# CHAPTER 5

# INITIAL EVALUATION

# CHAPTER 5 INITIAL EVALUATION

## 5.1 General

For assessment of the existing bridges surveyed by visual inspection, an initial evaluation was carried out by bridge engineer's judgment based on criteria on the degree of structural deterioration, including potential dangers to be brought about by the river condition, i.e. bank/slope erosion, local scouring and sedimentation, etc. Based on the criteria on extent of structural deterioration, the bridges were rated as A (Urgent Replacement or Repair), B (Needing Repair) or C (Maintenance only) through visual inspection.

## 5.2 Criteria for Initial Evaluation

### (1) Urgent Replacement or Repair (A Rate)

Bridge structures that are extremely deteriorated and subject to potential dangers which might be brought about by the river condition, such as bank/slope erosion, local scouring and sedimentation, severely affect the substructures and foundations. Besides the condition stated above, the A rate includes the bridges that have very important traffic flow, and those where traffic blocking result in large financial loss.

### (2) Needing Repair (B Rate)

The structural function of the bridge is sufficient. Deterioration and damages, however, are expected due to increase in traffic volume and heavy loads plus the potential danger caused by the river condition. Thus, light repair and/or protection shall be required accordingly after further observation.

### (3) Maintenance Only (C Rate)

To date the structural function is sufficiently safe. Periodic inspection and maintenance, however, shall be required in the future.

## 5.3 Noticeable Bridges for Rehabilitation

As a result of initial evaluation based on the criteria defined in the previous section, the 742 bridges were individually rated A, B or C in the comprehensive rating of bridge condition according to the degree of structural deterioration and damages. The numbers of bridges by rated categories are as follows:

| Nos. of Bridges | | Rating Evaluation | |
|---|---|---|---|
| 49 | } 99 | A | } A + B |
| 50 | | B | |
| 643 | | C | |
| 742 | | Actual Nos. Inspected | |

The bridges rated A and B (99 bridges) are defined as noticeable bridges and screened as the bridges to be urgently rehabilitated.

## 5.4 Classification of Deterioration and Damages

The degree of deterioration, damages and problems of the existing bridges vary with the condition of the bridges based on the year of construction, materials used, quality control, circumstances, etc. However in a broader classification, deterioration and damages of 99 noticeable bridges out of the 742 bridges actually inspected were categorized as follows:

Numbers of Bridges Rated by Type of Deteriorations and Damages

| Type of Deteriorations & Damages | | Rates A | Rates B | Rates C | Total |
|---|---|---|---|---|---|
| (1) | Corrosion/Collision of Major Member | 6 | 23 | - | 29 |
| (2) | Concrete Beam Crack/Spalling | 13 | 15 | - | 28 |
| (3) | Deck Slab Crack/Spalling | 28 | 22 | - | 50 |
| (4) | Substructure/Foundation | 5 | 14 | - | 19 |
| (5) | Bank Washing Away/Erosion | - | 2 | - | 2 |
| (6) | Slope Protection Erosion | 7 | 7 | - | 14 |
| (7) | Clearance Shortage | 1 | - | - | 1 |
| (8) | River Current Incoincidence | 2 | 1 | - | 3 |
| (9) | Inadequate Bridge Width | 6 | 3 | - | 9 |
| (10) | Approach Road | - | 3 | - | 3 |
| (11) | Others | 2 | - | - | 2 |
| | Total | 70 | 90 | - | 160 |

# CHAPTER 6

# SELECTION OF BRIDGES FOR REHABILITATION AND PRELIMINARY DESIGN

# CHAPTER 6 SELECTION OF BRIDGES FOR REHABILITATION AND PRELIMINARY DESIGN

## 6.1 General

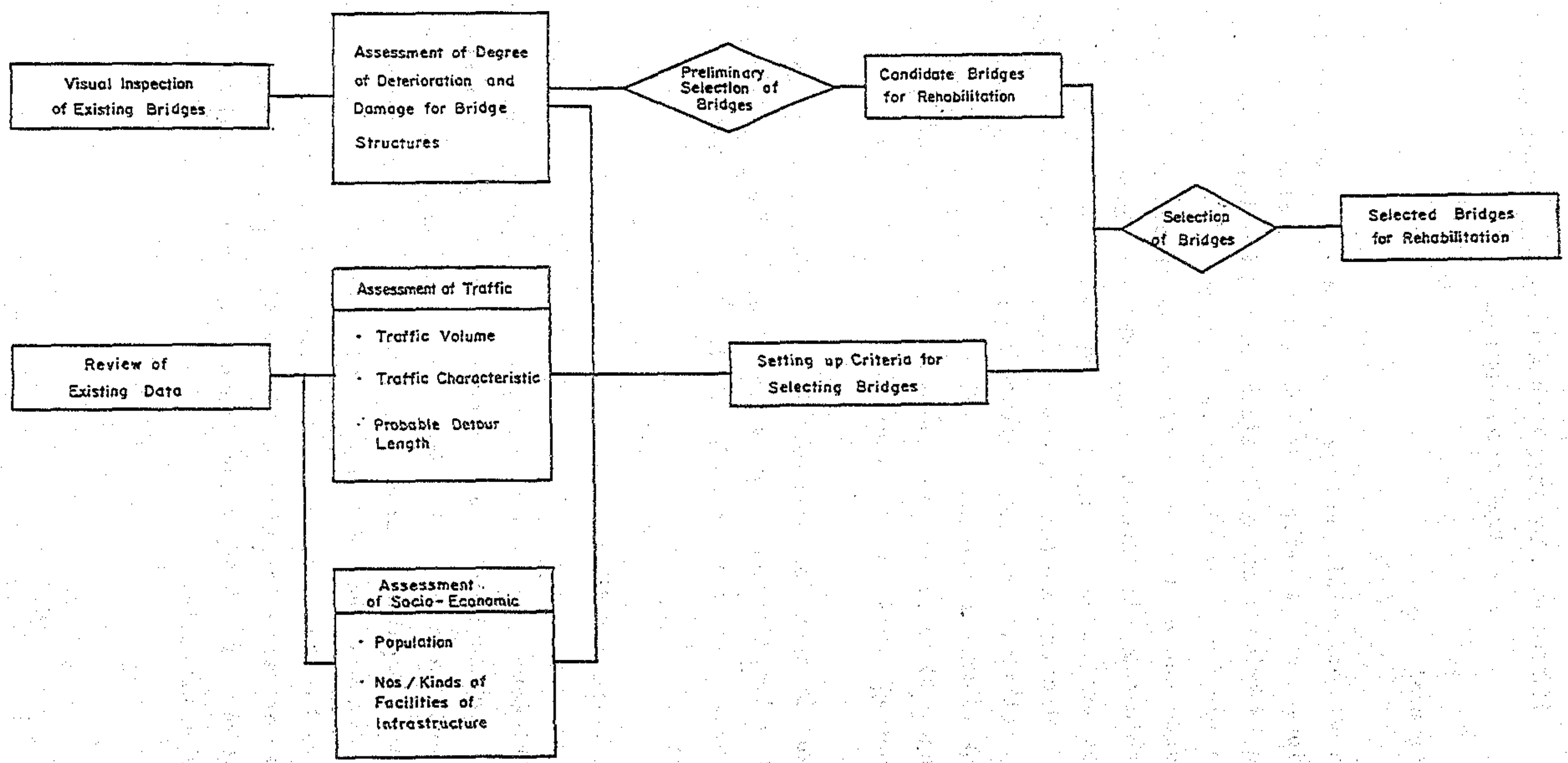
The noticeable bridges (99 bridges) judged to have serious deterioration and damages in the initial evaluation were selected as candidate bridges for rehabilitation. To establish the bridge rehabilitation program, selection of the bridges to be urgently rehabilitated were made out of the noticeable bridges based on the technical rating and socio-economic circumstances. The procedures for selection of the bridges are shown in Fig. 6.1. The technical rating was categorized into: 1) corrosion/collision of major members, 2) concrete beam crack/spalling, 3) deck slab/spalling, 4) substructure/foundation, 5) bank washing away/erosion, 6) slope protection erosion, 7) clearance shortage, 8) river current incoincidence, 9) inadequate bridge width, 10) approach road and 11) others.

The bridges for preliminary design were also selected out of the urgent rehabilitation bridges, considering the representative bridges which will cover every possible rehabilitation method in the feasibility study.

## 6.2 Setting up of Criteria

Criteria for selecting bridges to be urgently rehabilitated consist of the technical criteria related to the above categorized items and the socio-economic circumstances viz. traffic volume, probable detouring, population along the roads on which the bridges are located and infrastructure facilities. The bridges for rehabilitation were selected based on the technical criteria shown in Tables 6.1 to 6.3, the degree of deterioration and considering the results of visual inspection. The bridges for rehabilitation were screened based on the following criteria.

Fig. 6.1 FLOW CHART DIAGRAM OF THE PROCEDURE FOR SELECTING BRIDGES



(1) Bridges which require urgent replacement and/or repair

Bridges which are unable to normally function unless urgent replacement and/or repair of serious structural deterioration and damage is done. These bridges are rated A based on the technical criteria for selecting bridges for rehabilitation shown in Tables 6.1 to 6.3.

(2) Bridges on the roads where traffic volume is considerably high and having inadequate width

Heavy-type vehicles such as trucks contribute greatly to the deterioration of bridge structures. A number of approx. more than 200 trucks corresponding to AADT=2,000 vehicles is critical to cause damages. The existing bridges with a width of less 7.0 m and AADT of more than 5,000 vehicles are also considered as critical through type bridges subject to damages by collision.

(3) Bridges located within the range of no probable detouring

Traffic blocking due to bridge collapse or failure seriously affects social activities around the bridges which are located within a range of non probable detouring road.

(4) Bridges located within the area where the population of the individual province along the road is more than 300,000

There is a relationship between the population of an individual province along the road and the amount of agricultural products. The area where the population is not less than 300,000 persons corresponds to the area where the amount of agricultural products is not less than 7,000 x $10^6$ peso. This area has a more considerable importance in the economic development than the other areas.

(5) Bridges located within the area where the number of infrastructure facilities is more than 10 in each province

In the above area, there are more types of infrastructure facilities compared with other areas. The major facilities such as port, airport, power station and irrigation induce the transportation of goods, material and passengers.

The results of selection of bridges for rehabilitation based on the technical criteria are shown in Tables 6.4 to 6.8. The noticiable bridges with A and B rates, however, are only marked in the table, while the bridges with C rate, which require simply normal maintenance, are not. In the technical rating, the total assessment results are filled up in the Tables. A bridge is assessed to be of A rate if at least one of its categorized items is rated A, while it is assessed as of B rate if it has at least one B rate and none A rate among its categorized items.

Table 6.1 TECHNICAL CRITERIA OF SELECTING 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<br>· Serious deflection or deformation to inadequate design such as insufficient rigidness and/or withstand stress | · Main beam/girder is seriously deteriorated<br>· Visible cracks and concrete spalling are observed for extensive range<br>· Exposure of reinforcing bars<br>· Spalling of concrete due to corrosion of bar | · Serious and progressive cracks and spalling due to heavy load and inadequate design<br>· Reinforcing bars exposure in condition of corrosion | · Serious deterioration such as concrete spalling and reinforcing bar exposure or structure<br>· 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<br>· But no serious deterioration such as structural deformation and/or failure. | · Visible cracks due to heavy load<br>· Visible cracks due to shrinkage | · Many minor cracks but no exposure of reinforcing bars on the substructure<br>· 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<br>· Healthy enough on appearance and function | · No crack or hair crack only on structure surface<br>· Healthy enough on appearance and function | · No deterioration and damage on substructure<br>· No movement of substructure |

Table 6.2 TECHNICAL CRITERIA OF SELECTING 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<br>· Remaining healthy / intact protection after construction | · No erosion or scouring<br>· Remaining healthy / intact protection after construction | · Adequate clearance and no marked river flood | · River current is rightful against the bridge location |

Table 6.2 TECHNICAL CRITERIA OF SELECTING 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 6.4 SELECTING BRIDGES FOR REHABILITATION (1/5)

MANILA NORTH ROAD
(MANILA - LAOAG)

TYPES OF DETERIORATION & DAMAGES

| NO. | BR. NO. | BRIDGE NAME | BRIDGE TYPE | BR. LENGTH | STRUCTURE (1) Corrosion / Collision of Major Members | STRUCTURE (2) Concrete Beam Crack / Spalling | STRUCTURE (3) Deck Slab Crack / Spalling | STRUCTURE (4) Substructure / Foundation | RIVER (5) Bank Washing Away / Erosion | RIVER (6) Slope Protection Erosion | RIVER (7) Clearance Shortage | RIVER (8) River Current Incoincident | TRAFFIC (9) Inadequate Bridge Width | TRAFFIC (10) Approach Road | TRAFFIC (11) Others | Technical Rating | SOCIO-ECONOMIC Traffic Volume | SOCIO-ECONOMIC Detouring | SOCIO-ECONOMIC Population | SOCIO-ECONOMIC Facilities | SELECTED BR. 52 | SELECTED BR. 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | MARILAO | RCDG | 60.00 | | B | A | | | | | | | | | A | * | | * | | O | |
| 2 | 14 | LABANGAN I | S-I-B | 100.00 | | | B | A | | | | | | | | A* | * | * | * | | O | O |
| 3 | 22 | SULIPAN | PONY / TRUSS | 328.50 | B | | | | | | | | A | | | A | * | * | * | | O | |
| 4 | 31 | PULONG BULO | RCDG | 32.00 | | | | B | | | | | | | | B | * | * | * | | | |
| 5 | 37 | SAN FELIPE | RC-SLAB S-I-B | 36.00 | | | B | | | | | | | | | B | * | * | * | | | |
| 6 | 48 | PLARIDEL | TRUSS | 634.40 | | | B | | | | | | | | | B | * | * | | * | O | |
| 7 | 53 | TABUSOK | RCDG | 36.00 | | | | | | B | | | B | | | B | * | | | * | | |
| 8 | 54 | TAGAMUSING | RCDG | 40.38 | | A | A | A | | A | | | A | | | A* | * | | | * | O | O |
| 9 | 58 | BUED | PONY / TRUSS RCDG / S-I-B | 500.25 | B | | | | | | A | | A | | | A* | * | | | * | O | O |
| 10 | 65 | LOMBOY | RCDG | 45.00 | | A | | B | | | | | | | | A | * | | | * | O | O |
| 11 | 77 | BAUANG I | PONY | 221.40 | B | | | | | | | | A | | A | A | * | * | * | | O | O |
| 12 | 77-1 | BAUANG II | PONY | 187.20 | B | | | | | | | | A | | A | A | * | * | * | | O | |
| 13 | 84 | BORORO | RCDG | 176.00 | | B | | | | | | | | | | B | * | | * | | | |
| 14 | 102 | CANAYON | S-I-B | 35.00 | B | | | B | | | | | | | | B | | * | | | | |
| 15 | 104 | STA. CRUZ I | S-I-B / RCDG | 260.50 | | | | | B | | | A | | | | A* | | * | | | O | |
| 16 | 113 | LANGLANGKA I | RCDG | 14.00 | | A | | B | | | | | | | | A | | * | | | O | |
| 17 | 120 | STA. MARIA | TRUSS | 298.20 | | | | | | | | A | | | | A* | | * | | | O | |
| 18 | 121 | SAN ANTONIO | RCDG | 60.00 | | | | | B | | | | | | | B* | | * | | | | |
| 19 | 123 | TULAY | RCDG | 37.00 | | | | | | B | | | | | | B | | * | | | | |
| 20 | 137 | PARSUA | RCDG | 36.00 | | | | | | | | B | | | | B* | | * | | | | |
| 21 | 140 | OSMENA | RCDG / S-I-B | 179.00 | | B | | | | | | | | | | B | | * | | | | |
| 22 | 142 | SAPILANG | S-I-B | 29.70 | B | | | B | | | | | | | | B | | * | | | | |
| 23 | 148 | TIPCAL | RCDG | 35.00 | | A | | A | | | | | | | | A | | | | * | O | |

Note : RCDG : Reinforced Concrete Deck Girder
PCDG : Prestressed Concrete Deck Girder
S-I-B : Steel I-Beam
TRUSS : Steel Through Truss
PONY : Steel Pony Truss
R.C.SLAB : Reinforced Concrete Slab

(SOCIO-ECONOMIC)

| LEGEND | TRAFFIC (VEHICLES) | DETOUR | POPULATION (PERSONS) |
|---|---|---|---|
| BLANK | <2000 | PROBABLE | <300,000 |
| * | >2000 | NONE | >300,000 |

Table 6.5 SELECTING BRIDGES FOR REHABILITATION (2/5)

PAN-PHILIPPINE HIGHWAY
(MANILA-ALLACAPAN)

TYPES OF DETERIORATION & DAMAGES

| NO. | BR. NO. | BRIDGE NAME | BRIDGE TYPE | BR. LENGTH | STRUCTURE (1) Corrosion/Collision of Major Members | STRUCTURE (2) Concrete Beam Crack/Spalling | STRUCTURE (3) Deck Slab Crack/Spalling | STRUCTURE (4) Substructure/Foundation | RIVER (5) Bank Washing Away/Erosion | RIVER (6) Slope Protection Erosion | RIVER (7) Clearance Shortage | RIVER (8) River Current Incoincident | TRAFFIC (9) Inadequate Bridge Width | TRAFFIC (10) Approach Road | TRAFFIC (11) Others | Technical Rating | SOCIO-ECONOMIC Traffic Volume | SOCIO-ECONOMIC Detouring | SOCIO-ECONOMIC Population | SOCIO-ECONOMIC Facilities | SELECTED BR. 52 | SELECTED BR. 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 3 | PLARIDEL-PULIAN | S-I-B | 171.20 | | | A | | | | | | | | | A | * | | * | | ○ | |
| 25 | 14 | SAN ROQUE | RCDG | 84.00 | | A | | | | | | | | | | A | * | | * | | ○ | |
| 26 | 16 | ANYATAM I | RCDG<br>R.C. SLAB | 24.00 | | B | B | | | | | | | | | B | * | | * | | | |
| 27 | 31 | MALIMBA | R.C. SLAB | 30.40 | | B | | | | | | | | | | B | * | | * | | | |
| 28 | 41 | GEN. LUNA | PCDG | 611.00 | | B | | B | | | | | | | | B | * | | * | | | |
| 29 | 43 | SICSICAN | TRUSS | 150.00 | | | A | | | | | | | | | A | * | | * | | ○ | ○ |
| 30 | 71 | INDIANA | S-I-B<br>PONY | 98.90 | | | B | | | | | | B | | | B* | * | * | | | ○ | ○ |
| 31 | 73 | BATU | TRUSS | 350.00 | | | B | | | A | | | | | | A* | * | * | | | ○ | ○ |
| 32 | 86 | NAMANPARAN I | RCDG | 45.00 | | A | | | | | | | | | | A | * | * | | | ○ | |
| 33 | 86-1 | NAMANPARAN II | R.C. SLAB | 6.00 | | | B | | | | | | | | | B | * | * | | | | |
| 34 | 89 | SAN LUIS | RCDG | 24.00 | | A | | | | | | | | | | A | | * | | | ○ | |
| 35 | 93 | DUBINAN | RCDG | 21.00 | | B | B | | | | | | | | | B | * | * | | * | | |
| 36 | 103 | DEL PILAR | RCDG | 9.50 | | | B | | | | | | | | | B | * | | | * | | |
| 37 | 105 | MINANTE | S-I-B | 10.20 | | | B | | | | | | | | | B | * | | | * | | |
| 38 | 109 | NAGUILIAN | S-I-B<br>TRUSS | 675.00 | | | A | | | | | | | | | A* | | | | * | ○ | ○ |
| 39 | 113 | MALALAM | S-I-B<br>TRUSS | 475.40 | | | A | | | | | | | | | A* | | | | * | ○ | ○ |
| 40 | 126 | BALASIG | TRUSS | 75.00 | | | | | | A | | | | | | A* | | | | * | ○ | |
| 41 | 129 | SAN PABLO | S-I-B<br>TRUSS | 278.80 | | | A | | | | | | | | | A | | | | * | ○ | |
| 42 | 139 | PINACANAUAN | S-I-B<br>TRUSS | 383.40 | | | A | A | | | | | | | | A* | | * | | * | ○ | ○ |
| 43 | 148 | MALABBAC | RCDG<br>PONY | 59.70 | | | B | | | | | | | | | B | | * | | * | | |
| 44 | 154 | PARED | PONY/RCDG<br>TRUSS | 193.10 | A | | A | | | A | | | | | | A* | | * | | * | ○ | ○ |

