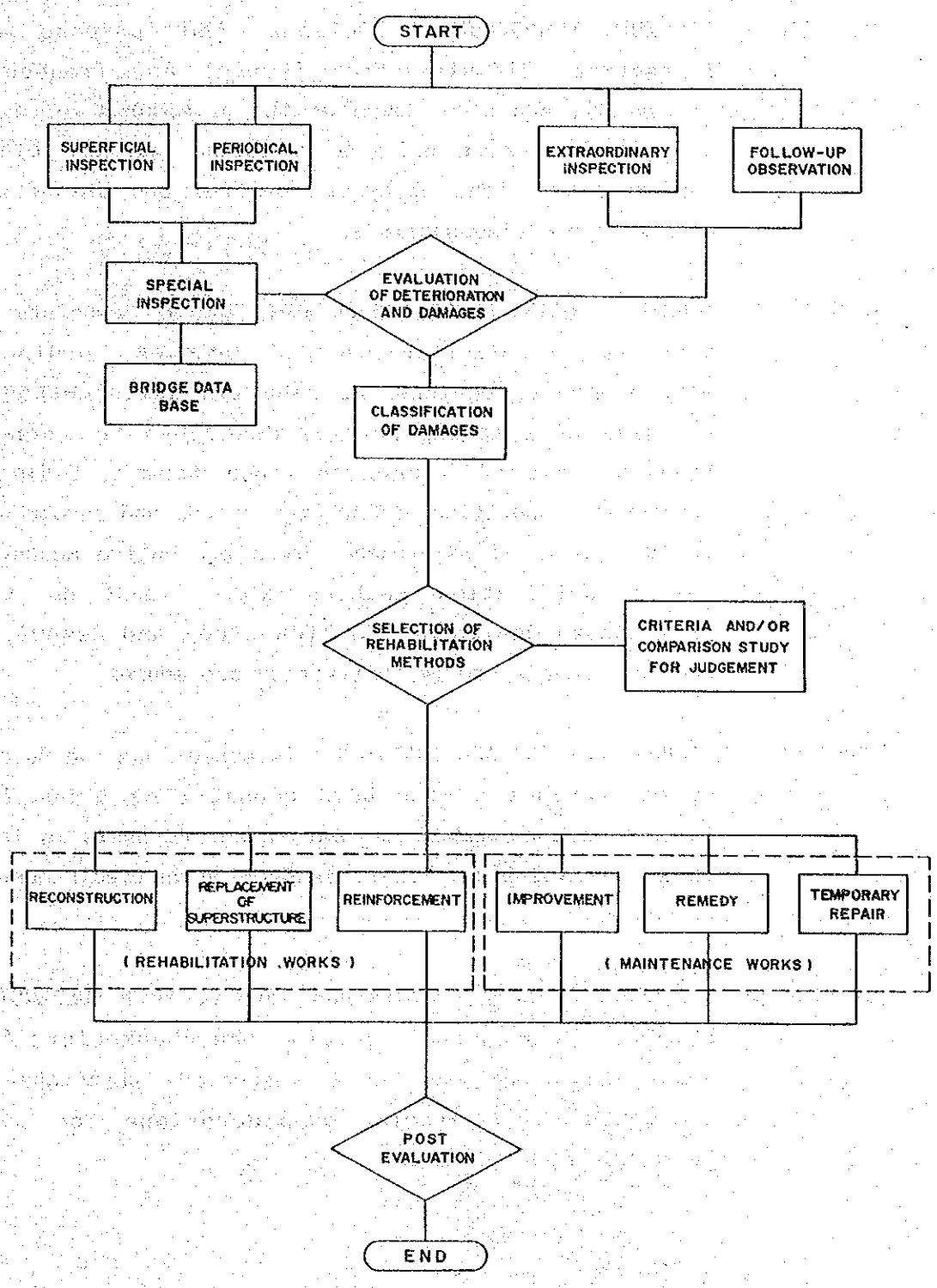
3. Techniques for detailed assessment of structures and evaluation of load carrying capacity.

4. Identification of major preventive and corrective maintenance problem areas.

5. Compilation of ideas and methods used in bridge maintenance and rehabilitation work.

6. Recommendation of organization, management and training for bridge inspection and maintenance.

Fig. 1.1 FLOWCHART DIAGRAM FOR INSPECTION AND MAINTENANCE



1.3 Structure of Report

The subsequent chapters of the inspection and maintenance report are as follows:

CHAPTER 2: ''BRIDGE INSPECTION'' defines the purpose of inspection, classification (types) and frequency (interval), and also describes the procedures for each type of inspection using a guideline and key-point. Evaluation of load carrying capacity and inspection equipment are also outlined.

CHAPTER 3: ''BRIDGE MAINTENANCE AND REHABILITATION'' consists of features of existing damaged bridges, ordinary maintenance operations and rehabilitation methods. Features of existing bridges describes the common characteristic of deterioration and damages. Ordinary maintenance operation defines the scopes and recommends the key-point of maintenance as a preventive measure. The rehabilitation methods were based on the preliminary design of the JICA study and describes damages, causes and rehabilitation procedures.

CHAPTER 4: ''ORGANIZATION AND TRAINING'' is based from the Bureau of Maintenance of the DPWH considering a Special Inspection Team and Bridge Data Base. Emphasis is laid on the training of bridge inspection and maintenance personnel.

CHAPTER 5: ''INSPECTION AND MAINTENANCE FOR MAGAPIT SUSPENSION BRIDGE'' This chapter contains the checkpoints for inspection, locations to be inspected, keypoints of maintenance and special considerations for some keypoints.

CHAPTER 2
BRIDGE INSPECTION

CHAPTER 2 BRIDGE INSPECTION

2.1 General

Bridge inspection as a starting point of bridge management should be done regularly in order to ensure safety and also to minimize traffic interruptions. When damage or deterioration is apparent, inspection should be made specifically to search for its causes. As a result, inspection would establish an assessment and rating scheme for bridges that can be used in programming of remedial and preventive maintenance as well as repair works. It is essential that inspection is made continuously in the case of old bridges no longer adopted to modern traffic conditions and whose materials have deteriorated as a result of weathering.

Another important aspect of bridge inspection is to keep detailed bridge records in computerized data base and use it in a variety ways such as budgetary planning, bridge replacement and routing of overland vehicles.

The main purposes of bridge inspection as described above are as follows:

1) to identify actual/potential damage and deterioration of bridges as the earliest possible stage.
2) to provide an assurance that the bridge is structurally safe as well as provide a preventing method when the apparent damage is to be urgently repaired.
3) to record systematically and periodically the state of bridges in a computerized data base.
4) to provide the necessary information on maintenance, repair, replacement of superstructure and reconstruction of bridges on which decisions will be based and carried out.
5) to provide a feedback of information to designers, contractors and anyone who are interested in bridge data.

2.2 Inspection Classification and Frequency

The classification and frequency of inspection can be identified in terms of the degree of skill that is required in the inspection procedure and in the authorities responsible for bridge inspection and maintenance (see Section 4.2).

Inspection in this report are broadly classified into (1) superficial inspection, (2) periodical inspection, (3) special inspection and (4) extraordinary inspection. They are briefly described as follows.

(1) Superficial Inspection

Superficial inspection is carried out in each district or city office by a team of highway maintenance personnel who have a good practical knowledge of road structures but not necessarily trained in bridge inspection. This inspection usually occur as the opportunity arises such as during regular routine road or bridge maintenance. Any adverse condition during such inspection should be properly recorded and reported to the Regional Office without delay.

(2) Periodical Inspection

A periodical inspection is divided into two categories referred to as general and major inspection defined by frequency and intensity. General inspection is made by a trained inspector under the supervision of a bridge engineer from each Regional Office. This inspection is carried out periodically at an interval of one (1) year to provide assurances that the bridge is safe for traffic. It is usually done by visual examination using standard instrument aids on and under the bridge against a prepared inventory sheet and check lists. The major inspection is more intensive in scope because of the special inspection team organized under the main office of the Bureau of Maintenance, which is specially composed of trained bridge engineers, and it requires close examination using special access facilities or inspection mobile. Major inspection is carried out at an interval of five (5) years for updating of records in the data base and for making a rating and assessment of

current bridge condition against a prepared inventory sheet.

(3) Special Inspection

A special inspection is made in connection with the occurence of unusual circumstances such as exceptional load passing, collapse, accidental damage and major weakness or with reassessment of the structure against revised specifications and regulations by the special Inspection Team. This Special Inspection Team requires a good deal of non-destructive testing equipment and a specialist operating these equipment. It will also require involvement of a bridge engineer who will make definitive decision regarding assessment and rating in the strength and quality with the extensive data gathered through non-destructive testing.

(4) Extraordinary Inspection

An extraordinary inspection is made by army force in connection with the occurence of extraordinary collapse such as an explosion. This inspection will gather information and photographs of the damage and safety circumstance of the bridge and report it to the Regional Office.

2.3 Inspection Procedure and Check List

As pointed out in Section 2.2, inspection is classified into superficial inspection, periodical inspection, special inspection and extraordinary inspection. Each inspection is carried out using uniform procedures and checklists, so that valid comparisons can be made between inspections from different locations at different times by different personnel. The procedure and list of inspection should be limited to the major points to be inspected in each category of the inspection.

2.3.1 Superficial Inspection

Superficial inspection is a visual inspection on the bridge according to the following inspection items.

(1) Pavement or deck slab: Existence of cracking and exposure of reinforcing bar, or check of the traveling condition.
(2) Curbs and Railing: Existence of cracks, spalls and other deterioration of concrete or steel.
(3) Expansion Joint: Existence of abnormal sound and check of the traveling condition.
(4) Drainage: Observation of drainage on the bridge surface.
(5) Bridge connection: Existence of gap or unequal settlement.

2.3.2 Periodical Inspection

The periodical inspection is carried out to check level of safety and ensure appropriate serviceability on and under the bridges. The periodical inspection will have to rely primarily on visual assessment according to the following inspection items which coincide in inventory sheet No. 3 but it will also be supported by means of the standard tools stated in section 2.7.

(1) Pavement: Condition of waving, abrasion, cracking and pot-hole
(2) Curb and railing: Condition of damage and deterioration
(3) Expansion joint: Condition of leakage, difference in level and noise
(4) Deck Slab: Condition of cracking, exposure of reinforcing bar, spalling and pot-hole
(5) Concrete beam: Condition of cracking, exposure of reinforcing bar, spalling and deformation
(6) Steel beam: Condition of cracking, corrosion and deformation
(7) Painting: Condition of discoloration, rust and exfoliation
(8) Shoe: Defection of shoe and defection of shoe base
(9) Abutment: Condition of cracking, exposure of reinforcing bar, settlement, movement, declining and scouring
(10) Pier: Condition of cracking, exposure of reinforcing bar settlement, movement, declining and scouring.
(11) Slope protection: Condition of settlement, movement, declining and scouring
(12) Drainage: Condition of drain outlet and gulleys
(13) Approach road: Condition of settlement and cracking
(14) River course: Condition of scouring and sedimentation

The guideline and key points to inspect the above items are summarized in Appendix 2.1.

2.3.3 Special Inspection

The special inspection is made against severe damages discovered in the periodical inspection and damages caused by natural calamities like cyclone, flood and earthquake. The special inspection will require advance assessment techniques. As stated below, to analyze the load capacity of the existing bridge, advance instruments (non-destructive testing) and inspection mobile (described in section 2.7) will be required but it will still be aided by visual assessment.

(1) Assessment of concrete strength
(2) Assessment of the quality of in-situ concrete
(3) Assessment of concrete cover
(4) Detecting and determining reinforcement bar
(5) Assessment of pile length
(6) Assessment of steel cracks and strength
(7) Assessment of cable or wire failure
(8) Assessment of the load-carrying capacity
(9) Assessment of underwater structures
(10) Assessment of groval behaviour (movement)

The special inspection is also carried out for the renewal of the data base as well as rating of damages.

2.4 Bridge Documentation

Bridge documentation is composed of bridge inventory, data base, data check, renewal of data and data retrieval. Its initial function is to have a complete and accurate record of each bridge and store them into a computer data base. Initial documentation was carried out by the JICA Feasibility Study Team in 1988, however, it is still necessary to update this record of bridge periodically.

2.4.1 Bridge Inventory

The bridge inventory system contains three sheets: Inventory sheet No. 1 is a summary list of the existing bridges to be inspected, Inventory sheet No. 2 covers the relevant bridge data items and Inventory sheet No. 3 covers the degree of deterioration and damages of existing structures as shown in Table 2.1, Table 2.2 and Table 2.3 respectively. The guidelines and key points of inspection to be carried out to ensure a uniform standard are summarized accordingly in APPENDIX 2.1, APPENDIX 2.2 and APPENDIX 2.3.

2.4.2 Bridge Data Base

The bridge data base developed by the JICA Feasibility Study Team stored more than 50 items of data (in a computer disc) per bridge for all of the 742 bridges on the arterial roads. The bridge management system (BRIDAMAS) is developed (as the backbone of bridge documentation) in order to maintain and manage necessary bridge data systematically for easy retrieval and update for making decisions on engineering, economic and policy matters.

(1) Structure of the System (BRIDAMAS)

The BRIDAMAS consists of two major functions which are data processing and data management. Data processing involves; 1) inventory sheet check, 2) data entry, 3) data check, 4) others, while data management involves, 5) Update, 6) Retrieval and 7) Graphics. These data processing and management are diagramed in Fig. 2.1 and described in detail as follows:

1) Inventory Sheet Check: This includes:

   a) To add a serial number to each sheet and check if Inventory Sheet Nos. 2 and 3 exist.
   b) To check the Bridge No. within the given range, and
   c) To check the Bridge Name if it is not blank.

2) Data Entry: This is executed by using program soft (dBASE III Plus) to avoid input error and to make for easier retrieval. This includes the following:

a) Determine the name, type, width by item.
b) Create data base file and screen
c) Data entry

3) Data check: This is executed in order to check the data for the following items:

a) Summary Table, which includes important items
b) Complete data table, which includes all data items

4) Others: Other existing related data have been separately prepared to include into master file and graphics:

a) Maintenance Record (improvement year, etc.)
b) Coordinates of the bridge and boundary of the island (mapping).

5) Update: This have five functions which can be selected from the menu. The menu is shown as follows:

Update System

A ---------- Add a record
C ---------- Change a record
D ---------- Delete a record
V ---------- View a record
P ---------- Print a record
X ---------- Exit

6) Retrieval: This is the main system of BRIDAMAS. The following information can be obtained:

a) Summary Table

b) Bridge Structure Table (Type, Length, Width, etc.)

c) Rating Table by item of inventory

d) List of Year Built

The retrieval system has options which can output the data by specified region, type of bridge etc. The location of the bridges can be displayed with colored marks.

7) Graphics: This has two options. i.e., scaling and selection of the color.

a) Scaling:

This displays the map of the entire area at first, then the user can select the specific scope.

b) Selection of the Color:

Bridges can be grouped, then the user can select different colors by group.

(2) Operational Procedure

All data of BRIDAMAS are stored with almost the same format as inventory sheet No. 2 and inventory sheet No. 3. The data can be utilized by using the following equivalent computer and devices.

a) Computer : IBM PC compatible with CPU 80286 (AT)

b) Hard disc : 40 Mega

c) FDD : 5.25 inch 1.2 Mega, 360 K

d) Memory : 1 Mega

e) Printer : EPSON LQ 2500 + or equivalent

BRIDAMAS is very helpful in getting information on the location and condition of bridges, assessment of future need for remedial actions and allocation of budgets such as maintenance and remedial cost. Furthermore, it can be used advantegeously in an

engineering aspects as described below:

a) Retrieval System

Retrieval system can select the objective bridge after referring to several retrieval items. For example,

i) Number and name of bridges belonging to the group in Reinforced concrete bridges (Type), less than 50 m (length), and class A (Rating).

ii) Number and name of bridges belonging to the group in Region I (Region), Prestressed concrete bridge (Type of bridge), T-beam (Type of beam) and built in and after 1950.

Combination of retrieval items is made on user's options. The retrieval items are mainly:

- Region	: Region I, II, III, IV-A, V, VIII
- Bridge Type	: Steel, RC, PC and others
- Type of Beam	: I-Beam, T-beam, box beam, slab and others
- Span Length	: User's option
- Bridge Width	: User's option
- Traffic Volume	: User's option
- Rating (slab)	: Rating A, B, C
- Rating (Superstructure)	: Rating A, B, C
- Rating (Substructure)	: Rating A, B, C
- Comprehensive rating	: Rating A, B, C
- Year built	: 1901-1925, 1925-1940, 1941-1955, 1956-1970, 1971-

b) Graphic System

The location map of the 742 bridges or objective bridges after referring to retrieval items can be viewed on the computer display or printed out of the printer.

(3) Update and Correction to Bridge Data

The initial data base was developed by the JICA study Team with collected data as of 1988. However, it is not continuously new in itself. The data should be updated and corrected periodically at an interval of at least three (3) years in order to give latest information to planners, designers, contractors and maintainers. The update and correction of data will be carried out by the personnel of Inventory Division in the Bureau of Maintenance based on the results of the periodical or special inspection. The procedure for updating and correction of bridge data will be basically made as follows;

a) When scheduling periodical inspection, the inspectors are requested to use Inspection Sheet No. 1, No. 2 and No. 3 which were utilized during the last periodical inspection in order to update a data and revise a rating.

b) The Inspection Sheet No. 1, No. 2 and No. 3 updated and revised in the periodical inspection are collected and submitted to the Inspectorate Division in Bureau of Maintenance and verified by the engineers in the Special Inspection Team.

c) After being certified by the Special Inspection Team, the updated and revised data are then stored into BRIDAMAS.

d) If the special inspection is carried out for the damaged bridges, the Special Inspection Team is also requested to update data and revise ratings.

e) Updated and corrected bridge data are stored in the BRIDAMAS.

(4) Control of the Date Base

The data base of bridges is under the control of the Inventory Division in the Bureau of Maintenance, while the update of bridge data is carried out by the Inspectorate division.

2.5 Rating of Bridge

Rating of bridge is carried out on two stages: the first stage is assessment by visual inspection in periodical inspection and the second stage is assessment by non-destructive dynamic test. Non-destructive dynamic tests are undertaken in order to determine the compliance of physical, chemical, mechanical properties in the special inspection.

