12.4.2 Economic Costs

(1) Deduction of Transfer Payment

As the bridge rehabilitation costs in Chapter 11 are presented in financial terms, it is necessary to convert them to economic costs for economic evaluation. To calculate economic costs, all taxes, escalation and other transfer payment such as interest and subsidy should be deducted from financial costs. In this project, tax payments and escallation have a fixed percentage of 10 % and 15 % of financial costs respectively for all bridges.

(2) Shadow Pricing

Under a perfectly competitive economy, market commodity and wage prices used in the financial cost analysis must reflect the actual economic values of those commodity and wages. However, the actual economic world, particularly in a developing country such as the Philippines, is generally characterized by market imperfections. In such cases, market prices do not accurately reflect the actual values of commodity and wages to society. Consequently, it is necessary to adjust market prices to their actual social opportunity costs for social cost-benefit analyses.

Usually, the economic evaluation conducted in developing countries requires two critical cost items which need to be "shadow-priced". They are Foreign Currency Costs and Unskilled Labor Costs.

a) Shadow Exchange Rate

Generally, in less developed countries, there is substantial divergency between market (or official) foreign exchange cost of a commodity and its actual social value to the economy because of the imperfections of foreign exchange market and trade. For that reason, it is necessary to use the shadow exchange rate for the foreign exchange component of inputs to the project valued at market exchange rates.

The shadow exchange rate (SER) are usually calculated as follows:

$$SER = OER/SCF$$

$$SCF = \frac{M+X}{(M+T_M)+(X+T_X)}$$

Where: SER = Shadow Exchange Rate (in domestic price value of a foreign currency)

OER = Official Exchange Rate (in domestic price value of a foreign currency)

SCF = Shadow conversion factor

M = CIF value of visible imports

X = FOB value of visible exports

T_M = Value of total import duties

T_X = Value of export subsidies

Available Government data and experts in the Philippines suggests a SCF value of approximately between 0.9 and 0.8. NEDA usually evaluates a 20 % undervaluation of foreign currency in market price, which corresponds to the SCF's lower bound of 0.8. Thus, SCF of 0.8 is used for the economic evaluation in this study.

Foreign, local and tax components are presented as percentage of financial project costs in Table 12.16. below.

Table 12.16 FOREIGN, LOCAL AND TAX COMPONENTS OF CONSTRUCTION LABOUR, MATERIALS AND EQUIPMENT

Item	FOREIGN (%)	LOCAL (%)	TAXES (%)
Heavy Equipment	75	15	10
Portland Cement	60	30	10
Reinforcing Steel	75	15	10
Structural Steel	85	5	10
Lumber	35	55	10
Asphalt	75	15	10
Diesel Fuel	60	30	10
Engine Oil	60	30	10
Tires	47	43	10
Imported Miscellaneous Materials	75	15	10
Locally Produced Misc. Materials	35	55	10
Skilled Foreign Labor	65	25	10
Skilled Local Labor	0	90	10
Unskilled Labor	0	90	10

Remark(1): Figures of above component are obtained from the latest project in the DPWH under OECF loan.
Remark(2): Taxes are applied on VAT (Value-Added Tax) introduced in the Philippines January 1, 1988, pursuant to Executive Order No.273.

b) Shadow Pricing for Unskilled Labour Costs

Developing countries like the Philippines are usually characterized by an over-supply of unskilled labour, especially in the rural areas. The value of marginal product of unskilled labour in rural areas will be less than the wages paid to unskilled labour which are usually established by law such as minimum wage system.

On the other hand, skilled labour working in the project areas would be valued at the market wage rate. If they are not employed at market wage rate, they would work at higher wages in other areas. For this reason, the shadow wage rate (SWR) is used for only unskilled labour costs.

The shadow price of unskilled labour consists of two components: a direct and an indirect opportunity costs. The direct opportunity cost of labour is usually measured by the value of marginal output given by transferring from its present employment (including the case of former) to project employment. The indirect component in the shadow wage rate consists of the net social cost of increased consumption of labour. Finally the shadow wage rate is given by summing up these direct and indirect opportunity costs. However, it is generally difficult to calculate the marginal output in rural area because of lack of available data. In this study, 60 % of the market wage rate was used as the direct and indirect opportunity costs according to the suggestion from NEDA staff,

(3) Economic Cost of Individual Bridges

Table 12.17 shows the economic project costs of the proposed individual rehabilitation bridges after deduction of transfer payment and shadow pricing of foreign exchange component and wage of unskilled labour cost. The costs are divided into years in which the bridge rehabilitation project will be implemented.

Table 12.17 ECONOMIC PROJECT COST FOR INDIVIDUAL BRIDGES (AFTER SHADOW PRICING)

Bridge No.	Bridge Name	Economic Cost	Distribution of Costs of Construction Years				
			1990	1991	1992	1993	1994
1	MARILAO	1,181	58	1,123	0	0	0
2	LABANGANI	74,286	3,717	11,140	25,997	25,997	7,434
3	SULIPAN	122,852	6,137	18,424	42,997	42,997	12,298
4	PLARIDEL	36,581	1,830	0	9,148	18,296	7,307
5	TAGAMUSING	15,205	764	3,798	7,608	3,034	0
6	BUED	119,969	5,998	17,995	41,989	41,989	11,997
7	LOMBOY	973	46	926	0	0	0
8	BAUANG1	72,468	3,625	10,874	25,360	25,360	7,249
9	BAUANG2	44,687	2,235	11,175	22,349	8,928	0
10	STA CRUZ1	18,679	938	4,667	9,345	3,729	0
11	LANGLANGKA1	2,606	127	0	0	0	2,478
12	STA MARIA	33,570	1,679	8,396	16,791	6,705	0
13	TIPCAL	3,509	174	0	0	0	3,335
14	PLARIDEL-PULII	28,232	1,413	7.064	14,116	5,639	0
15	SAN ROQUE	730	35	695	0	0	0
16	SICSICAN	3,995	197	3,798	0	0	0
17	INDIANA	26,287	0	1,320	6,577	13,143	5,246
18	BATU	31,428	0	1,575	7,863	15,714	6,276
19	NAMANPARAN	4,887	0	243	4,644	0	0
20	SAN LUIS	313	0	12	301	0	0
21	NAGUILAN	29,761	0	1,494	7,446	14,880	5,941
22	MALALAN	9,021	0	452	8,569	0	0
23	BALASIG	4,007	0	197	3,810	0	0
24	SAN PABLO	14,614	0	730	3,659	7,307	2,918
25	PINACANAUAN	14,683	0	730	3,671	7,342	2,941
26	PARED	22,129	0	1,112	5,535	11,070	4,412
27	SUJE(RIZAL)	3,138	0	162	0	0	2,976
28	GUINOBATAN	880	0	46	0	0	834
29	SAN FERNANDC	1,691	0	81	0	1,610	0
30	PAMUKID	1,100	0	58	0	1,042	0
31	SAN ISIDRO	1,679	0	81	0	1,598	0
32	SAN GABRIEL	1,656	0	81	0	1,575	0
33	PAHOHO	266	0	12	0	255	0
34	TINIGUIBAN	1,668	0	81	0	1,586	0
35	SGT.MATLAS	197	0	12	0	185	0
36	NAUBOD1	950	0	46	0	903	0
37	SOOK	892	0	46	845	0	0
38	KANAPAWAN	1,552	0	81	1,471	0	0
39	BASIAD	2,733	0	139	2,594	0	0
40	GUMACA	2,559	127	0	0	2,432	0
41	TALABA	2,652	127	0	0	2,524	0
42	BINAHAAN	4,065	208	0	0	3,856	0
43	PALSABANGON	4,285	220	0	0	4,065	0
44	LAGNAS2	197	12	0	185	0	0
45	STO CRISTO	2,941	151	0	2,791	0	0
46	MAGAPONG	3,011	151	0	2,860	0	0
47	BIGA	961	46	0	915	0	0
48	SAN CRISTBAL	5,975	301	0	5,674	0	0
49	JIABONG	19,315	0	961	4,829	9,658	3,868
50	HONOGBONGAN	2,061	0	104	1,957	0	0
51	JUBASAN2	9,669	0	486	9,183	0	0
52	JUBASAN1	19,408	0	973	4,852	9,704	3,879
		832,150	30,316	111,388	305,932	293,125	91,389

12.4.3 Benefits of Bridge Rehabilitation

(1) Types of Benefits

Three types of benefits would accrue from the bridges rehabilitation project. The first of them is the direct economic benefits to the people who use the bridges and to those who live in the area near the bridges. This type of benefits is called user's benefits. The second type is indirect social benefits resulting mainly from:

a) improvement of access to public facilities, such as school, hospital, post office, market, etc.

b) increase of mobility to travel to other towns and cities

c) improvement of social environment, such as public security, living condition, etc.