Note : RCDG : Reinforced Concrete Deck Girder
PCDG : Prestressed Concrete Deck Girder
S-I-B : Steel I-Beam
TRUSS : Steel Through Truss
PONY : Steel Pony Truss
R.C. SLAB : Reinforced Concrete Slab

(SOCIO-ECONOMIC)

| LEGEND | LEGEND (VEHICLES) | DETOUR | POPULATION (PERSONS) |
|---|---|---|---|
| BLANK | <2000 | PROBABLE | <300,000 |
| * | >2000 | NONE | >300,000 |

Table 6.6 SELECTING BRIDGES FOR REHABILITATION (3/5)

PAN - PHILIPPINE HIGHWAY
(MATNOG - MANILA)

TYPES OF DETERIORATION & DAMAGES

| NO. | BR. NO. | BRIDGE NAME | BRIDGE TYPE | BR. LENGTH | STRUCTURE (1) Corrosion / Collision of Major Members | STRUCTURE (2) Concrete Beam Crack / Spalling | STRUCTURE (3) Deck Slab Crack / Spalling | STRUCTURE (4) Substructure / Foundation | RIVER (5) Bank Washing Away / Erosion | RIVER (6) Slope Protection Erosion | RIVER (7) Clearance Shortage | RIVER (8) River Current-Incoincident | TRAFFIC (9) Inadequate Bridge Width | TRAFFIC (10) Approach Road | TRAFFIC (11) Others | Technical Rating | SOCIO-ECONOMIC Traffic Volume | SOCIO-ECONOMIC Detouring | SOCIO-ECONOMIC Population | SOCIO-ECONOMIC Facilities | SELECTED BR. 52 | SELECTED BR. 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 14 | RANGAS | S-I-B | 61.80 | B | | | B | | | | | | | | B | | * | | | | |
| 46 | 18 | HIMAOYON | S-I-B | 18.70 | B | | | | | | | | | | | B | | * | | | | |
| 47 | 19 | SUJE (RIZAL) | RC SLAB | 12.00 | | A | A | | | | | | | | | A | | * | | | ○ | ○ |
| 48 | 22 | ABUYOG | RCDG | 11.90 | | B | | | | | | | | | | B | | * | | | | |
| 49 | 25 | CAWAYAN | PCDG | 155.00 | | | | | | B | | | | | | B* | | * | | | | |
| 50 | 43 | GUINOBATAN | S-I-B | 55.60 | | | | | | A | | | | | | A | * | | | * | ○ | |
| 51 | 70 | MABULO | TRUSS S-I-B | 111.40 | | | | B | | | | | | | | B | * | | * | * | | |
| 52 | 75 | SAN FERNANDO | S-I-B | 21.80 | | | A | | | | | | | | | A | * | | * | * | ○ | |
| 53 | 76 | PAMUKID | S-I-B | 22.50 | B | | B | | | | | | | | | B | * | | * | * | ○ | |
| 54 | 77 | SAN ISIDRO | S-I-B | 22.50 | | | A | | | | | | | | | A | * | | * | * | ○ | |
| 55 | 78 | SAN GABRIEL | RC SLAB | 19.50 | | | A | B | | | | | | | | A | * | | * | * | ○ | ○ |
| 56 | 79 | PAHOHO | RCDG | 12.00 | | | A | | | | | | | | | A | * | | * | * | ○ | |
| 57 | 80 | TINIGUIBAN | RCDG | 19.90 | | B | A | | | | | | | | | A | * | | * | * | ○ | |
| 58 | 82 | SGT MATIAS | RCDG | 15.00 | | | A | | | | | | | | | A | * | | * | * | ○ | |
| 59 | 86 | NAUBOD I | S-I-B | 15.00 | B | | A | | | | | | | | | A | * | | * | * | ○ | |
| 60 | 93 | CULOY CULOY | RCDG | 18.00 | | | B | | | | | | | | | B | | * | * | * | | |
| 61 | 94 | ABOBO | RCDG | 22.30 | | | B | | | | | | | | | B | | * | * | * | | |
| 62 | 97 | SIPANG | RCDG | 22.40 | | B | B | | | | | | | | | B | | | * | * | | |
| 63 | 99 | SOOK | S-I-B | 33.30 | | | A | | | | | | | | | A | | | * | * | ○ | |
| 64 | 123 | POTOT | S-I-B | 24.0 | B | | B | | | | | | | | | B | | | | | | |
| 65 | 143 | KANAPAWAN | S-I-B | 45.60 | | | A | | | | | | | | | A | | * | | | ○ | |
| 66 | 152 | MINASAG | TRUSS | 49.60 | B | | B | | | | | | | | | B | | * | | | | |
| 67 | 154 | BASIAD | TRUSS | 58.50 | A | | A | | | | | | | | | A | | * | | | ○ | |
| 68 | 168 | OVERHEAD | RCDG | 20.10 | | B | B | | | | | | B | | | B | | * | * | * | | |

Note : RCDG : Reinforced Concrete Deck Girder
PCDG : Prestressed Concrete Deck Girder
S-I-B : Steel I-Beam
TRUSS : Steel Through Truss
PONY : Steel Pony Truss
R.C. SLAB : Reinforced Concrete Slab

(SOCIO-ECONOMIC)

| LEGEND | TRAFFIC (VEHICLES) | DETOUR | POPULATION (PERSONS) |
|---|---|---|---|
| BLANK | <2000 | PROBABLE | <300,000 |
| * | >2000 | NONE | >300,000 |

MANILA NORTH ROAD
(MATNOG - MANILA)

Table 6.7 SELECTING BRIDGES FOR REHABILITATION (4/5)

TYPES OF DETERIORATION & DAMAGES

| NO. | BR. NO. | BRIDGE NAME | BRIDGE TYPE | BR. LENGTH | STRUCTURE (1) Corrosion / Collision of Major Members | STRUCTURE (2) Concrete Beam Crack / Spalling | STRUCTURE (3) Deck Slab Crack / Spalling | STRUCTURE (4) Substructure / Foundation | RIVER (5) Bank Washing Away / Erosion | RIVER (6) Slope Protection Erosion | RIVER (7) Clearance Shortage | RIVER (8) River Current Incoincident | TRAFFIC (9) Inadequate Bridge Width | TRAFFIC (10) Approach Road | TRAFFIC (11) Others | Technical Rating | SOCIO-ECONOMIC Traffic Volume | SOCIO-ECONOMIC Detouring | SOCIO-ECONOMIC Population | SOCIO-ECONOMIC Facilities | SELECTED BR. 52 | SELECTED BR. 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 69 | 173 | GUMACA | RCDG | 46.20 | | A | A | | | | | | | | | A | | • | • | • | ○ | |
| 70 | 181 | TALABA | RCDG | 23.20 | | A | | | | | | | | | | A | • | | • | • | ○ | |
| 71 | 188 | BINAHAAN | RCDG | 48.00 | | B | A | | | | | | | | | A | • | • | • | • | ○ | ○ |
| 72 | 190 | PALSABANGON | RCDG | 57.00 | | A | A | | | | | | | | | A | • | • | • | • | ○ | |
| 73 | 194 | DOMOCLONG I | PCDG | 25.00 | | B | | | | | | | | | | B | • | | • | • | | |
| 74 | 206 | LAGNAS II | RC-SLAB | 20.00 | | | A | | | | | | | | | A | • | • | • | • | ○ | |
| 75 | 208 | STO. CRISTO | RCDG | 36.00 | | A | | | | | | | | | | A | • | • | • | • | ○ | ○ |
| 76 | 220 | MAGAPONG | PONY | 25.70 | A | | B | | | | | | A | | | A | • | | • | • | ○ | ○ |
| 77 | 223 | BIGA | S-I-B | 46.00 | B | | A | | | A | | | | | | A | • | | • | | ○ | |
| 78 | 227 | SAN CRISTOBAL | RCDG / TRUSS | 73.60 | A | | A | B | | | | | | | | A | • | • | • | | ○ | ○ |
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Note : RCDG : Reinforced Concrete Deck Girder
PCDG : Prestressed Concrete Deck Girder
S-I-B : Steel I-Beam
TRUSS : Steel Through Truss
PONY : Steel Pony Truss
R.C. SLAB : Reinforced Concrete Slab

(SOCIO-ECONOMIC)

| LEGEND | TRAFFIC (VEHICLES) | DETOUR | POPULATION (PERSONS) |
|---|---|---|---|
| BLANK | <2000 | PROBABLE | <300,000 |
| * | >2000 | NONE | >300,000 |

## Table 6.8 SELECTING BRIDGES FOR REHABILITATION (5/5)

PAN-PHILIPPINE HIGHWAYS
(LILOAN-ALLEN)

TYPES OF DETERIORATION & DAMAGES

| NO. | BR. NO. | BRIDGE NAME | BRIDGE TYPE | BR. LENGTH | STRUCTURE | | | | RIVER | | | | TRAFFIC | | | | SOCIO-ECONOMIC | | | | SELECTED BR. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (1) Corrosion/Collision of Major Members | (2) Concrete Beam Crack/Spalling | (3) Deck Slab Crack/Spalling | (4) Substructure/Foundation | (5) Bank Washing Away/Erosion | (6) Slope Protection Erosion | (7) Clearance Shortage | (8) River Current Incoincident | (9) Inadequate Bridge Width | (10) Approach Road | (11) Others | Technical Rating | Traffic Volume | Detouring | Population | Facilities | 52 | 22 |
| 79 | 4 | ILAG | S-I-B | 68.20 | B | | | | | | | | | | | B | | * | | | | |
| 80 | 35 | LAYOG | TRUSS | 148.00 | B | | | | | | | | | | | B | | * | | * | | |
| 81 | 41 | HILUSIG | S-I-B | 62.40 | | | | B | | | | | | | | B | | * | | * | | |
| 82 | 65 | TELEGRAFO II | RC SLAB | 7.25 | | | B | | | B | | | | | | B | * | * | | * | | |
| 83 | 88 | SILAGA | RCDG | 56.00 | | | | | | | | | | B | | B | | * | * | | | |
| 84 | 104 | TINAGO | RCDG | 10.00 | | | | B | | B | | | | | | B | | * | * | | | |
| 85 | 106 | BATO | S-I-B | 15.70 | B | | | | | | | | | | | B | | * | * | | | |
| 86 | 107 | BURAY | RC-SLAB | 6.00 | | B | | | | | | | | | | B | | * | * | | | |
| 87 | 109 | JIABONG | RC-SLAB | 74.80 | | A | A | B | | | | | | | | A* | | * | * | | O | O |
| 88 | 111 | ANTIAO | RCDG | 36.00 | | B | | | | | | | | | | B | | * | * | | | |
| 89 | 114 | SAPINIT I | S-I-B | 32.00 | | | | | | B | | | | | | B | | * | * | | | |
| 90 | 119 | NACOBE | S-I-B | 22.00 | B | | | | | | | | | B | | B | | * | * | | | |
| 91 | 120 | HINOGBONGAN | S-I-B | 21.80 | | | B | A | | A | | | | | | A* | | * | * | | O | O |
| 92 | 122 | ILO | S-I-B | 31.00 | B | | | | | | | | | | | B | | * | * | | | |
| 93 | 127 | CARAYMAN | S-I-B | 15.60 | B | | | | | B | | | | | | B | | * | * | | | |
| 94 | 133 | TINAMBACAN | S-I-B | 25.00 | B | | | | | | | | | | | B | | * | * | | | |
| 95 | 135 | MALAJOG | S-I-B | 31.00 | B | | | | | | | | | B | | B | | * | * | | | |
| 96 | 145 | MANOK-MANOK | S-I-B | 37.40 | B | | | | | | | | | | | B | | * | * | | | |
| 97 | 146 | CALAGNIPAO | S-I-B | 55.90 | B | | B | B | | | | | | | | B | | * | * | | | |
| 98 | 160 | JUBASAN II | PONY | 44.60 | A | | A | | | | | | | | | A | | * | | | O | O |
| 99 | 161 | JUBASAN I | TRUSS | 74.00 | A | | | | | | | | | | | A | | * | | | O | O |

Note : RCDG : Reinforced Concrete Deck Girder
PCDG : Prestressed Concrete Deck Girder
S-I-B : Steel I-Beam
TRUSS : Steel Through Truss
PONY : Steel Pony Truss
R.C. SLAB : Reinforced Concrete Slab

(SOCIO-ECONOMIC)

| LEGEND | TRAFFIC (VEHICLES) | DETOUR | POPULATION (PERSONS) |
|---|---|---|---|
| BLANK | <2000 | PROBABLE | <300,000 |
| * | >2000 | NONE | >300,000 |

## 6.3 Selected Bridges for Rehabilitation and Preliminary Design

Among the 99 bridges which were pre-evaluated, 52 bridges were selected for urgent rehabilitation based on the criteria for selection mentioned in Section 6.2.

| Noticeable Bridges (Candidate Bridges) | | Selected Bridges for Urgent Rehabilitation |
|---|---|---|
| 49 | A | 49 |
| 50 | B | 3 |
| 99 Bridges | A + B | 52 Briges |

Note: The results of visual inspection for 52 bridges are summarized in APPENDIX 6.1.

The selected 52 bridges are distributed in the following 6 regions.

| Region | Nos. of Selected Bridges |
|---|---|
| I | 10 |
| II | 10 |
| III | 6 |
| IV-A | 9 |
| V | 13 |
| VIII | 4 |
| 6 Regions | 52 Bridges |

The bridges to be taken up for preliminary design were chosen with consideration that they are representative among the 52 bridges previously selected, regarding the types of bridges and deterioration and damages, and also considering the following conditions:

(1) Risk of collapse or failure in the near future due to deterioration and/or damages of major members.

(2) Risk of being washed away by flood or falling down of bridge by riverbed scouring,

(3) Risk of utilization-limit of bridge function due to structural deterioration and damages deck slabs and other members, and

(4) Consequently, the traffic blocking which may occur due to the above risk may create serious impact to socio-economic conditions.

22 bridges were selected for preliminary design based on the above conditions and the study team's judgment which envisages representative rehabilitation methods. The relationship between the bridge types and numbers by deterioration and damages of the selected bridges (52 bridges and 22 bridges) are shown in Tables 6.9 and 6.10.

22 bridges were selected as the representative rehabilitation bridges for preliminary design out of the 52 bridges requiring urgent priority. The diagnostic record of the 22 existing bridges is summarized in APPENDIX 6.2.

| Br. No. | | Bridge Name | Br. Type |
|---|---|---|---|
| Manila - Laoag | | | |
| (1) | 14 | Labangan I | SIB |
| (2) | 54 | Tagamusing | RCDG |
| (3) | 58 | Bued | PONY/TRUSS/RCDG/SIB |
| (4) | 65 | Lomboy | RCDG |
| (5) | 77 | Bauang I | PONY |
| Manila - Allacapan | | | |
| (6) | 43 | Sicsican | TRUSS |
| (7) | 71 | Indiana | SIB/PONY |
| (8) | 73 | Batu | TRUS |
| (9) | 109 | Naguilian | SIB/TRUSS |
| (10) | 113 | Malalam | SIB/TRUSS |
| (11) | 139 | Pinacanauan | SIB/TRUSS |
| (12) | 154 | Pared | PONY/RCDG/TRUSS |
| Matnog - Manila | | | |
| (13) | 19 | Suje | RC-SLAB |
| (14) | 78 | San Gabriel | RC-SLAB |
| (15) | 188 | Binanaan | RCDG |
| (16) | 208 | Sto. Cristo | RCDG |
| (17) | 220 | Magapon | PONY |
| (18) | 227 | San Cristobal | RCDG/TRUSS |
| Liloan - Allen | | | |
| (19) | 209 | Jiabong | RC-SLAB |
| (20) | 120 | Hinogbongan | SIB |
| (21) | 160 | Jubasan II | PONY |
| (22) | 161 | Jubasan I | TRUSS |

## Table 6.9 SELECTED BRIDGES WITH DETERIORATION AND DAMAGES

| Types of Bridges | Inspected Bridges 742 Brs. | Selected Bridges 22 Brs. / 52 Brs. | Types of Deterioration and Damages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | (1) Corrosion/collision of Major Memb. | (2) Conc. Beam Crack/ Spalling | (3) Deck Slab Crack/Spalling | (4) Substucture/ Foundation | (5) River/Bank Protect. | (6) Others | Total (1)−(6) |
| (1) Steel Bridges | | | | | | | | | |
| Truss | 34 | 9/15 | 4/6 | − | 7/9 | 2/2 | 3/5 | 1/2 | 17/24 |
| Pony | 7 | 4/5 | 3/4 | − | 3/3 | 0/0 | 0/0 | 4/6 | 10/13 |
| S.I.B | 247 | 2/11 | 0/3 ※ | − | 2/10 | 2/3 | 1/3 | 0/0 | 5/19 |
| Others | 0 | − | − | − | − | − | − | − | − |
| Sub Total | 288 | 15/31 | 7/13 | − | 12/22 | 4/5 | 4/8 | 5/8 | 32/56 |
| (2) Concrete Bridges | | | | | | | | | |
| R. C. D. G. | 311 | 4/17 | − | 4/13 | 2/8 | 2/3 | 1/3 | 1/1 | 10/28 |
| Conc. Slab | 69 | 3/4 | − | 2/3 | 3/4 | 2/2 | 0/0 | 0/0 | 7/9 |
| P. C. D. G. | 30 | − | − | − | − | − | − | − | − |
| Arch | 31 | − | − | − | − | − | − | − | − |
| Sub Total | 441 | 7/21 | − | 6/16 | 5/12 | 4/5 | 1/3 | 1/1 | 17/37 |
| (3) Others | 13 | − | − | − | − | − | − | − | − |
| Total | 742 | 22/52 | 7/13 | 6/16 | 17/34 | 8/10 | 5/11 | 6/9 | 49/93 |

Note:

※ : The type of deterioration of major memb. is included in that of Truss Bridges of the 22 bridges.

A/B : A=Numbers from 22 Bridges.
B=Numbers from 52 Bridges.

Table 6.10 NUMBER OF DETERIORATION AND DAMAGES

| FROM/TO | NOS. OF BRIDGE | Corrosion / Collision of Major Memb. | Concrete Beam Crack / Spalling | Deck Slab Crack / Spalling | Substructure / Foundation | Bank Washing Away / Erosion | Slope Protection | Clearance Shortage | River Current Coincident | Inadequate Bridge Width | Approach Road | Others | Total | River Study is to be required | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MANILA ~ | 5 | 2 | 2 | 2 | 3 | 0 | 1 | 1 | 0 | 3 | — | 1 | 15 | 3 | |
| LAOAG | 13 | 4 | 5 | 4 | 5 | 1 | 1 | 1 | 2 | 5 | — | 2 | 30 | 5 | |
| MANILA ~ | 7 | 1 | 0 | 7 | 1 | 0 | 2 | 0 | 0 | 1 | — | 0 | 12 | 6 | |
| ALLACAPAN | 13 | 1 | 3 | 8 | 1 | 0 | 3 | 0 | 0 | 1 | — | 0 | 17 | 7 | |
| MATNOG ~ | 6 | 2 | 3 | 5 | 2 | 0 | 0 | 0 | 0 | 1 | — | 0 | 13 | 0 | |
| MANILA | 22 | 6 | 7 | 19 | 2 | 0 | 2 | 0 | 0 | 1 | — | 0 | 37 | 0 | |
| LILOAN ~ | 4 | 2 | 1 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | — | 0 | 9 | 2 | |
| ALLEN | 4 | 2 | 1 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | — | 0 | 9 | 2 | |
| TOTAL | 22 | 7 | 6 | 17 | 8 | 0 | 4 | 1 | 0 | 5 | — | 1 | 49 | 11 | |
| | 52 | 13 | 16 | 34 | 10 | 1 | 7 | 1 | 2 | 7 | — | 2 | 93 | 14 | |

Note : Upper part is the numbers from the bridges for preliminary design.
Lower part is the numbers from the bridges requiring rehabilitation.