In periodical inspection, a fairly experienced bridge inspector may be able to accomplish a satisfactory visual assessment with his naked eye. However, the experienced bridge inspector in charge of the periodical inspection is obviously limited to the regional office. It is therefore considered that the visual assessment in periodical inspection will be reasonably reliable and effective when supplemented by the judgement of experienced inspectors and bridge engineers in Special Inspection Team. Inspectors in periodical inspection carry out of rating evaluation in the degree of structural deterioration including potential dangers brought about by river condition, local scouring, meandering and sedimentation in accordance with the inspection sheet No. 3 and technical criteria. Based on his own judgement of the extent of structural deterioration, the bridges are rated A, B or C in accordance with the following standards:

A: Urgent Replacement or Repair

Bridge structures that are extremely deteriorated or facing potential dangers due to river condition such as local scouring, meandering and sedimentation severely affecting the substructures and foundations. Besides the condition stated above, the bridge that maintains traffic flow is very important, and where traffic is blocked, large amount of financial loss is the end-result.

B: Need Repir

Structural function of the bridge sufficiently works. Deterioration, however, is expected due to increase in traffic volume and heavy loads plus the potential danger of the river condition. Thus, light repair and/or protection shall be required

accordingly after further observation.

C: Maintenance Only

To date, structural function is sufficiently safe. Periodical inspection, however, as maintenance activity shall be required in the future.

In the feasibility study, rating (A, B or C) was made with the use of the technical criteria shown in Table 2.4. It is considered that this criteria is reasonably effective for inspectors, in charge of the periodical inspection, to use as a checkpoint of his judgement.

For instance, the visual inspection was conducted by using this criteria to determine the degree of structural deterioration and damages of bridges in the feasibility study. As a result, the number of bridges having a rating of A, B or C are as follows:

Rating Evaluation	No. of Bridges
A	49
B	50
C	643
Actual No. Inspected	742

2.6 Evaluation of Load Carrying Capacity

One of the assessment needed for rehabilitation or replacement is an evaluation of load carrying capacity. The evaluation is usually made either by calculation or full scale loading test. Full scale loading test is very valuable in assessing the load carrying capacity and duration of existing old bridges. However, full scale loading test is very costly and causes traffic interruption during testing. It is generally known that the need of assessment for rehabilitation or replacement is governed more by economic and traffic considerations

rather than by structural function or load carrying capacity.

This report introduces two evaluations of load capacity carried out by the JICA Study Team as a demonstration to turn attention to bridge rehabilitation.

2.6.1 Full Scale Loading Test

The loading test was conducted for the following bridge at station 48 + 660 along the Pan-Philippine Highway (Manila-Matnog) Calamba, Laguna, Luzon.

Bridge No./Name	: No. 227, SAN CRISTOBAL
Bridge Type	: Steel Through Truss/RCDG
Span Arrangement	: 12.0 (RCDG) + 49.6 (Truss) + 12.0 (RCDG) = 73.6 m

Gross weight of trucks was measured and then placed at loading points on the bridge designated by the results of theoretical calculations subject to the phasing of loading modes.

The deflection and strain of the members of bridge structure were then surveyed, observed and recorded under the actions of the phasing of loading modes. The following present results were an approach on the full scale loading test and the recorded results are analyzed and then compared with theoretical values as shown in APPENDIX 2.4.

(1) Preparation of Counter-Weight

The trucks were loaded with granular materials near Calamba. The loading weight were then measured at Calamba Weight-Bridge Office of Region IV-A. The gross weight of individual truck were almost 15 tons. The required equipment in the making of counter-weight are:

- 4 - Dump Trucks (15 tons)
- 1 - Wheel-Loader
- Sand Bag, if necessary
- Weigh bridge

(2) Theoretical Loading Computation

The theoretical loading computation was carried out by utilizing the following:

- Computer	NEC PC 9801E
- Program	UC-1, FORUM-8
- No. of Loading Cases	11 - case

(3) Scaffolding

The scaffolding work have been firmly and safely fabricated. It was able to sustain the survey and measurement works carried out on them.

(4) Providing and Placing the Strain Gauges

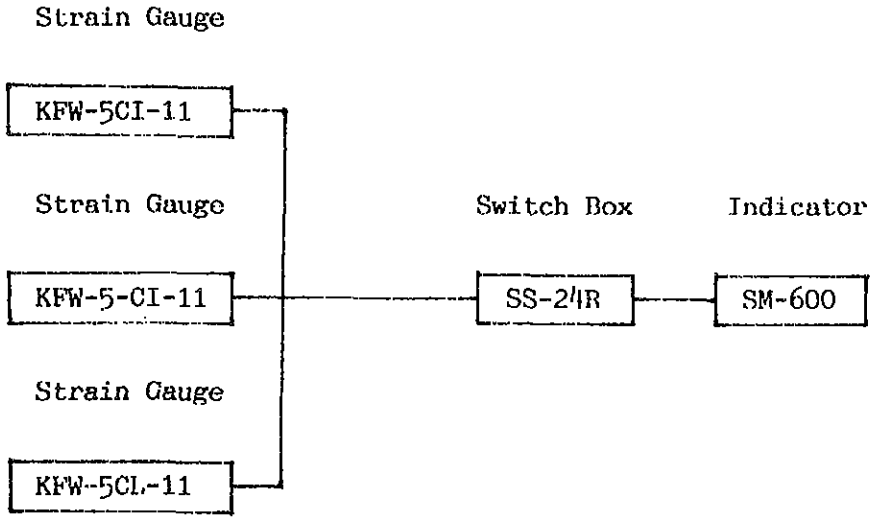
The actions of providing and placing the strain gauge included the determination of the location of bonding strain gauges, cleaning the surfaces of a structural members with sand-paper, bonding the strain gauge with resin, placing strain gauge and lead wire with solder, protecting the strain gauge by coating material, and connecting the lead wire up to the switch box.

(5) Application of Loading

The loading points and phasing of loading modes were determined in consideration of the different cases in the theoretical computation which was conducted in advance. The exact points of application of loading have been marked by paint using the specified color code.

(6) Measurement of Strains

The strain of structural members have been measured under the structural behavior in the various loading modes. This was observed under the phased loading modes through the indicator, and have been recorded on the recording sheet that were prepared before testing.



(7) Measurement of Deflection

The deflection of structural members was measured by using a levelling scope under the structural behavior in the various loading modes. The scales for measuring deflection have been bonded on the structural members of the bridge and then measured from the point where the levelling scope was provided.

(8) Equipment and Instruments

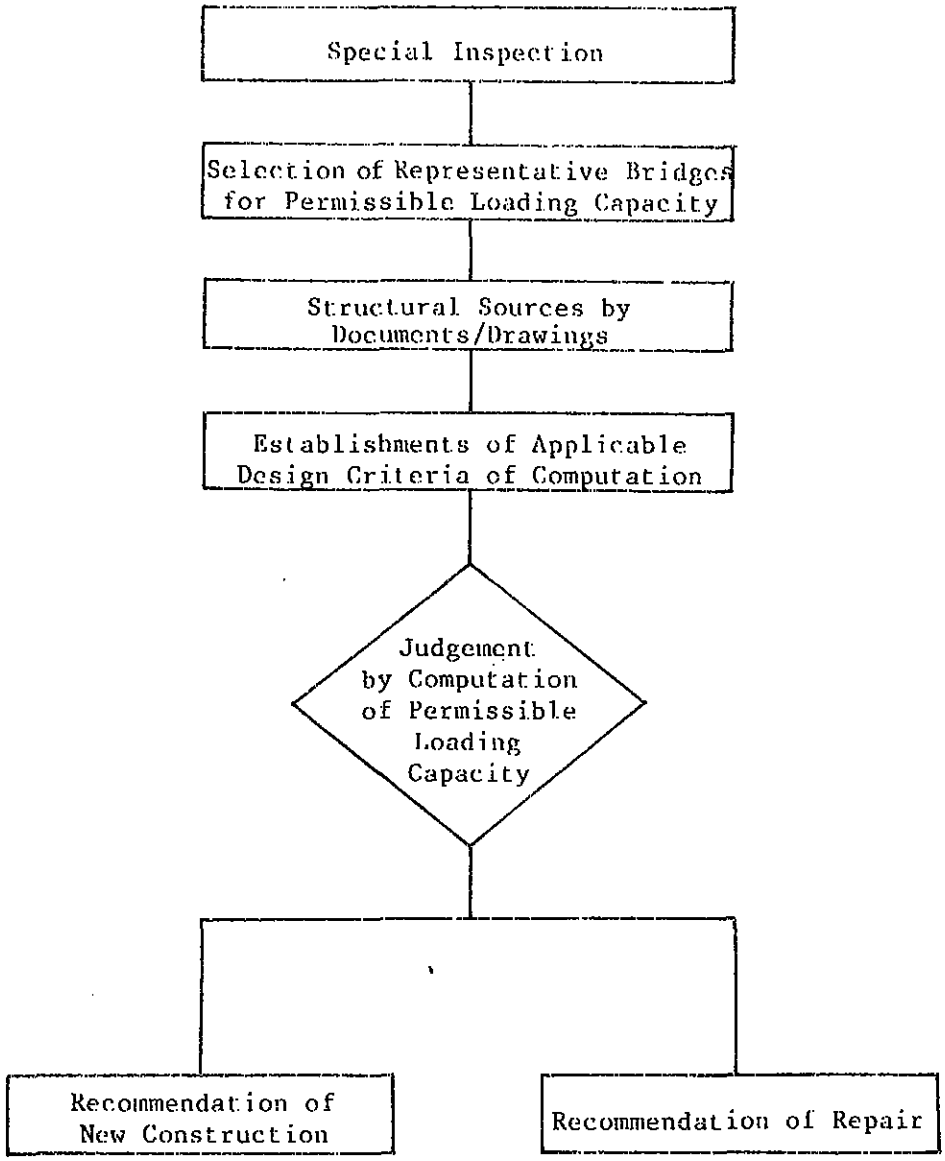
The equipment and instruments utilized during the loading test are listed below.

Description		Model/Type	Quantity
(1)	Dump Truck	15 tons	4
(2)	Wheel-Loader	2.0 cu. m.	1
(3)	Cargo Truck	4 tons	1
(4)	Generator	100 V	2
(5)	Theodolite	-	1
(6)	Auto-Level	-	1
(7)	Strain Gauge	KFW-5CI-11,L100	48 (pieces)
(8)	Lead Wire	L-2	3,000 (m)
(9)	Switch Box	SS-24R	2
(10)	Indicator	SM-60D	1
(11)	Gauge Tester	GT-7G	1
(12)	Tools for gauge	-	1 (set)
(13)	Coating Agent	-	1 (set)
(14)	Cloth Shelter for the Observing Station	-	1 (set)
(15)	Desks/Chairs	-	as required
(16)	Handy Lighting	-	as required
(17)	Traffic Sign Board	A Type	2 (pieces)
(18)	Traffic Sign Board	B Type	4 (pieces)
(19)	Traffic Sign Board	C Type	2 (pieces)
(20)	Traffic Sign Board	D Type	2 (pieces)
(21)	Rubber cone	-	8 (pieces)
(22)	Barricade	-	4 (pieces)
(23)	Early Warning Devices	A Type	2 (sets)
		B Type	16 (sets)
		C Type	16 (sets)

2.6.2 Permissible Loading Capacity by Calculation Formula

The procedure to rate a permissible loading capacity can be referred to the following flow diagram.

FLOW DIAGRAM FOR JUDGEMENT OF NEW CONSTRUCTION OR REPAIR IN ACCORDANCE WITH COMPUTATION OF PERMISSIBLE LOADING CAPACITY



To judge whether rehabilitation or repair of bridge is needed, permissible loading capacity is a prerequistie. For this analysis, M 13.5 (135 KN) loading is considered as critical loading to examine the minimum required duration of the existing bridge. The examining procedure can be referred to the flowing flow diagram for judgement of new construction or repair through computation of permissible loading capacity. The judgement will be made in accordance with the following criterion.

$P < 135$ KN : New Construction of Bridge

$P \geq 135$ KN : Repair of Bridge

where:

P = basic permissible loading capacity

The following formula is to be adopted to rate mainly the permissible loading capacity of steel-I-beams, pony truss and steel through truss bridges. The 13.5 vehicle weight is considered as minimally required loading of the existing steel type bridges.

$$P = 135 \times \frac{Fa - Fd}{FL + i}$$

where P = basic permissible loading capacity

$F_L + i$ = stress due to M 13.5 (135 KN) loading including impact

Fa = allowable stress of the materials referring to the following Table.

Fd = stress due to dead load

To rate the existing bridge structure, the capacity shall be computed by deducting the stress due to dead load from the allowable stress of the materials. This difference after deduction is the live load capacity of the structure expressed by stress.

The following are allowable stress (Loading Capacity) based on Manual for Maintenance Inspection of Bridges, AASHTO, 1983

(1)STRUCTURAL STEEL

(Unit; Mpa)

Structural Carbon Steel		AASHTO M 183
Minimum Yield Strength		Fy = 248
Axial Tensile Strength in members		0.55 Fy=136
Flexural compressive stress	Supported laterally its Full length by embedment in concrete	0.55 Fy=136
	Partially supported or unsupported	$0.55Fy\left[1-\frac{\left(\frac{L}{r}\right)^2 Fy}{4\pi^2 E}\right]$
Compressive in concentrically loaded columns	$K\frac{L}{R}\leq\sqrt{\frac{2\pi^2E}{Fy}}$	$\frac{Fy}{2.12}\left[1-\frac{\left(K\frac{L}{r}\right)^2 Fy}{4\pi^2 E}\right]$ $=117.073-0.004\left(\frac{KL}{r}\right)^2$
	$K\frac{L}{R}>\frac{2\pi^2E}{Fy}$	$\frac{\pi^2E}{2.12\left(K\frac{L}{r}\right)^2}$
Shear in girder webs, gross section		0.33 Fy = 82

(2)REINFORCEMENT & CONCRETE

(Unit: MPa) Minimum

	Tensile Strength	Compressive Strength	Shear Stress	Yield Strength
Reinforcement Grade 40	138	—	—	275.8
Concrete Class A (3,000psi = 20.68Mpa)	—	0.4 fc'=8.3	0.05fc' = 1.03	—

This live load capacity which is divided by the minimum required live load M 13.5 loading is the rating factor. To arrive at the basic permissible loading capacity (vehicle weight), the 13.5 ton vehicle weight shall be multiplied by the rating factor.

In addition, the operational live load capacity being practically applied is determined considering and multiplying the following modulus to the basic permissible capacity.

Modulus: Ks : subject to stress
Kr : subject to bridge surface condition
Kt : subject to traffic volume
Ko : subject to others

Modulus Corresponding to Bridge Types (Ks)

Bridge Type	Members	Ks
S-1-B	Main Beam	1.2
	Deck Slab	1.0
TRUSS/PONY	Upper/Lower Chord	1.2
	Vertical/Diagonal Chord	1.0
	Floor System	1.6
	Deck Slab	1.0
R.C.D.G.	Beam	1.2
	Deck Slab	1.0
R.C. SLAB	Slab	1.0

Factor by Pavement Condition (Kr)

Rating of Damage	Kr
A	0.8
B	0.9

Samples of calculation of permissible loading capacity using the formula stated above are shown in APPENDIX 2.5 divided into Case 1 and 2 respectively.

2.7 Mean of Access and Inspection Equipment

It is usually a problem how to reach damaged locations when bridge inspection is carried out especially in cases whose decks or beams are located high above ground level. The erection of scaffolding will constitute a major part of the cost of bridge inspection, then would be unacceptable from the economic standpoint. It is therefore advantageous to consider the access problem during bridge design stages and that is provide access ladders, platforms, etc.,. As to the existing bridge inspection, mean of access should be selected considering the safety of inspection personnel and traffic interruption during inspection and cost. The optimum mean of access is expected by the use of a suitable combination of the various means of access. The relative merits and demerits of the each mean of access will be assessed by its cost and effectiveness. Some possible means of access are mentioned below:

2.7.1 Bridge Inspection Vehicles

In recent years, several types of bridge inspection vehicles have been developed generally for the inspection of deck bridges. Such bridge inspection vehicles have normally the following characteristics:

- truck mounted and ability for normal road travel;
- own power supply;
- load capacity of platform or bucket to carry the weight of at least 2 persons and standard inspection tools;
- designed to provide an overall possible access to all bridge vital components.

Table 2.5 is a summary of the present function of the bridge inspection vehicles.

These bridge inspection vehicles have considerably helped to increase the effectiveness of inspection of deck bridges. The advantages of mobility, speed, time saving and economy seem to be generally acknowledged. However, it is necessary to understand the disadvantages regarding to the use of the bridge inspection vehicles as stated below:

- restricted to a truss bridge because it is only designed for deck bridge.
- traffic interruption caused by operation of inspection vehicles because the outriggers may obstruct traffic on two lanes bridges,
- the need to train specialists in the operation of inspection vehicles so as to ensure safety for inspection personnel and
- initial investment is costly

2.7.2 Scaffolding

Another possible and proper access to all or specific damaged structures can be the installation of scaffoldings. It is likely to be restricted to special occassions in the case of no appropriate method from the standpoint of economy as well as time constraints. The typical scaffolding, which is commonly used in the Philippines, is illustrated Fig. 2.2.

2.7.3 Means of Access under Water

There is sometime a need for inspection of parts of structures or foundations under water. One of possible means of access under water is the use of television cameras with remote control brought into the

proper position by a diver with advice from inspector.

2.7.4 Inspection Equipment

The inspection equipment and tools should be selected in relation to the number of bridges to be inspected, level of inspection and personnel available with the appropriate professional training. Therefore, it is considered that the inspection equipment and tools will be classified by the types of Inspection as follows.

- Superficial inspection will use no tool basically and rely mainly on visual inspection.
- Periodical inspection will use standard inspection tools but still rely on visual inspection.
- Special inspection will use non-destructive testing equipment with advance techniques but will still rely on visual assessment.

It is recognized that a number of reliable equipment techniques and methods have been developed to suit the need of assessing movements, strains, forces, strength, quality etc.. To describe testing procedures of all the various testing equipment would be beyond of the objective and scope of this report. Therefore the following are just introduced, inspection equipment and tools for each type of Inspection, although some equipment used in the detail survey of the JICA Study are described in APPENDIX 2.6.

(1) Standard Inspection Tools used in Periodical Inspection

In the periodical inspection, the measurement of cracks width on the concrete structures and movement or settlement of substructures and the other changes are generally carried out by using the following tools.

- White board, magic-pens, markers for indication
- Camera, field glass (binoculars), magnifying glass for researching and recording
- Pocket tapes, steel tapes (10--50 m), feelers gauges, calipers for measurement

- Straight edge, level, blump bob for measurement of horizontal and vertical line.
- Chipping and ballpen hammer, torque wrench for examining concrete or bolts.
- Pocket knife, wire brush, scraper, pick shovel for miscellaneous tools.