The third type is benefits for those who supply transport services. In this study the bridge supplier is mainly the government.

The methodology of quantification of these benefits is fairly developed for direct economic benefits of bridge users, as transport cost saving methodology. However, it is difficult to measure the indirect social benefits resulting from the bridges rehabilitation project. No reliable methodologies have been developed to calculate the indirect social benefits. For this reason, in the following procedure of calculating benefits, the quantifiable direct benefits will be separately discussed.

(2) Quantifiable Benefits

a) Cost Savings for Bridge Users

The cost savings of bridge users accrue for drivers and passengers who drive or ride in vehicles passing the bridges. These vehicle operating cost consist of 1) vehicle running costs,

2) vehicle fixed costs, and 3) time costs. The improvement of a bridge should decrease these costs. In the case of a bridge rehabilitation project, vehicle operating cost savings arise from the following:

- reduction of probability of bridge unserviceability
- increase of loading capacity
- reduction of bridge unserviceability caused by flood

- Probability of Bridge Unserviceability

If an existing bridge is in poor condition and it is neither maintained nor repaired, the risk of its becoming unusable will be high. The risk factor of bridge unusability is considered to reflect the bridge life.

Bridge Life

Usually it is said that a new by constructed bridge has a 50-year life. This life is mainly fitted for calculating property tax and does not reflect the real bridge life time until a bridge is physically unusable. If a bridge is well maintained and repaired, its physical life time must be longer than 50 years. However, the bridge life is not necessarily considered as the physical life time. A bridge will be unserviceable by the social factors such as having not enough width or loading capacity for increased traffic volume, old-fashioned design and other administrative reasons.

Therefore, for the purpose of economic evaluation in this study, the bridge life was defined as the bridge age in which a half of the bridges are statistically unserviceable by physical or social factors.

It is difficult to determine the accurate bridge life for the existing individual bridges. Each bridge has different remaining life according to its age and the different physical and social conditions. However, the actual construction year is not known for some of the existing bridges. The present condition of a bridge is not necessarily related to the bridge age. (The condition of bridges and the construction year were surveyed and the results are stored in Bridge Data Base by our engineering staff.)

Therefore, for the purpose of economic evaluation, the life of the existing bridges was determined based on the following assumptions.

The life of concrete bridges is different from that of steel bridges. Generally, the concrete bridges have a longer life.

The traffic volumes on the bridges will affect the bridge life. The bridges with heavy traffic volumes will have shorter bridge life.

The present bridge condition also will affect the future bridge life. The bridges with heavy damages will have shorter bridge life.

On the other hand, the life of rehabilitated bridges would be a less influenced by the above factor, if they are well rehabilitated.

Table 12.18 shows the estimated bridge life based on the above assumption.

Table 12.18 ESTIMATED LIFE OF BRIDGES

Years

Status of Bridges	Degree of Damages	Traffic Volume	Rehabilitation Method	Bridge Type	
				Concrete	Steel
Existing Bridges (Without)	Light or Middle	Heavy		20(30)	15(25)
		Light		25(35)	20(30)
	Heavy	All		10(20)	10(20)
Rehabilitated Bridges (With)	All	All	Reconstruction	50	50
			Replacement	30	30
			Repair	25	25

Note: First year of existing bridges is 1990

First year of rehabilitated bridges is constructed year

( ) is total life of bridges

Probability of Bridge Unserviceability

In this study the annual probability of Bridge Unserviceability is assumed to follow a logistic curve as follows:

$$Pr = 100/(1+e^{-0.2(t-y)})$$

Where: Pr: Probability of Bridge Unserviceability (%)
y : Bridge life (year)
t : year

In this equation, a half of the bridges will become unserviceable at the end of the bridge life. Approximately one fourth of bridges (27 %) will become unserviceable 5 years before the end of bridge life and 12 % 10 years before the end of bridge life.

Fig. 12.4 shows the logistic curve of probability of bridge unserviceability and Tables 12.19 and 20 show the probabilities of unserviceability by year for different types/conditions of bridges.

Fig. 12.4 LOGISTIC CURVE OF PROBABILITY OF BRIDGE UNSERVICEABILITY

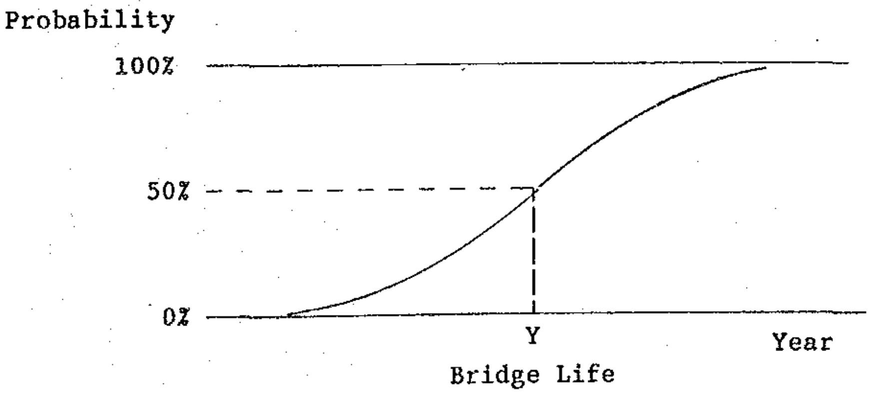


Table 12.19 DISTRIBUTION OF PROBABILITIES OF BRIDGE UNSERVICEABILITY (CONCRETE BRIDGE)

Status of Bridges	Degree of Damages	Traffic Volume	Rehabilitation Method	Probability of Bridge Unserviceability by Year (Concrete Bridges) %														
				1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Existing	Light or	Heavy		2.2	2.7	3.2	3.9	4.7	5.7	6.9	8.3	10.0	11.9	14.2	16.8	19.8	23.1	26.9
Bridges	Middle	Light		0.8	1.0	1.2	1.5	1.8	2.2	2.7	3.2	3.9	4.7	5.7	6.9	8.3	10.0	11.9
(Without)	Heavy	All		14.2	16.8	19.8	23.1	26.9	31.0	35.4	40.1	45.0	50.0	55.0	59.9	64.6	69.0	73.1

Probability of Bridge Unserviceability by Year (Concrete Bridges) %									
2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
31.0	35.4	40.1	45.0	50.0	55.0	59.9	64.6	69.0	73.1
14.2	16.8	19.8	23.1	26.9	31.0	35.4	40.1	45.0	50.0
76.9	80.2	83.2	85.8	88.1	90.0	91.7	93.1	94.3	95.3
76.9	80.2	83.2	85.8	88.1	90.0	91.7	93.1	94.3	95.3

Status of Bridges	Degree of Damages	Traffic Volume	Rehabilitation Method	Probability of Bridge Unserviceability by Year (Concrete Bridges) %														
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Rehabilitated			Reconstruction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Bridges	All	All	Replacement	0.3	0.4	0.4	0.5	0.7	0.8	1.0	1.2	1.5	1.8	2.2	2.7	3.2	3.9	4.7
(With)			Repair	0.8	1.0	1.2	1.5	1.8	2.2	2.7	3.2	3.9	4.7	5.7	6.9	8.3	10.0	11.9

Probability of Bridge Unserviceability by Year (Concrete Bridges) %									
16	17	18	19	20	21	22	23	24	25
0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.7
5.7	6.9	8.3	10.0	11.9	14.2	16.8	19.8	23.1	26.9
14.2	16.8	19.8	23.1	26.9	31.0	35.4	40.1	45.0	50.0