## 6.4 Categorization and Number of Bridges

Consequently, the numbers of bridges for the individual phase are described below and shown in Fig. 6.2.

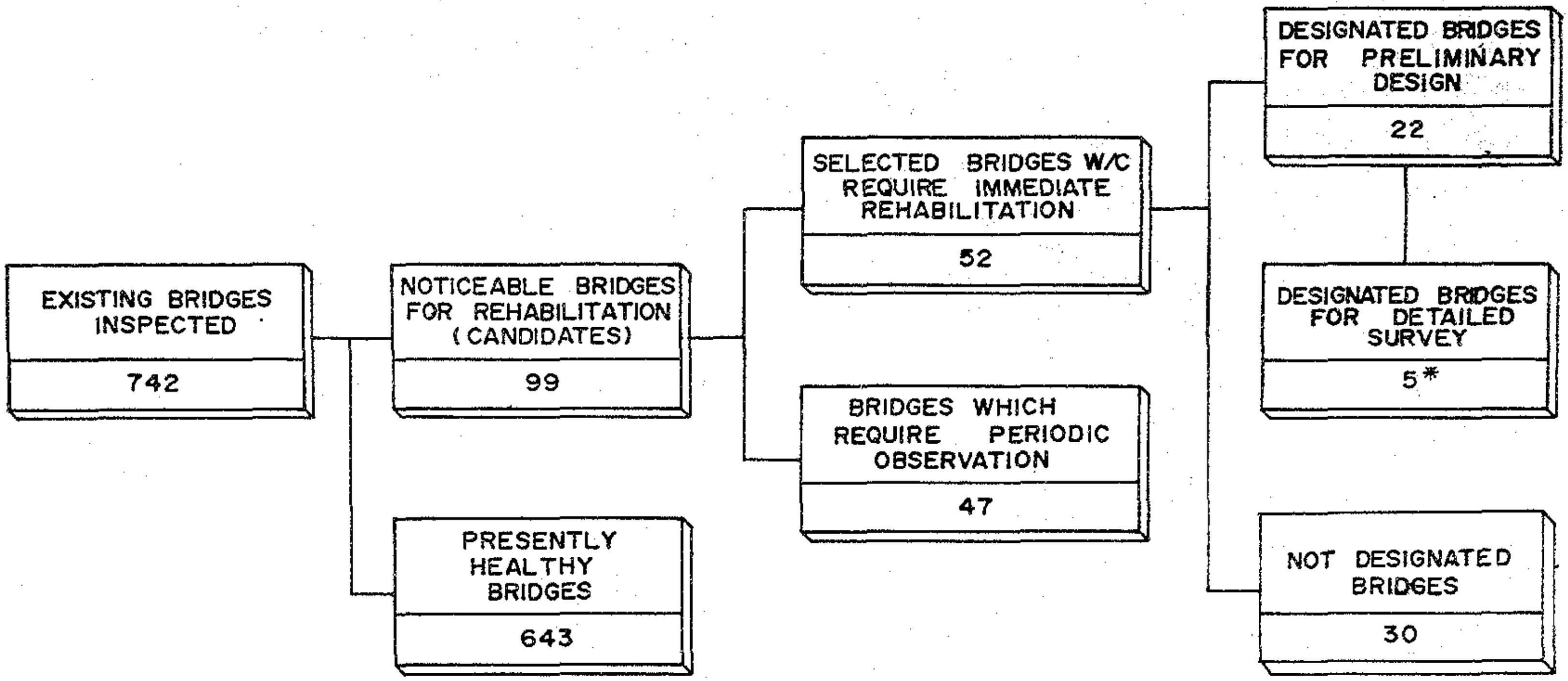
- Results of initial evaluation showed 99 damaged and 643 healthy bridges (those under normal condition).

- Of the 99 bridges for rehabilitation, 52 were selected for urgent rehabilitation and 47 categorized as "requiring periodical observation".

- Out of the above 52 bridges, 22 bridges requiring preliminary design were selected.

- 5 bridges were selected for detailed survey for obtaining necessary data for preliminary design.

Fig. 6.2 NUMBER OF BRIDGES PER INDIVIDUAL PHASE




Note: Figures correspond to number of bridges

*: One from 99 bridges

# CHAPTER 7

# BRIDGE DETAILED SURVEY

# CHAPTER 7 BRIDGE DETAILED SURVEY

## 7.1 General

A bridge detailed survey was conducted in order to know the actual condition of the existing structures, and to get geotechnical data and topographic maps of the representative bridge sites. The survey consisted mainly of structural survey, topographic survey, geotechnical survey and actual loading tests. The structural survey was carried out by measurement of structural sizes to use for analysis of loading capacity of bridges and non-destructive test to assess the physical (strength), chemical, mechanical properties. The topographic and geotechnical surveys were also carried out to prepare topographic maps of complicate terrain and to make sure the bearing strata for bridge foundation respectively at the representative bridge sites. A full scale loading test was conducted to compare the results of loading test with calculation formula and to turn attention to bridge rehabilitation as a demonstration.

Summary of the bridge detailed survey and its results are described in the subsequent sections.

## 7.2 Structural Survey

A structural survey was conducted on the following 5 representative bridges out of the 22 bridges selected for preliminary design. These bridges were considered to be insufficient in loading capacity through visual inspection and need to be checked by calculation formula.

1) Labangan I Bridge in Calumpit, Bulacan,
2) Bauang I Bridge in Bauang, La Union,
3) Antayam I Bridge in San Ildefonso, Bulacan,
4) Sto. Cristo Bridge in Sariaya, Quezon, and
5) San. Cristobal Bridge in Calamba, Leguna

The structural survey consisted of the measurement of structural sizes and non-destructive tests. The results of detailed structural survey are shown in APPENDIX 7.1.

### 7.2.1 Measurement of Structural Sizes and Damages

Dimensions of superstructures such as span arrangement, carriageway width, height and thickness of major members, deck slab thickness, position and height of bearing shoe and handrail width and height were measured using steel tape and nogis.

Dimensions of substructures such as width and length of parapet, bearing bed, stem and wing wall of abutment, cap, footing and foundation pier were measured using steel tape.

Measurement of crack width on structural concrete was carried out by means of microscope and steel tape. Movement (inclination) of abutments and piers was measured by plumb-bob and settlement of substructures and approach as measured by level and staff.

Degree of corrosion of steel structure was judged by means of photographic comparison.

### 7.2.2 Non-Destructive Test and Neutrality Test

Non-destructive tests are aimed at 1) assessing concrete strength, 2) assessing hardness (strength) of structural steel, 3) assessing neutrality and quality of concrete, 4) detecting concrete cover and reinforcing steel, 5) detecting cracks of structural steel and 6) assessing pile length.

For the bridge detailed survey in the Feasibility Study, concrete strength test, hardness test (strength) of structural steel and neutrality test were undertaken to obtain the necessary data for calculating loading capacity.

(1) Concrete Strength Test

The presumption methods of concrete strength by Schmidt Hammer method was adopted in this study. The "rebound number" was measured at the specified locations along the concrete slab, concrete beam, abutment, pier, etc. The rebound number corresponds to the strength of concrete.

(2) Hardness Test (Strength) of Structural Steel

Hardness tests are used for quality control in the manufacture of structural steel. In this study, the portable type Ernst testing machine, which is a well known 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.

(3) Neutrality Test

In this study, the neutrality test (phenolphtalen method) was conducted along the specified locations of the concrete slab, concrete beam, abutment and pier by spraying a chemical reagent called phenolphtalen (1% liquid) on the newly crushed face of structural concrete. After chemical reaction has taken place, neutrality depth was measured by use of a steel scale.

(4) Test Results of Non-Destructive Test

The field survey test results of concrete strength, steel strength and neutrality depth are given below:

a) Concrete Strength Test Results

The concrete strength test results obtained as shown below are higher than 3000 psi (210 kg/cm$^2$) specified in Item 405; Structural Concrete of the Standard Specifications for Public Works and Highways, Volume II, Standard Specifications for Highways, Bridges and Airports, 1988 edition. The higher values indicate that the quality control during construction was good.

| Br.No. | Bridge Name | Location of Test | Concrete Strength | Remarks |
|---|---|---|---|---|
| 14 | LABANGAN I | Abutment | 340 $kg/cm^2$ | |
| | | Deck Slab | 400 $kg/cm^2$ | |
| 77 | BAUANG I | Abutment (A1) | 290 $kg/cm^2$ | |
| | | Pier (P1) | 380 $kg/cm^2$ | |
| | | Deck Slab | 400 $kg/cm^2$ | |
| 16 | ANTAYAM I | Pier (P2) | 450 $kg/cm^2$ | |
| | | Deck Slab | 350-400 $kg/cm^2$ | |
| | | Pile | 480 $kg/cm^2$ | |
| 208 | STO. CRISTO | Abutment (A2) | 380 $kg/cm^2$ | |
| | | Pier (P1) | 420 $kg/cm^2$ | |
| | | Beam | 380-450 $kg/cm^2$ | |
| 227 | SAN CRISTOBAL | Abutment (A2) | 360 $kg/cm^2$ | |
| | | Pier (P2) | 350 $kg/cm^2$ | |
| | | Deck Slab | 420 $kg/cm^2$ | |

Note: A1 is abutment on Manila side
P1 is pier number from A1

b) Steel Strength Test Results

The hardness test was conducted on the following three (3) bridges, namely Labangan I, Bauang I and San Cristobal. The values obtained range from 130 HB to 160 HB (4800-5500 $kg/cm^2$). These values are judged to be almost equivalent to the AASHTO M183 structural steel tensile requirements of 400-500 MPa (4080-5080 $kg/cm^2$) and Japan Industrial Standard G3101, SS41 (4100-5200 $kg/cm^2$). The hardness test results of the three bridges are summarized below:

| Br. No. | Bridge Name | Location Test | Hardness | Steel Strength |
|---|---|---|---|---|
| 14 | LABANGAN I | Steel I-Beam | 130-140HB | 4000-5000kg/cm$^2$ |
| 77 | BAUANG I | Top Chord | 140-150HB | 5000-5200kg/cm$^2$ |
| 227 | SAN CRISTOBAL | Top Chord | 140-160HB | 5000-5500kg/cm$^2$ |
| | | Lower Chord | 130HB | 4800kg/cm$^2$ |
| | | Cross Beam | 160HB | 5500kg/cm$^2$ |

Note: HB is the unit of Brinell Hardness

c) Neutrality Test Results

The neutrality test gauges the degree of deterioration of structural concrete, which may be caused by low concrete strength due to lack of quality control. The concrete strength test conducted in this study shows that the values obtained are higher than those required in the specifications. The neutrality test shows that the neutrality depth is only 10 mm while the covering concrete of steel reinforcement is 30 mm. These results confirm that the concrete used is of high grade.

The results of neutrality test are summarized below:

| Br. No. | Bridge Name | Place of Testing | Neurality Depth | Remarks | Const. Year | Distance, Bridge to Sea |
|---|---|---|---|---|---|---|
| 14 | LABANGAN I | Abutment | 10 m/m | Reinforcing Steel is not exposed | 1910 | 0.5 km |
| | | Deck Slab | 10 m/m | Reinforcing Steel is not exposed | | |
| 77 | BAUANG I | Abutment $A_1$ | 10 m/m | Reinforcing Steel is not exposed | 1911 | 1.5 km |
| | | Deck Slab | 10 m/m | Corrosion of Reinforcing Steel is observed | | |
| 16 | ANTAYAM I | Deck Slab | 0 m/m | Reinforcing Steel is not exposed | | 3.0 km |
| | | Pier $P_2$ | 0 m/m | Reinforcing Steel is not exposed | | |
| 208 | STO. CRISTO | Beam | 15 m/m | Reinforcing Steel is not exposed | | 1.0 km |
| | | Pier $P_2$ | 20 m/m | Reinforcing Steel is not exposed | | |
| 227 | SAN CRISTOBAL | Beam | 10 m/m | Reinforcing Steel is not exposed | | 3.5 km |
| | | Pier $P_2$ | 20 m/m | Reinforcing Steel is not exposed | | |

## 7.3 Topographic Survey

Topographic surveys were conducted on 5 typical bridge types among the 22 bridges selected for preliminary design. The name and location of the selected bridges are as follows:

- Labangan I Bridge in Calumpit, Bulacan,
- Bauang I Bridge in Bauang, La Union,
- Antayam I Bridge in San Ildefonso, Bulacan,
- Sto. Cristo Bridge in Sariaya, Quezon, and
- San Cristobal Bridge in Calamba, Laguna

The survey comprised the following:

- Centerline survey
- Profile survey to determine the elevation of every changeable inclination points on the proposed centerline.
- Approach Cross-Section Survey carried out at 20 m intervals, 50 m from the centerline of both sides of the approach road and 50 m aw from both the first and second approaches.
- Based on the centerline, profile and cross-section surveys, a topographic map was prepared.

## 7.4 Geotechnical Survey

Among the 22 bridges picked out for preliminary design, geotechnical surveys were conducted at the following bridge locations.

- Indiana Bridge in Aritao, Nueva Viscaya,
- Pinacanauan Bridge in Tuguegarao, Cagayan,
- Bauang I Bridge in Bauang, La Union
- Bued Bridge in Sison, Pangasinan, and
- Labangan I Bridge in Calumpit, Bulacan

The results of geotechnical surveys are shown in APPENDIX 7.2.

A concise explanation of the survey results is given below.

### (1) Indiana Bridge (Region II)

The location of the borehole viewed from Manila side of the bridge is near the right side of the pier 2. The boring results show that the bearing stratum starts at 12 m from the river bed and recovered soil samples range from loose, light brown, scarse to fine sand to very dense, dark brown, coarse to fine silty sand with some gravel. Judging from the above-mentioned results, penetration is recommended to be made to a depth of 15 m.

(2) Pinacanauan Bridge (Region II)

The location of the borehole viewed from Manila side of the bridge is near the left side of the pier 14. The boring results show that the bearing stratum starts at 4 m from the river surface and recovered soil samples range from loose, light brown, medium to fine silty sand to very dense, dark brown, gravelly sand from coarse to fine grained with little silt. Judging from the above-mentioned results, penetration depth of pile foundation is recommended to be 7 m.

(3) Bauang I Bridge (Region I)

The location of the borehole is near the left side of abutment No.1. The boring results show that the bearing stratum starts at 35 m from the surface and recovered soil samples range from loose dark brown, silty fine sand to very dense, dark gray silty sand and gravel. Based on the above-mentioned results, penetration depth of pile foundation is recommended to be 39 m.

(4) Bued Bridge (Region I)

The borehole location viewed from Manila side of the bridge is near the left side of abutment No. 2. The boring results show that the bearing stratum lies about one meter below the river bed. Spread footing can be used as foundation but the soil condition of the river side at the middle portion of the bridge is not so dense and according to as-built drawings of the existing bridge, steel H-pile was used as foundation. From the above mentioned results, it is recommended that steel H piles be used with a penetration depth of 12 m.

(5) Labangan Bridge (Region III)

The borehole location is near the left side of abutment No. 1. The boring results shows that the bearing stratum starts at 35 m below the surface and recovered soil samples range from medium stiff light brown, sandy silt with low plasticity to very dense brownly to dark gray silty sand with little gravel. From the above mentioned results, penetration depth for pile foundation is recommended to be 39 m.

## 7.5 Full Scale Loading Test

### 7.5.1 Purpose

Full-scale loading test is valuable for assessing the load-carrying capacity and duration of existence of the old bridges. The loading test allows direct comparison between theoretical calculation formula and those observed experimentally under the action of test loading. The analyzed results through the loading test might affect the study of the rehabilitation, maintenance and repair on old bridges.

### 7.5.2 Location of Loading Test

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

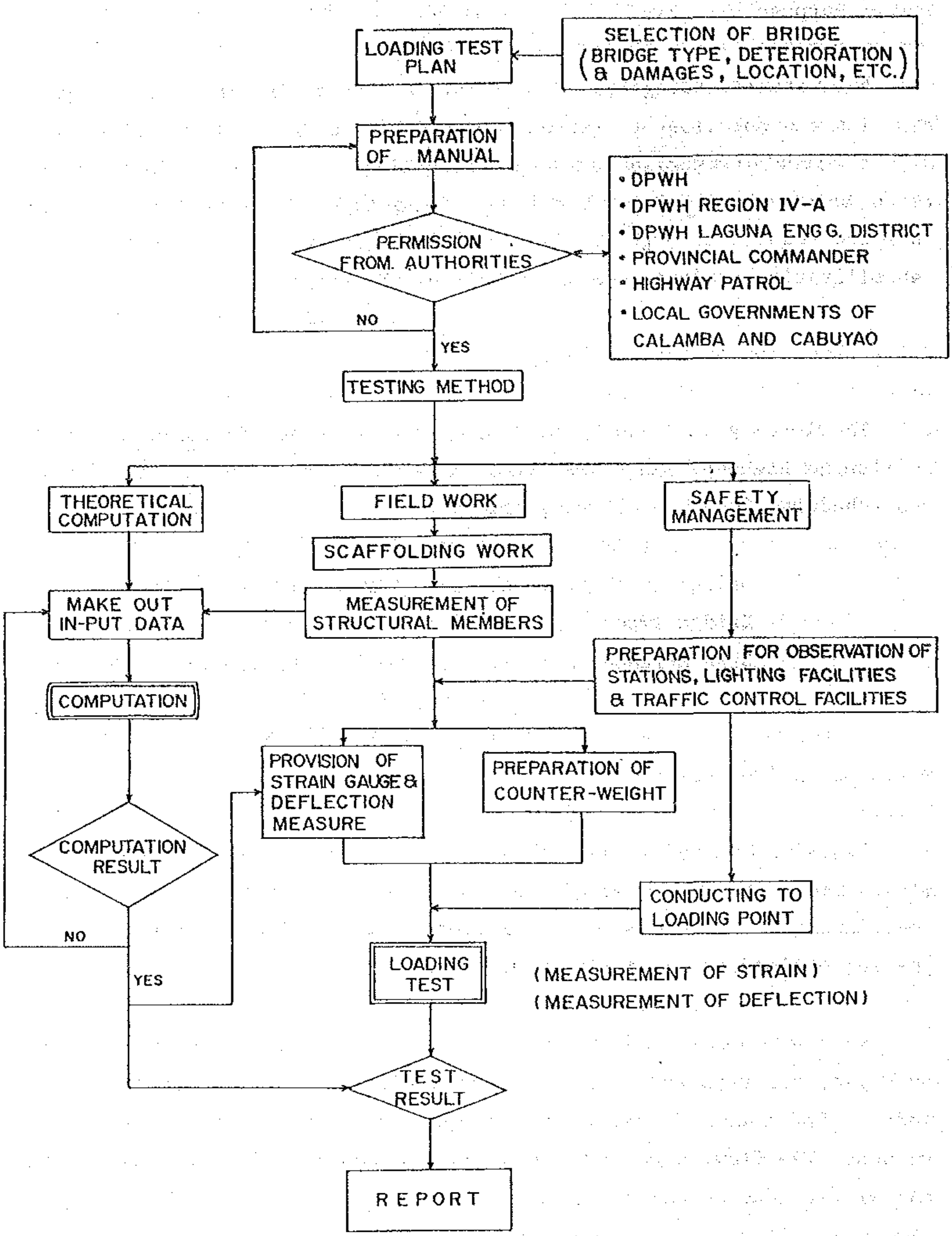
| | | |
|---|---|---|
| Bridge No./Name | : | No. 277, SAN CRISTOBAL |
| Bridge Type | : | Steel Through Truss/RCDG |
| Span Arrangement | : | 12.0 (RCDG) + 49.6 (Truss) + 12.0 (RCDG) = 73.6 m |

### 7.5.3 Method of Loading Test

Gross weight of trucks measured at designated offices shall be placed at the points based on the loading points on the bridge, considering the results of theoretical calculations subject to the phasing of loading modes.

The deflection and strain of members of bridge structures are surveyed, observed and recorded under the actions of the phased loading modes. The recorded results are analyzed and compared with theoretical values. The flow chart of loading test is shown in Fig. 7.1 and in the manual for loading test.