(2) Non-Destructive Test and Neutrality Test to be used in the Special Inspection

Non-destructive tests are classified into

- Concrete strength,
- Hardness test (strength) of structural steel,
- Neutrality and quality of concrete,
- Detecting concrete cover and reinforcement bar,
- Assessment of pile length.

The non-destructive test equipment classified above are briefly described as follows.

a) Concrete Strength Test

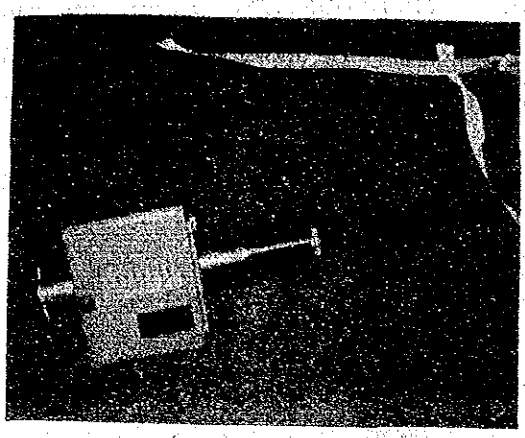
The presumption methods of concrete strength by means of the Schmidt hammer was adopted and used in this Study. The ``rebound number'' was measured at the specified locations along the concrete slab, concrete beam, abutment, pier, etc. The rebound number measured stands for the strength of concrete.

b) Hardness Test (Strength) of Structural Steel

Hardness test methods are used as quality control in the manufacture of structural test. In the study, the Ernst testing machine (portable type) which is a well known are reliable hardness test instrument was used.

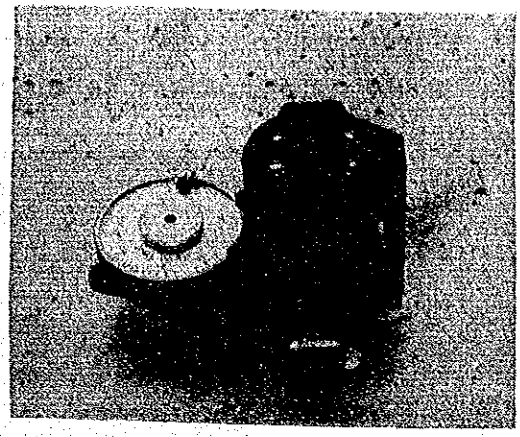
The Ernst testing machine works on the static principle of penetration depth difference and its degree of accuracy is 0.0006 mm.

Concrete Strength Test



Schmidt Hammer

Hardness Test

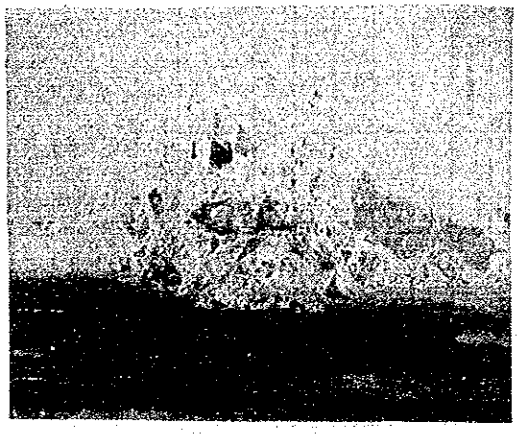


Ernst

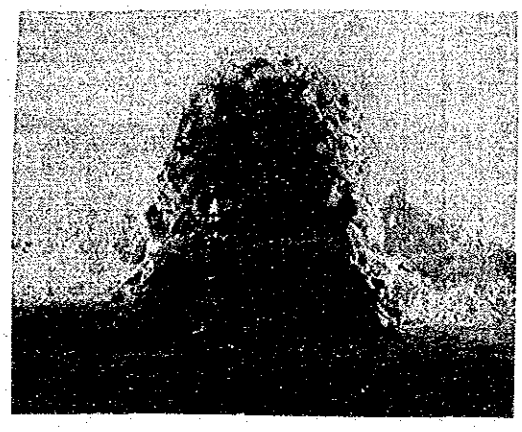
c) Neutrality Test

Generally, neutrality test method is called phenolphtalen method. In this study, the neutrality test was conducted at specified locations at the concrete slab, concrete beam, abutment and pier by spraying a chemical reagent called phenolphtalen (10%) liequid on the newly crushed face of the structural concrete. After a chemical reaction has taken place, neutrality depth was measured with the use of a steel scale.

Neutrality Test



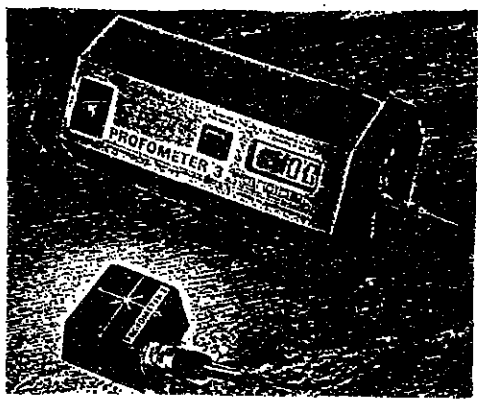
Before spraying the phenolphtalen liquid



After spraying the phenolphtalen liquid

d) Detecting Concrete cover and reinforcement bar

Solid-state magnetic detector (PPOFOMETER) works on the principle of changes in magnetic flux. It is used to measure the concrete cover and to detect reinforcement bar and its diameter.



e) Detecting craks of structural steel

Ultra-sonic technique is frequently and successfully used in the search for and detection of cracks. Hidden cracks can be discovered by the ultra-sonic technique. However, a skilled operator is required in order to operate and interpret the results showing on the display.

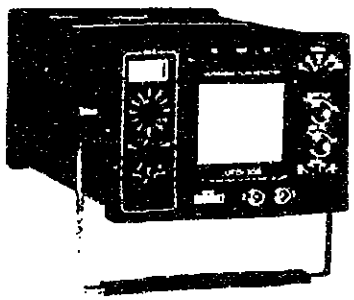


Table 2.1 INVENTORY SHEET NO.1

REGION NO : NO :

NO	STATION	BRIDGE NAME	TYPE	NO OF SPAN	SPAN LENGTH	BRIDGE LENGTH	WIDTH	DESIGN LOAD	YEAR OF CONST'	PRI-ORITY	REMARK

NOTE ; 1 Reinforced concrete deck girder 4 Arch 7 Bailey 0 Other
2 Concrete slab 5 Pony 8 Truss
3 Prestressed concrete deck girder 6 Steel I-Beam 9 Timber

Table 2.2 INVENTORY SHEET NO.2

INVENTORY SHEET NO.2			Bridge No.		
(1) Road Name/Sec.			(2) Name of Bridge		
(3) Location	km from		(4) Name of River		
(5) Year Built	19		(6) Design Load		
(7) Bridge Length			(8) Span		
(9) Bridge Width			(10) Carriageway Width		
(11) Crossing Condition	Crossing River, Railway Roadway, valley, Others		(12) Clearance		
(13) Plan of Bridge	Straight, Curve, Skew				
(14) Environment	Detour Length, Scio-Economic				
(15) Type of Bridge	Steel, R.C, P.C (Post, Pre), Other ( )				
(16) Type of Support	Simple,Continuous (spans),Rigid-Frame,Other( )				
(17) Type of Beam	I-beam, T-beam, Box-beam, Slab, Other( )				
(18) Beam	Nos.		(19) Cross Beam	Nos.	
	Pitch		(20) Stringer	Nos.	
(21) Slab	Type		(22) Pavement	Ashalt. Concrete	
	Span		(23) Railing	Concrete, Steel, Aluminium	
(24) Expansion Joint		Steel( ), Rubber( ), Dummy Joint( )			
(25) Substructure	Abutment	Cant, Pile-bent, Open			
	Pier	Wall, Colum, Pile-bent			
(26) Foundation		Spread, Pile( ), Others			
(27) Waterway Width			(28) Flood Velocity		
(29) Orientation of Water-way and Bridge		Coincident, Incoincident( )			
(30) Traffic Volume					

Note :

Table 2.3 INVENTORY SHEET NO.3

INVENTORY SHEET NO.3		Bridge No.		
Bridge Number		Inventory Date		
Item of Inventory	Defective Condition			Rating
(1) Pavement	Waving, Abrasion, Cracking, Pot-Hole			
	Condition			
(2) Curve & Railing				
(3) Exansion Joint	Noise, Leakage, Deference in level,			
	Condition			
(4) Deck Slab	Cracking, Exposure of R-bar, Spalling, Pot-Hole			
	Condition			
(5) Concrete Beam	Cracking, Exposure of R-bar, Spalling, Deformation			
	Condition			
(6) Steel Beam (Bracing, etc.)	Cracking, Corrosion, Painting, Deformation			
	Condition			
(7) Painting Cond.	Discoloration, Rust, Exfoliation			
	Condition			
(8) Shoe	Defection of Shoe, Defection of shoe Base			
	Condition			
(9) Abutment	Settlement, Movement, Declining, Scouring,			
	Condition			
(10) Pier	Settlement, Movement, Declining, Scouring,			
	Condition			
(11) Slope Protection	Settlement, Movement, Declining, Scouring,			
	Condition			
(12) Drainage				
(13) Approach Road				
(14) River Condititon		Scouring, Sedimentation, Others		

Rating of Evalution	Note(Major Causes or Recommendation)	Rating of Repair
		A:Urgent replacement repair B:Need repair C:Maintenance only

Table 2.4 TECHNICAL CRITERIA OF SELECTIN BRIDGE FOR URGENT REHABILITATION (1/3)

ASSESSMENT RATING	(1) Corrosion/Collision Of Major Members	(2) Concrete Beam Crack/Spalling	(3) Deck Slab Crack/ Spalling	(4) Substructure/ Foundation
A	· Loss or growth of tin for sectional area of main steel structural member due to corrosion · Serious deflection or deformation to inadequate design such as insufficient rigidness and/or withstand stress	· Main beam/girder is seriously deteriorated · Visible cracks and concrete spalling are observed for extensive range · Exposure of reinforcing bars · Spalling of concrete due to corrosion of bar	· Serious and progressive cracks and spalling due to heavy load and inadequate design · Reinforcing bars exposure in condition of corrosion	· Serious deterioration such as concrete spalling and reinforcing bar exposure or structure · Displacement, tilting and settlement of substruction due to scouring of river-bed
B	· Minor corrosion on members being covered by ordinary remedial works and/or repainting	· Many visible cracks due to heavy load and shrinkage · But no serious deterioration such as structural deformation and/or failure.	· Visible cracks due to heavy load · Visible cracks due to shrinkage	· Many minor cracks but no exposure of reinforcing bars on the substructure · Exposed foundation with stable condition but to progressive scouring of river bed
C	· Minor and partial deterioration and damaged being covered by maintenance activities	· No cracks or hair cracks only on structure surface · Healthy enough on appearance and function	· No crack or hair crack only on structure surface · Healthy enough on appearance and function	· No deterioration and damage on substructure · No movement of substructure

Table 2.4 TECHNICAL CRITERIA OF SELECTIN BRIDGE FOR URGENT REHABILITATION (2/3)

ASSESSMENT RATING	(5) Bank Washing Away/ Erosion	(6) Slope Protection Erosion	(7) Clearance shortage	(8) River Current Incoincident
A	· Serious erosion or washing away of river bank due to river blood	· Serious erosion or scouring of slope protection due to meandering and/or incoincidental river flow	· Beam/Girder is submerged due to inadequate Free-Board when river flood	· River current is immensely incoincident, and making erosion of bank and submergence of beam/girder
B	· Slight erosion but no progressive appearance with normal river condition	· Slight erosion or scouring but no progressive appearance with normal river condition	· Submergence of beam/girder may be occurred but it shall be analyzed by hydrological study	· River current is slightly incoincident but it shall be checked by hydro-logical study
C	· No erosion · Remaining healthy / intact protection after construction	· No erosion or scouring · Remaining healthy / intact protection after construction	· Adequate clearance and no marked river flood	· River current is rightful against the bridge location

Table 2.4 TECHNICAL CRITERIA OF SELECTIN BRIDGE FOR URGENT REHABILITATION (3/3)

ASSESSMENT RATING	(9) Inadequate Bridge Width	(10) Approach Road	(11) Others	Remarks
A	· The existing bridge width is inadequate and through type bridge	· Approach alignment is immensely bad in geometric requirement and approach portion is seriously cracked	· The bridge type is very old-fashoned and costly maintenance works have ever been carried out	
B	· The existing bridge is inadequate or through type bridge	· Approach alignment is slightly bad and pavement has small cracks	· The slight maintenance works have ever been carried out	
C	· The existing bridge is open type bridge	· Good approach condition	· No maintenance works have been carried out because of good condition	

Table 2.5 BRIDGE INSPECTION VEHICLES

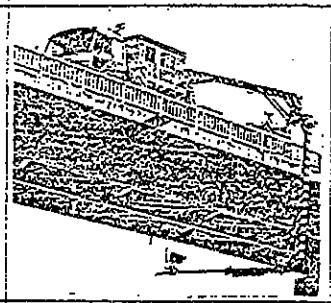
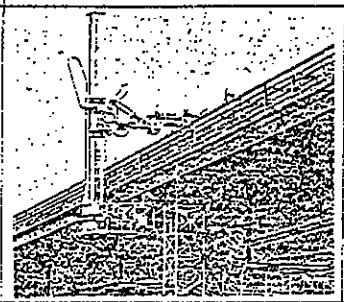
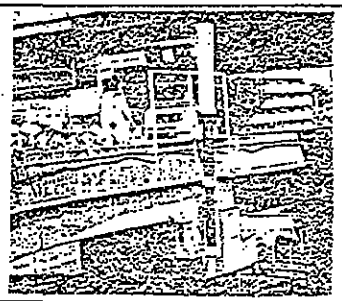
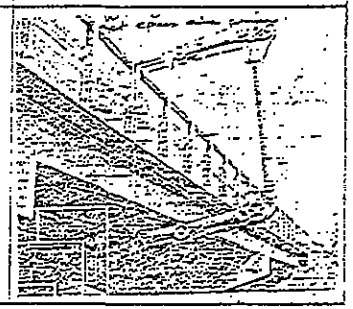
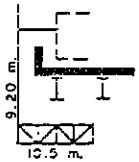
NO		1	2	3	4
MANUFACTURE		FUJI CAR MANUFACTURING CO., LTD., OSAKA	NIPPON KEI-KINZOKU, TOKYO	NIKKEN RENTAL, TOKYO	CORRECT MANUFACTURING, LONDON
TYPE		TV MONITORED BRIDGE CHECKER	NLM-KIC	OVER-FENCE	SKY-WORKER (MODEL O & U)
PHOTOS					
CHECKING WIDTH		12.0 m.	10.5 m.	—	—
ROTATING ANGLE		210°	90°	120°	—
BOOM OPERATION		Auto Operation	Hydraulic Boom	Hyraulic Boom	—
BOOM STROKE/LENGTH					
LOADING CAPACITY		—	200 kg. (2 - Persons)	150 kg. (2 - Persons)	—
DIMENSION OF VEHICLES	L	11.92 m.	11.95 m.	5.09 m.	—
	W	2.49 m.	2.49 m.	2.00 m.	—
	H	3.18 m.	3.74 m.	3.55 m.	—
TOTAL VEHICLE WEIGHT		14,710 kg.	19,875 kg.	5,550 kg.	—
PRICE		—	—	—	—
MANUFACTURING PERIOD		—	—	—	—