Table 12.20 DISTRIBUTION OF PROBABILITIES OF BRIDGE UNSERVICEABILITY (STEEL BRIDGE)

Status of Bridges	Degree of Damages	Traffic Volume	Rehabilitation Method	Probability of Bridge Unserviceability by Year (Steel Bridges) % 1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Existing	Light or	Heavy		5.7	6.9	8.3	10.0	11.9	14.2	16.8	19.8	23.1	26.9	31.0	35.4	40.1	45.0	50.0
Bridges	Middle	Light		2.2	2.7	3.2	3.9	4.7	5.7	6.9	8.3	10.0	11.9	14.2	16.8	19.8	23.1	26.9
(Without)	Heavy	All		14.2	16.8	19.8	23.1	26.9	31.0	35.4	40.1	45.0	50.0	55.0	59.9	64.6	69.0	73.1

Probability of Bridge Unserviceability by Year (Steel Bridges) % 2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
55.0	59.9	64.6	69.0	73.1	76.9	80.2	83.2	85.8	88.1
31.0	35.4	40.1	45.0	50.0	55.0	59.9	64.6	69.0	73.1
76.9	80.2	83.2	85.8	88.1	90.0	91.7	93.1	94.3	95.3
76.9	80.2	83.2	85.8	88.1	90.0	91.7	93.1	94.3	95.3

Status of Bridges	Degree of Damages	Traffic Volume	Rehabilitation Method	Probability of Bridge Unserviceability by Year (Steel Bridges) % 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Rehabilitated			Reconstruction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Bridges	All	All	Replacement	0.3	0.4	0.4	0.5	0.7	0.8	1.0	1.2	1.5	1.8	2.2	2.7	3.2	3.9	4.7
(With)			Repair	0.8	1.0	1.2	1.5	1.8	2.2	2.7	3.2	3.9	4.7	5.7	6.9	8.3	10.0	11.9

Probability of Bridge Unserviceability by Year (Steel Bridges) % 16	17	18	19	20	21	22	23	24	25
0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.7
5.7	6.9	8.3	10.0	11.9	14.2	16.8	19.8	23.1	26.9
14.2	16.8	19.8	23.1	26.9	31.0	35.4	40.1	45.0	50.0

- Increase of Loading Capacity

The bridge rehabilitation works will upgrade the bearing strength (loading capacity) of some bridges. This would affect only the benefit of truck traffic, since vehicles of other types can cross even if the bridges are in bad condition. The increase in bridge loading capacity would result in a reduction of truck traffic. If truck drivers or owners could increase their load factor per trip, they would make fewer trips per day to carry a given weight of cargo.

In this study a 5 % reduction of truck traffic volume (AADT) was assumed to result from the upgrading of loading capacity. Among the 52 proposed rehabilitation bridges, 18 bridges will have a benefit from upgrading loading capacity as shown in Table 12.21.

- Reduction of Bridge Unserviceability Caused by Flood

Philippines is often struck by typhoons. Typhoons or heavy rains in the rainy season cause floods along rivers, resulting in making some bridges unserviceable. The bridge rehabilitation works including river protection will reduce the risk of bridge unserviceability. In this study, the benefits from reduction of these risks were calculated based on the number of flood days and the traffic diversion cost.

Table 12.21 LOADING CAPACITY OF EXISTING AND REHABILITATED BRIDGES

Bridge No.	Bridge Name	Live Load Existing Bridge	Live Load Bridge to be Rehabilitated	Change in Load Capacity
1	MARILAO	M 13.5	M 18	Yes
2	LABANGAN 1	M 13.5	M 18	Yes
3	SULIPAN	M 13.5	M 18	Yes
4	PLARIDEL	M 18	M 18	No
5	TAGAMUSING	M 13.5	M 18	Yes
6	BUED	M 18	M 18	No
7	LOMBOY	M 18	M 18	No
8	BAUANG 1	M 18	M 18	No
9	BAUANG 2	M 18	M 18	No
10	STA CRUZ 1	M 18	M 18	No
11	LANGLANGKA 1	M 18	M 18	No
12	STA MARIA	M 18	M 18	No
13	TIPCAL	M 13.5	M 18	Yes
14	PLARIDEL-PULIL.	M 13.5	M 18	Yes
15	SAN ROQUE	M 18	M 18	No
16	SICSICAN	M 13.5	M 18	Yes
17	INDIANA	M 13.5	M 18	Yes
18	BATU	M 13.5	M 18	Yes
19	NAMANPARAN 1	M 13.5	M 18	Yes
20	SAN LUIS	M 13.5	M 13.5	No
21	NAGUILAN	M 13.5	M 18	Yes
22	MALALAN	M 13.5	M 18	Yes
23	BALASIG	M 13.5	M 13.5	No
24	SAN PABLO	M 13.5	M 18	Yes
25	PINACANDAUAN	M 18	M 18	No
26	PARED	M 13.5	M 18	Yes
27	SUJE (RIZAL)	M 18	M 18	No
28	GUINOBATAN	M 18	M 18	No
29	SAN FERNANDO	M 18	M 18	No
30	PAMUKID	M 18	M 18	No
31	SAN ISIDRO	M 18	M 18	No
32	SAN GABRIEL	M 18	M 18	No
33	PAHOHO	M 18	M 18	No
34	TINIGUIBAN	M 18	M 18	No
35	SGT. MATIAS	M 18	M 18	No
36	NAUBOD 1	M 18	M 18	No
37	SOOK	M 18	M 18	No
38	KANAPAWAN	M 13.5	M 18	Yes
39	BASIAD	M 13.5	M 18	Yes
40	GUMACA	M 18	M 18	No
41	TALABA	M 18	M 18	No
42	BINAHAAN	M 18	M 18	No
43	PALSABANGON	M 18	M 18	No
44	LAGNAS 2	M 18	M 18	No
45	STO CRISTO	M 18	M 18	No
46	MAGAPONG	M 13.5	M 18	Yes
47	BIGA	M 18	M 18	No
48	SAN CRISTBAL	M 18	M 18	No
49	JIABONG	M 13.5	M 18	Yes
50	HINOGBONGAN	M 18	M 18	No
51	JUBASAN 2	M 18	M 18	No
52	JUBASAN 1	M 18	M 18	No

(3) Other Quantifiable Benefits

Besides the cost savings for bridge users, there are other important quantifiable benefits of a bridge rehabilitation project, namely: maintenance cost savings and residual value of the rehabilitated bridges at the end of the project period.

a) Maintenance Cost Savings

The maintenance cost savings accrue from different maintenance cost expenditures required over the period of analysis of the existing bridges ("without" project case) and those required for the rehabilitated bridges. Maintenance costs are higher for the existing bridges which are not repaired or reconstructed than those for the rehabilitated bridges.

b) Residual Value

A newly reconstructed bridge is usually assumed to have a life of 50 years. For the economic evaluation established over a 20-year period, the reconstructed bridge will have a residual value of three fifth of its construction cost at the end of the period. This residual value should be counted as a benefit in the 20th year. For replaced bridges which are assumed to have a life of 30 years, one third of its construction cost will be counted as the residual value. For repaired bridges with a 20-year life, it is not necessary to consider the residual value.

(4) Non-quantifiable Benefits

If an existing bridge is unserviceable, it is assumed that social and economic activities in the surrounding area will be hindered and social cost for these activities will be increased. For this reason, the rehabilitation of the bridge will produce the benefit of saving of these social costs. As described before, however, there is no available approach for quantifying social benefits. In this study, these social benefits are only pointed out and discussed as qualitative benefits.

a) Access to Public Facilities

Public facilities such as high schools, hospitals, recreational and social facilities are few in the rural areas. People who live on the opposite side of the bridges leading to these public facilities will lose their access to the facilities, if the bridges are unserviceable.

b) Improvement of Social Environment

If a bridge is unusable, it is difficult for the military and police authorities to capture criminal elements. The rehabilitation of bridges may have an important contribution to mobility of these government authorities and assist in the improvement of social environment including peace and security.

c) Access to Market

Those who live on the opposite side of the unserviceable bridges may lose the opportunity to sell their agricultural products and to buy daily necessities or production inputs.

d) Access to Development Program

Many rural development programs are being conducted in the Philippines for encouraging greater production and improving living conditions. The unserviceability of bridges may reduce benefits from these programs.