Fig. 7.1 FLOW CHART DIAGRAM OF LOADING TEST



(1) Preparation of Counter-Weight

Trucks shall be loaded with granular materials at the material pit near Calamba, Laguna. The total gross weight of each individual truck shall not be more than 15 tons. The loading weight can be measured at Calamba Weigh-Bridge Office of Region IV-A. The required equipment to make the counter-weight are:

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

(2) Scaffolding

The scaffolding work is to be firmly and safely fabricated to sustain the survey and measurement to be works carried out on it.

(3) Providing and Placing Strain Gauges

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

(4) Application of Loading

The loading points and phasing of loading modes are determined in consideration of the cases in the theoretical computation conducted in advance. The exact points of application of loading will be marked by using the specified color paints.

(5) Measurement of Strains

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

(6) Measurement of Deflection

The deflection of structural members shall be measured by using levelling scope under the structural behavior in various loading modes. The scales for measuring deflection shall be bonded to the structural members of the bridge, and measured from the point where the levelling scope is provided.

### 7.5.4 Results of Loading Test

The loading test on the San Cristobal bridge was carried out in July 1988 in accordance with the manual for loading test. The results of loading test are expressed in contrast with those of theoretical computation and allowable stress is computed according to NSCP and also the Japanese Specification, for reference.

The following cases are considered for both theoretical computation and actual loading test.

Case - 1: Dead Load (DL) only
Case - 5: DL + 2 trucks (2 x 15 = 30 tons)
Case - 6: DL + 3 trucks (3 x 15 = 45 tons)
Case - 7: DL + 4 trucks (4 x 15 = 60 tons)

The measured results of strain of major members are shown below and the ratio of strains by loading test and theoretical computation is 1.24 to 1.51. The strain by loading test is greater than that by theoretical computation.

| Members | Allowable Stress (kg/cm$^2$) | Axle Force (ton) Computed | L.Test | Stress (kg/cm$^2$) Computed | L.Test | Deflection (mm) Computed | L.Test |
|---|---|---|---|---|---|---|---|
| U-2 | 1087 | -145 | -143 | 808 | 797 | - | - |
| D-3 | 1395 | 16 | 19 | 260 | 304 | - | - |
| L-3 | 1395 | 136 | 123 | 844 | 766 | 11.6 | 11.0 |

Note: U - Upper Chord
D - Diagonal Chord
L - Lower Chord

As seen from the above results, stress is not so much different between theoretical computation and loading test within an elastic range. Deflection is also smaller than its allowable value of 8.3 cm (1/600). It is roughly expected that the San Cristobal bridge has more surplus of displacement incurred by the vehicular loading which is greater than the case of loading test.

# CHAPTER 8

# RIVER HYDROLOGICAL SURVEY

# CHAPTER 8 RIVER HYDROLOGICAL SURVEY

## 8.1 General

This chapter presents the results of river hydrological study for the bridges which are subject to feasibility study in this project. 19 bridges out of the 52 bridges which were judged to require urgent rehabilitation were selected for the study based on the following findings during visual inspection.

- Damage by attacking river flow to bridge abutment portion because of undesirable river alignment
- Inadequate river width/bridge length judged from the design flood runoff
- Bank erosion
- Damage by slope erosion in the bridge abutment portion
- Degradation of bed
- Influence to bridge pier by local scouring
- Aggradation by sedimentation (Reduction of river flow capacity)

The result of visual inspection are shown in Tables 8.1 and 8.2. The other 33 bridges (52 - 19 bridges) were not selected for this study because these bridges were judged not to be affected seriously by the problems mentioned above. Detailed field investigation of river hydrographical damages was carried out by river engineers at the selected 19 bridge sites. The river hydrographical damages were studied on the basis of hydrological study described in the subsequent section.

## Table 8.1 SELECTED BRIDGES SUBJECT TO RIVER HYDROLOGICAL STUDY (1/2)

MANILA NORTH ROAD
(MANILA - LAOAG)

| REG. | NO. | BR. NO. | BR. NAME | BR. TYPE | LENGTH | TECH. RATING | MAJOR DETERIORATION/DAMAGES | RIVER STUDIES NEEDED: RIVER ALIGNMENT | RIVER WIDTH BRIDGE WIDTH | BANK PROTECTION | SLOPE PROTECTION | RIVERBED PROTECTION | LOCAL SCOURING | BRIDGE CLEARANCE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| III | 1 | 3 | MARILAO | RCDG | 60.00 | A | Deterioration of concrete slab & beams | | | | | | | | |
| | 2 | 14 | LABANGAN I | SIB | 100.00 | A | Washed out pier | | | ○ | ○ | | ○ | | • Selected Bridge |
| | 3 | 22 | SULIPAN | PONY/TRUSS | 328.50 | A | Deflection and corrosion of truss members<br>Narrow width | | | | | | | | |
| I | 4 | 48 | PLARIDEL | TRUSS | 634.40 | B | Deterioration of deck slab | | | | | | | | |
| | 5 | 54 | TAGAMUSING | RCDG | 40.00 | A | Deterioration of deck slab & beams<br>Scouring of substructure | | | ○ | ○ | ○ | ○ | | • |
| | 6 | 58 | BUED | PONY/TRUSS/SIB | 500.38 | A | Narrow width on pony & truss<br>No clearance by sedimentation | | | | | | | ○ | • |
| | 7 | 65 | LONBOY | RCDG | 45.00 | A | Deterioration of beams | | | | | | | | |
| | 8 | 77 | BAUANG I | PONY | 221.40 | A | Deformed & corroded pony members<br>Narrow width | | | ○ | ○ | | ○ | | • |
| | 9 | 77-1 | BAUANG II | PONY | 187.20 | A | Corroded pony members<br>Narrow width | | | | | | | | |
| | 10 | 104 | STA. CRUZ I | SIB/RCDG | 260.60 | A | Upstream bank seriously eroded | | ○ | ○ | ○ | | ○ | | • |
| | 11 | 113 | LANGLANGKA I | RCDG | 14.00 | A | Deterioration of beams | | | | | | | | |
| | 12 | 120 | STA. MARIA | TRUSS | 298.20 | A | Upstream bank seriously eroded | | ○ | ○ | ○ | | ○ | | • |
| | 13 | 148 | TIPICAL | RCOG | 35.00 | A | Deterioration of beams | | | | | | | | |

PAN-PHILIPPINE HIGHWAY
(MANILA - ALLACAPAN)

| REG. | NO. | BR. NO. | BR. NAME | BR. TYPE | LENGTH | TECH. RATING | MAJOR DETERIORATION/DAMAGES | RIVER STUDIES NEEDED: RIVER ALIGNMENT | RIVER WIDTH BRIDGE WIDTH | BANK PROTECTION | SLOPE PROTECTION | RIVERBED PROTECTION | LOCAL SCOURING | BRIDGE CLEARANCE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| III | 14 | 3 | PLARIDEL-PULILAN | SIB | 171.20 | A | Deteriorated at deck slab | | | | | | | | |
| | 15 | 14 | SAN ROQUE | RCDG | 84.00 | A | Deteriorated at beams | | | | | | | | |
| | 16 | 43 | SICSICAN | TRUSS | 150.00 | A | Deteriorated at deck slab | | | | | | | | |
| II | 17 | 71 | INDIANA | SIB | 98.90 | B | Narrow width | | | ○ | ○ | | ○ | | • |
| | 18 | 73 | BATU | TRUSS | 350.00 | A | Incoincident current and slope protection eroded | ○ | | ○ | ○ | ○ | ○ | | • |
| | 19 | 86 | NAMANPARAN-I | RCDG | 45.00 | A | Deteriorated at beams | | | | | | | | |
| | 20 | 89 | SAN LUIS | RCDG | 24.00 | A | -do- | | | | | | | | |
| | 21 | 109 | NAGUILIAN | SIB/TRUSS | 675.00 | A | Deteriorated at deck slab | | | | | | ○ | | • |
| | 22 | 113 | MALALA | SIB/TRUSS | 475.40 | A | -do- | ○ | | | | | ○ | | • |
| | 23 | 126 | BALASIG | TRUSS | 75.00 | A | Erosion of river bank at A2 side | | | ○ | ○ | | | | • |
| | 24 | 129 | SAN PABLO | SIB/TRUSS | 278.80 | A | Deteriorated at deck slab | | | | | | | | |
| | 25 | 139 | PINACANAUAN | SIB/TRUSS | 383.40 | A | Deteriorated at deck slab<br>Serious eriosion around pier | ○ | | ○ | | | ○ | | • |
| | 26 | 154 | PARED | PONY/RCDG/TRUSS | 193.10 | A | Deteriorated at deck slab<br>Temporary bailey bridge | | | | ○ | | ○ | | • |

## Table 8.1 SELECTED BRIDGES SUBJECT TO RIVER HYDROLOGICAL STUDY (2/2)

PAN-PHILIPPINE HIGHWAY
(MATNOG-MANILA 2)

| REG. | NO. | BR. NO. | BR. NAME | BR. TYPE | LENGTH | TECH. RATING | MAJOR DETERIORATION/DAMAGES | RIVER STUDIES NEEDED: RIVER ALIGNMENT | RIVER WIDTH BRIDGE WIDTH | BANK PROTECTION | SLOPE PROTECTION | RIVERBED PROTECTION | LOCAL SCOURING | BRIDGE CLEARANCE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 27 | 19 | SUJE (RIZAL) | RC SLAB | 12.00 | A | Deteriorated at deck slab | | | | | | | | |
| | 28 | 43 | GUINOBATAN | SIB | 55.60 | A | Slope protection is scoured | | | ○ | ○ | | | | * Selected Bridge |
| | 29 | 75 | SAN FERNANDO | SIB | 21.80 | A | Deteriorated at deck slab | | | | | | | | |
| | 30 | 76 | PAMUKID | SIB | 22.50 | B | Deteriorated at deck slab<br>Steel girders are rust | | | | | | | | |
| | 31 | 77 | SAN ISIDRO | SIB | 22.50 | A | -do- | | | | | | | | |
| | 32 | 78 | SAN GABRIEL | RC SLAB | 19.50 | A | Serious longitudinal cracks and deflection has seen at slab | | | | | | | | |
| V | 33 | 79 | PAHOHO | RCDG | 12.00 | A | Deteriorated at deck slab & beams | | | | | | | | |
| | 34 | 80 | TINIGUIBAN | RCDG | 19.90 | A | -do- | | | | | | | | |
| | 35 | 82 | SGT. MATIAS | RCDG | 15.00 | A | -do- | | | | | | | | |
| | 36 | 86 | NAUBOD I | SIB | 16.00 | A | Deteriorated at deck slab<br>Steel girders are rust | | | | | | | | |
| | 37 | 99 | SOOK | SIB | 33.30 | A | Deteriorated at deck slab | | | | | | | | |
| | 38 | 143 | KANAPAWAN | SIB | 45.60 | A | -do- | | | | | | | | |
| | 39 | 154 | BASIAD | TRUSS | 58.50 | A | Deteriorated at deck slab<br>Steel girders are rust | | | ○ | | | ○ | | * |
| | 40 | 173 | GUMACA | RCDG | 46.20 | A | Deteriorated at concrete slab and Beams. | | | | | | | | |
| | 41 | 181 | TALABA | RCDG | 23.20 | A | -do- | | | | | | | | |
| | 42 | 188 | BINAHAAN | RCDG | 48.00 | A | -do- | | | | | | | | |
| | 43 | 190 | PALSABANGON | RCDG | 57.00 | A | -do- | | | ○ | | | ○ | | * |
| IV-A | 44 | 206 | LAGNAS II | RC SLAB | 20.00 | A | Longitudinal cracks at concrete slab for rigid frame | | | | | | | | |
| | 45 | 208 | STO. CRISTO | RCDG | 36.00 | A | Shear cack at concrete beam with temporary support | | | | | | | | |
| | 46 | 220 | MAGAPONG | PONY | 25.70 | A | Rusty of steel member<br>Narrow Bridge | | | | | | | | |
| | 47 | 223 | BIGA | SIB | 46.00 | A | Deteriorated at deck slab<br>Steel members are rust | | | | | | | | |
| | 48 | 227 | SAN CRISTOBAL | RCDG/TRUSS | 73.60 | A | -do- | | | | | | | | |

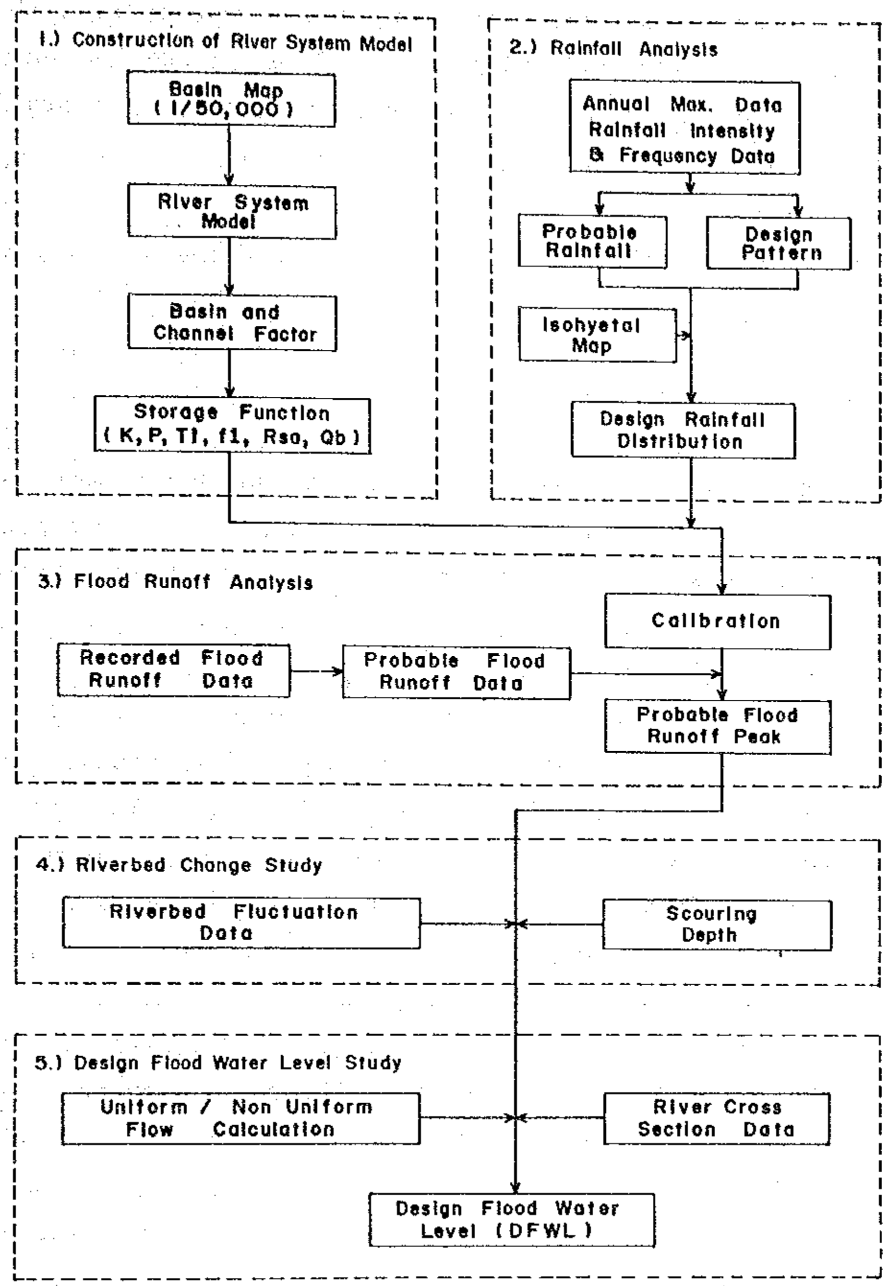
PAN-PHILIPPINE HIGHWAY
(LILOAN-ALLEN)

| REG. | NO. | BR. NO. | BR. NAME | BR. TYPE | LENGTH | TECH. RATING | MAJOR DETERIORATION/DAMAGES | RIVER STUDIES NEEDED: RIVER ALIGNMENT | RIVER WIDTH BRIDGE WIDTH | BANK PROTECTION | SLOPE PROTECTION | RIVERBED PROTECTION | LOCAL SCOURING | BRIDGE CLEARANCE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 49 | 109 | JIABONG | RC SLAB | 74.00 | A | Deteriorated at concrete slab and beams | | | | ○ | | | | * |
| VII | 50 | 120 | HINOGBONGAN | SIB | 21.80 | A | Surious erosion for both abutment | | | | ○ | | | | * |
| | 51 | 160 | JUBASAN II | PONY | 44.60 | A | Exposure of rebars at deck slab<br>Serious corrosion at joint | | | | | | | | |
| | 52 | 161 | JUBASAN I | TRUSS | 74.00 | A | Exposure of the bars at deck slab<br>Serious corrosion for all members | | | | ○ | | | | * |

## 8.2 Methodology of Hydrological Study

The hydrological study was made on the basis of analysis of collected data (Refer to APPENDIX 8.1 and APPENDIX 8.2) and in accordance with the general procedure shown in the flow chart below. As observed in this procedure, the study was performed through five substantial works: 1) construction of river system model, 2) rainfall analysis, 3) flood runoff analysis, 4) riverbed change study, and 5) design flood water level study.

Construction of river system model and rainfall analysis are a preparation works to study the flood runoff, riverbed change and design flood water level. In the flood runoff study, probable flood runoff (design discharge) is estimated to determine the required bridge length or minimum bridge span or to consider the bank protection and slope protection. In the riverbed change study, the scouring depth and riverbed fluctuation are examined for riverbed protection or local scouring. In the flood water level study, the bridge clearance is examined based on the estimated design flood water level considering of sedimentation.




FLOW CHART DIAGRAM OF THE HYDROLOGICAL STUDY

### 8.2.1 River System Model

The river system model is a necessary tool for flood runoff calculation with the aid of an electronic computer. The model comprises all the elements of flood runoff mechanism such as river basins and channels.

These elements are linked together by the base points, which are the principal points for estimating the flood runoff and for determining the flood distribution along the river. The base points are located principally at the following points:

- Main river at junction of major tributary
- Bridge sites

8.2.2 Method of rainfall analysis

The rainfall analysis aims to estimate the basin mean probable rainfall and its hourly distribution. The results of rainfall analysis (Refer to APPENDIX 8.3) are used for computation of the probable flood runoff.

The basin mean probable rainfall is estimated directly from the recorded probable rainfall data by adjustment of isohyetal map. The hourly rainfall distribution is assumed to have a center-concentrated pattern which is commonly applied to estimate the design flood runoff. This pattern is derived from the rainfall intensity-duration curve using the actual hourly rainfall data of selected stations. To obtain this pattern, the hourly rainfall increments from the intensity curve are distributed in such a way that the maximum hourly rainfall increment is put at the center of total rainfall duration and the succeeding hourly rainfall increments are alternately distributed before and after the central increment: this is done so that intensity of continuous rainfall around the center could be in accordance with the rainfall intensity-duration curve of the station.

8.2.3 Method of flood runoff analysis

Judging from the availability of flood runoff records, the flood runoff analysis is made by applying rainfall data to flood runoff simulation mode. The storage function model is applied as the simulation model, which is commonly used and judged to be suitable due to data availability. The estimation results are evaluated by comparing with the recorded data to determine the final figures of the probable flood runoff.

The basin factors are prepared using 1/50,000 topographic maps. They are catchment area of basin/subbasin ($km^2$), river length in basin/subbasin (km), and overall slope of the longest water course from the point of interest to watershed divide.

The basic equation of storage function method is described below.

$$r - q_l = dS/dt$$
$$A_l = K - q_l^P$$
$$q_l = q-(t+T_l)$$
$$Q = 0.2778 \,(f - q_l + (1-f) - q_{sa})\, A + Q_B$$

Where,

$r$ : Basin average hourly rainfall (mm/hr)

$q_l$ : Runoff depth from a basin (mm/hr)

$S_l$ : Storage (mm)

$q$ : Runoff depth from a basin with lag time, T (mm/hr)

$q_{sa}$ : Runoff depth from a basin after saturation of rainfall, $R_{sa}$ (mm/hr)

$Q$ : Runoff ($m^3/s$)

$f$ : Runoff coefficient
($r \leqq R_{sa}$ $f = f_1$, $r > R_{sa}$ $f = 1.0$)

$A$ : Catchment area ($km^2$)

$Q_B$ : Baseflow ($m^3/S$)

$K, P$ : Coefficient

$t$ : Time (hr)

The coefficient of storage function and lag time are estimated by the formulas below. Expressed by the river length and the river bed slope, they are calibrated through simulation of the flood records from the rainfall.

$$K = 118.84*i-0.3$$
$$P = 0.175*i-0.235$$
$$T = 0.047*L - 0.56$$

Where, i : Riverbed slope
L : River length (km)
T : Lag time (hrs)
K,P : Coefficient for a function

Primary runoff coefficient and the saturated rainfall are assumed to be 0.5 and 150.0 mm, respectively. The baseflow is estimated by the following formula (commonly used in Japan):

$$\text{Baseflow} = \text{Catchment area} \times 0.04\ (m^3/S/km^2)$$

8.2.4 Method of Riverbed Change Study

The channel section recorded on the discharge measurement notes is utilized. The fluctuated riverbed elevation is observed and the change of the Bued riverbed in the future shall be examined.