Fig. 2.1 FLOW CHART PROGRAM OF BRIDGE DATA MANAGEMENT SYSTEM

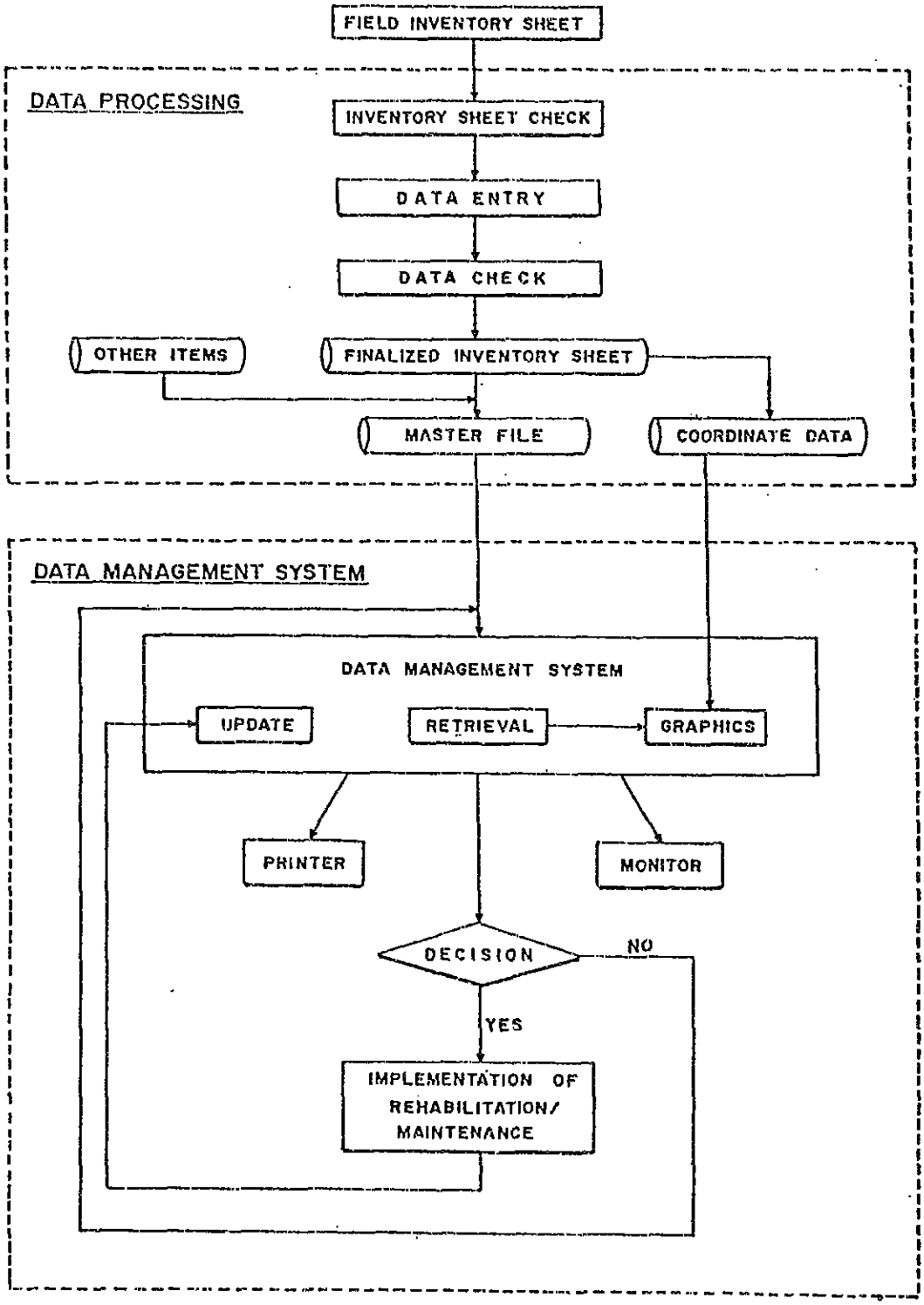
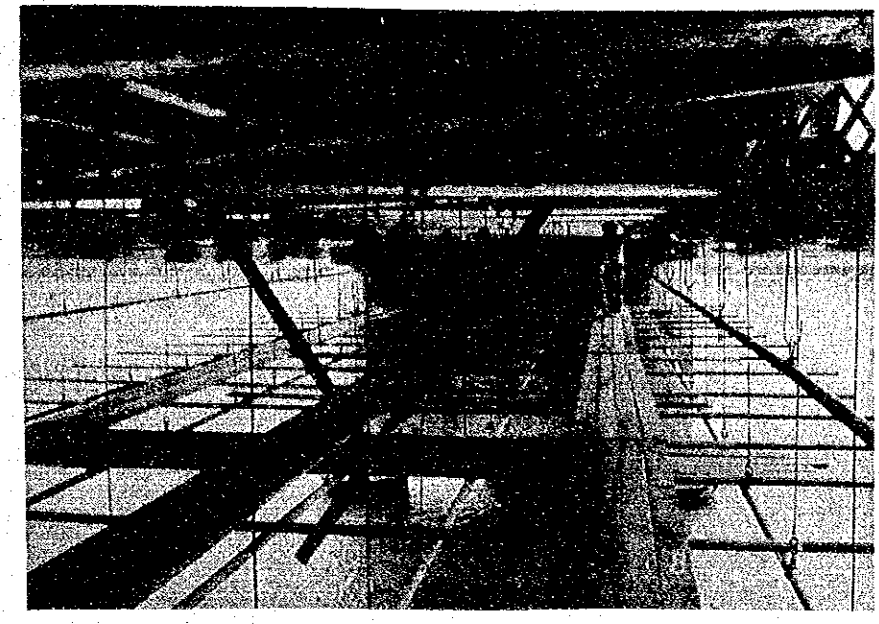
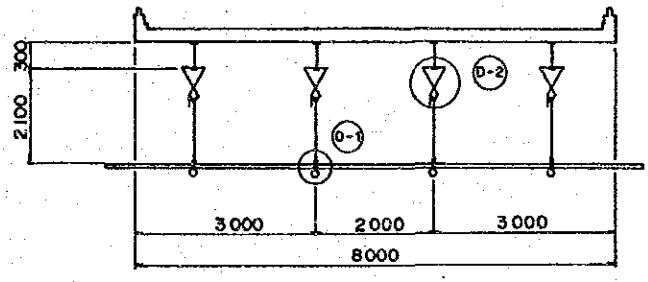
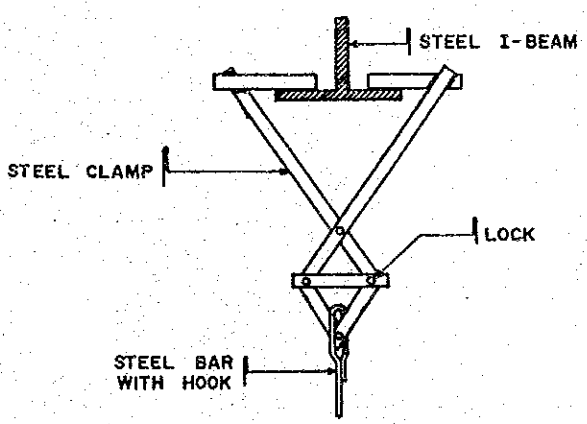


Fig. 2.2 HANGER TYPE SCAFFOLDING

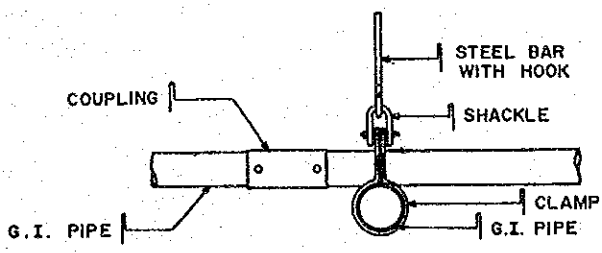




ELEVATION



D-2 SUSPENDED CLAMP DETAIL



D-1 CONNECTION DETAIL

CHAPTER 3
BRIDGE MANINTENANCE AND REHABILITATION

CHAPTER 3 BRIDGE MAINTENANCE AND REHABILITATION

3.1 General

This chapter presents briefly a more simple but important method on bridge maintenance and rehabilitation. These methods were considered and envisaged during bridge inspection along the arterial road in the JICA Feasibility Study. Detailed methods well-known and established in the world are therefore not presented in this report. For further details or additional information regarding specific bridges, refer to the AASHTO MANUAL FOR BRIDGE MAINTENANCE or other equivalent manual.

In this report, bridge maintenance and rehabilitation are;

Maintenance: Ordinary maintenance, is established for recurring maintenance, depending on the type of bridge structure and operating condition (traffic climate, etc.), to prevent defects.

Rehabilitation: Specialized maintenance is to repair or replace or reconstruction of the bridge based on the results of periodical or special inspection.

3.2 Features of Existing Bridges

Before presenting such a bridge maintenance considering the characteristic of damage, it is necessary to understand the common nature or feature of deterioration and damages of existing bridges for each section. The following are an analysis of the tendency and characteristic of deterioration and damages in each section (Fig. 3.1 and Fig. 3.2).

(1) Manila - Laoag

The Manila-Laoag section referred to as the Manila North Road starts from km 13 + 990 to km 486 + 960. This road section traverses two regions, Region III on the south and Region I and the north. The topography of the south is mainly flat while the north is generally mountainous. Most of the road on the north are located near the coast facing the China Sea. Big rivers are found only on the south, so it is

in this part wherein long span bridges are concentrated. The RCDG Bridge is the most common type used in the Manila North Road due to the fact that it is of mountainous terrain and its being easy to construct.

For the Manila North Road, the deterioration, damage and problems of the bridge structures are generally summarized as follows;

- Concrete structures have deteriorated considerably due to the swelling of corroded reinforcing bars;

- Steel structures such as I-beams and truss bridges have been more or less corroded by salt because of its proximity to the coast;

- The upstream and the approach portions of the bridges have been seriously eroded by floods at several large sized rivers;

- And the clearance below the bridge beam decreased due to the rising of riverbed by sedimentation.

(2) Manila-Allacapan

This road section which starts from km 38 + 900 to km 700 + 100 forms a part of the Pan-Philippine Highway. It traverses a flat terrain on the southern part extending up to the Metro Manila area and mountainous area on the northern portion. Big rivers like the Magat river and Cagayan river are located on this road section, thus, the long span bridges were constructed. Compared to other road sections on the Pan-Philippine Highway, this section has the longest aggregate length of Trusses.

As to the Pan-Philippine Highway (Allacapan to Manila), the deterioration, damage and problems of the bridge structures are described as follows:

- Deck slabs of steel and concrete bridges have cracks;
- Deck slab cracks are critical in long span bridges such as in pony and through-truss bridges;
- And the cause of the deterioration and damages of the deck slab

portion might be due to the excessive loads passing through these low designed bridges.

(3) Liloan-Allen

This section of the Pan-Philippine Highway runs from Liloan (km 1058 + 870), the most southern part of Leyte to Allen (km 666 + 100), the most northern part of Samar Island. It traverses two big islands, Samar and Leyte, which are connected by the Marcos Bridge having the length of 2.2 kms. The topography of this section is mostly mountainous. Most of the highways in the northern part of Samar is located near the coast. In this section, the Steel-I-Beam type of bridge is concentrated, while the RCDG type is most commonly used in other road sections.

As to the Pan-Philippine Highway (Liloan to Allen) the deterioration and damages of the existing bridges are:

- Traffic volume is relatively small, although middlesized buses for long distance trips were sometimes observed during inspection. This traffic condition may not induce serious deterioration and damages on the existing bridges along the area.
- Steel-I-beams, however, are generally rusty. Some of them are seriously corroded on lower flange of beams.
- And, the presence of cracks and/or gaps on the concrete slab of the approach portion of most bridges from Tacloban to Allen were observed.

(4) Matnog-Manila

The Matnog-Manila road section of the Pan-Philippine Highway runs from the most southern part of Luzon (km 644 + 440) to San Pedro, Laguna (km 29 + 150). The topography of the northern part is mainly flat while that of the southern portion is generally mountainous. A portion of this highiway (northern part) passes along the coast of Quezon Province facing the Pacific Ocean. Many small rivers abound in this section, thus, the reason why short span bridges like the RCDG and S-I-B type were constructed here. It

is in this part of the Pan-Philippine Highway where the RCDG type is concentrated.

As to the Pan-Philippine Highway (Matnog to Manila), the deterioration and damages of the existing bridges are:

- For RCDG and Steel-I-Beam bridges, there are visible cracks on concrete deck slab.
- Most of the short span bridges on the northside of Naga City have serious cracks and potholes on their concrete deck slab.
- In Albay province and northern part of Sorsogon there are various types of arch bridges, either concrete or stone masonry.
- The bridges crossing over the stream flowing down from the Mayon volcano have inadequate clearances due to sedimentation.
- Local scouring around pier foundations have been observed in some bridges, although they were not classified as in serious condition.

3.3 Maintenance Operation

The maintenance operation is carried out by maintenance personnel in Regional Offices. It is important for bridge engineers and maintainers to examine the tendency and characteristic of deterioration and damages in each region because maintenance is usually widely distributed geographically over a variety of types of bridges.

When understanding the tendency and characteristics of deterioration in detail, it should be born in mind that maintenance applied can slow down further development of damages.

3.3.1 Scope of Ordinary Maintenance

The scope of ordinary maintenance which is carried out by each city or district offices, in consideration with the personnel involved in bridge maintainance are listed below:

- Simple clearing of carriageways, footpaths, joints, drains, shoes, expansion joint, gutters, etc. by hand and removal of

foreign materials such as trash, mud or vegetation.

- Small restoration works on concrete structure, slab and railing, carried out with mortar or concrete.
- Small restoration works on slope protection (stone masonry or stone pitching), replacement of missing stones, sealing and repairs with mortar.
- Protection from local scouring around piers and abutment with stone placed during dry season.
- Localized painting operations to protect against corrosion.
- Lubrication and greasing of bearing shoes.
- Repair of drainage system.
- Minor clearing of river channel in upstream and downstream.

3.3.2 Key-points of Maintenance

The JICA Study Team understood from their bridge inspection that the bridges were in poor condition (defects or damages) through inadequate maintenance in the past, probably as result of constraints in the maintenance budget. It is however considered that these defects or damages could have been avoided without straining the budget, if initial maintenance was done promptly as soon as the defects or damages which have led to defect were detected or foreseen. As results of the bridge inventory, the following are therefore recommended as key-point for maintenance.

1) Mud and vegetation on flanges of steel beams should be cleaned to prevent corrosion.

2) Trash around abutment should be removed and the area around it must be prohibited from being used as a dumping ground to prevent local scouring around abutments due to dammed-up water.

3) Remove inflammables such as houses or wooden materials especially under steel bridges, because the loading capacity of steel beams deteriorates rapidly due to the fire.

4) During dry season when local scouring around piers and abutments can be easily detected stones or other materials that

can be easily procured should be placed as s temporary protection measure.

5) It is considered that the main cause of defects on slab is due to impact load of heavy vehicles. Traffic signs and road markings should be prominently displayed at both sides of the bridge when the bridge deck is deteriorated or foreseen to be damaged.

6) Most bridge decks continue to deteriorate due to lack of waterproofing and heavy traffic. The patching of a deteriorated concrete deck or overlay on the entire concrete deck should be made as a protective maintenance until deck replacement is made. Since rapid restoration of deck surface is needed, asphalt should be used for patching or overlay because it is relatively cheaper and easy to place.

7) The gap or boundary between abutment and approach road should be flatted by asphalt overlay because the parapet and expansion joints will be damaged due to impact of heavy traffic.

8) Periodic cleaning and spot painting on localized areas such as beam ends, under expansion joints, lower flanges of beams, under floor drains, etc. will prevent corrosion and prolong the life of the total paint system.

9) Total paint is included in ordinary maintenance because paint is not considered as one of the proposed rehabilitation method in the JICA Study. The time interval between painting operation and first application of paintcoat will depend on the following;

- climate
- relative humidity
- presence of aggressive agents

However, it is difficult to determine the time interval between painting operations based on the above standardized

criteria because they differ from region to region. Therefore, painting criteria are generally based on the degree of corrosion by means of a photographic comparison.

In the JICA Study area, the bridges in Region V and VIII are located along the sea so that these are considerably corroded due to aggressive agents as shown in Fig. 3.1.

Paint materials and procedures to be used in protecting steel bridge from weather and corrosive material in the water should be referred to the AASHTO MANUAL FOR BRIDGE MAINTENANCE.

10) Cleaning of the deck, expansion joints and substructure caps will help prevent deterioration of the structures beneath the deck and help prevent foreign material from being wedged in the expansion joint. When the expansion joints are maintained, provisions should be made to provide for increased joint opening and sealing of joints against leakage.

11) Bridges are normally designed to minimize the build up of debris and collection of water on or near bearing shoes. However, most of the bridges are not properly protected from the build up of debris and water in the study area. It is therefore necessary to have a program in cleaning dirt and debris off bridge seats and bearing shoes at frequent regular intervals and if necessary to paint and lubricate them.

12) Maintenance of bridge drainage is very important in good preventive maintenance but it is almost neglected in the study areas. The drainage pipes which made of steel are already heavily decayed and getting shorter and higher than the lower flanges of steel beams. The lower flanges are corroded due to the splash of water from short drain pipes. When these drainage pipes are therefore replaced and relaid, the following points should be kept in mind;

- drainage pipes should be of a vinyl chloride pipe
- drainage pipe should be longer and lower than the lowest flange of steel beams.

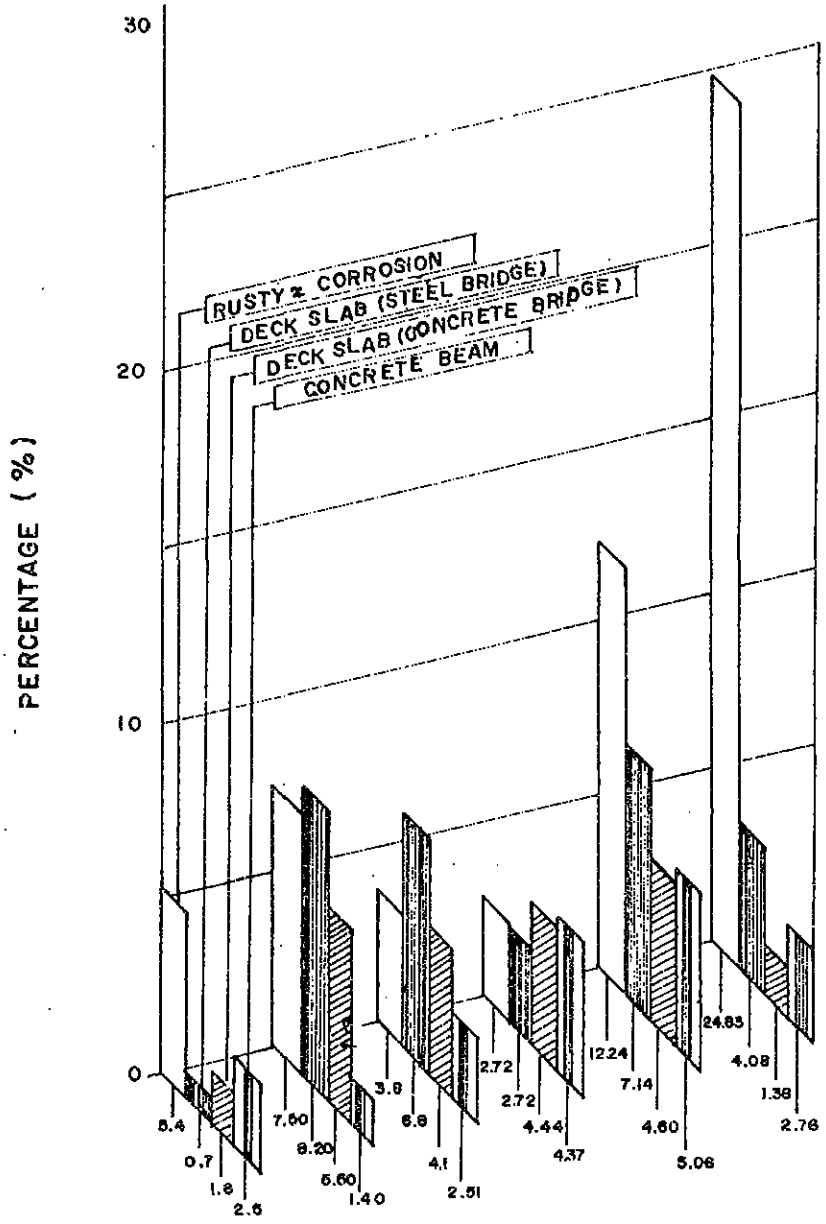
13) It is also important to inspect the location where water is being drained because it frequently happens that the water during concentrated heavy rains is discharged at vulnerable points such as at the backside of abutment or embankment slope. Based on the result of the inspection, the diversion drain should be located so as not to concentrate rain water. It is also considered as a preventive maintenance.

14) It often happens that ``sand bar'' in the riverbed caused by deposition in the stream can deflect the current against abutments or piers. The mis-alignment and concentration of flow caused an increase in velocity at that point which greatly increased the streams erosive ability. When the river dries up during dry season, a bulldozer can be used to push fallen trees and other water-borne debris and move it out of the river. Rocks and stone can be redistributed evenly to maintain the original river bottom or it can be placed along the banks.

15) The waterway of river will properly be channelled to ensure the opening under the bridge so that approach of either side of the bridge will be prevented from scouring.

16) Minor clearing of river channel in the upstream and downstream during dry season so that when rainy season comes the flow of water will be going along the river channel under the bridge.