Therefore, the unserviceability of bridges may result in the loss of a great amount of non-quantifiable benefits as mentioned above.

(5) Equation for Benefit Calculation

The equations developed for calculating benefits are based on two options, namely: 1) bridge rehabilitation (with project) and 2) do nothing (without project).

a) Equations for calculation of benefits of cost saving due to reduction of risk of bridge unserviceability

The following equations are used in calculating the benefits of cost saving accrued from the different probabilities of bridge unserviceability.

- $BRU = EVL_O - EVL_W$

- $EVL = Pr\ [(TDC \text{ or } DBC) \times 365]$

- $TDC = (\sum_{i=1}^{4} VOC_i \times ADT_i) \times DL$

where:

BRU	:	benefit from reduced risk of bridge unserviceability
EVL	:	expected value of losses due to bridge unserviceability (₱)
Pr	:	probability of bridge unserviceability (%)
TDC	:	total traffic diversion cost (₱)
DBC	:	construction cost of detour bridge (₱)
Voc_i	:	vehicle operation cost of vehicle type (₱/vehicle)
$ADDT_i$	:	average daily traffic volume of vehicle type i (vehicle/day)
DL	:	detouring distance (km)

The Equation (BRU) indicates that the total benefits which can be derived from the difference of expected value of losses between "without" and "with" project conditions.

The Equation EVL computes the expected value of losses in case the bridge become unserviceable. The expected value of losses consists of cost of traffic diversion to an alternative detour route or construction cost of detour bridge.

In this study, it was assumed that the detouring distance is less than 10 km. If the link on which the bridges are located has a detouring length of more than 10 km, detour bridges are to be constructed. The construction cost of a detour bridge was assumed to be equal to the traffic diversion cost over a detouring distance of 10 km on a gravel road.

The probabilities of bridge unserviceability are presented in Tables 12.19 and 12.20.

The Equation TDC gives the total traffic diversion costs which are computed from the vehicle operating costs including fixed and time costs and the projected average daily traffic volume described in section 12.3.4 and 12.3.5. The traffic diversion costs are calculated by vehicle type and by surface condition of detour road.

b) Equation for calculation of benefits from increase of loading capacity

- $SCHV = TCHV_O - TCHV_W$
- $TCHV = VOC_T \times ADT_T \times 365 \times LL$

Where:
- SCHV: saving costs of heavy vehicles traffic (₱)
- TCHV: traffic costs of heavy vehicles (₱)
- VOC_T: vehicle operation cost of trucks (₱/vehicle)
- ADT_T: average daily traffic volume of trucks (vehicle/day)
- LL : link length (km)

The Equation SCHV presents the cost saving due to the increase of loading capacity of bridges. The increase of loading capacity will reduce the average daily traffic volume of heavy vehicles such as trucks become truck operators can use larger trucks.

The Equation TCHV computes the traffic costs of heavy vehicles calculated from vehicle operating costs and projected average daily traffic volume of trucks on the road link. In this study, a reduction of truck traffic volume of 5 % is assumed after rehabilitation of bridges.

c) Equations for calculation of benefits from reduction of bridge unserviceability caused by flood.

- $SCF = CF_o - CF_w$
- $CF = TDC \times DF$
- $TDC = (\sum_{i=1}^{4} VOC_i \times ADT_i) \times DL$

Where: SCF : saving cost by reduction of bridge unserviceability caused by flood (₱)

CF : cost from flooding (₱)

TDC : total traffic diversion cost (₱)

DF : duration of flood (days)

VOC_i: vehicle operating cost of vehicle type i (₱/vehicle)

ADT : average daily traffic volume of vehicle type i (vehicle/day)

DL : detouring length (km)

The Equation SCF gives the cost savings from reduction of bridge unserviceability caused by flood. 14 bridges out of the 52 rehabilitation bridges are expected to be rendered unserviceable by flood especially in the typhoon season. The bridge rehabilitation works including river protection will reduce the unserviceability of these bridges.

The Equation CF gives the traffic costs calculated from the traffic diversion costs and the duration of bridge unserviceability in case of flood. In this study, the period during which the bridge is ususable as a cause of flood is assumed to be 7 days a year. After rehabilitation of bridges, there will be no more unserviceable days.

12.4.4 Priority Ranking of Rehabilitation Bridges

(1) Priority Ranking of Individual Rehabilitation Bridges

The cost/benefit stream tables for 52 rehabilitation bridges are shown in APPENDIX 12.4. They are summarized in Table 12.22. It shows the priority ranking for all the 52 rehabilitation bridges evaluated by their "Internal Rate of Return" (IRR). As the lowest ranked bridge has an IRR of 22.2 %, the project of rehabilitation of all the 52 bridges is considered to be feasible and is recommended to be implemented.

The same table shows that the reconstruction bridges which should have a high priority for rehabilitation are however ranked low, from 25th rank down. As the reconstruction bridges have a high construction cost compared to the repair bridges, IRRs of the reconstruction bridges are smaller than those of the repair bridges. However, most of the reconstruction bridges have a large "Net Present Value" (NPV) which is equivalent to the net benefits of project. For that reason, these reconstruction bridges should be given higher priority among the 52 rehabilitation bridges.

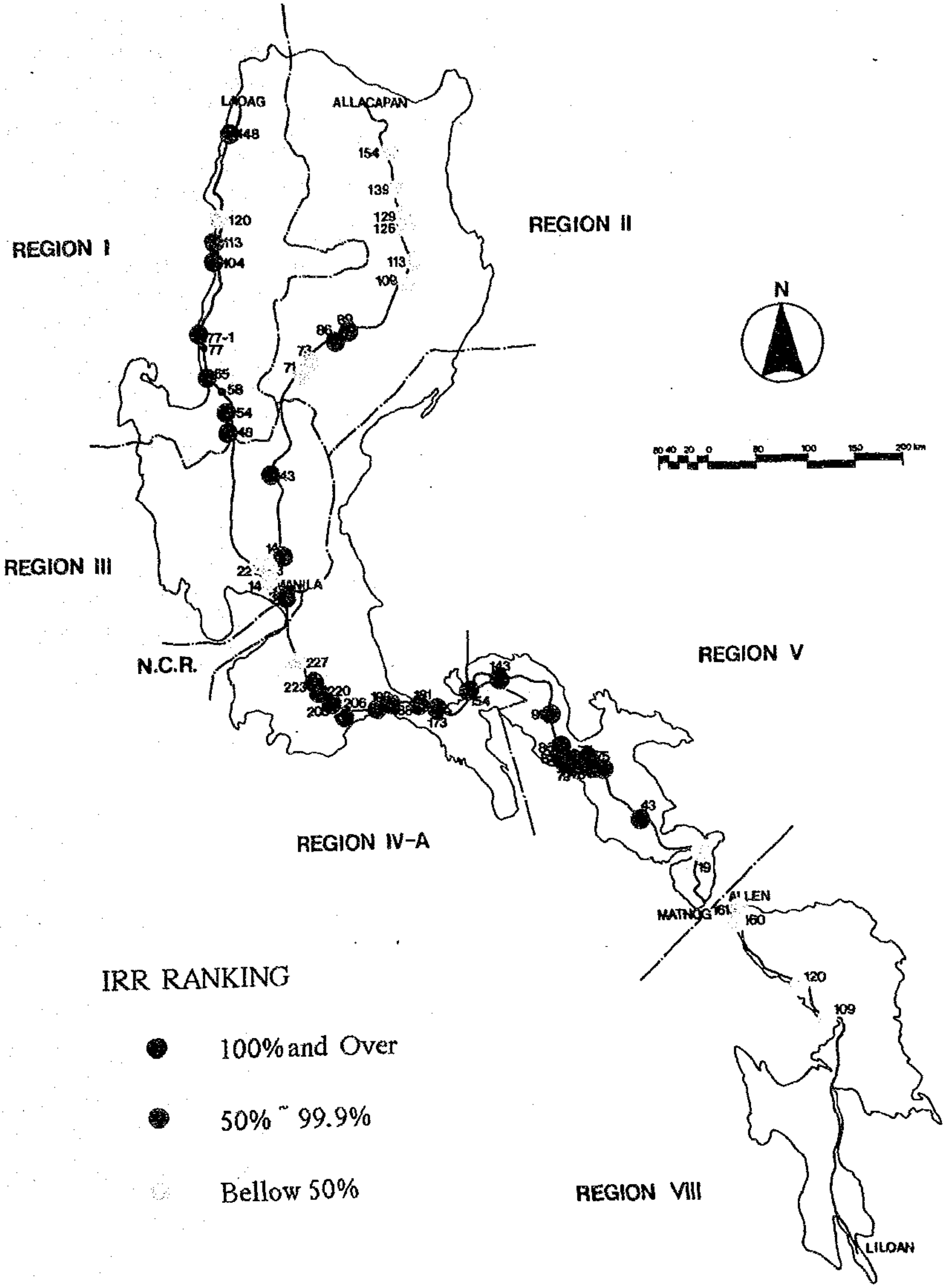
Fig.12.5 shows the locations of rehabilitation bridges divided into 3 groups of IRR ranking.