The local scouring study is conducted by the following empirical formulas.

- Laursen formula

$$\frac{D}{ho} = 5.5\,\frac{Zse}{ho}\,\left(\left(1/11.5\,\frac{Zse}{no} + 1\right)^{1.7} - 1\right)$$

- Breusere formula

$$\frac{Zse}{D} = 1.4$$

- Neil formula

$$\frac{Zse}{D} = 1.5\,\left(\frac{ho}{D}\right)^{0.3}$$

Where,

D = Width/diameter of pier (m)
ho = Average depth (m)
Zse = Scouring depth from riverbed around pier

8.2.5 Method of Design Flood Water Level Study

The design flood water levels are estimated based on the probable flood runoff and the riverbed change study.

The levels are converted from the probable flood runoff by Non-Uniform or Uniform flow calculations as described below.

Non-Uniform Flow Calculation

The Ida method developed for the non-uniform flow calculation of the compound channel section is applied.

$$He = (H_2 + \frac{D_2}{2g} ( \frac{Q_2}{A_2} )^2) - (H_1 + \frac{D_1}{2g} ( \frac{Q_1}{A_1} )^2)$$

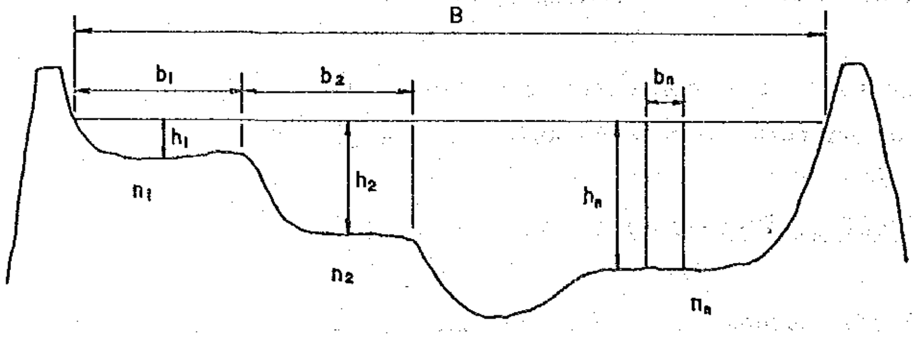
$$= 1/2 \left( \frac{{N_1}^2 \cdot {Q_1}^2}{{A_1}^2 \cdot {R_1}^{4/3}} + \frac{{N_2}^2 \cdot {Q_2}^2}{{A_2}^2 \cdot {R_2}^{4/3}} \right) dX$$

Where,

A : Catchment area ($km^2$)
$H_1$ : Water depth at point 1
$H_2$ : Water depth at point 2
D : Energy correction factor
He : Loss of energy head (m)
N : Composite channel roughness (sec, m)
R : Composite channel hydraulic radius (m)
X : Distance between the sections (m)
g : Acceleration of gravity g = 9.8 m/s
Q : Design flood runoff ($m^3/sec$)

The subscripts 1 and 2 denote the values at lower and upper sections under consideration, respectively.

According to the Ida method, the energy correction factor, composite channel roughness, and composite hydraulic radius of the compound section are the function of the depth, roughness, and the width of each river sub-section as shown below.




$$D = a \left(A^2 \int_0^B (h^2/n^3)\, db\right) / \left(\int_0^B (h^{5/3}/n)\, db\right)^3$$

$$N = \left(\int_0^B h^{5/3}\, db\right) / \left(\int_0^B (h^{5/3}/n)\, db\right)$$

$$R = \left(\frac{1}{A} \int_0^B h^{5/3}\, db\right)^{3/2}$$

Where,

B : Surface width (m)

b,h,n: Width (m), depth (m), and roughness (sec, m) of each vertical strip, respectively.

a : Velocity distribution coefficient

Uniform Flow Calculation

Manning's uniform flow formula is applied.

$$V = \frac{1}{n} R^{2/3} I^{1/2}$$

Where,

V : Mean velocity (m/sec)
n : Coefficient of roughness (sec, m)
R : Hydraulic radius (m)
I : Channel slope

The coefficient of roughness (n) used in the non-uniform and uniform flow calculations is assumed to be 0.04 in this study.

## 8.3 Results of Hydrological Study

The hydrological study consisting of flood runoff analysis, riverbed change study and design flood water level study, was carried out to examine the following results which could reveal the causes of river hydrographical problems.

1) Probable flood runoff
2) Scouring depth
3) Design high water level
4) Sedimentation (Riverbed fluctuation)
5) Recommended design bridge length
6) Required minimum bridge span length

### 8.3.1 Probable Flood Runoff

(1) Flood Runoff Model

The storage function was applied as the flood runoff model in this study (Refer to APPENDIX 8.4). The coefficient of storage function and lag time for subbasins were estimated by the formulas, which is well known as Tone River Formulas and applied for many rivers in Japan.

The estimated coefficients of storage function K, P and T are listed in APPENDIX 8.4. The primary runoff coefficient ($f_1$) and saturated rainfall (Rsa) were assumed to be 0.5 and 150 mm and the specific baseflow was adopted to be 0.04 $m^3/sec/km^2$ in this study.

2) Probable Flood Runoff

The probable flood runoff was estimated at each bridge site presented in Table 8.3. Some of these figures were compared and evaluated to the probable flood runoff estimated from the recorded flood runoff as below.

| River Name (Bridge) | From Rainfall | | From Records | | Ratio |
|---|---|---|---|---|---|
| | Probable Flood ($m^3/s$) | Specific Flood/1 ($m^3/s/km^2$) | Probable Flood ($m^3/s$) | Specific Flood/2 ($m^3/s/km^2$) | /1 / /2 |
| Sta. Maria | 291 | 10.2 | 3,050 | 24 | 0.4 |
| Bued | 1,014 | 9.3 | 1,500 | 7.2 | 1.3 |
| Buaya (Sta. Cruz) | 1,539 | 8.7 | 1,130 | 6.5 | 1.3 |
| Cawayan | 82 | 5.8 | 446 | 5.5 | 1.1 |

The probable flood runoff estimated from rainfall is usually considered to be obtained as the under-estimated value of 10 to 30% to the actual runoff because of the difficulty in monitoring the flood runoff peak. Therefore, the above ratios were judged to be reasonable except for the Sta. Maria river/bridge case. However, the specific flood from rainfall at Sta. Maria was judged to be reliable referring from the result of the Buaya river (nearest river from Sta. Maria river). The flood hydrograph at the bridge sites and the specific flood runoff curves are presented in APPENDIX 8.4.

Table 8.3 PROBABLE FLOOD RUNOFF AT THE BRIDGE SITES

(Unit: $m^3/s$)

| No. | Br. Name | Catchment Area ($km^2$) | Return Period (Yr) 1/25 | /50 | Remarks |
|---|---|---|---|---|---|
| 1 | Labangan I | 948 | 1,850 | - | /2 |
| 2 | Tagamusing | 148 | 830<br>(5,6) | 1,100<br>(7.4) | |
| 3 | Bued | 161 | 1,500<br>(9.3) | 1,920<br>(11.9) | |
| 4 | Bauang I | 530 | * 1,990<br>** 3,880<br>(7.3) | * 2,435<br>** 4,870<br>(9.2) | |
| 5 | Sta. Cruz I | 222 | 1,930<br>(8.7) | 2,620<br>(11.8) | |
| 6 | Sta. Maria | 299 | 3,050<br>(10.2) | 4,060<br>(13.6) | |
| 7 | Indiana | 318 | 680<br>(3.1) | 830<br>(2:6) | |
| 8 | Batu | 2,020 | 4,310 | 5,250 | |
| 9 | Naguilian | 6,610 | | 10,700 | /1 |
| 10 | Malalan | 3,100 | | 6,700 | /1 |
| 11 | Balasig | 185 | 2,050 | 2,510 | |
| | Guinobatan | 76 | 440<br>(11.1) | 580<br>(13.6) | |
| 12 | Pinacanauan | 657 | 3,000 | - | /1 |
| 13 | Pared | 935 | 8,270<br>(88) | 10,210<br>(10.9) | |
| 14 | Guinobatan | 76 | 440<br>(5.8) | 580<br>(7.6) | |
| 15 | Basiad | 26 | 120<br>(4.6) | 140<br>(5.4) | |
| 16 | Palsabangon | 9 | 50<br>(2.6) | 70<br>(3.7) | |
| 17 | Jiabong | 67 | 420<br>(6.3) | 560<br>(8.4) | |
| 18 | Hinogbongan | 20 | 110<br>(5.5) | 140<br>(7.0) | |
| 19 | Jubasan I | 13 | 60<br>(4.6) | 70<br>(5.4) | |

Note: . Values in parentheses mean specific flood runoff ($m^3/s/km^2$)
. Value marked by * is flood runoff at Bauang I Site.
. Value marked by ** is flood runoff of Bauang I+II sites.
. /1 Obtained from Cagayan Master Plan Project Study in 1985, JICA.
. /2 Pampanga Delta Development Study in 1988, DPWH.

### 8.3.2 Riverbed Fluctuation and Scouring

(1) Rivers subject to riverbed change study

The riverbed change study was conducted to characterize the riverbed fluctuation and local scouring around the bridge pier. The study results were used as basic data for preliminary design of river facilities around the bridge site.

The riverbed fluctuation study covered the Bued river because of if has the problem of apparant aggradation of bed. In the upstream portion of the Bued river there are many slope slidings and mines, thus the extreme amount of sedimentation comes from upstream to the Bued site. The local scouring study covered the following rivers because their flow velocity is generally high due to the steeper river slope and/or by judgement from field investigation.

The remaining 5 bridges (Balasig, Guinobatan, Jiabang, Hinogbongan and Jubasan I) out of 19 bridges were not taken up in this study.

| No. | Bridge/River Name | River Slope |
|---|---|---|
| 1 | Labangan/Labangan | 1/4,000 |
| 2 | Tagamusing/Tagamusing | 1/60 |
| 3 | Bued/Bued | 1/80 |
| 4 | Bauang/Bauang | 1/40 |
| 5 | Sta. Cruz/Buaya | 1/100 |
| 6 | Sta. Maria/Sta. Maria | 1/100 |
| 7 | Indiana/Sta. Fe | 1/100 |
| 8 | Batu/Magat | 1/100 |
| 9 | Naguilian/Cagayan | 1/2,900 |
| 10 | Malalam/Ilagan | 1/2,500 |
| 11 | Pinacanauan/Tugnegarao | 1/70 |
| 12 | Pared/Pared | 1/140 |
| 13 | Basiad/Basiad | 1/40 |
| 14 | Palsabangon/Palsabangan | 1/200 |

(2) Riverbed Fluctuation

The study aims to grasp the trend of the riverbed fluctuation in the Bued river with lapse of time. In order to determine the figures, the channel section recorded in the discharge measurement notes was utilized and the riverbed elevation at the gauging station was studied. Comparative studies of the river cross sections in 1972 and 1988 were also performed as shown in APPENDIX 8.5.

The annual rising of the Bued riverbed was estimated to be 0.02 m/yr. The tendency of riverbed rising seems to be still kept in recent years. The Bued riverbed rising in the foregoing 50 years was assumed to be 1.0 m in total.

(3) Local Scouring

Local scouring study was conducted on the riverbed around the bridge pier. The Laursen, Breusere and Neil formulas were applied to estimate the scouring depth around the pier and the computed results derived from formulas were compared with the scouring depth measured by the survey. In the following table, the maximum scoring depth around pier was estimated by the Lauren formula to be 5.1 m at Naguilian and the minimum 1.1 m at Basiad and Palsabangon bridge sites by Lauren formula. The results obtain from calculation by formula coincide well with the survey results.

## SCOURING DEPTH

| | D (m) | ho (m) | /1 Laursen | /2 Breusere | /3 Neil | Max. Survey |
|---|---|---|---|---|---|---|
| | | | Scouring Depth Zse (m) | | | |
| Labangan | 2.0 | 2.6 | 2.5 | 2.8 | 3.2 | 2.8 |
| Tagamusing | 1.5 | 2.8 | 2.2 | 2.1 | 2.7 | 2.3 |
| Bauang I | 2.0 | 3.1 | 2.7 | 2.8 | 3.4 | 3.0 |
| Sta. Cruz I | 1.5 | 1.8 | 1.8 | 2.1 | 2.4 | 2.1 |
| Sta. Maria | 1.5 | 4.0 | 2.7 | 2.1 | 3.0 | 2.6 |
| Indiana | 2.0 | 5.6 | 3.5 | 2.8 | 3.5 | 3.0 |
| Batu | 2.0 | 3.3 | 2.8 | 2.8 | 3.5 | 3.0 |
| Naguilian | 2.0 | 10.6 | 5.1 | 2.8 | 4.9 | 4.3 |
| Malalam | 2.0 | 8.0 | 4.4 | 2.8 | 4.5 | 3.9 |
| Pinacanauan | 2.0 | 2.9 | 2.6 | 2.8 | 3.4 | 2.9 |
| Pared | 2.0 | 8.8 | 4.6 | 2.8 | 4.7 | 3.6 |
| Basiad | 2.0 | 0.5 | 1.1 | 2.8 | 2.0 | 2.0 |
| Palsabangon | 2.0 | 0.5 | 1.1 | 2.8 | 2.0 | 2.0 |

Note: D : Width/diameter of pier

ho : Average depth (m)

Zse : Scouring depth from riverbed around pier

/1 : Laursen formula

$D/ho = 5.5\ Zse/ho\ ((1/11.5\ Zse/ho + 1)^{1.7} - 1)$

/2 : Breusere formula

$Zse/D = 1.4$

/3 : Neil formula

$Zse/D = 1.5\ (ho/D)^{0.3}$

### 8.3.3 Design Flood Water Level

#### (1) Design Scale

A river shall be generally planned to function in such a manner that the design flood runoff can be safely flowed down to protect the assets in the downstream area. This plan therefore shall be formulated with an appropriate design scale which is evaluated by the return period corresponding to the degree of required safety in the plan.

The return periods of 1 to 25 years, 50 years and 100 years are usually adopted for the design scale of various rivers in Japan referring to the factors below:

a) Statistical evaluation of recorded maximum flood
b) Size of basin/catchment area
c) Population in the town located downstream
d) Economic impact to downstream area

In this study, the design scale of the object rivers was basically set up with the return period of 1 to 50 years for big rivers and 25 years for small rivers. The return period of 1 to 50 years was adopted for Batu, Naguilian and Malalam bridge basins taking into consideration the size of the basin (C.A. more than 2,000 $km^2$), population in the town located downstream, and the economic impact to downstream area, while the return period applied for other rivers was 1 to 25 years. Through statistical evaluationof the flood data,the recorded maximum flood was evaluated as that with less probability than 1 to 25 years flood as presented below:

| Bridge Name | (1) 1/25 Probable Flood Water Level (m) | (2) Recorded Flood Water Level (m) | (1)-(2) Difference (m) |
|---|---|---|---|
| Tagamusing | 27.10 | 26.50 | 0.60 |
| Sta. Cruz | 18.70 | 18.60 | 0.10 |
| Malalam | 37.80 | 33.00 | 4.80 |
| Pinacanauan | 24.50 | 20.00 | 4.50 |
| Guinobatan | (4.60) | 3.00 | 1.60 |
| Palsabangon | (2.00) | 2.00 | 0.00 |
| Jiabong | (5.10) | 5.00 | 0.10 |

The river plan with the return period of 1 to 25 years is usually adopted as the long term plan in the Philippines taking into account the factors a), b), c) and d) mentioned above. In terms of cost effectiveness of the plan, 1 to 20 - 25 years return period is also taken up for the plan. The design scale was therefore judged to be an appropriate value with the return period of 1 to 50 years for big rivers and 1 to 25 years for small rivers.

(2) Design Flood Water Level

The design flood water levels at the bridge sites were analyzed based on the probable flood runoff and the riverbed change study. The annual increasing rate of the riverbed in the Bued river was assumed to be 0.02 m/year. The levels were converted from probable flood runoff by the Non-uniform or Uniform flow calculation methods. The initial sea water levels to be used in the Non-uniform flow calculations are summarized in APPENDIX 8.1. Table 8.4 shows the estimated design flood water levels at the object bridge sites.

## Table 8.4 DESIGN FLOOD WATER LEVEL

| No. | Bridge Name | (a) El. of Bridge Surface (El.m) | (b) Distance from Br. Surface to Lowest Beam (m) | (c) El. of Lowest Beam (m) | (d) Free Board | (e) (c) - (d) | (f) 1/50 Probable Flood Water Level (El.m) | (g) (e) - (f) | (h) 1/25 Probable Flood Water Level (El.m) | (i) (e) - (h) | (j) Design Flood Water Level (El.m) | (k) Design Distance from Br. Surface to Lowest Beam (m) | (l) (d)+(j)+(k) | (m) Design El. of Bridge Surface (El.m) | (h) Required Height to be up. (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Labangan | 5.72 | 1.30 | 4.42 | 1.2 | 3.22 | - | - | /1 5.22 | -2.00 | 5.22 | 1.80 | 8.22 | 8.22 | +2.50 m |
| 2 | Tagamusing | 32.83 | 0.90 | 31.93 | 1.0 | 30.93 | 31.63 | -0.70 | 27.10 | 3.83 | 27.10 | 1.75 | 29.85 | 32.83 | |
| 3 | Bued | 134.56 | 1.20 | 133.36 | 1.5 | 131.86 | 132.40 | -0.54 | 132.20 | -0.34 | /2 133.20 | 2.00 | 136.70 | 136.70 | +2.14 m |
| 4 | Bauang I | 7.27 | 1.10 | 6.17 | 1.2 | 4.97 | 3.83 | 1.14 | 3.30 | 1.67 | 3.30 | 1.85 | 6.36 | 7.27 | |
| 5 | Sta. Cruz I | 21.90 | 0.90 | 21.00 | 1.0 | 20.00 | 16.83 | 3.17 | 16.40 | 3.60 | 16.40 | 0.90 | 18.30 | 21.90 | |
| 6 | Sta. Maria | 19.80 | 1.10 | 18.70 | 1.2 | 17.50 | 17.90 | -0.40 | 17.40 | 0.10 | 17.40 | 1.10 | 19.70 | 19.80 | |
| 7 | Indiana | 338.55 | 1.10 | 337.45 | 1.0 | 336.45 | 331.90 | 4.55 | 331.70 | 4.45 | 331.70 | 1.30 | 334.0 | 338.55 | |
| 8 | Batu | 303.72 | 1.10 | 302.62 | 1.2 | 301.42 | 299.40 | 2.02 | 298.70 | 2.72 | 299.40 | 1.10 | 301.70 | 303.72 | |
| 9 | Naguilian | 46.92 | 1.20 | 45.72 | 1.5 | 44.22 | /3 44.00 | 0.22 | /3 43.00 | 1.22 | 44.00 | 1.20 | 46.70 | 46.92 | |
| 10 | Malalam | 40.96 | 1.20 | 39.76 | 1.5 | 38.26 | /3 39.00 | -0.74 | /3 37.80 | 0.46 | 39.00 | 1.20 | 41.70 | 40.96 | |
| 11 | Balasig | 31.79 | 1.20 | 30.59 | 1.2 | 29.39 | 24.40 | 4.99 | 23.60 | 5.79 | 23.60 | 1.20 | 26.00 | 31.79 | |
| | | | | | | | /3 (31.50) | | /3 (30.50) | | | | | | |
| 12 | Pinacanauan | 30.45 | 1.20 | 29.25 | 1.2 | 28.05 | /3 26.00 | 2.05 | /3 24.50 | 3.55 | 24.50 | 1.20 | 26.90 | 30.45 | |
| 13 | Pared | 17.94 | 1.20 | 16.74 | 1.2 | 15.54 | 10.40 | 5.14 | 9.30 | 6.24 | 9.30 | 1.90 | 11.70 | 17.94 | |
| | | | | | | | /3 (18.50) | | /3 (17.40) | | | | | | |
| 14 | Guinobatan | /5 (7.80) | 0.80 | (7.00) | 1.0 | /4 (6.00) | (5.50) | (0.50) | (4.60) | (1.40) | (4.60) | (0.80) | (6.40) | (7.80) | |
| 15 | Basiad | /5 (8.20) | 1.20 | (7.00) | 1.0 | /4 (6.00) | (3.00) | (3.00) | (2.50) | (3.50) | (2.50) | (1.20) | (4.70) | (8.20) | |
| 16 | Palsabangon | /5 (8.10) | 1.10 | (7.00) | 1.0 | /4 (6.00) | (5.20) | (0.80) | (5.00) | (1.00) | (5.00) | (1.10) | (7.10) | (8.10) | |
| 17 | Jiabong | /5 (4.70) | 0.70 | (4.00) | 1.0 | /4 (3.00) | (2.70) | (0.30) | (2.30) | (0.70) | (2.30) | (0.86) | (4.16) | (4.70) | |
| 18 | Honogbongan | /5 (8.20) | 1.20 | (7.00) | 1.0 | /4 (6.00) | (6.40) | (0.40) | (5.70) | (0.30) | (5.70) | (1.20) | (7.90) | (8.20) | |
| 19 | Jubasan I | /5 (8.70) | 1.20 | (7.50) | 1.0 | /4 (6.50) | (4.70) | (1.80) | (3.60) | (2.90) | (3.60) | (2.20) | (6.80) | (8.70) | |

Note :
/1 : The value was designed in the Detail Study Report on the Pampanga Delta Development Project, 1988, JICA (Return Period 1/20)
/2 : 1.0 m of rising riverbed istaken into consideration to decide the design flood water level in the Bued river.
/3 : The value is estimated on the results of design water level studied in the Cagayan Master Plan Project Study, 1987, JICA
/4 : Distance from riverbed to free board
/5 : Elevation data not available. The figures are indicated as the distance from riverbed for Guinobatan, Basiad Palsabangon, Jiabong, Hinogbongan and Jubasan.