Fig.3.1 **DETERIORATION AND DAMAGES (SUPERSTRUCTURE)**

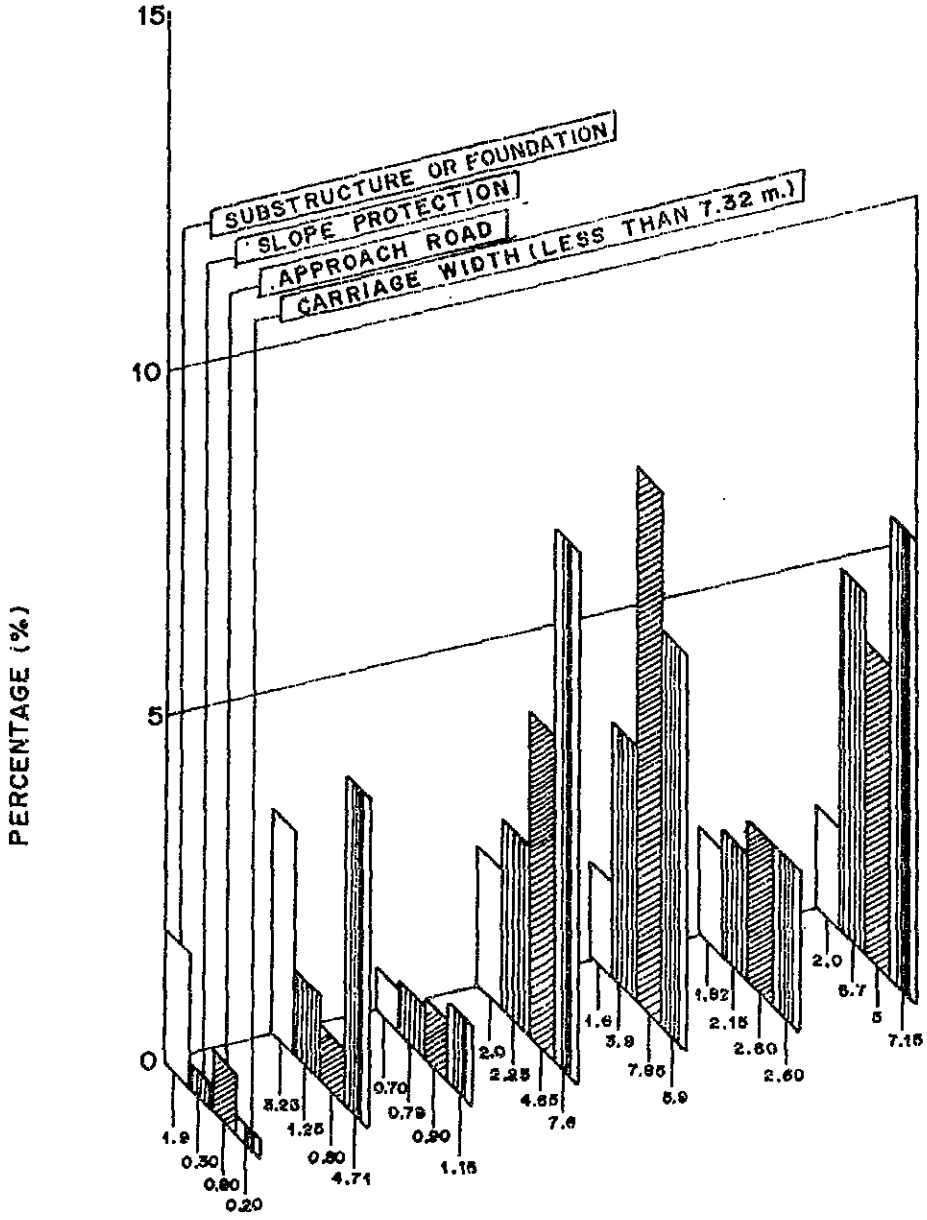


BR. NO.	109	123	110	81	158	161
REGION	I	II	III	IV-A	V	VIII

LEGEND:

- RUSTY - CORROSION
- DECK SLAB (STEEL BRIDGE)
- DECK SLAB (CONCRETE BRIDGE)
- CONCRETE BEAM

Fig. 3.2 DETERIORATION AND DAMAGES
(SUBSTRUCTURE)



BRIDGE NO.	48	109	62	123	158	81	161
REGION	III	I	III	II	V	IV-A	VIII

LEGEND :

- SUBSTRUCTURE OR FOUNDATION
- SLOPE PROTECTION
- APPROACH ROAD
- CARRIAGE WIDTH (LESS THAN 7.32 m.)

3.4 Representative Rehabilitation Methods

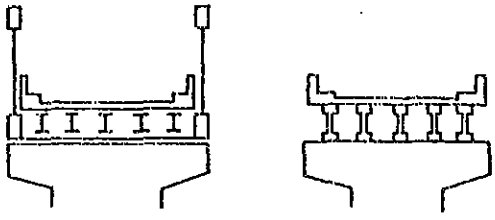
The following sixteen (16) representative rehabilitation methods are prepared based on the study of Rehabilitation and Maintenance of Bridges along Arterial Road. It is also intended that the rehabilitation methods introduced here will be applied to other similar existing bridges in the Philippinies. The 16 rehabilitation methods are presented in detail, in the form of a table. Each method includes a description of deterioration and damages, its causes, application of the rehabilitation method to the deterioration and damages, and rehabilitation procedure including its sketch.

REHABILITATION METHODS (1/4)

REHABILITATION METHODS	SECTIONS	
	BEFORE ACTIONS	AFTER ACTIONS

1.) Reconstraction

The new construction of bridge covering superstructure, sub-structure and foundation is considered due to the serious conditions from viewpoint of functional and physical requirement.

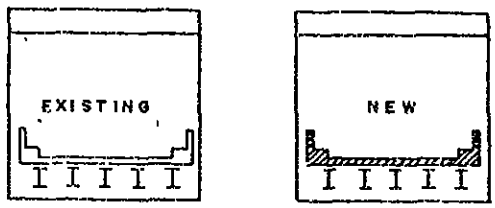


2.) Replacement of Superstructure

The reconstruction of the super-structure portion is considered due to the inadequate bridge width and serious damages on the wide range of bridge sttucture.

3.) Replacement of Deck Slab.

Concrete deck slab is replaced due to its serious deteriora-tion and damages.



4.) Reinforcement of Deck Slab:

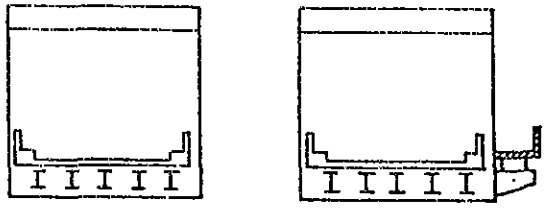
The existing concrete deck slab is sustaind with additional stringer at the middle of the existing deck span, and cross beam is reinforced, if necessary.

REHABILITATION METHODS (2/4)

REHABILITATION METHODS	SECTIONS	
	BEFORE ACTIONS	AFTER ACTIONS

5.) Additional Sidewalk

Additional sidewalk is provided out of the existing bridge (Steel Truss) because of shortage of the required width.

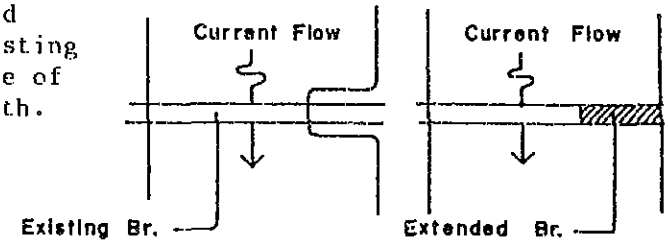


6.) Widening of Girder Bridge

Additional girders are provided at both sides of the existing bridge in case the roadway width is short of the requirement.

7.) Extension of Approach Span

New bridge spans are provided for the extension of the existing bridge as a side span because of the requirement of river width.



8.) Reinforcing Concrete Beam of RCDG.

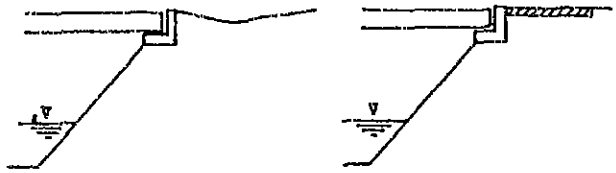
The deteriorated or damage concrete beam and/or deck slab is reinforced by jacketing repair method. The shear cracks on the beam are repaired with additional rebars and jacketing concrete.

REHABILITATION METHODS (3/4)

REHABILITATION METHODS	SECTIONS	
	BEFORE ACTIONS	AFTER ACTIONS

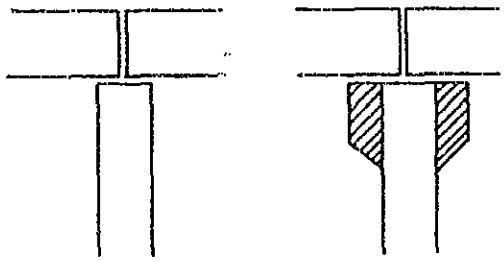
9.) Link Slab

Link slab is installed at the approach portion of the existing bridge where it severely settles down because of soft ground and other intricated conditions.



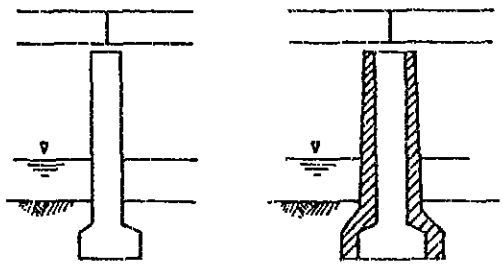
10.) Widening Pier Cap/ Bearing Bed

Pier cap and bearing bed are widened in case that reconstruction of superstructure is planned or the existing cap and bed spacing is too narrow to sustain RCDG bridge sufficient.



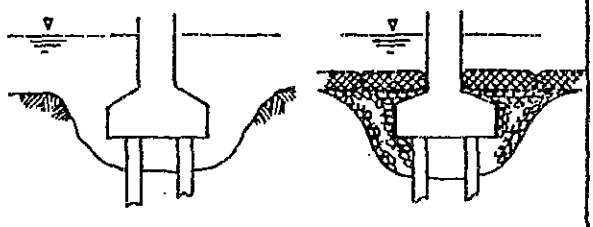
11.) Reinforcement of Substructure

Substructure is reinforced since its structural size is too short to sustain the superstructure and/or damage is serious.



12.) Protection of Pier Foundation

Foundation is protected with suitable manners and materials to prevent the developing scour occurring around pier foundation.

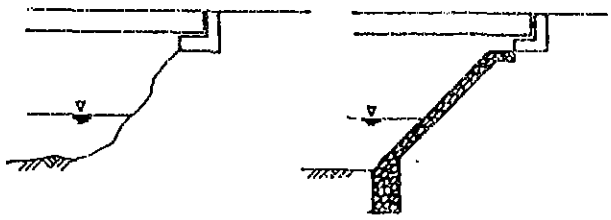


REHABILITATION METHODS (4/4)

REHABILITATION METHODS	SECTIONS	
	BEFORE ACTIONS	AFTER ACTIONS

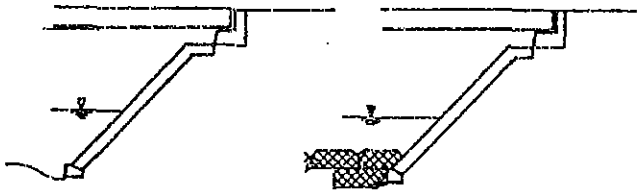
13) *Slope Protection / River Bank*

The protection is put in front of the abutment and on the riverbank to prevent erosion by river current.



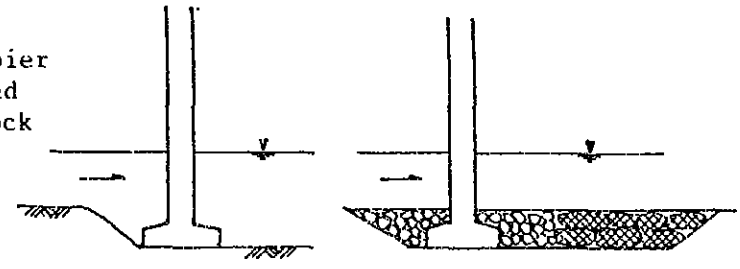
14) Foot Protection

The foot portion of bank slope is protected from erosion by providing gabion or concrete block mattress.



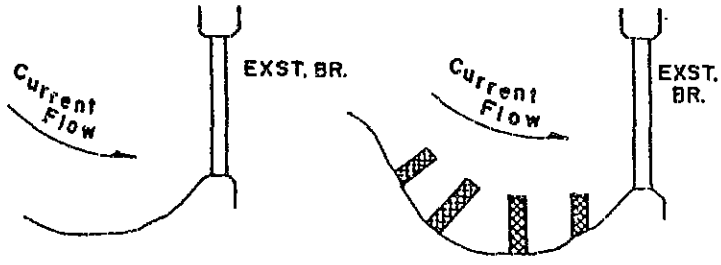
15) River Bed Protection

The riverbed around the pier and abutment are protected with gabion, concrete block and pitching stone.



16) Groyne

Stone masonry is provided to control river current flow at the place where current flow is rushing or curving sharply.



REPRESENTATIVE REHABILITATION METHODS

REHABILITATION METHOD				SHEET NO.	1/49
NO.	(1)	DESCRIPTION	RECONSTRUCTION		
REFERENCE: BR. NO. 77 BAUANG I, REGION - 1					

1. New Construction is required due to the following conditions.

   (1) Deterioration and damages are very serious on the bridge structure and substructure.

   (2) Bridge site alignment is undesirable from the geometrical viewpoint of the highway.

   (3) Freeboard below bridge girder is seriously short due to riverbed rising induced by sedimentation.

   (4) Bridge width does not meet the requirement due to increasing traffic volume.

   (5) Lack of duration is confirmed by physical check even though the structure is still stable through visual assessment.

   (6) Potential risk is recognized as a result of river study, such as shortage of bridge length, lower elevation and unstableness due to riverbed scouring.

2. Checkpoints for Selection of Bridge Type

   The following checkpoints are to be considered for selection of bridge type.

   (1) Procurement of Materials
   (2) Soil Condition
   (3) Bridge Length and Scale
   (4) Circumstances of Bridge Site
   (5) Capability of Execution of Construction

3. Checkpoints for Selection of Construction Method

   The following checkpoints are to be considered for selection of construction method.

   (1) Topographical Condition at Bridge Site
   (2) Limitation on Activities of Construction
   (3) Usability of Construction Equipment
   (4) Transport Condition of Construction Equipment and Materials

(5) Type and Scale of Bridge Structure

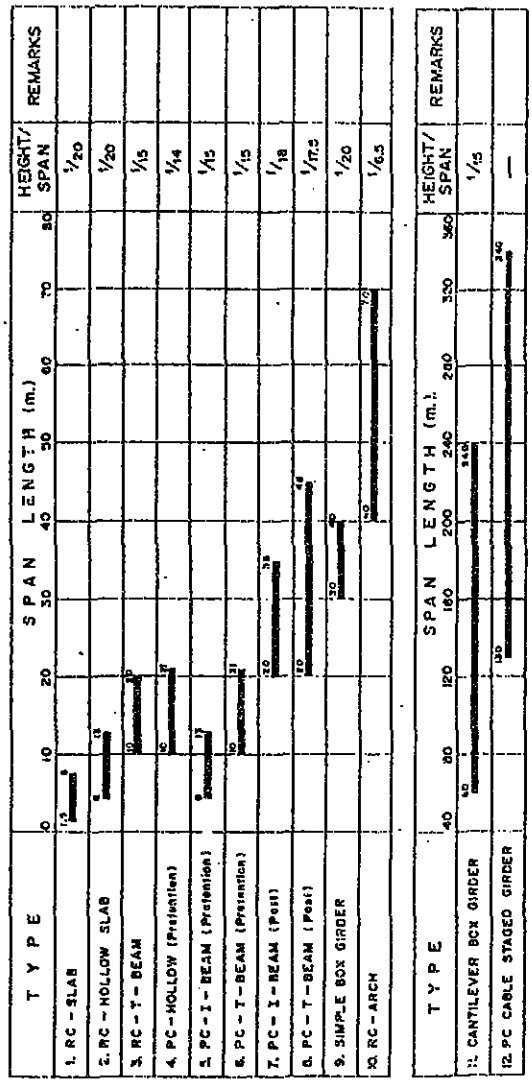
(6) Coordination between Design and Construction