Table 12.22 PRIORITY RANKING OF INDIVIDUAL REHABILITATION BRIDGES

IRR Rank	Rehab. Bridge Seq.No.of 52 Bridges	Bridge Number	Bridge Name	Rehab. Method	Economic Cost P'000	IRR %	NPV P'000
1	1	3	MARILAO	Replace	1,181	572.1	142,128
2	15	14	SAN ROQUE	Repair	730	475.6	165,892
3	44	206	LAGNAS 2	Repair	197	381.4	64,659
4	16	43	SICSICAN	Repair	3,995	367.7	373,240
5	35	82	SGT. MATIAS	Repair	197	317.4	29,743
6	20	89	SAN LUIS	Repair	313	305.3	36,123
7	33	79	PAHOHO	Repair	266	289.5	29,705
8	36	86	NAUBOD 1	Repair	950	247.8	58,793
9	38	143	KANAPAWAN	Repair	1,552	243.5	67.841
10	28	43	GUINOBATAN	Repair	880	223.4	67,171
11	30	76	PAMKID	Repair	1,100	222.9	58,706
12	31	77	SAN ISIDRO	Repair	1,679	173.7	58,381
13	29	75	SAN FERNAND	Repair	1,691	173.1	58,374
14	39	154	BASIRD	Repair	2,733	172.0	71,365
15	47	223	BIGA	Repair	961	153.5	40,808
16	46	220	MAGAPONG	Replace	3,011	120.2	48,929
17	7	65	LOMBOY	Replace	973	100.0	37,968
18	19	86	NAMANPARAN 1	Replace	4,887	100.0	69,557
19	32	78	SAN GABRIEL	Replace	1,656	98.2	35,215
20	34	80	TINIGUIBAN	Replace	1,668	97.9	35,209
21	37	99	SOOK	Repair	892	92.8	31,259
22	40	173	GUMACA	Replace	2,559	88.2	60,266
23	45	208	STO. CRISTO	Replace	2,941	88.0	80,552
24	41	181	TALABA	Replace	2,652	86.9	60,215
25	5	54	TAGAMUSING	Reconst	15,205	82.1	236,316 *
26	11	113	LANGLANGKA 1	Replace	2,606	79.5	40,650
27	42	188	BINAHAAN	Replace	4,065	67.1	57,708
28	43	190	PALSABANGON	Replace	4,285	65.3	57,582
29	9	77-1	BAUANG 2	Reconst	44,687	61.0	421,075 *
30	4	48	PLARIDEL	Repair	36,581	54.2	273,554
31	10	104	STA. CRUS 1	Reconst	18,679	50.0	122,888 *
32	13	148	TIPCAL	Replace	3,509	50.0	28,115
33	14	3	PLARIDEL PULIA	Repair	28,232	48.9	190,505
34	3	22	SULIPAN	Reconst	122,852	48.4	607,005 *
35	23	126	BALASIG	Repair	4,007	47.7	31,524
36	8	77	BAUANG 1	Reconst	72,468	46.4	386,476 *
37	27	19	SUJE	Replace	3,138	46.1	18,617
38	17	71	INDIANA	Reconst	26,287	45.9	105,907*
39	48	227	SAN CRISTBAL	Repair	5,975	38.9	21,469
40	12	120	STA. MARRIA	Reconst	33,570	37.2	102,668 *
41	18	73	BATU	Repair	31,428	37.2	86,445
42	2	14	LABANGAN 1	Reconst	74,286	37.1	186,355 *
43	21	109	NAGUILIAN	Repair	29,761	36.5	83,191
44	52	161	JUBASAN 1	Reconst	19,408	35.4	44,772 **
45	50	120	HINOGBONGAN	Repair	2,061	34.4	6,456
46	24	129	SANPABLO	Repair	14,614	32.4	34,530
47	51	160	JUBASAN 2	Replace	9,669	30.7	25,835
48	49	109	JIABONG	Reconst	19,315	30.0	27,295 **
49	22	113	MALALAN	Repair	9,021	29.6	16,298
50	26	154	PARED	Reconst	22,129	26.8	23,247 **
51	25	139	PINACANAUAN	Repair	14,683	24.1	15,379
52	6	58	BUED	Reconst	119,969	22.2	81,193 **

NOTE; * ; RECONSTRUCTION BRIDGE HAVING NPV OVER 100 MILLION PESOS
** ; RECONSTRUCTION BRIDGE HAVING NPV UNDER 100 MILLION PESOS

Figure 12.5 PRIORITY RANKING OF INDIVIDUAL REHABILITATION BRIDGES



(2) Economic Evaluation of Rehabilitation Bridges by Road Link

In the economic evaluation, benefits of rehabilitation bridges are calculated mainly based on the probability of bridge unserviceability and traffic diversion costs for the road links in which bridges are located. In case there are more than two bridges in the same road link, the probability of unserviceability of the road links is not equal to that of the individual bridges.

The combined probability of unserviceability of road links is calculated as follows:

$$Pr_L = 1-(1-Pr_1)(1-Pr_2) \cdots (1-Pr_n)$$

Where: Pr_L: combined probability of road link unserviceability (%)
Pr_i: probability of unserviceability of bridge i, located in a road link. (%)

The benefits for each road link were calculated using the above combined probabilities. In this case, all the bridges in a link are assumed to be rehabilitated at the same time.

Table 12.23 shows the economic indicators of road links.

Table 12.23 PRIORITY RANKING BY ROAD LINK

Link No. 52	Rehabilitation Bridge No.	Bridge No.	Bridge Name	IRR for Link Rehab. All	Rehab. Separate
MN-1	1	3	MARILAO	572.1	
MN-2	2	14	LABANGAN 1	37.1	
MN-3	3	22	SULIPAN	48.4	
MN-4	-	-	-	-	
MN-5	4	48	PLARIDEL	54.2	
MN-6	5	54	TAGAMUSING	82.1	
MN-7	6	58	BUED	22.2	
MN-8	7	65	LOMBOY	100.0	
MN-9	8	77	BAUANG 1		32.1
	9	77-1	BAUANG 2	60.4	45.6
MN-10	-	-	-	-	
MN-11	10	104	STA.CRUZ	50.0	
MN-12	11	113	LANGLANGKA 1	79.5	
MN-13	-	-	-	-	
MN-14	12	120	STA.MARIA	37.2	
MN-15	-	-	-	-	
MN-16	13	148	TIPCAL	50.0	
MN-17	-	-	-	-	
MANILA NORTH ROAD				44.5	
PN-1	14	3	PLARIDEL PULIAI	48.9	
PN-2	15	14	SAN ROQUE	475.6	
PN-3	-	-	-	-	
PN-4	16	43	SICSICAN	367.7	
PN-5	-	-	-	-	
PN-6	17	71	INDIANA	45.9	
PN-7	18	73	BATU	37.2	
PN-8	19	86	NAMANPARAN 1		99.2
	20	89	SAN LUIS	153.1	289.1
PN-9	-	-	-	-	
PN-10	21	109	NAGUILAN	36.5	
PN-11	22	113	MALALAN	29.6	
PN-12	23	126	BALASIG	47.7	
PN-13	24	129	SAN PABLO		27.8
	25	139	PINACANAUAN	31.2	17.3
PN-14	26	154	PARED	26.8	
PN-15	-	-	-	-	
PAN-PHILIPPINE HIGHWAY NORTH				57.3	