8.3.4 Recommended Design Bridge Length

The river width is generally determined on the scale of design discharge, river channel profile, topography and geology. In this study, the river width is examined by the figure below, in which the river width is currently designed and/or constructed showing relationship between river width and design discharge.

The bridges/rivers which have inadequate length were studied and the study results are summarized in Table 8.5. The river width was estimated to be more than twice the present river width for Labangan and Tagamusing. The bridge length shall be extended up to 260 m for Labargan which was planned by the Pampanga Delta Project Team in 1988. However, the length of Tagamusing bridge was judged not to require extension because the river width both upstream and downstream are almost same as that at the bridge site. The length of Sta. Cruz and Sta. Maria bridges was planned to be extended by about 35 m and 45 m, respectively because the indesirable river alignment due to damage caused by river flow to bridge abutment portion.

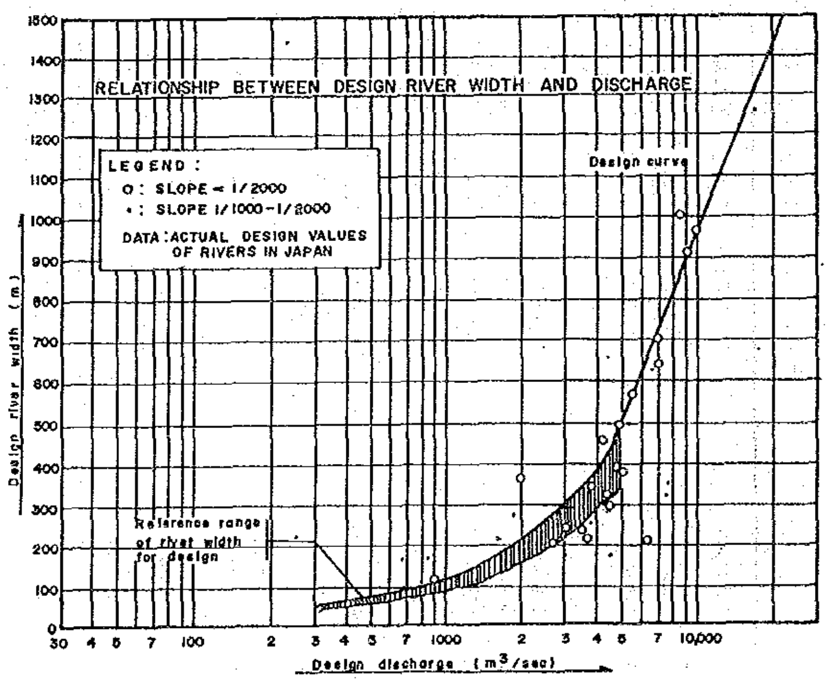


Table 8.5 RECOMMENDED DESIGN BRIDGE LENGTH

| Bridge | River | Area ($km^2$) | Design discharge ($m^3/S$) | Estimated River Width (m) | Present Bridge Length (m) | Recommended design River Bridge Width Length (m) | Remarks |
|---|---|---|---|---|---|---|---|
| Labangan I | Labangan | 948 | 1,850 | 170-220 | 100.0 | 260.0 | Planned by Pampanga Delta Project Team |
| Tagamusing | Tagamusing | 148 | 830 | 80-90 | 40.0 | 50(40+10)* | |
| Bued | Bued | 161 | 1,500 | 120-150 | 500.4 | 500.5** | Difficult to make it shorter because of river alignment and sediment problem |
| Bauang | Bauang | 530 | 3,820 | 280-360 | 221.4 | 235.0 | |
| Sta. Cruz | Buaya | 222 | 1,930 | 170-200 | 260.6 | 295.6 | 35m extension of side span approach because of undesirable river alignment |
| Sta. Maria | Sta. Maria | 299 | 3,050 | 220-300 | 298.2 | 343.2 | 45m extension of side span approach because of undesirable river alignment |
| Indiana | Sta. Fe | 319 | 680 | 80-90 | 98.9 | 110.0 | |
| Batu | Magat | 2,020 | 5,250 | 300-450 | 350.0 | 350.0 | |
| Naguilian | Cagaya | 6,610 | 10,700 | 1,000 | 675.0 | 675.0 | |
| Malalam | Ilagan | 3,100 | 6,700 | 650 | 475.4 | 475.4 | |
| Balasig | Balasig | 185 | 2,050 | 170-120 | 75.0 | 75.0 | |
| Pinacanauan | Tuguegarao | 657 | 3,000 | 210-300 | 383.4 | 383.4 | |
| Pared | Pared | 935 | 8,270 | 220 | 193.1 | 193.1 | |
| Guinobatan | San Francisco | 76 | 440 | 60 | 55.6 | 55.6 | |
| Basiad | Basiad | 26 | 120 | 30 | 58.5 | 58.5 | |
| Palsabangon | Palsabangon | 9 | 50 | 20 | 57.0 | 57.0 | |
| Jiabong | Jiabong | 67 | 420 | 60 | 74.8 | 74.8 | |
| Hinogbongan | Hinogbongan | 20 | 110 | 20 | 21.8 | 21.8 | |
| Jubasan I | Jubasan | 12 | 60 | 20 | 74.0 | 74.0 | |

Note: * 10 m extension of side span approach is planned.

** If bridge length is planned to be made shorter, many problem will occur such as damage of abutment by sediment flow, thus bridge length is designed taking into consideration of the present river width.

### 8.3.5 Required Minimum Bridge Span Length

The required minimum bridge span length was estimated by the following equation which has been established as a design standard by the Ministry of Construction of Japan.

$$L = 20 + 0.005\ Q$$

Where, L: Required minimum bridge span length
Q: Design flood runoff

The bridge span is generally determined by the above equation with an exception of the case in which nothing will be affected by an exceptional bridge span length from the viewpoint of flood control in the object river.

The span length for the Bued and Bauang I bridges was planned to be 25.0 m from the viewpoint mentioned above as well as for economic reason as shown in Table 8.6. Only one side span extension for the Sta. Cruz and Sta. Maria bridges was planned because of the undesirable river alignment, which was also judged as an exceptional case in this study. This length was designed for both bridges based on the topographic and river alignment conditions.

Table 8.6 REQUIRED MINIMUM BRIDGE SPAN LENGTH

| No. | Br. Name | Existing (Planning) Span Length (m) | Design Flood Runoff ($m^3/S$) | Required Minimum Bridge Span Length/2 (m) | Remarks |
|---|---|---|---|---|---|
| 1. | Labangan I | 50.0 (32.5) | 1,850 | 29.3 | - Reconstruction |
| 2. | Tagamusing | 10.0 (20.0) | 830 | 24.2 | |
| 3. | Bued | 32.5 (25.0)/1 | 1,500 | 27.5 | - Reconstruction |
| 4. | Bauang I | 25.0 (25.0)/1 | 1,990 | 30.0 | - Reconstruction |
| 5. | Sta. Cruz | 11.7 (17.5) | 1,930 | 29.7 | - Sidespan extension |
| 6. | Sta. Maria | 49.7 (22.5) | 3,050 | 35.3 | - Sidespan extention |
| 7. | Indiana | 25.0 (25.0) | 680 | 23.4 | |
| 8. | Batu | 50.0 | * 5,250 | 41.6 | |
| 9. | Naguilian | 75.0 | *12,500 | 82.5 | |
| 10. | Malalam | 74.0 | * 7,600 | 58.0 | |
| 11. | Balasig | 75.0 | 2,050 | 30.3 | |
| 12. | Pinacanuan | 60.0 | 3,000 | 35.0 | |
| 13. | Pared | 49.2 | 8,270 | 61.4 | |
| 14. | Guinobatan | 27.9 | 440 | 22.2 | |
| 15. | Basiad | 58.5 | 120 | 20.6 | |
| 16. | Palsabangon | 15.0 | 50 | 20.3 | |
| 17. | Jiabong | 6.8 (25.0) | 420 | 22.1 | - Reconstruction |
| 18. | Hinogbongan | 21.8 | 110 | 20.6 | |
| 19. | Jubasan I | 74.0 (37.0) | 60 | 20.3 | - Reconstruction |

Note: /1 Planning span length for Bued and Bauang I bridges for reconstruction is determined from the economical view point although they have some length shortage in comparison with required minimum bridge span length estimated by the design flood runoff.

/2 Required minimum bridge span length is estimated by the following formula established by the Ministry of Construction in Japan

$$L = 20 + 0.005\,Q$$

where, L : Required minimum bridge span length

Q : Design flood runoff

### 8.3.6 Recommendation of River Training

According to the results of hydrological study, the following river trainings were recommended for preliminary design. The design value which was derived from hydrological and the river studies is presented in Tables 8.4 and 8.5. Based on these study results, the following planning conditions were taken up for bridge design.

1) Bridge elevation to be raised

| | |
|---|---|
| - Labangan I Bridge | + 2.50 m |
| - Bued Bridge | + 2.14 m |

2) Bridge Length to be extended

| | |
|---|---|
| - Labangan I Bridge | + 160 m |
| - Sta. Cruz Bridge | + 35 m |
| - Sta. Maria Bridge | + 45 m |

The protection works for presenting local scouring around the bridge pier were planned as follows.

- protection method     Gabion (20 m x 30 m)

The dimension of gabion (20 m x 30 m) was determined based on the study results in the section 8.3.2. The maximum scouring depth of 5.0 m was taken up for the sites in consideration of the safety fuctor.

# CHAPTER 9

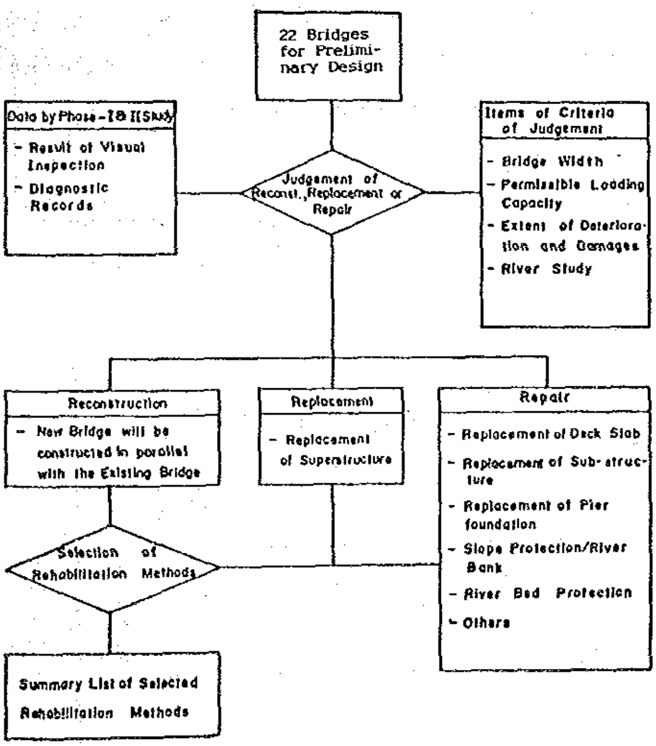
# CLASSIFICATION OF REHABILITATION BRIDGES

## CHAPTER 9 CLASSIFICATION OF REHABILITATION BRIDGES

### 9.1 General

The classification of the 22 bridges to be rehabilitated was made taking into consideration the bridge width, permissible loading capacity and extent of deterioration and damages. The classification is certainly applicable to the remaining 30 bridges which require urgent rehabilitation through study of the likeness of bridge types. Judgement on reconstruction, replacement of superstructure and repair of bridge is needed to be made through the criteria established under the conditions mentioned below. Following the assortment of reconstruction, replacement of superstructure and repair by criteria, further study was carried out to select the most suitable method to be applied to the existing bridges.

FLOW CHART OF CLASSIFICATION OF REHABILITATION BRIDGES



## 9.2 Criteria for Judgment on Reconstruction, Replacement of Superstructure and Repair

The following were considered in judging the reconstruction, replacement of superstructure and repair needed for the existing bridges.

- Bridge Width
- Permissible Loading Capacity
- Extent of Deterioration and Damages

### 9.2.1 Bridge Width

The bridge width considered in this feasibility study is classified into three kinds based on AADT in the year 2,000, that is applicable width for reconstruction, desirable width for repair and minimum required width as listed below and shown in Table 9.1. The required minimum width is to be adopted on the criteria for the said judgement considering that the actual existing width varies from 6.1 to 7.32 m.

In case the existing roadway width is less than the required minimum width previously studied, the following rehabilitation methods will be considered according to the types of the existing bridges.

| Exist. Bridge Type | Reconstruction | Replacement of superstructure | Widening |
|---|---|---|---|
| Through Truss | O | - | O* |
| Pony Truss | O | - | - |
| SIB | - | O | O |
| RCDG | - | O | O |
| Conc. Slab | - | O | - |

Note:

* : sidewalk widening

O : to be considered

Table 9.1 BRIDGE WIDTH TO BE REHABILITATED

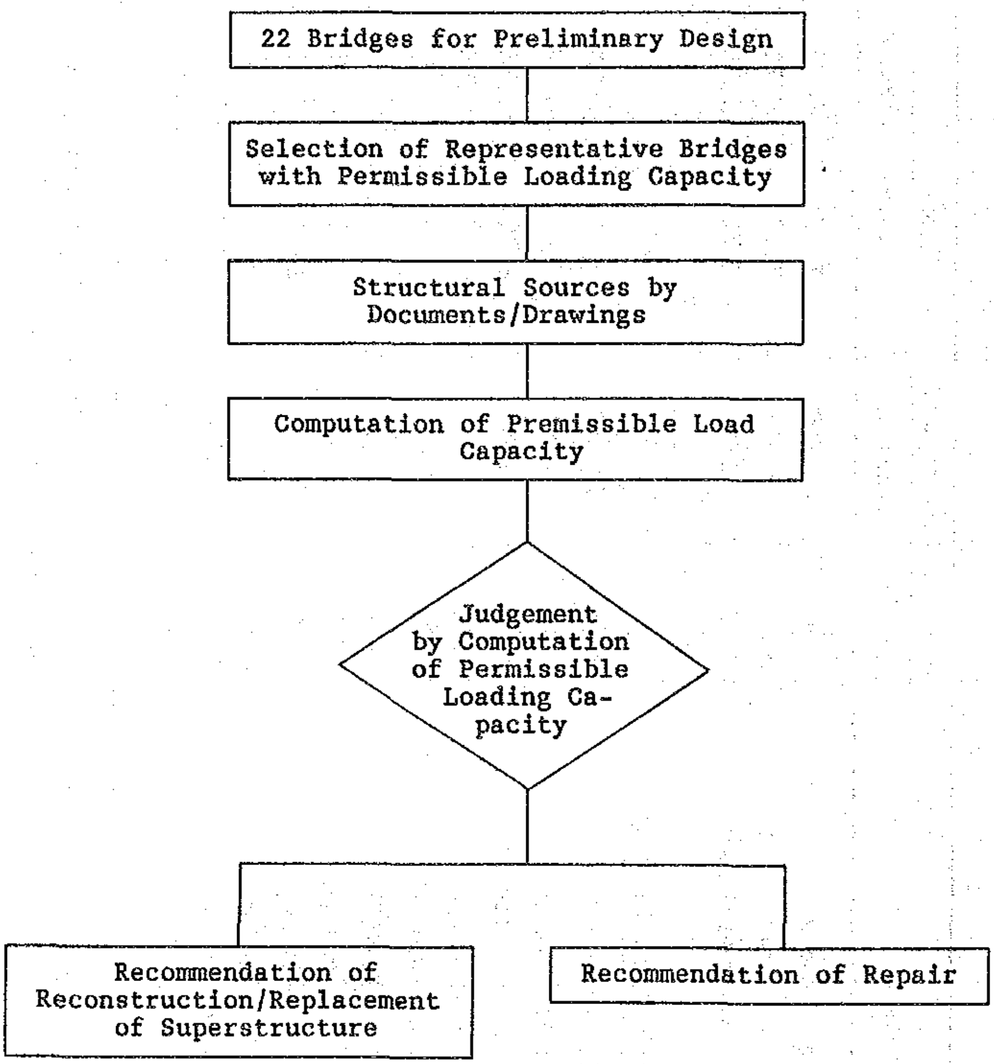
| | Sections | Reconst. / Replacement | | Repair * - 1 | | Min. Req. * - 2 | Traffic Volume |
|---|---|---|---|---|---|---|---|
| | | Roadway | sidewalk | Roadway | sidewalk | Roadway | (AADT 2000 Year) |
| (1) | Manila – Rosario | 7.94 | 0.76 | 7.32 | 0.76 | 7.32 | > 20,000 |
| (2) | Rosario – San Fernando | 7.32 | 0.76 | 7.32 | 0.76 | 6.72 | > 10,000 |
| (3) | San Fernando – Laoag | 7.32 | 0.76 | 6.72 | 0.76 | 6.10 | > 5,000 |
| | Pan-Philippine Highway | | | | | | |
| (1) | Manila – Santa Fe | 7.94 | 0.76 | 7.32 | 0.76 | 7.32 | > 20,000 |
| (2) | Santa Fe – Santiago | 7.32 | 0.76 | 7.32 | 0.76 | 6.72 | > 10,000 |
| (3) | Santiago – Allacapan | 7.32 | 0.76 | 6.72 | 0.76 | 6.10 | < 5,000 |
| (4) | Manila – Calamba | 7.94 | 0.76 | 7.32 | 0.76 | 7.32 | > 20,000 |
| (5) | Calamba – Calauag | 7.32 | 0.76 | 7.32 | 0.76 | 6.72 | > 10,000 |
| (6) | Calauag – Sipocot | 7.32 | 0.76 | 7.32 | 0.76 | 6.10 | > 5,000 |
| (7) | Sipocot - Sorsogon | 7.32 | 0.76 | 7.32 | 0.76 | 6.72 | > 10,000 |
| (8) | Sorsogon – Matnog | 7.32 | 0.76 | 6.72 | 0.76 | 6.10 | < 5,000 |
| (9) | Allen – Tacloban | 7.32 | 0.76 | 6.72 | 0.76 | 6.10 | < 5,000 |
| (10) | Tacloban – Mac Arthur | 7.32 | 0.76 | 7.32 | 0.76 | 6.72 | > 10,000 |
| (11) | Mac Arthur – Liloan | 7.32 | 0.76 | 6.72 | 0.76 | 6.10 | < 5,000 |

* - 1 : All Width of repair are desirable values otherwise the existing width is to be considered.
* - 2 : Minimum requirement for considing existing bridge repair.