(7) Safety Condition

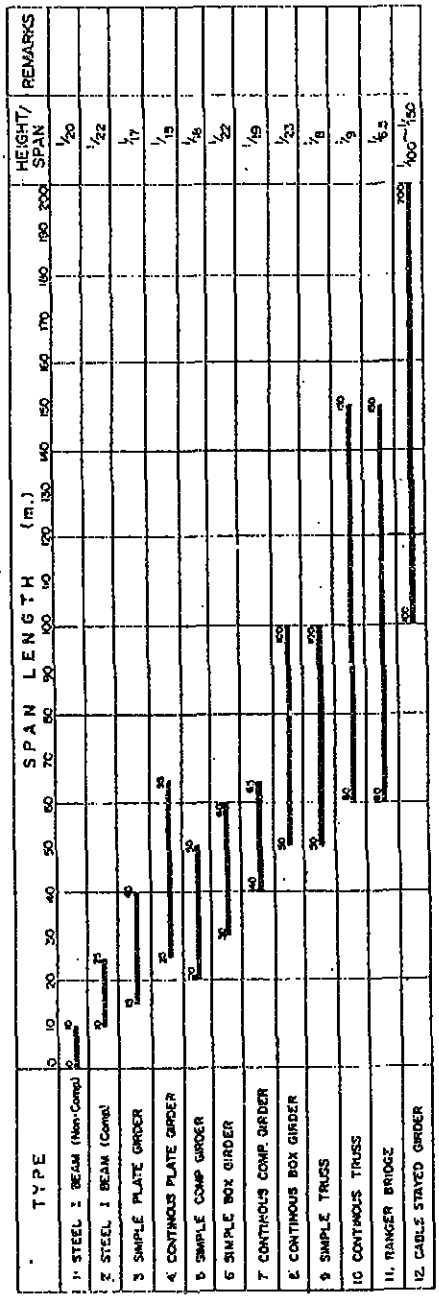
(8) Economic Consideration

REHABILITATION METHOD				SHEET NO.	3/49
NO.	(1)	DESCRIPTION	RECONSTRUCTION		

APPLICABLE TYPES OF CONCRETE BRIDGE

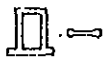


APPLICABLE TYPES OF STEEL BRIDGE



REHABILITATION METHOD		SHEET NO.	4/49
NO.	(1)	DESCRIPTION	RECONSTRUCTION

APPLICABLE TYPES OF PIER

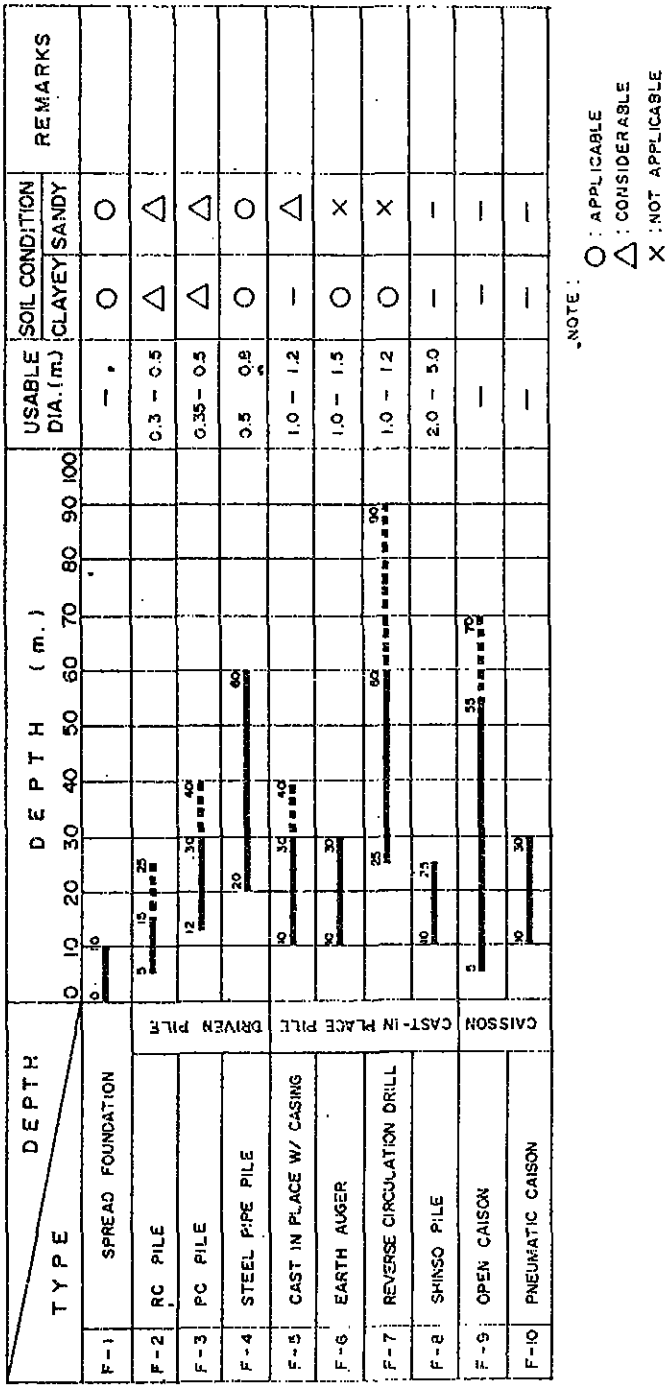
TYPE		HEIGHT(m) 0 10 20 30 40	REMARKS
P-1	Column Type	0 — 15	
P-2	Rigid Frame Type (1storey)	5 — 15	
P-3	Rigid Frame Type(2storey)	15 — 25	
P-4	Wall Type	10 — 30	
P-5	Wall Type (1section	25 — 40	

APPLICABLE TYPES OF ABUTMENT

TYPE		HEIGHT (m) 0 10 20 30	REMARKS
A-1	CHAIR TYPE	3	
A-2	GRAVITY TYPE	4	
A-3	SEMI GRAVITY TYPE	4 6	
A-4	INVERSE T-TYPE	6 10	
A-5	BUTTRESSED TYPE	10 15	
A-6	BOX TYPE	10 20	
A-7	SUSTAINING WALL TYPE	10 15	

REHABILITATION METHOD				SHEET NO.	5/49
NO.	(1)	DESCRIPTION	RECONSTRUCTION		

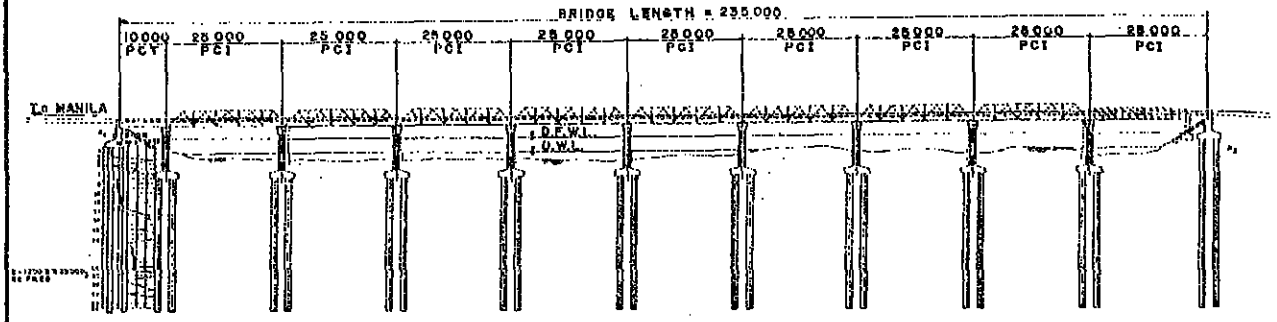
APPLICABLE TYPES OF FOUNDATION



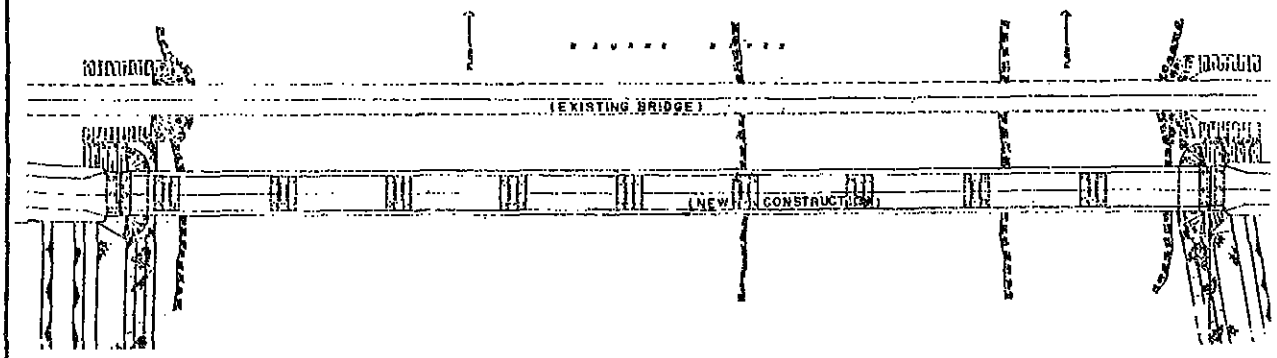
REHABILITATION METHOD				SHEET NO.	6/49
NO.	(1)	DESCRIPTION	RECONSTRUCTION		

(REHABILITATION)

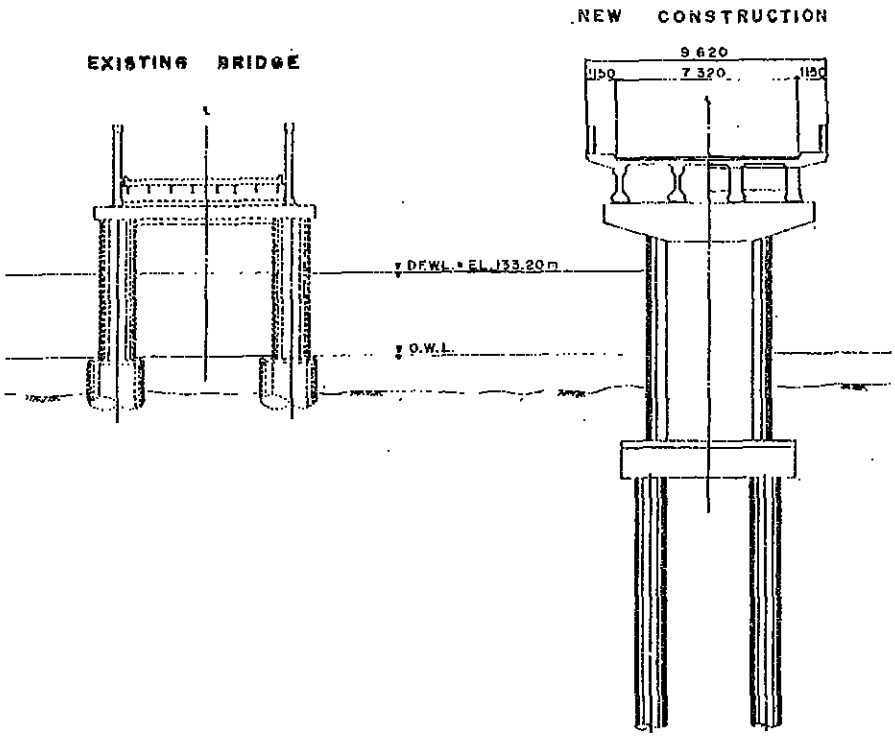
PROFILE



PLAN



CROSS SECTION



REHABILITATION METHOD				SHEET NO.	7/49
NO.	(2)	DESCRIPTION	REPLACEMENT OF SUPERSTRUCTURE		

REFERENCE: BR. NO. 208 STO. CRISTO, REGION IV-A

A. Cases Requiring Replacement of Superstructure

(1) Deterioration and damages are very serious on the bridge structure.

(2) Bridge width does not meet the requirement due to increasing traffic volume.

(3) Lack of duration is confirmed by the physical check even though the structure is still stable through visual assessment.

(4) Potential risk is recognized as a result of river study, such as shortage of bridge length, lower elevation and unstableness due to riverbed scouring.

B. Causes of Deterioration and Damages for Specific Type of Superstructure

1. Deck-Slab of Concrete Bridge and RC-Slab Bridge

(1) Deterioration and Damages:

Scaling, spalling and cracks are frequent and clearly visible.

(2) Cause:

- No pavement overlay direct load actions on the deck slab without any distribution and therefore increases the impace to the deck slab.
- The quality of concrete is poor and the aggregates (sand and gravel) are often segregated.

2. Reinforced Concrete Deck Girder Bridge (RCDG)

(1) Deterioration and Damages:

Shear cracks, exposure of reinforcing bars and spalling of concrete are observed.

(2) Cause:

- Shortage of the bearing seat width at the top of the substructure induces shear crack at the beam end and at the cap of pier.
- Swell of corroded reinforcing bars induces spalling of the bottom concrete of the beam.

3. Prestressed Concrete Deck Girder Bridge (PCDG)

(1) Deterioration and Damages:

Insufficient surface finishing of the concrete beam are observed. It may induce the concrete spalling in the future.

(2) Cause:

In correct formworks and insufficient vibration during concrete pouring make poor finishing of the concrete surface.

4. Steel-I-Beam Bridge (SIB)

(1) Deterioration and Damages:

The rust and corrosion on the bottom flange, connections of the floor beam and the bearing seat are seen. The crack conditions of deck slab is more serious than that of a concrete bridge.

(2) Cause:

- The lack of rigidness and non providing of diaphragms may induce differential deflection of the steel-I-beam which causes serious crack on the deck slab.
- Overloading induce the cracks on the deck slab.

5. Pony and Through Truss Bridges

(1) Deterioration and Damages:

The concrete deck slab portion of these bridges are seriously deteriorated as in the case of spalling and potholing. Some bridges located along the coast have excessive corrosion on the lower chords, stringers and floor beams.

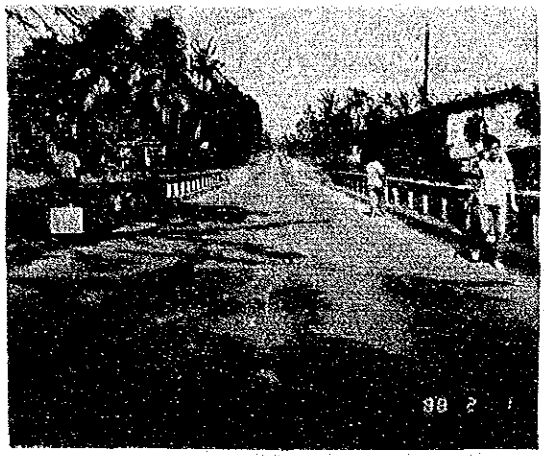
REHABILITATION METHOD				SHEET NO.	9/49
NO.	(2)	DESCRIPTION	REPLACEMENT OF SUPERSTRUCTURE		

(2) Cause:

- Overloading allows direct action of the wheels on the deck slab.
- Overloading allows increase of the swagging of steel on long span bridges and induces crack of deck slab.
- Lack of maintenance such as cleaning and repainting causes serious corrosion on the members.

REHABILITATION METHOD			SHEET NO.	10/49
NO.	(2)	DESCRIPTION	REPLACEMENT OF SUPERSTRUCTURE	

(EXST. SITUATION)



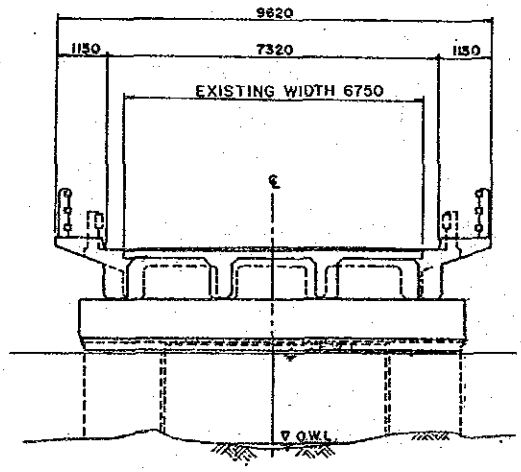
NARROW WIDTH FOR INCREASING TRAFFIC VOLUME

TEMPORARY COUNTER MEASURE OF SERIOUS DAMAGE OF BEAMS

(REHABILITATION)

CROSS SECTION

(RECONSTRUCTION OF RCDG)



REHABILITATION METHOD .				SHEET NO.	11/49
NO.	(3)	DESCRIPTION	REPLACEMENT OF DECK SLAB		

1. REFERENCE: BR. NO. 48 PLARIDEL, REGION - I

2. DETERIORATION AND DAMAGES:

- Concrete deck slab are seriously cracked. Transverse are longitudinal cracks are observed.

3. CAUSES:

- Excessive laod passing over deck slabs without pavement overlay allows direct action of the wheels to the deck slab.
- Excessive laod allows increase of the swagging of on long span bridges and induce deck slab cracks.

4. APPLICATION:

- Remove the existing damage and reconstruct the new concrete deck slab on existing floor structures.

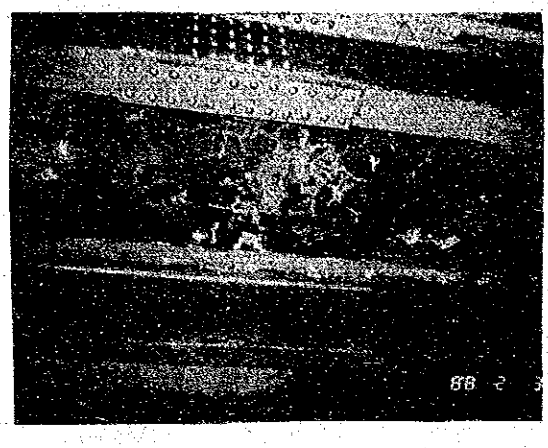
5. PROCEDURE:

1. Demolish existing concrete deck slab using Jack hammer.
2. Install scaffolding works.
3. Cut existing reinforcing bars.
4. Set-up form works,
5. Place reinforcing steel bars, and additional reinforcement bars.
6. Pour the concrete.
7. Transfer preparation work to the opposite side of the lane.
8. Repeat (1) to (6).

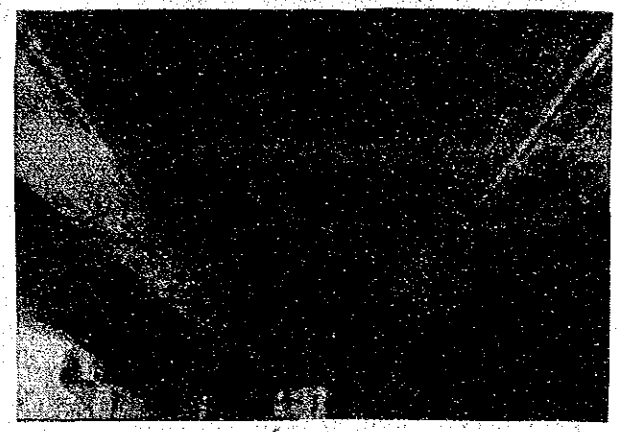
Note: It must have one lane open during construction.

REHABILITATION METHOD				SHEET NO.	12/49
NO.	(3)	DESCRIPTION	REPLACEMENT OF DECK SLAB		

(EXST. SITUATION)



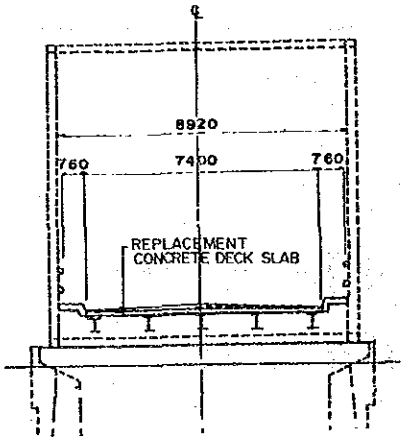
SERIOUS CRACKS ON CONCRETE DECK SLAB (STEEL BRIDGE)

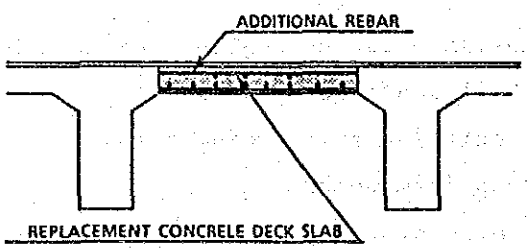


EXPOUSED REINFORCING BAR ON DECK SLAB (CONCRETE BRIDGE)

CROSS SECTION

(DECK SLAB REPLACEMENT)





REHABILITATION METHOD				SHEET NO.	13/49
NO.	(4)	DESCRIPTION	REINFORCEMENT DECK SLAB		

1. REFERENCE: BR. NO. 129 SAN PABLO, REGION - II

2. DETERIORATION AND DAMAGES:

- The concrete deck slab is seriously damaged.
- Many potholes and exposed reinforcing bars are observved.