Table 12.23 PRIORITY RANKING BY ROAD LINK (Cont'd)

Link No. 52	Rehabilitation Bridge No.	Bridge No.	Bridge Name	IRR for Link Rehab. All	Rehab. Separate
PS-1	27	19	SUJE	46.1	
PS-2	-	-	-	-	
PS-3	28	43	GUINOBATAN	223.4	
PS-4	-	-	-	-	
PS-5	29	75	SAN FERNANDO		103.8
	30	76	PAMKID		142.5
	31	77	SAN ISIDRO		104.3
	32	78	SAN GABRIEL		45.3
	33	79	PAHOHO		178.5
	34	80	TINIGUIBAN		45.1
	35	82	SGT. MATIAS		206.5
	36	86	NAUBOD 1	466.4	160.7
PS-6	-	-	-	-	
PS-7	37	99	SOOK	92.8	
PS-8	-	-	-	-	
PS-9	38	143	KANAPAWAN	243.5	
PS-10	39	154	BASIAD	172.0	
PS-11	-	-	-	-	
PS-12	40	173	GUMACA	88.2	
PS-13	41	181	TALABA	86.9	
PS-14	42	188	BINAHAAN		63.2
	43	190	PALUSABANGON	90.8	61.4
PS-15	44	206	LAGNAS 2		369.1
	45	208	STO. CRISTO	187.8	83.8
PS-16	46	220	MAGAPONG		116.2
	47	223	BIGA	168.2	141
PS-17	48	227	SAN CRISTOBAL	38.9	
PAN-PHILIPPINE HIGHWAY SOUTH				187.2	
PL-1	-	-	-	-	
PL-2	-	-	-	-	
PL-3	49	109	JIABONG	30.0	
PL-4	50	120	HINOGBONGAN	34.4	
PL-5	51	160	JUBASAN 2		17.9
	52	161	JUBASAN 1	39.3	29.3
PAN-PHILIPPINE HIGHWAY SAMAR LEYTE				34.8	

(3) Economic Evaluation of Alternative Bridge Combinations

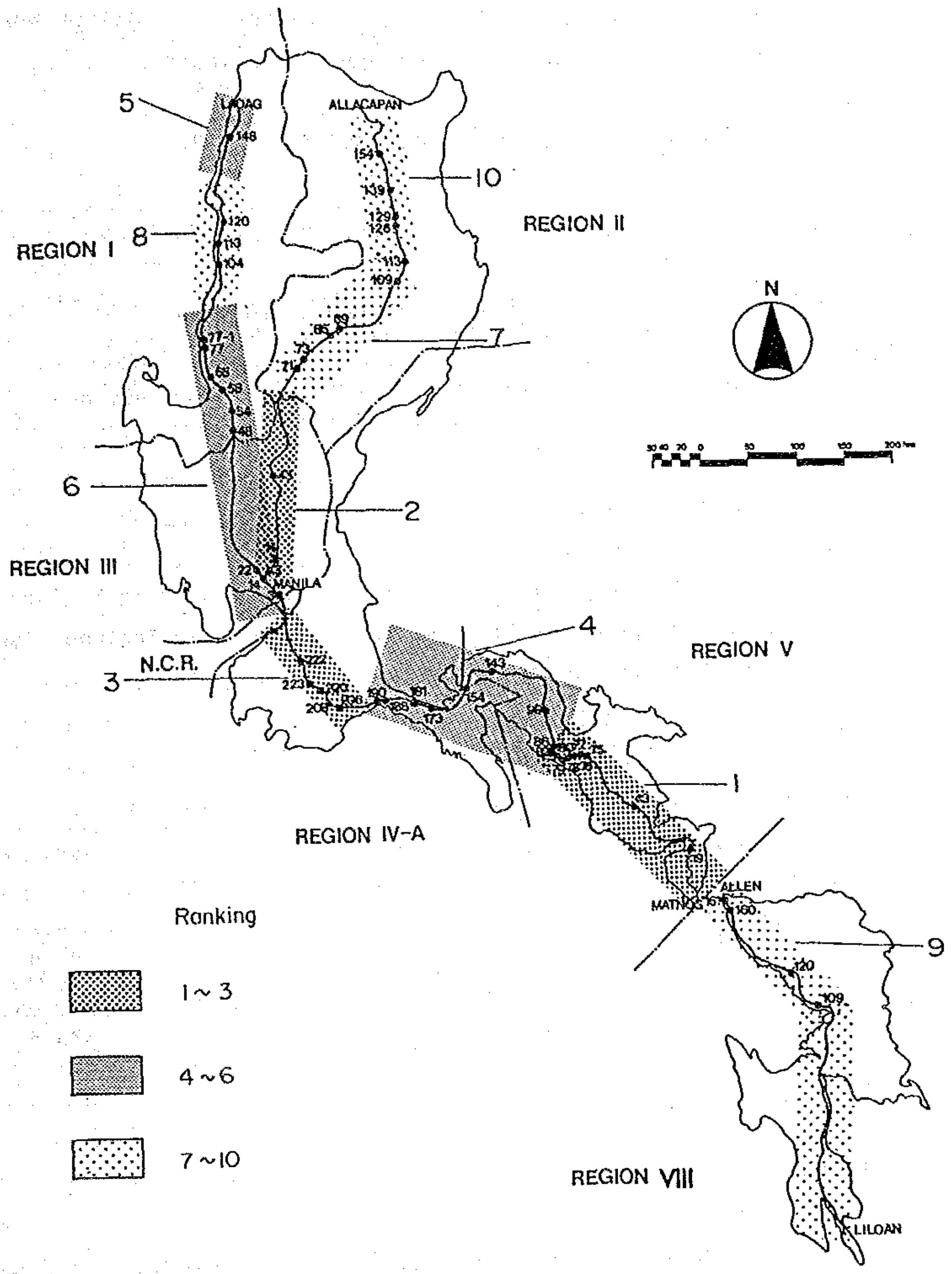
a) Evaluation by Road Section

Table 12.24 and Fig. 12.6 show the result of economic evaluation by road sections. According to this result, the Sections 4, 7 and 9 on the Pan-Philippine Highway near by Manila and in the southern part have a high IRR, while the Section 6 in the northern part and the Section 10 in Samar/Leyte on the Pan-Philippine Highway have low IRR.

Table 12.24 ECONOMIC EVALUATION BY ROAD SECTION

ROAD	ROAD SECTION (BRIDGE)	No.of Bridges	Cost	IRR	RANK
MANILA NORTH ROAD	1. MARILAO (3) - BAUANG II (77-1)	9	488,199	46.3	6
	2. STA. CRUZ I -(104) sta. maria (120)	3	54,855	42.0	8
	3. TIPCAL (148)	1	3,509	50.0	5
PAN-PHILIPPINE HIGHWAY NORTH	4. PLARIDEL DPULIAN (3) - SICSICAN (43)	3	32,957	122.9	2
	5. INDIANA (71) - NAGUILIAN (109)	5	92,675	44.2	7
	6. MALALAM (113) - PARED (154)	5	64,455	29.8	10
P.P.H. SOUTH	7. SUJE (19) - NAUBOD I (86)	10	13,224	411.5	1
	8. SOOK (99) - PALSABANGON (190)	7	18,735	100.0	4
	9. LAGNAS II (206) - SAN CRISTOBAL (227)	5	13,086	122.1	3
P.P.H. LEYTE	10. JIABONG (109) - JUBASAN I (161)	4	50,453	34.8	9

Figure 12.6 ECONOMIC EVALUATION BY ROAD SECTION



b) Evaluation by Route

Table 12.25 shows the result of economic evaluation by route. It is deduced that the southern part of the Pan-Philippine Highway has a high priority in terms of IRR. However, the Manila North Road which has a high NPV must be given high priority.