9.2.2 Permissible Loading Capacity

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

FLOW CHART DIAGRAM FOR JUDGEMENT ON RECONSTRUCTION, REPLACEMENT OF SUPERSTRUCTURE OR REPAIR IN ACCORDANCE WITH COMPUTATION OR PERMISSIBLE LOADING CAPACITY



To judge whether reconstruction, replacement of superstructure or repair of bridge is needed, the permissible loading capacity is analyzed as a prerequisite. For this analysis, the M 13.5 (135 KN) loading is considered as the critical loading to examine the required minimum duration of the existing bridges. The examining procedure can be referred to in the flow chart for judgement on reconstruction, replacement of superstructure or repair through computation of permissible loading capacity. The judgement will be made in accordance with the following criteria.

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 M 13.5 vehicle weight is considered as the required minimal loading of the existing steel type bridges.

$P < 135$ KN: Reconstruction or Replacement of Superstructure of Bridge

$P \geq 135$ KN: Repair of Bridge

Where:

P = basic permissible loading capacity

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

P = basic permissible loading capacity

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

Fa = allowable stress of the materials

Fd = stress due to dead load

To rate the existing bridge structures the capacity shall be computed by deducting the stress due to dead load from the allowable stress of the materials. The difference after deduction (Fa-Fd) is the permissible live load capacity of the bridge structure.

This live load capacity which is divided by the required minimum live load of M 13.5 is the rating factor. To arrive at the basic permissible loading capacity (vehicle weight), the 135 KN vehicle weight shall be multiplied by the rating factor.

In addition, the operational live load capacity being applied is determined by 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 |
|---|---|---|
| SIB | Main Beam<br>Deck Slab | 1.2<br>1.0 |
| TRUSS/PONY | Upper/Lower Chord<br>Vertical/Diagonal Chord<br>Floor System<br>Deck Slab | 1.2<br>1.0<br>1.6<br>1.0 |
| RCDG | Beam<br>Deck Slab | 1.2<br>1.0 |
| R.C. SLAB | Slab | 1.0 |

FACTOR BY PAVEMENT CONDITION (Kr)

| Rating of Damage | Kr |
|---|---|
| A | 0.8 |
| B | 0.9 |

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 | $0.55\,Fy\left[1-\frac{\left(\frac{L}{r}\right)^2 Fy}{4\,\pi^2\cdot E}\right]$ |
| Compressive in centrally loaded columns | $K\frac{L}{R}\leq\sqrt{\frac{2\,\pi^2 E}{Fy}}$ | $\frac{Fy}{2.12}\left[1-\frac{\left(K\frac{L}{r}\right)^2 Fy}{4\,\pi^2 E}\right]=117.073-0.004\left(\frac{KL}{r}\right)^2$ |
| | $K\frac{L}{R}>\frac{2\,\pi^2 E}{Fy}$ | $\frac{\pi^2 E}{2.12\left(K\frac{L}{r}\right)^2}$ |
| 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 ( 3,000 psi = 20.68 Mpa ) | — | 0.4 fc'=8.3 | 0.05fc' = 1.03 | — |

### 9.2.3 Extent of Deterioration and Damage

The extent of deterioration and damages will be the basic criterion for selecting the rehabilitation strategy. The rating evaluation described earlier will provide the basis of the assessment. Thus the classification of A (Urgent Replacement) or B (Needing Repair) will determine the strategy of reconstruction, replacement of superstructure or repair.

## 9.3 Judgement on Reconstruction, Replacement of Superstructure and Repair

To make the final judgement on whether reconstruction, replacement of superstructure or repair is needed for the 22 bridges, an assessment was carried out through the criteria established individually, i.e. required minimum bridge width, basic permissible loading capacity and extent of deterioration and damages. Furthermore, an overall assessment was carried out as shown in Table 9.2, taking into consideration the results of individual judgement based on the following conditions:

- The actual bridge width does not meet the width usually required by traffic volume.

- Surplus live load analized with permissible loading capacity is not enough due to large spacing between stringers for SIB bridges, and over stress on lower chord for Truss bridges.

- Structural members are severely deteriorated and damaged.

- Raising up and length extension of the existing bridges in accordance with the results of river study, design flood water level and river width are required.

The same procedures of as mentioned above judgement were applied for all the 52 bridges as shown in Table 9.3.

### (1) Reconstruction

Reconstruction involves reconstruction of superstructure, substructure and foundation. The bridge types were determined through the comparative design and applicable bridge types as shown in planning conditions, in consideration of the actual bridge site condition and the existing bridge types. A comparative design was considered for eight (8) bridges out of the 22 bridges which have alternatives on alignment, span arrangement and bridge types. The steel type bridge was basically considered for the site where long span bridge and/or deep foundation is required.

(2) Replacement of Superstructure

Replacement of superstructure involves replacement of superstructure and reinforcement and repair of substructure and foundation. The types of superstructure were selected in the same manner as in the case of reconstruction. Reinforcement and repair of substructure and foundation were determined in consideration of the existing bridge types and the actual circumstance at the bridge sites.

(3) Repair

Repair mainly involves reinforcement of deck slab substructure and foundation, and was determined based on the results of diagnostic study (refer to APPENDIX 4.5) of urgent rehabilitation bridges.

Reconstruction is selected instead of replacement of superstructure in case the bridge width cannot be widened, deterioration and damages of substructure are severe, alignment does not meet requirement. On the other hand, replacement of superstructure is required by judging from the previous conditions. In principle, reconstruction was considered for the bridges which have more than two marked conditions for judgement.

As an exception, however, the Batu and Pinacanauan bridges do not meet the requirements:

- The present Batu Bridge is considered to be a bridge needing repair because its width (6.10m) is not considerably different from the required width (6.70 m). Therefore, an additional sidewalk would be adapted as a repair method instead of replacement of super-structure.

- The Pinacanauan Bridge is also considered to be a bridge needing repair because partial replacement slab will be adopted, although the deck slab has severe damages.

## Table 9.2 JUDGEMENT OF RECONSUTRUCTION, REPLACEMENT OF SUPERSTRUCTURE AND REPAIR (22 Br.)

| BRIDGE DESCRIPTION | | | | BRIDGE WIDTH | | | LOADING CAPACITY | | | DETERIORATION AND DAMAGES | | | | | | | | | | | | JUDGEMENT OF RECONSTRUCTION REPLACEMENT & REPAIR | APPLICABLE LIVE LOAD | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | BRIDGE NUMBER | BRIDGE NAME | EXISTING BRIDGE TYPE | ACTUAL WIDTH | REQUIRED WIDTH | JUDGEMENT | MAJOR MEMBER | DECK SLAB / FLOOR SYSTEM | JUDGEMENT | (1)CORROSION/COLLISION OF MAJOR MEMBERS. | (2)CONCRETE BEAM CRACK/SPALLING | (3)DECK SLAB CRACK/ SPALLING | (4)SUBSTRUCTURE FOUNDATION | (5)BANK WASHING AWAY/EROSION | (6)SLOPE PROTECTION/ EROSION | (7)CLEARANCE SHORTAGE | (8)RIVER CURRENT INCOINCIDENT | (9)INADEQUATE BRIDGE WIDTH | (10)APPROACH ROAD | (11)OTHERS | (12)JUDGEMENT | | | |
| 1 | 14 | LABANGAN I | SIB | 6.50 | 7.32 | — | 18 | 133 | ●*-1,2 | | | B | A | | | | | | | | ● | ●* | MS18 | bs = 2.59 m |
| 2 | 54 | TAGAMUSING | RCDG | 6.20 | 7.32 | ● | — | — | — | | A | A | A | | A | | | A | | | ● | ●* | MS18 | PIER |
| 3 | 58 | BUED | PONY TRUSS RCDG/SIB | 6.14 | 7.32 | ● | — | — | ●*-2(PONY) | B | | | | | | A | | A | | | ○ | ●* | MS18 | PONY(Lower ch.) |
| 4 | 65 | LOMBOY | RCDG | 7.45 | 6.70 | — | — | — | ○*-1 | | A | | B | | | | | | | | ● | ● | MS18 | Temporary Support |
| 5 | 77 | BAUANG I | PONY | 6.10 | 6.10 | ● | 196/58 | 154 | ●*-2 | B | | | | | | | | A | | A | ● | ●* | MS18 | PONY.(Tower ch.) |
| 6 | 43 | SICSICAN | TRUSS | 7.40 | 7.32 | — | — | — | ○*-1 | | | A | | | | | | | | | ○ | ○ | MS18 | bs = 2.125 m (Deck) |
| 7 | 71 | INDIANA | SIB/PONY | 6.20 | 6.70 | ● | — | — | ●*-2 (PONY) | | | B | | | | | | B | | | ○ | ●* | MS18 | PONY.(Lower ch.) |
| 8 | 73 | BATU | TRUSS | 6.15 | 6.70 | ● | – | — | — | | | B | | | A | | | | | | ○ | ○ | MS18 | |
| 9 | 109 | NAGUILIAN | SIB/TRUSS | 6.15 | 6.10 | — | — | — | ○*-1 (TRUSS) | | | A | | | | | | | | | ○ | ○ | MS18 | bs = 2.10 m(Truss) |
| 10 | 113 | MALALAM | SIB/TRUSS | 6.15 | 6.10 | — | — | — | — | | | A | | | | | | | | | ○ | ○ | MS18 | |
| 11 | 139 | PINACANAUAN | SIB/TRUSS | 6.06 | 6.10 | — | 232/317 | 138 | — | | | A | A | | | | | | | | ● | ○ | MS18 | bs = 1.83 m (Deck) |
| 12 | 154 | PARED | PONY/TRUSS/ RIGID FRAME | 6.15 | 6.10 | — | — | — | ●*-2 (PONY) | A | | A | | | | | | | | | ● | ●* | MS18 | PONY(Lower ch.) |
| 13 | 19 | SUJE | RC-SLAB | 7.85 | 6.10 | — | — | — | ○*1,2 | | A | A | | | A | | | | | | ○ | ● | MS18 | RC-SLAB |
| 14 | 78 | SAN GABRIEL | RC-SLAB | 7.50 | 6.70 | — | 121 | — | ●*-2 | | | A | B | | | | | | | | ○ | ● | MS18 | RC-SLAB |
| 15 | 188 | BINAHAAN | RCDG | 6.70 | 6.70 | — | 141 | 131 | ●*-1 | | B | A | | | | | | | | | ○ | ● | MS18 | bs = 2.20 m (Deck) |
| 16 | 208 | STO. CRISTO | RCDG | 6.75 | 6.70 | — | — | — | — | | A | | | | | | | | | | ○ | ● | MS18 | Temporary Support |
| 17 | 220 | MAGAPON | PONY | 6.00 | 6.70 | ● | — | — | ●*-2 | A | | | | | | | | A | | | ○ | ● | MS18 | PONY(Lower Ch.) |
| 18 | 227 | SAN CRISTOBAL | RCDG/TRUSS | 8.00 | 7.32 | — | — | 115 | ○*-1 (TRUSS) | A | | B | B | | | | | | | | ○ | ○ | MS18 | bs = 2.35 m (Truss) (Deck) |
| 19 | 109 | JIABONG | RC-SLAB | 6.85 | 6.10 | — | — | — | ●* 1,2 | | A | A | B | | | | | | | | ● | ●* | MS18 | RC-SLAB |
| 20 | 120 | HINOGBONGAN | SIB | 7.30 | 6.10 | — | — | — | ○*-1 | | | A | A | | A | | | | | | ○ | ○ | M 18 | bs = 2.05 m (Deck) |
| 21 | 160 | JUBASAN II | PONY | 7.35 | 6.10 | — | — | — | ●*1,2 | A | | B | | | | | | | | | ● | ● | MS18 | bs = 2.10 m PONY(Lower ch.) |
| 22 | 161 | JUBASAN I | TRUSS | 7.30 | 6.10 | — | — | — | ○*-1 | A | | A | | | | | | | | | ● | ●* | MS18 | bs = 3.00 m (Deck) |

●* : RECONSTRUCTION
● : REPLACEMENT OF SUPERSTRUCTURE
○ : REPAIR

* 1 : SUBJECT TO DECK SLAB (b>1.83)
* 2 : SUBJECT TO MAJOR MEMBER
I/J : LOADING CAPACITY (I = upper, J = lower ch.)

Summary of Table 9.2 is shown as a result of judgement below.

| BRIDGE DESCRIPTION | | | | JUDGEMENT | | | | |
|---|---|---|---|---|---|---|---|---|
| NUMBER | BRIDGE NUMBER | BRIDGE NAME | EXISTING BRIDGE TYPE | BRIDGE WIDTH | LOADING CAPACITY | DETERIORATION AND DAMAGES | RIVER STUDY | TOTAL |
| 1 | 14 | LABANGAN I | SIB | — | ● | ● | ● | ●* |
| 2 | 54 | TAGAMUSING | RCDG | ● | — | ● | — | ●* |
| 3 | 56 | BUED | PONY TRUSS RCDG/SIB | ● | ● | ○ | ● | ●* |
| 4 | 65 | LOMBOY | RCDG | — | ○ | ● | — | ● |
| 5 | 77 | BAUANG I | PONY | ● | ● | ● | — | ●* |
| 6 | 43 | SICSICAN | TRUSS | — | ○ | ○ | — | ○ |
| 7 | 71 | INDIANA | SIB / PONY | ● | ● | ○ | — | ●* |
| 8 | 73 | BATU | TRUSS | ● | — | ○ | — | ○ |
| 9 | 109 | NAGUILIAN | SIB / TRUSS | — | ○ | ○ | — | ○ |
| 10 | 113 | MALALAM | SIB / TRUSS | — | — | ○ | — | ○ |
| 11 | 139 | PINACANAUAN | SIB / TRUSS | — | — | ● | — | ○ |
| 12 | 154 | PARED | PONY TRUSS RCDG/SIB | — | ● | ● | — | ●* |
| 13 | 19 | SUJE | RC-SLAB | — | ○ | ○ | — | ● |
| 14 | 76 | SAN GABRIEL | RC-SLAB | — | ○ | ○ | — | ● |
| 15 | 186 | BINAHAAN | RCDG | — | ○ | ○ | — | ● |
| 16 | 208 | STO. CRISTO | RCDG | — | — | ○ | — | ● |
| 17 | 220 | MAGAPON | PONY | ● | ● | ○ | — | ● |
| 18 | 227 | SAN CRISTOBAL | RCDG/TRUSS | — | ○ | ○ | — | ○ |
| 19 | 109 | JIABONG | RC-SLAB | — | ● | ● | — | ●* |
| 20 | 120 | MINOGBONGAN | SIB | — | ○ | ○ | — | ○ |
| 21 | 160 | JUBASAN II | PONY | — | ● | ● | — | ● |
| 22 | 161 | JUBASAN I | TRUSS | — | ○ | ● | — | ●* |

●* : RECONSTRUCTION

● : REPLACEMENT OF SUPERSTRUCTURE

○ : RERPAIR

The result of overall assessment is that reconstruction will be needed for 8 bridges, replacement of superstructure for 7 bridges and repair for 7 bridges. The same procedures of judgement for the above 22 bridges are applied for the 52 bridges which require urgent rehabilitation as shown below. Specially, the reconstruction bridges are lacking width and loading capacity and having serious deterioration and damages. Thus, these bidges are important in the future rehabilitation program.

Table 9.3 RECONSTRUCTION, REPLACEMENT OF SUPERSTRUCTURE OR REPAIR

| BRIDGE DESCRIPTION | | | | JUDGEMENT | | | JUDGEMENT OF RECONSTRUCTION REPLACEMENT OF SUPERSTRUCTURE OR REPAIR | REMARKS |
|---|---|---|---|---|---|---|---|---|
| NUMBER | BRIDGE NUMBER | BRIDGE NAME | BRIDGE TYPE (EXST.) | BRIDGE WIDTH | LOADING CAPACITY | DETERIORATION AND DAMAGES | | |
| 1 | 3 | MARILAO | RCDG | — | — | ○ | ● | Damage of Deck Slab |
| 2 | 14 | LABANGAN | S I B | — | ● | ● | [●*] | S I. B (Beam) |
| 3 | 22 | SULIPAN | Pony/Truss | ● | ● | ○ | ●* | Bridge width, Pony (Lower Ch.) |
| 4 | 48 | PLARIDEL | Truss | — | — | ○ | ○ | Damage of deck slab |
| 5 | 54 | TAGAMUSING | RCDG | ● | — | ● | [●*] | Damage of foundation |
| 6 | 58 | BUED | Pony/Truss/S-I-B | ● | ● | ○ | [●*] | Pony (Lower Ch.) Sedimentation |
| 7 | 65 | LOMBOY | RCDG | — | ○ | ● | [●] | Damage of superstructure |
| 8 | 77 | BAUANG I | Pony | ● | ● | ● | [●*] | Bridge width, Pony (Lower Ch) |
| 9 | 77-1 | BAUANG II | Pony | ● | ● | ○ | ●* | Bridge width, Pony (Lower Ch.) |
| 10 | 104 | STA. CRUZ I | SIB/RCDG | — | — | ○ | ●* | Extension of Span |
| 11 | 113 | LANGLANGKA. I | RCDG | — | — | ○ | ● | Damage of RCDG |
| 12 | 120 | STA. MARIA | Truss | — | ○ | ○ | ●* | Inadequate Bridge Length and width |
| 13 | 148 | TIPCAL | RCDG | — | — | ● | ● | Damage of RCDG |
| 14 | 3 | PLARIDEL PULILAN | S-I-B | — | ○ | ○ | ○ | bs = 4.4 m, 2 beams only |
| 15 | 14 | SAN ROQUE | RCDG | — | — | ○ | ○ | Damage of RCDG (2 spans) |
| 16 | 43 | SICSICAN | Truss | — | ○ | ○ | [○] | Damage of deck slab |
| 17 | 71 | INDIANA | S-I-B | ● | ● | ○ | [●*] | Pony (Lower Ch.) |
| 18 | 73 | BATU | Truss | ● | — | ○ | [○] | Damage of damage slab |
| 19 | 86 | NAMANPARAN | RCDG | — | — | ○ | ● | Damage of RCDG |
| 20 | 89 | SAN LUIS | RCDG | — | — | ○ | ○ | Shortage of Bearing Width |
| 21 | 109 | NAGUILIAN | SIB/Truss | — | ○ | ○ | [○] | Damage of deck slab |
| 22 | 113 | MALALAM | SIB/Truss | — | — | ○ | [○] | Damage of deck slab |
| 23 | 126 | BALASIG | Truss | — | — | ○ | ○ | Damage of deck slab |
| 24 | 129 | SAN PABLO | S-I-B/Truss | — | — | ○ | ○ | Damage of deck slab |
| 25 | 139 | PINACANAUAN | S-I-B Truss | — | — | ● | [○] | Damage of deck slab |
| 26 | 154 | PARED | Pony Truss Rigid Frame | — | ● | ● | [●*] | Pony (Lower Ch.), Bailey Br. |
| 27 | 19 | SUJE (RIZAL) | RC Slab | — | ○ | ○ | [●] | Damage of superstructure |
| 28 | 43 | GUINOBATAN | S-I-B | — | ○ | ○ | ○ | Erosion of slope at abutment |
| 29 | 75 | SAN FERNANDO | S-I-B | — | ○ | ○ | ○ | Damage of deck slab |
| 30 | 76 | PAMUKID | S-I-B | — | ○ | ○ | ○ | Damage of slab & Superstructure |
| 31 | 77 | SAN ISIDRO | S-I-B | — | ○ | ○ | ○ | Damage of deck slab |
| 32 | 78 | SAN GABRIEL | RC Slab | — | ● | ○ | [●] | Damage of superstructure |
| 33 | 79 | PAHOHO | RCDG | — | — | ○ | ○ | Damage of deck slab |
| 34 | 80 | TINIGUIBAN | RCDG/RC Slab | — | — | ○ | ● | Damage of RCDG |
| 35 | 82 | SGT. MATIAS | RCDG | — | — | ○ | ○ | Damage of deck slab |
| 36 | 86 | NAUBOD I | S-I-B | — | — | ○ | ○ | Damage of superstructure |
| 38 | 99 | SOOK | S-I-B | — | ○ | ○ | ○ | Damage of deck slab |
| 38 | 143 | KANAPAWAN | S-I-B | — | — | ○ | ○ | Damage of deck slab |
| 39 | 154 | BASIAD | Truss | — | ○ | ○ | ○ | Damage of deck slab |
| 40 | 173 | GUMACA | RCDG | — | — | ○ | ● | Damage of superstructure |
| 41 | 181 | TALABA | RCDG | — | — | ○ | ● | Damage of superstructure |
| 42 | 188 | BINAHAAN | RCDG | — | ○ | ○ | [●] | Damage of superstructure |
| 43 | 190 | PALSABANGON | RCDG | — | — | ○ | ● | Damage of superstructure |
| 44 | 200 | LAGNAS II | RC Slab | — | — | ○ | ○ | Damage of deck slab |
| 45 | 208 | STO. CRISTO | RCDG | — | — | ○ | [●] | Damage of superstructure |
| 46 | 220 | MAGAPONG | Pony | ● | ● | ○ | [●] | Pony (Lower Ch.) |
| 47 | 223 | BIGA | S-I-B | — | — | ○ | ○ | Damage of deck slab |
| 48 | 227 | SAN CRISTOBAL | RCDG/Truss | — | ○ | ○ | [○] | Damage of deck slab |
| 49 | 109 | JIABONG | RC Slab | — | ● | ● | [●*] | Damage of deck and beam |
| 50 | 120 | HINOGBONGAN | S-I-B | — | ○ | ○ | [○] | Damage of foundation |
| 51 | 160 | JUBASAN II | Pony | — | ● | ● | [●] | Pony (Lower Ch.) |
| 52 | 161 | JUBASAN I | Truss | — | ○ | ● | [●*] | Damage of Truss (corrosion) |