3. CAUSES:

- Excessive load causes deck slab cracks.
- Wide spacing of floor stringers induces the increase of cracks.

4. APPLICATION:

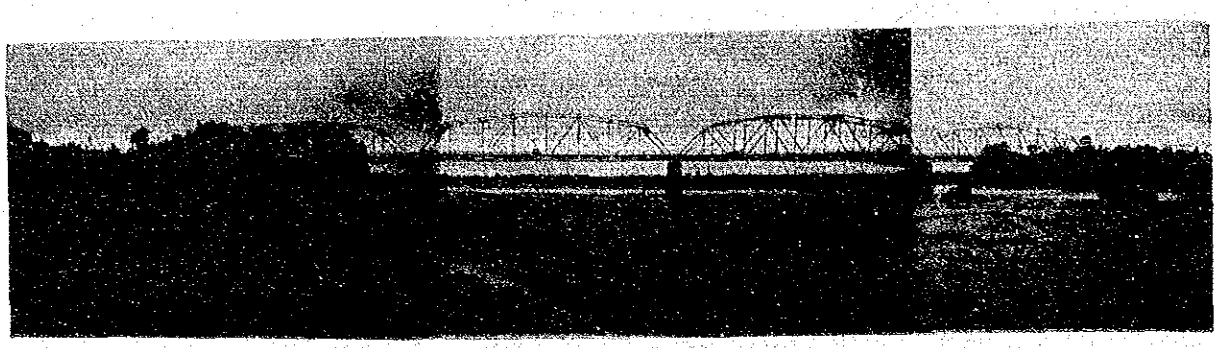
- To replace the existing concrete deck slab and increase the strength of floor structure with additional stringer.

5. PROCEDURE:

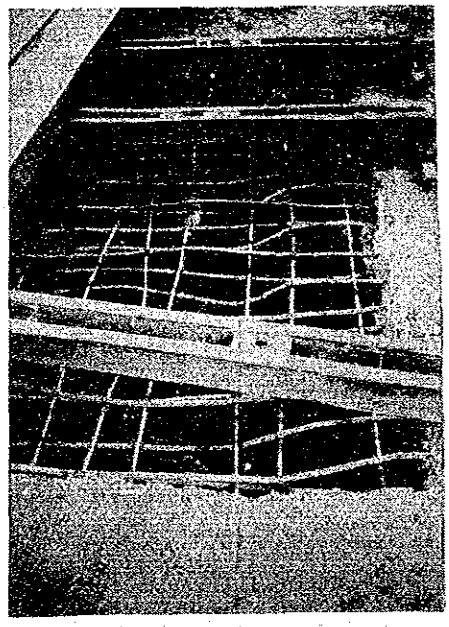
1. Weld the new connection plates to the web of existing cross beams.
2. Place additional stringers and connect to the connection plates with High Tension Bolt (H.T.B.).
3. Clean and smooth on the surface of the exisiting concrete deck slab touched to the flange of additional stringer.
4. Set up formwork for haunch.
5. Grout mortar to the haunch.
6. After the mortar has reached sufficient strength, place jackes against the additional stringers.
7. Grout a bonding agent.

REHABILITATION METHOD				SHEET NO.	14/49
NO.	(4)	DESCRIPTION	REINFORCEMENT OF DECK SLAB		

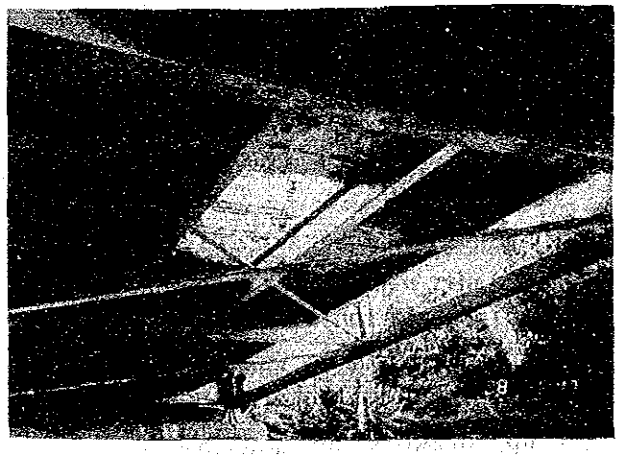
(EXST. SITUATION)



GENERAL VIEW OF SAN PABLO BRIDGE



UNDER REPAIRING OF
CONCRETE SLAB

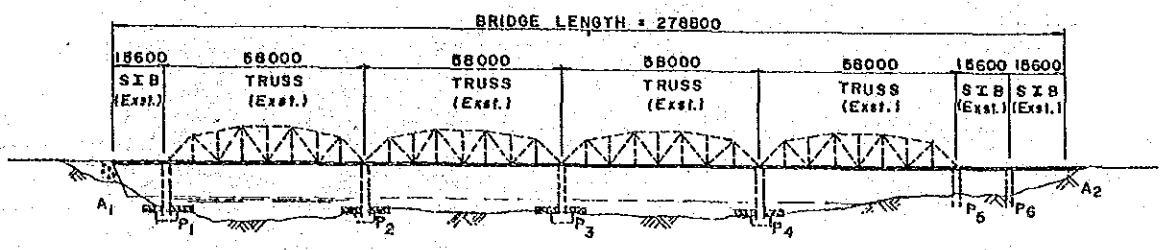


EXAMPLES OF SEVERE DETERIORATION
OF CONCRETE SLAB

REHABILITATION METHOD			SHEET NO.	15/49
NO.	(4)	DESCRIPTION	REINFORCEMENT OF DECK SLAB	

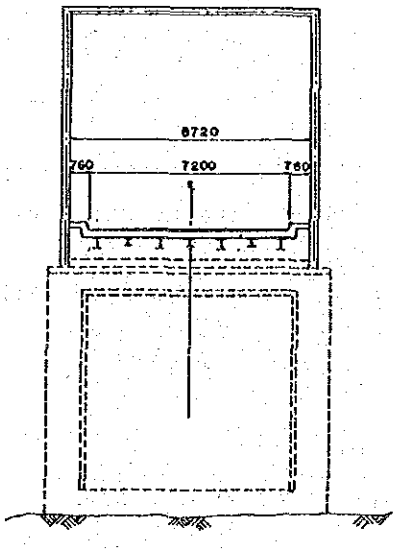
(REHABILITATION)

PROFILE

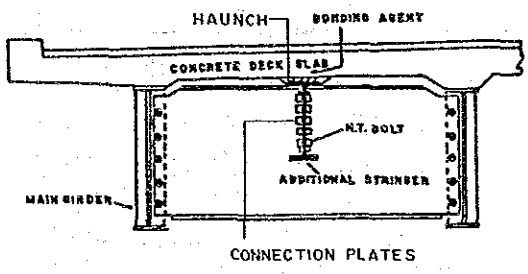


CROSS SECTION

(ADDITIONAL STRINGER)



ADDITIONAL STRINGER



REHABILITATION METHOD				SHEET NO.	16/49
NO.	(5)	DESCRIPTION	ADDITIONAL SIDEWALK		

1. REFERENCE: BR. NO. 73 BATU, REGION - II

2. DETERIORATION AND DAMAGES:

- Deformation and damage to members of truss bridge.
- Danger to pedestrians due to narrow width.

3. CAUSES:

- Narrow bridge width causes damage of major members due to the collision of vehicles.

4. APPLICATION:

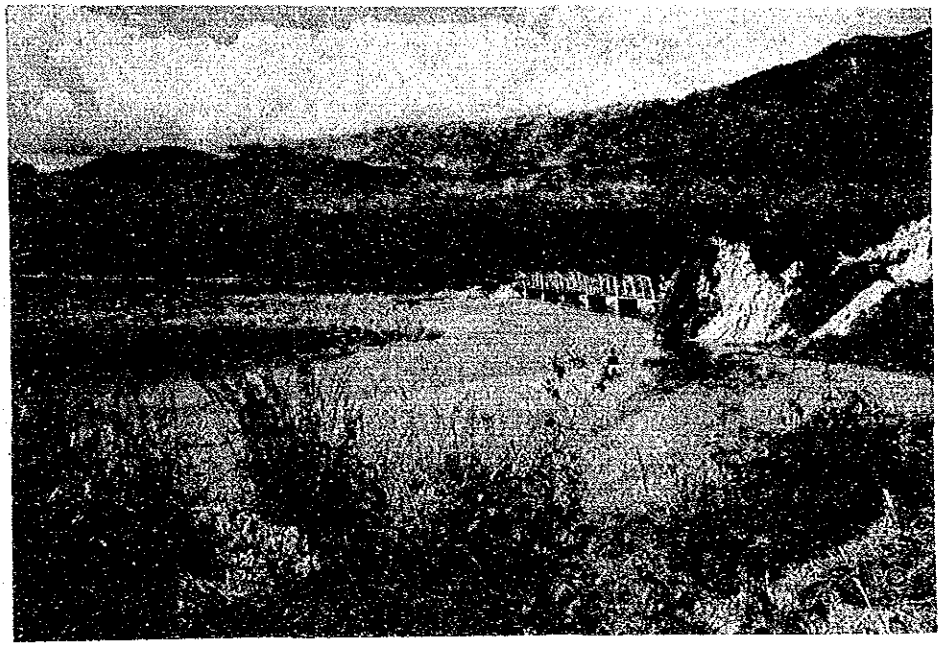
- Provide additional sidewalk outside of truss members for pedestrians.

5. PROCEDURE:

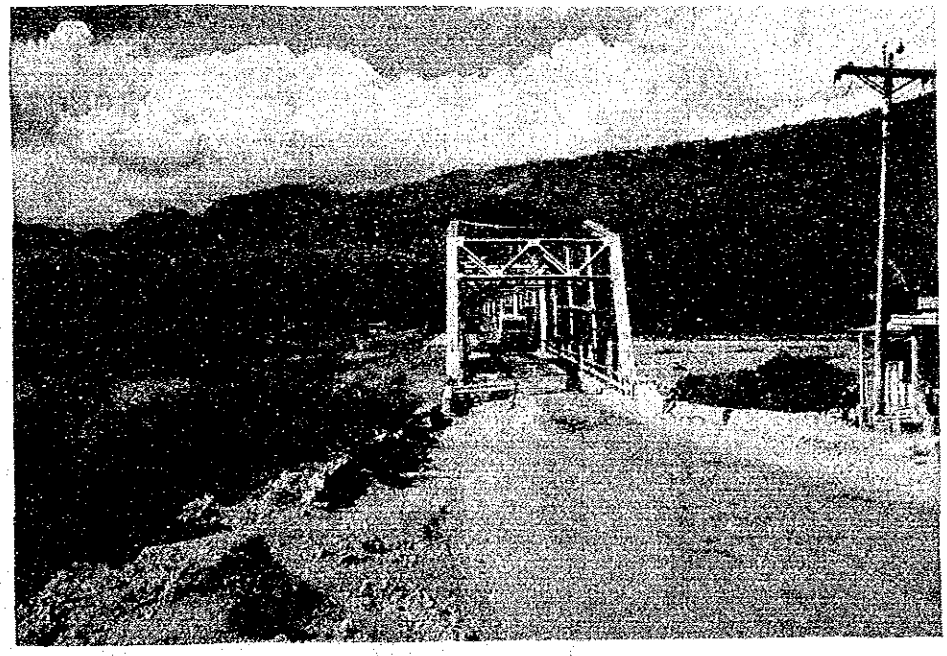
1. Place adequate H-beam (Bracket) and connect to lower chord at cross beam of existing truss bridge with High-tension bolts (H.T.B.).
2. Both upper franges of the bracket and the cross beam are connected with a connection plate and H.T.B.
3. Place stringers of channel steel and connect to upper frange of the bracket with H.T.B.
4. Place of pre-cast deck slab and adequate drain pipes.
5. Install the steel handrailing and connect to stringers with H.T.B.

REHABILITATION METHOD				SHEET NO.	17/49
NO.	(5)	DESCRIPTION	ADDITIONAL SIDEWALK		

(EXST. SITUATION)



GENERAL VIEW OF BATU BRIDGE

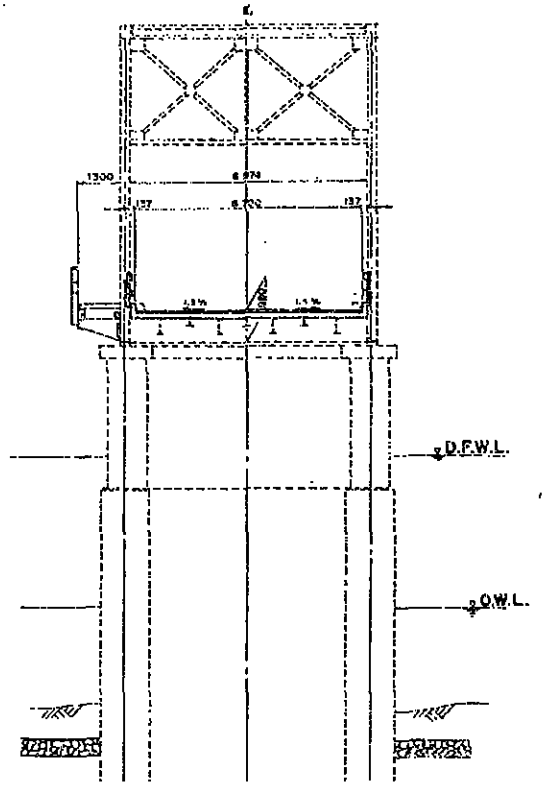


NARROW WIDTH FOR INCREASING TRAFFIC

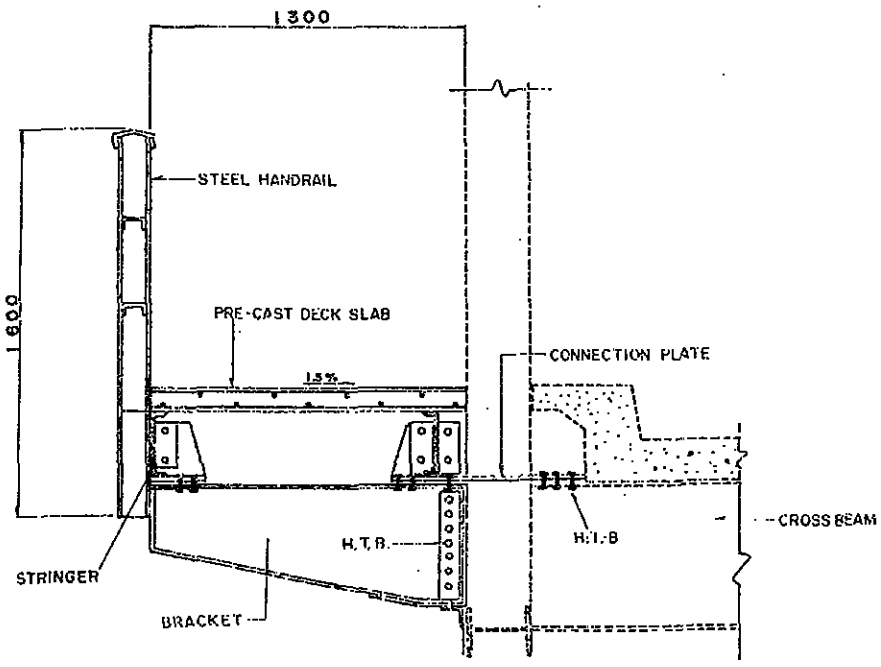
REHABILITATION METHOD			SHEET NO.	18/49
NO.	(5)	DESCRIPTION	ADDITIONAL SIDEWALK	

CROSS SECTION

ADDITIONAL SIDEWALK, DECK SLAB REPLACEMENT



ADDITIONAL SIDEWALK



REHABILITATION METHOD				SHEET NO.	19/49
NO.	(6)	DESCRIPTION	WIDENING OF GIRDER BRIDGE		

1. REFERENCE: BR. NO. 71 INDIANA, REGION - II

2. DETERIORATION AND DAMAGES:

- Concrete deck slab are seriously cracked but SUB sufficiently durable.
- Disturbance and danger to pedestrians due to the narrow width.

3. CAUSES:

- Increasing traffic of large size trucks induce damage to slab.
- Narrow width does not meet the minimum requirement of design criteria.

4. APPLICATION:

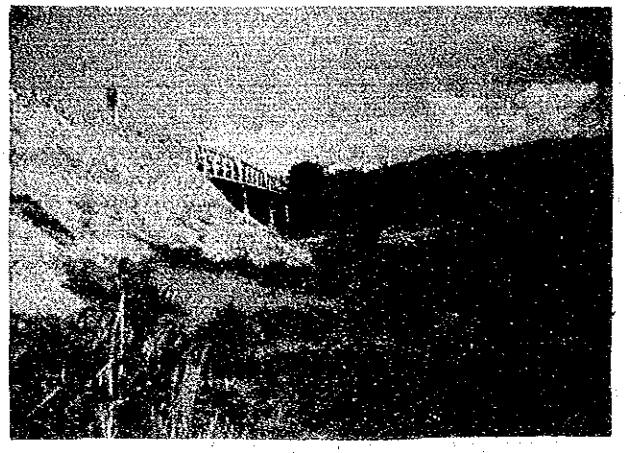
- To provide additional girders which would sustain the newly widened deck slab.

5. PROCEDURE:

1. Construct a detour bridge for existing traffic.
2. Demolish existing concrete deck slab by jack hammer.
3. Dismember the steel girder bridge and keep them.
4. Widen the existing bridge seat of abutment and pier
5. Place the existing and additional steel girders.
6. Install scaffolding works for concrete deck slab.
7. Paint the steel structure.
8. Set-up form works.
9. Place reinforcing steel bars.
10. Pour the concrete.