Table 12.25 ECONOMIC EVALUATION FOR ROUTE

Route	Bridges	Costs	NPV	B/C	IRR	Rank
Namla North Road	13	546,563	2973980	8.38	44.50	3
PPH North	13	190,087	1305640	10.76	57.29	2
PPH South	22	45,045	1720577	55.35	187.21	1
PPH Samar/Leyte	4	50,454	141609	5.03	34.83	4

c) Evaluation by Region

Table 12.26 shows that the rehabilitation bridges in Regions 4 and 5 have a high priority in terms of IRR. Those in Regions 1 and 3 also have a high priority if evaluated in terms of NPV.

Table 12.26 ECONOMIC EVALUATION FOR REGION

Region	Bridges	Cost	NPV	B/C	IRR
1	10	348,244	2025367	8.87	44.95
2	10	157,130	574795	6.34	37.40
3	6	231,276	1679467	10.79	56.75
4	9	26,645	665807	35.67	109.00
5	13	18,400	1054770	85.71	323.69
8	4	50,454	141509	5.03	34.83

d) Evaluation for Whole Project

Table 12.27 shows the economic evaluation for the whole project of rehabilitation of rhe 52 bridges. As seen in the table, the whole project has an IRR of 55.7 %. It is considered to be feasible as a project of improvement of infrastructure.

Table 12.27 ECONOMIC EVALUATION FOR WHOLE PROJECT

Total Bridges	Cost	NPV	B/C	IRR
52	832,150	6141815	11.18	55.69

12.4.5 Sensitivity Analyses

The following three sensitivity analyses were conducted on the economic evaluation to test the impact of changes in rehabilitation costs and traffic.

1) Increase and decrease of 15 % in rehabilitation costs;
2) Increase and decrease of 15 % in traffic (AADT); and
3) Combination increase of 15 % in rehabilitation costs and decrease of 15 % in traffic (AADT) (Worst Case).

Table 12.28 shows the results of the above sensitivity tests by road section. An increase of 15 % in rehabilitation costs will reduce the base IRR value by 81 % to 93 %, except for the Road Section 3 in Manila North Road, while a decrease of 15 % in rehabilitation costs will increase IRR by 108 % to 113 %. The Pan-Philippine Highway North is most sensitive to fluctuation of rehabilitation costs. On the other hand, an increase of 15 % in traffic volume (AADT) will increase IRR by 107 % - 128 %. But increase of IRR for the whole project is less than in case of cost decrease. A decrease of 15 % in traffic volume will reduce IRR by 81 % to 97 %.

A combined increas of 15 % in rehabilitation costs and decrease of 15 % in traffic volume as the worst case will reduce the IRR value by 78 % to 91 % in the base case. If this case is applied to bridge rehabilitation program, the bridge rehabilitation project is considered still feasible.

Table 12.28 SENSITIVITY TO FLUCTUATION OF REHABILITATION COST AND TRAFFIC VOLUME

ROAD NAME	Section Number	No.of Bridges	BASE CASE IRR(%)	Cost Increased by 15% IRR	Cost Increased by 15% % of Base	Cost Decreased by 15% IRR	Cost Decreased by 15% % of Base	Traffic Increased by 15% IRR	Traffic Increased by 15% % of Base	Traffic Decreased by 15% IRR	Traffic Decreased by 15% % of Base	Cost Inc. 15% and Traffic Dec. 15% IRR	Cost Inc. 15% and Traffic Dec. 15% % of Base
MANILA NORTH ROAD	1	9	46,25	42,92	92.8	50,00	108.1	49.55	107.1	42,75	92.4	39.72	85.9
	2	3	41.96	39.09	93.2	45.57	108.6	45.04	107.3	38.65	92.1	36.05	85.9
	3	1	50.00	50.00	100.0	58.71	117.4	63.80	127.6	48.02	96.0	45.34	90.7
	Sub-total	13	44.50	41.26	92.7	48.60	109.2	47.74	107.3	41.10	92.4	38.18	85.8
PAN-PHILIPPINE HIGHWAY NORTH	4	3	122.90	100.00	81.4	140.67	114.5	138.01	112.3	100.00	81.4	96.29	78.3
	5	5	44.16	40.85	92.5	48.51	109.9	47.87	108.4	40.34	91.3	37.39	84.7
	6	5	29.79	27.95	93.8	32.08	107.0	31.87	107.0	27.47	92.2	25.77	86.5
	Sub-total	13	57.29	50.00	87.3	64.95	113.4	63.65	111.1	50.0	87.3	46.46	81.1
PAN-PHILIPPINE HIGHWAY SOUTH	7	10	411.53	384.39	93.4	444.49	108.0	439.79	106.9	380.09	92.4	354.28	86.1
	8	7	100.00	100.00	100.0	100.00	100.0	100.00	100.0	97.71	97.7	89.01	89.0
	9	5	122.08	100.00	81.9	136.71	112.0	134.54	110.2	100.00	81.9	98.63	80.8
	Sub-total	22	187.21	173.00	92.4	204.65	109.3	202.17	108.0	168.13	89.8	155.11	82.9
PAN-PHILIPPINE HIGHWAY SAMAR-LEYTE	10	4	34.83	32.46	93.2	37.81	108.6	37.39	107.3	32.08	92.1	29.89	85.8
Total		52	55,69	50.00	89.8	61.54	110.5	60.59	108.8	50.00	89.8	46.55	83.6

CHAPTER 13

REHABILITATION PROGRAM

CHAPTER 13 REHABILITATION PROGRAM

13.1 General

742 bridges were inspected during the visual inspection in the Study. 99 bridges were pointed out as the noticeable bridges to be rehabilitated because of their physical damages. Furthermore, The 52 bridges, selected out of these 99 bridges as the urgent rehabilitation bridges, taking into consideration and the technical conditions related to the bridge structures and the traffic and socio-economic circumstances.

The above 52 bridges are scattered in Luzon, Samar and Leyte islands. It is required, therefore, to formulate a comprehensive strategy for realization of the rehabilitation project. The road sections to be rehabilitated were determined on the basis of homogeneous traffic conditions and economic evaluation. The economic evaluation was carried out on these sections taking into consideration the socio-economic impact, the necessity from the view point of transportation benefit and the rehabilitation costs. The priorities of rehabilitations were determined based on the above economic evaluation results and technical judgment on structural damages on the individual sections. The rehabilitation program, implementation schedule, fund requirement and additional engineering studies are to be programmed on the basis of these priorities in order to ensure the most effective project implementation.

Taking the above into consideration, it is programmed that the bridge rehabilitation work will be carried out phasewise. Before beginning the construction, it is necessary to execute such works as topographic survey, geotechnical survey, detailed engineering design and financial procurement.

The features of the rehabilitation projects are briefly described belows:

(1) Number of Bridges

The number of bridges picked out for rehabilitation is 52. These are categorized as belows:

Rehabilitation Method	Bridge Number
Reconstruction	12
Replacement of superstructure	15
Repair	25
Total	52

(2) Types and Length of Bridges

The numbers of rehabilitation bridges by type and length are summarized below:

Bridge Type	Bridge Number	Bridge Length
a) Steel Bridge		
Truss	10	3,220
SIB	13	1,088
Steel Box	1	177
Sub-Total	24	4,485
b) Concrete Bridge		
RCDG	13	300
PCDG	11	1,291
Concrete Slab	4	77
Sub-Total	28	1,668
Total	52	6,153

Note:

The bridge which has the main rehabilitation method are considered into the bridge types and numbers, if the bridge has more than two rehabilitation methods for one bridge.