LEGEND:

●* ; RECONSTRUCTION

● ; REPLACEMENT OF SUPERSTRUCTURE

○ ; REPAIR

[ ] ; 22 BRIDGES FOR PRELIMINARY DESIGN

# CHAPTER 10

# PRELIMINARY DESIGN

# CHAPTER 10 PRELIMINARY DESIGN

## 10.1 General

The preliminary design covering the 22 bridges selected out of the 52 bridges to be urgently rehabilitated was carried out based on the output of the previous detailed survey. The preliminary design covers reinforcement of superstructures and substructures and replacement and reconstruction of the selected bridges, including river training. The preliminary design involves the following studies:

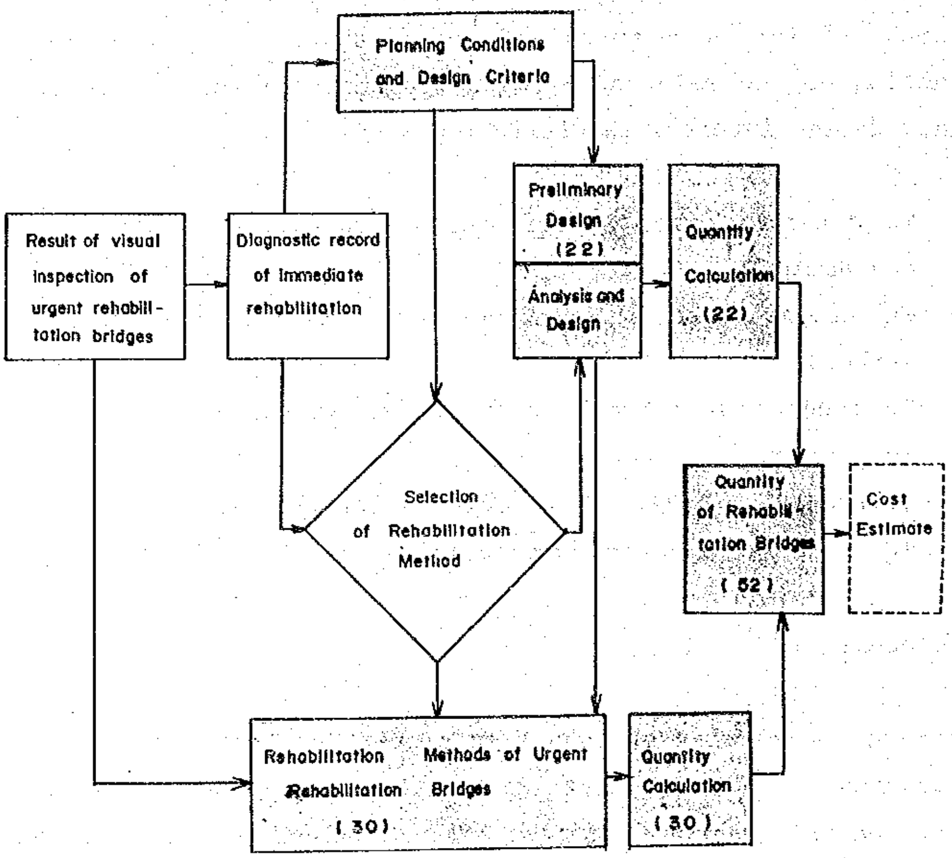
(1) To determine the classification and extent of deterioration and damages
(2) To compare the alternatives of rehabilitation and repair methods
(3) To conduct structural design based on the results of visual inspection
(4) To prepare rehabilitation methods for the existing bridge
(5) To estimate preliminary quantities

## 10.2 Procedures

Based on the results of visual inspection and detailed survey, the diagnostic records of the 22 bridges selected as the representative rehabilitation bridges were prepared for preliminary design. Meanwhile, the planning conditions and design criteria to be adopted for the preliminary design were established considering the standards such as AASHTO, BRIDGE DESIGN GUIDELINES (DPWH), NSCP. To develop an effective and practical plan, selection of rehabilitation methods was carried out on the 22 representative rehabilitation bridges, and the same bridge type and the same degree of deterioration and damages based on the results of preliminary design of these 22 bridges are applied to the remaining 30 urgent rehabilitation bridges. A comparative design was also executed as required. The rehabilitation methods are carefully selected, considering practical and economical ways and the standardized sections are designed to reflect the preliminary design. Finally, these designed sections are applied on the drawings which form the basic materials for cost estimate.

The flow chart of procedures followed for preliminary design is shown below:

FLOW CHART OF PROCEDURE OF PRELIMINARY DESIGN




( ) Figure in the bracket shows number of bridges

## 10.3 Planning Conditions

This study was conducted to set up the planning conditions which will be utilized in the preliminary design. The study covered the review of existing standards such as the National Structural Code of the Philippines Vol. I & II, the Standard Specifications for Highway Bridges, AASHTO, A policy on Geometric Design of Highways and Streets, Japanese Standard Specifications, etc. and the comparative alternatives of the said specifications. The planning conditions provide for the applicable size and type of bridge structures and the study results will be used for preliminary design. On the other hand, the design criteria will directly provide the methods and limitations of design. The planning conditions cover the following:

(1) Minimum Geometric Design Standard

The minimum geometric design standards being applied to this feasibility study are derived from the Highway Design Guidelines, DPWH, 1984 as tabulated in Table 10.1

(2) Standard of Bridge Width

The typical bridge cross section adopted for the preliminary design was reviewed in accordance with the National Structural Code of the Philippines, the Standard Specifications for Highway Bridges, AASHTO, 1983 and A Policy on Geometric Design of Highway and Streets, AASHTO, 1984. The following recommendations were made on preliminary design.

| Types of Highway | Lane Width (a) | Shoulder Width (b) | Side-walk Width (c) | Road Way d = (a)+2x(b) | Bridge Width (e) = (d)+2x(c) |
|---|---|---|---|---|---|
| (1) Main Highways | 7.32<br>(2x12=24') | 0.31 | 0.76<br>(30") | 7.94 | 9.46 |
| (2) Rural Highways | 6.70<br>(2x11=22')* | 0.31 | 0.76<br>(30") | 7.32 | 8.84 |

Note: Unit is meter (if not otherwise designated).

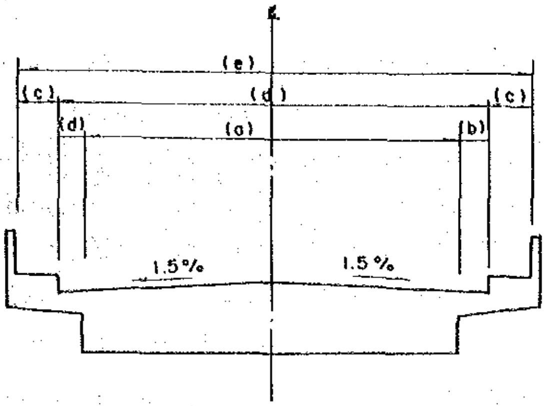
* with reference to Policy on Geometric Design of Highway

## Table 10-1 MINIMUM GEOMETRIC STANDARD

| Descriptions | Flat | | | Rolling | | | Mountainous | | |
|---|---|---|---|---|---|---|---|---|---|
| | AADT > 2000 | 2000-1000 | 1000-400 | >2000 | 2000-1000 | 1000-400 | >2000 | 2000-1000 | 1000-400 |
| (1) Design Speed ($k^m/hr$) | 90 | 80 | 70 | 70 | 60 | 60 | 60 | 50 | 40 |
| (2) Pavement Width (m) | 6.7 (7.30) | 6.7 | 6.1 | 6.7(7.30) | 6.7 | 6.1 | 6.7(7.30) | 6.7 | 6.1 |
| (3) Shoulder Width (m) | 3.0 | 2.5 | 1.5 | 3.0 | 2.5 | 1.5 | 3.0 | 2.5 | 1.5 |
| (4) R.O.W. Width (m) | 60 | 30 | 30 | 60 | 30 | 30 | 60 | 30 | 60 |
| (5) Non Passing S.D.(m) | 135 | 115 | 90 | 90 | 70 | 70 | 70 | 60 | 40 |
| (6) Min. Radius (m) | 280 | 220 | 160 | 180 | 120 | 120 | 100 | 80 | 50 |
| (7) Grade (%) | 3 | 3 | 3 | 4 | 5 | 5 | 5 | 6 | 6 |
| (8) Min. Length of V.C.(m) | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| (9) Vertical Clearance (m) | 4.27 | 4.27 | 4.27 | 4.27 | 4.27 | 4.27 | 4.27 | 4.27 | 4.27 |
| (10) Super elevation (%) | 10 (max) | 10 (max) | 10 (max) | 10 (max) | 10 (max) | 10 (max) | 10 (max) | 10 (max) | 10 (max) |

Source: Highway Design Guidelines, DPWH, 1984

The figures in parenthesis are desirable values.




(3) Applied Bridge Width

The bridge width applied in this study consists of the roadway width and the sidewalk width on both sides of the bridge. The applicable bridge width will be computed based on the existing width of bridges and highways, traffic volume and the existing standards concerning bridge width. The recommendations for bridge width in the study areas are shown in Table 10.2.

Table 10.2 APPLIED BRIDGE WIDTH

| | Sections | Reconst./Replacement | | Repair *-1 | | Traffic Volume |
|---|---|---|---|---|---|---|
| | | Roadway | sidewalk | Roadway | sidewalk *-2 | (AADT 2000 year) |
| | Manila North Road | | | | | |
| (1) | Manila - Rosario | 8.00 | 0.76 | 7.32 | 0.76 | >20,000 |
| (2) | Rosario - San Fernando | 7.32 | 0.76 | 7.32 | 0.76 | >10,000 |
| (3) | San Fernando - Laoag | 7.32 | 0.76 | 6.70 | 0.76 | > 5,000 |
| | Pan Philippine Highway | | | | | |
| (1) | Manila - Santa Fe | 8.00 | 0.76 | 7.32 | 0.76 | >20,000 |
| (2) | Santa Fe - Santiago | 7.32 | 0.76 | 7.32 | 0.76 | >10,000 |
| (3) | Santiago - Allacapan | 7.32 | 0.76 | 6.70 | 0.76 | < 5,000 |
| (4) | Manila - Calamba | 8.00 | 0.76 | 7.32 | 0.76 | >20,000 |
| (5) | Calamba - Calauag | 7.32 | 0.76 | 7.32 | 0.76 | >10,000 |
| (6) | Calauag - Sipocot | 7.32 | 0.76 | 7.32 | 0.76 | < 5,000 |
| (7) | Sipocot - Sorsogon | 7.32 | 0.76 | 7.32 | 0.76 | >10,000 |
| (8) | Sorsogon - Matnog | 7.32 | 0.76 | 6.70 | 0.76 | < 5,000 |
| (9) | Allen Tacloban | 7.32 | 0.76 | 6.70 | 0.76 | < 5,000 |
| (10) | Tacloban - Mac Arthur | 7.32 | 0.76 | 7.32 | 0.76 | >10,000 |
| (11) | Mac Arthur - Liloan | 7.32 | 0.76 | 6.70 | 0.76 | < 5,000 |

*-1 : All widths for repair are desirable values, otherwise the existing width is to be considered.

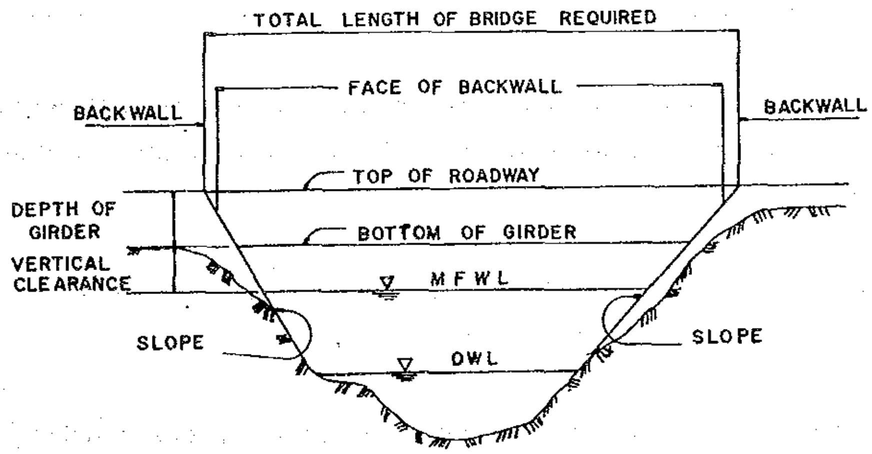
*-2 : 1.2 m. sidewalk width is to be considered likely at the city area.

(4) Clearances and Length of Bridges

The clearances of a bridge controls the bridge's length as indicated in the following excerpt from the Design Guidelines, Part IV, Bridge Design DPWH: "From the intersection of ordinary water level and ground surface as shown in the sketch below, the proposed slopes of the grouted riprap follow the slope of the bank as close as possible, having in mind not to constrict the area of the water way required." Then the top of roadway elevation was determined based on the Design Flood Water Level (DFWL).

The distance between the intersections of the slopes of grouted riprap and the top of roadway elevation represents the length of bridge required, which is the total distance between the back of backwalls. Minor adjustments shall be made, if necessary, to suit the length of standard type of superstructure to be adopted.

Vertical clearance under a bridge shall be determined taking into consideration the necessary space needed for river navigational ways and maintenance, etc. The river administrative clearance from the bottom of the bridge girder or beam to design flood water level will be 1.0 m to 1.5 m.




The design elevation of the bottom of bridge girder shall not be lower than the high water level plus the free board.

According to the Bridge Design Guidelines (Part-IV), DPWH, the vertical clearance below the bridge girder and the Navigational

Clearance are as follows.

Vertical Clearance (below the bridge) - Non Navigable river; general clearance between D.F.W.L. and the bottom of the lowest member of superstructure shall not be less than 1.50 for streams carrying debris and 1.00 for others.

Vertical Clearance (Navigable river); The Philippine Coast Guard shall be consulted for determining the minimum horizontal and vertical clearances under a bridge before preparing the final design and plans of the proposed bridge.

(5) Applicable Bridge Types

To select the applicable types of superstructure, substructure and foundation, the basic and important factors, i.e. economical construction, stability and safety, shorter construction period and ease of maintenance and operation, shall be given priority.

Fig. 10.1 and 10.2 show the relationship between the superstructure type and the span length based on the samples of bridges. The following items are fundamental in the selection of superstructure types:

- Reinforced concrete structures are initially considered except for special requirements of steel structure for easier maintenance.

- Reinforced concrete beam and steel I-beam types are applicable for short span length (10 m to 15 m).

- Prestressed concrete girder, and steel plate girder types are applicable for medium span length (20 m to 50 m).

- Prestressed concrete box girder, steel through truss and ranger girder types are to be applied for long span length (60 m to 150 m).

Fig. 10.3 and 10.4 show the applicable substructure types in accordance with the required structural height of a bridge. The selection of substructure types is based not only on specified figures but also on the following considerations:

- Reinforced concrete structures.

- The cross section of pier column in the river is circular or elliptical and rectangular shape with no restricted conditions.

- Non sliding of the back fill materials behind abutment structure is considered in the selection of the abutment type to avoid the approach settlement.

Fig. 10.5 shows the applicable foundation types in accordance with the required effective depth to sustain the upper structures. The following are considered in selecting the foundation type:

- Possible construction depth is studied in consideration of soil conditions.

- The advantageous type is considered for works above water e.g. reverse circulation drill pile.

- The prefabricated pile types are advantageous when the bearing stratum is within a shallow range.

## Fig. 10.1 APPLICABLE TYPES OF CONCRETE BRIDGE

| TYPE | SPAN LENGTH (m.) (0 – 80) | HEIGHT/SPAN | REMARKS |
|---|---|---|---|
| 1. RC - SLAB | 1.5 – 6 | 1/20 | |
| 2. RC - HOLLOW SLAB | 6 – 13 | 1/20 | |
| 3. RC - T - BEAM | 10 – 20 | 1/15 | |
| 4. PC - HOLLOW (Pretention) | 10 – 21 | 1/14 | |
| 5. PC - I - BEAM (Pretention) | 6 – 13 | 1/15 | |
| 6. PC - T - BEAM (Pretention) | 10 – 21 | 1/15 | |
| 7. PC - I - BEAM (Post) | 20 – 35 | 1/16 | |
| 8. PC - T - BEAM (Post) | 20 – 45 | 1/17.5 | |
| 9. SIMPLE BOX GIRDER | 30 – 40 | 1/20 | |
| 10. RC - ARCH | 40 – 70 | 1/6.5 | |

| TYPE | SPAN LENGTH (m.) (40 – 360) | HEIGHT/SPAN | REMARKS |
|---|---|---|---|
| 11. CANTILEVER BOX GIRDER | 60 – 240 | 1/15 | |
| 12. PC CABLE STAGED GIRDER | 130 – 340 | — | |

## Fig. 10.2 APPLICABLE TYPES OF STEEL BRIDGE

| TYPE | SPAN LENGTH (m.) (0 – 200) | HEIGHT/SPAN | REMARKS |
|---|---|---|---|
| 1. STEEL I BEAM (Non-Comp) | 0 – 10 | 1/20 | |
| 2. STEEL I BEAM (Comp) | 10 – 25 | 1/22 | |
| 3. SIMPLE PLATE GIRDER | 15 – 40 | 1/17 | |
| 4. CONTINOUS PLATE GIRDER | 25 – 65 | 1/18 | |
| 5. SIMPLE COMP. GIRDER | 20 – 50 | 1/18 | |
| 6. SIMPLE BOX GIRDER | 30 – 60 | 1/22 | |
| 7. CONTINOUS COMP. GIRDER | 40 – 65 | 1/19 | |
| 8. CONTINOUS BOX GIRDER | 50 – 100 | 1/23 | |
| 9. SIMPLE TRUSS | 50 – 100 | 1/8 | |
| 10. CONTINOUS TRUSS | 60 – 150 | 1/9 | |
| 11. RANGER BRIDGE | 60 – 150 | 1/6.5 | |
| 12. CABLE STAYED GIRDER | 100 – 200 | 1/100~1/150 | |