REHABILITATION METHOD				SHEET NO.	20/49
NO.	(6)	DESCRIPTION	WIDENING OF GIRDER BRIDGE		

(EXST. SITUATION)



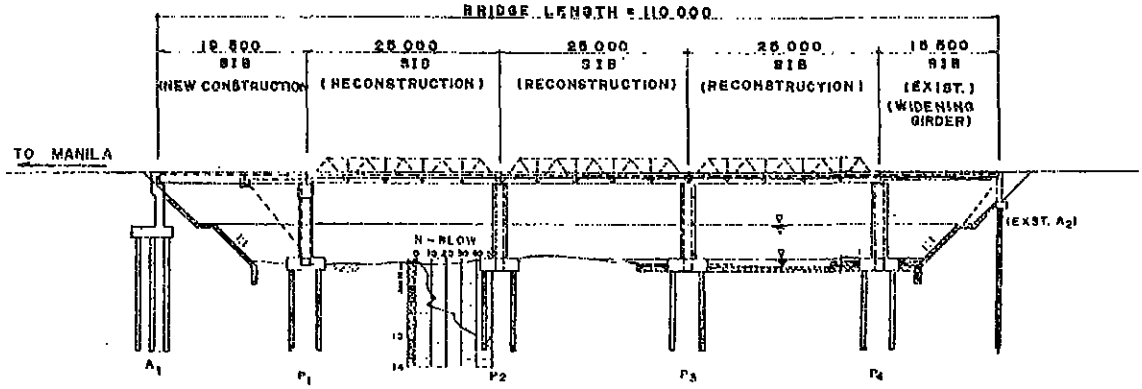
SIDE VIEW OF INDIANA BRIDGE

NARROW WIDTH OF EXISTING BRIDGE,
DANGER TO PEDESTRIANS

REHABILITATION METHOD				SHEET NO.	21/49
NO.	(6)	DESCRIPTION	WIDENING OF GIRDER BRIDGE		

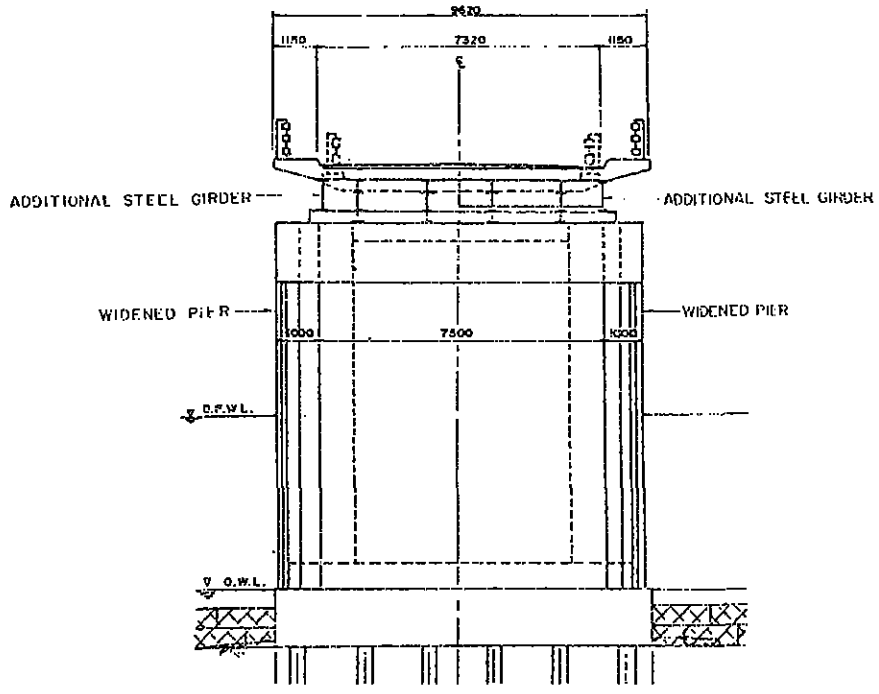
(REHABILITATION)

PROFILE



CROSS SECTION

(WIDENING GIRDER)



REHABILITATION METHOD				SHEET NO.	22/49
NO.	(7)	DESCRIPTION	EXTENSION OF APPROACH SPAN		

1. REFERENCE:

BR. NO. 104 CRUZ I, REGION - I

2. DETERIORATION AND DAMAGES:

- The approach embankment of the existing bridge disturbs the normal river current.
- Upstream side of the river bank is seriously eroded.

3. CAUSES:

- The bridge length does not meet the requirement with respect to the width of the river.
- Flood causes serious erosion due to the disturbance of river current by the approach embankment.

4. APPLICATION:

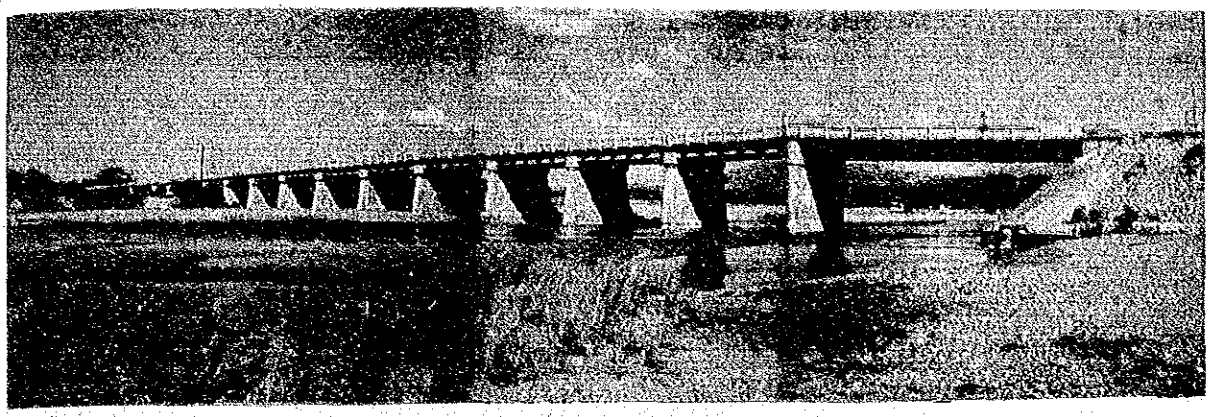
- To remove the approach embankment as required by river width and to provide a new bridge span to increase current area of the river.

5. PROCEDURE:

1. Construct a detour bridge for existing traffic.
2. Construct a temporary pier in front of existing abutment.
3. Demolish the abutment.
4. Excavate approach embankment.
5. Construct new abutment and pier (A_1, P_1 and P_2).
6. Erect steel girder.
7. Install scaffolding.
8. Set-up form works.
9. Place reinforcing steel bars.
10. Pour the concrete.
11. Install railings.

REHABILITATION METHOD			SHEET NO.	23/49
NO.	(7)	DESCRIPTION	EXTENSION OF APPROACH SPAN	

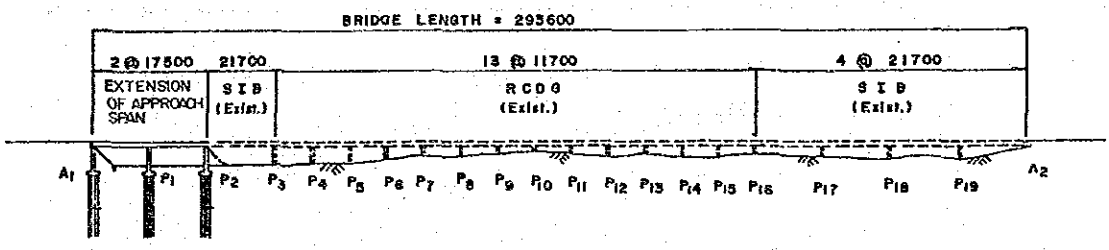
(EXST. SITUATION)



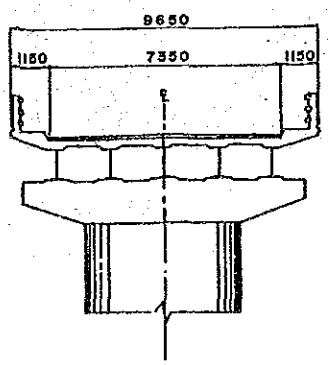
GENERAL VIEW OF STA. CRUZ (I)

(REHABILITATION)

PROFILE



CROSS SECTION



REHABILITATION METHOD				SHEET NO.	24/49
NO.	(8)	DESCRIPTION	REINFORCEMENT CONCRETE BEAM OF RCDG		

1. REFERENCE:

BR. NO. 14 SAN ROQUE, REGION - III

2. DETERIORATION AND DAMAGES:

- Cracks are observed on the deck slab.
- Shear cracks are also observed at the end of the concrete beam.

3. CAUSES:

- Construction defects causes deterioration on the concrete beam.
- Circumstance of bridge site like being along the coast induces cracks.

4. APPLICATION:

- Reinforce the concrete deck slab and beam by jacketing concrete.

5. PROCEDURE:

1. Install scaffolding works.
2. Remove the concrete of deck slab
3. Chip the surface of existing concrete girder.
4. Place steel reinforcing bars.
5. Set-up form works.
6. Pour concrete.

REHABILITATION METHOD				SHEET NO.	25/49
NO.	(8)	DESCRIPTION	REINFORCING CONCRETE BEAM OF RCDG		

(EXST. SITUATION).

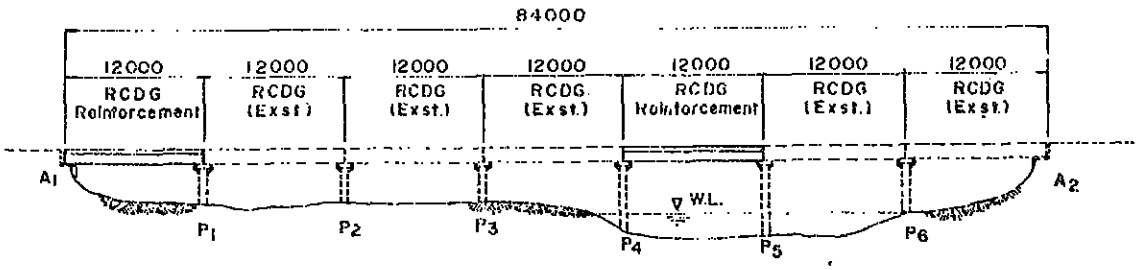
GENERAL VIEW OF SAN ROQUE BRIDGE

DETERIORATION OF THE CONCRETE BEAMS

REHABILITATION METHOD				SHEET NO.	26/49
NO.	(8)	DESCRIPTION	REINFORCING CONCRETE BEAM OF RCDG		

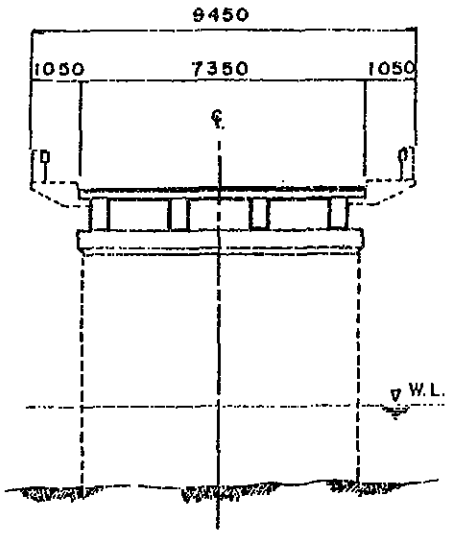
(REHABILITATION)

PROFILE

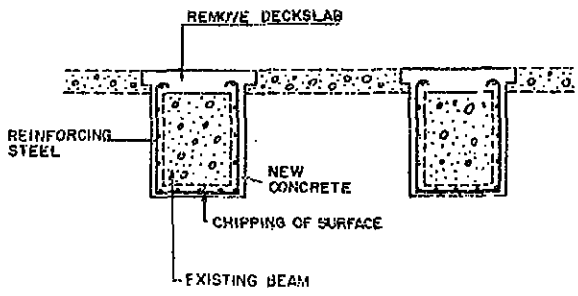


CROSS SECTION

DECK SLAB REPLACEMENT
REINFORCING CONCRETE BEAM



DETAIL OF REINFORCEMENT



REHABILITATION METHOD				SHEET NO.	27/49
NO.	(9)	DESCRIPTION	LINK SLAB		

1. REFERENCE:

BR. NO. 120 HINOGBONGAN, REGION - VIII

2. DETERIORATION AND DAMAGES:

- Settlement and uneven surface condition at the approach portion of the existing bridge.

3. CAUSES:

The following individual and intricate conditions induce settlement and uneveness.

- Inadequate compaction behind abutment.
- Loosened slope in front of abutment.
- No retaining wall due to pile bent type of abutment.

4. APPLICATION:

- To provide a concrete link slab at the approach portion in conjunction with slope protection.

5. PROCEDURE:

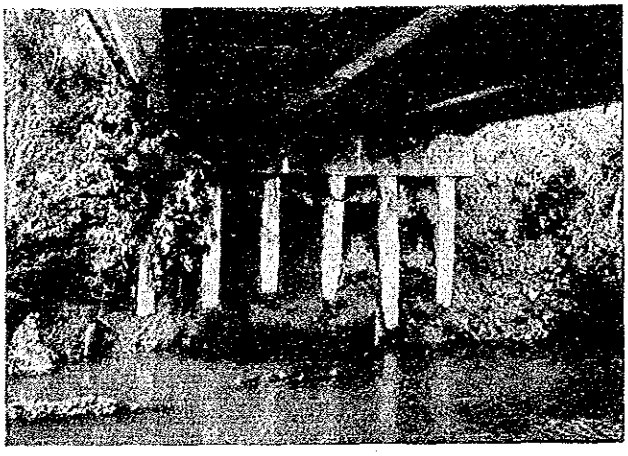
1. Demolish existing concrete pavement.
2. Excavate behind the abutment.
3. Reconstruct/repair of slope protection.
4. Compact every layer while placing backfilled materials.
5. Prepare subgrade.
6. Prepare subbase.
7. Set-up form works.
8. Place steel reinforcing bars.
9. Pour the concrete.

REHABILITATION METHOD				SHEET NO.	28/49
NO.	(9)	DESCRIPTION	LINK SLAB		

(EXST. SITUATION)

SETTLEMENT OR UNEVEN SURFACE AT APPROACH OF BRIDGE

EXPOSED ABUTMENT AFTER WASHING AWAY OF SLOPE PROTECTION

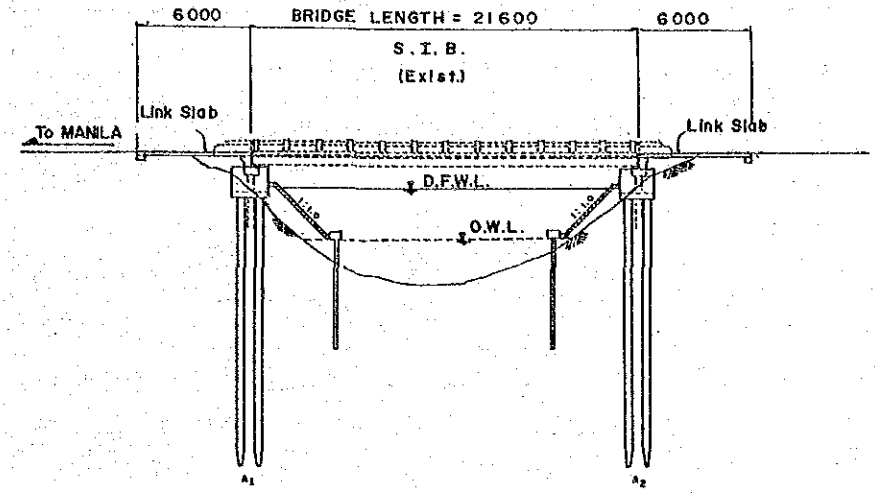


EXPOSED ABUTMENT AFTER WASHING AWAY OF SLOPE PROTECTION

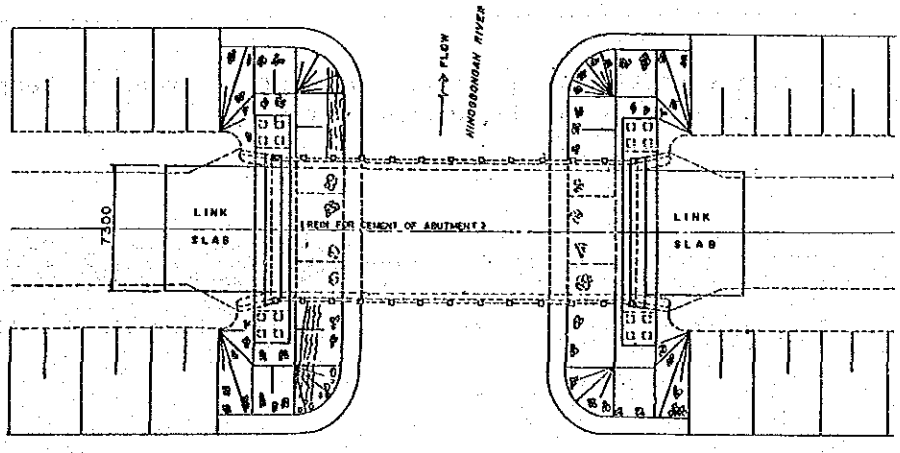
REHABILITATION METHOD				SHEET NO.	29/49
NO.	(9)	DESCRIPTION	LINK SLAB		

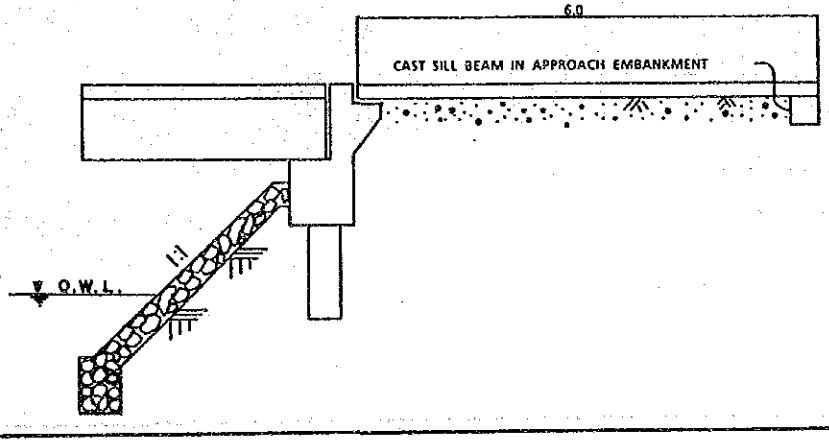
(REHABILITATION)

PROFILE



PLAN





REHABILITATION METHOD				SHEET NO.	30/49
NO.	(10)	DESCRIPTION	WIDENING PIER CAP/BEARING SHEET		

1. REFERENCE:

BR. NO. 188 BINAHAAN, REGION - IV-A

2. DETERIORATION AND DAMAGES:

- Cracked and spalled coping of pier and abutment.

3. CAUSES:

- Shortage of width causes the cracks and spalling of the coping.

4. APPLICATION:

- To widen the coping portion of pier and abutment in order to keep a sufficient width to sustain the superstructure.

5. PROCEDURE:

1. Install scaffolding works.
2. Remove loose or deteriorated concrete and chip the surface of concrete toutched to new concrete.
3. Drill anchor holes or dowel holes for setting hole-in anchor.
4. Place anchor steel bars or hole-in anchors
5. Connect reinforcing steels to hole-in anchors
6. Grout non-shrink mortar to the anchor holes
7. Set-up formworks.
8. Pour the concrete.