(3) The rehabilitation bridges are listed as belows:

Com. No.	Bridge No.	Bridge Name	Station	Br. Type	Br. Length	Categorization
1. MANILA NORTH ROAD (MANILA - LAOAG)						
REGION III						
1	3	MARILAO	22 + 000	RCDG	12.00	Replacement
2	14	LABANGAN I	48 + 340	SIB	260.00	Reconstruction
3	22	SULIPAN	53 + 244	SIB/STEEL BOX	328.50	Reconstruction
REGION I						
4	48	PLARIDEL	172 + 000	TRUSS	635.10	Repair
5	54	TAGAMUSING	186 + 730	PC-I	50.00	Reconstruction
6	58	BUED	211 + 453	PC-I/PC-T	500.50	Reconstruction
7	65	LOMBOY	232 + 250	RCDG	15.00	Replacement
8	77	BAUANG I	258 + 750	PRECAST-T/PC-I	235.00	Reconstruction
9	77-1	BAUANG II	259 + 200	PC-I	187.20	Reconstruction
10	104	STA.CRUZ I	334 + 932	SIB	35.00	Reconstruction
11	113	LANGLANGKA I	350 + 270	PC-I	14.00	Replacement
12	120	STA.MARIA	371 + 700	PC-I/TRUSS	343.20	Reconstruction
13	148	TIPCAL	457 + 760	PRECAST-T	35.00	Replacement
2. PAN-PHILIPPINE HIGHWAY (MANILA - ALLACAPAN)						
REGION III						
14	3	PLARIDEL-PULILAN	42 + 120	SIB	171.20	Repair
15	14	SAN ROQUE	61 + 460	RCDG	24.00	Repair
16	43	SICSICAN	132 + 916	TRUSS	150.00	Repair

Com. No.	Bridge No.	Bridge Name	Station	Br. Type	Br. Length	Categorization
REGION II						
17	71	INDIANA	246 + 480	SIB	110.00	Reconstruction
18	73	BATU	256 + 000	TRUSS	350.00	Repair
19	86	NAMANPARAN - I	301 + 100	RCDG	45.00	Replacement
20	89	SAN LUIS	304 + 148	RCDG	-	Repair
21	109	NAGUILIAN	380 + 371	SIB/TRUSS	675.00	Repair
22	113	MALALAM	402 + 765	SIB/TRUSS	475.40	Repair
23	126	BALASIG	439 + 054	TRUSS	75.00	Repair
24	129	SAN PABLO	449 + 178	SIB/TRUSS	278.80	Repair
25	139	PINACANAUAN	474 + 180	SIB/TRUSS	180.00	Repair
26	154	PARED	513 + 230	PC-I/TRUSS	197.60	Reconstruction
3. PAN-PHILIPPINE HIGHWAY (MATNOG - MANILA) REGION V						
27	19	SUJE	595 + 800	PRECAST - T	12.00	Replacement
28	43	GUINOBATAN	509 + 841	SIB	-	Repair
29	75	SAN FERNANDO	428 + 235	SIB	21.80	Repair
30	76	PAMUKID	427 + 808	SIB	22.50	Repair
31	77	SAN ISIDRO	422 + 808	SIB	22.50	Repair
32	78	SAN GABRIEL	422 + 403	RC-SLAB	19.50	Replacement
33	79	PAHOHO	421 + 978	RCDG	12.00	Repair
34	80	TINIGUIBAN	421 + 102	RCDG	19.90	Replacement
35	82	SGT. MATIAS	419 + 765	RCDG	15.00	Repair

Com. No.	Bridge No.	Bridge Name	Station	Br. Type	Br. Length	Categorization
36	86	NAUBOD I	409 + 917	SIB	15.00	Repair
37	99	SOOK	377 + 089	SIB	33.30	Repair
38	143	KAPANAWAN	290 + 185	SIB	45.60	Repair
39	154	BASIAD	259 + 680	TRUSS	58.50	Repair
REGION IV-A						
40	173	GUMACA	199 + 195	RCDG	29.80	Replacement
41	181	TALABA	178 + 240	RCDG	23.20	Replacement
42	188	BINAHAAN	147 + 380	RCDG	38.00	Replacement
43	190	PALSABANGON	143 + 950	RCDG	30.00	Replacement
44	206	LAGNAS II	117 + 800	RC-SLAB	-	Repair
45	208	STO. CRISTO	116 + 130	RCDG	36.00	Replacement
46	220	MAGAPONG	79 + 780	PC-I	25.70	Replacement
47	223	BIGA	56 + 900	SIB	46.00	Repair
48	227	SAN CRISTOBAL	48 + 660	RCDG/TRUSS	49.60	Repair
4. PAN-PHILIPPINE HIGHWAY (LILOAN - ALLEN) REGION VIII						
49	109	JIABONG	816 + 727	PC-I	75.00	Reconstruction
50	120	HINOGBONGAN	758 + 469	SIB	-	Repair
51	160	JUBASAN II	666 + 900	PC-I	44.60	Replacement
52	161	JUBASAN I	666 + 100	PC-T	74.00	Reconstruction

13.2 Implementation Schedule

The overall project implementation period is scheduled to be 4 years and 6 months from the detailed engineering studies to the completion of construction. The detailed engineering studies, including mainly topographic survey, geotechnical survey and detailed design would take 1.5 years. Prequalification evaluation and tender process will be carried out in parallel with the detailed engineering studies. The construction period would be 3 years, including Phase-I of 3 years and Phase-II of 2 years.

(1) Detailed Engineering Studies

The detailed engineering studies involve topographic survey of bridge sites, geotechnical survey at the locations which will be designated as required for foundation design and the detailed design will be conducted with review of the feasibility study results.

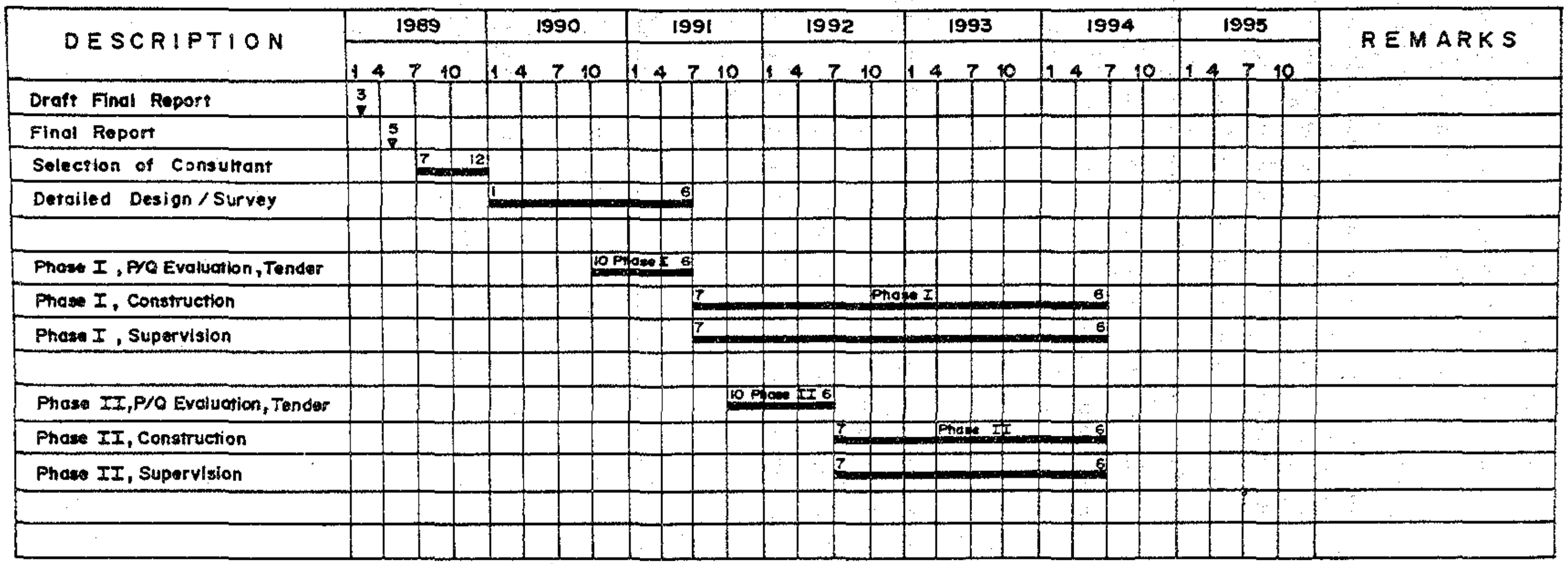
(2) Tender Process

The prequalification of constractors, tender call and bidding will be carried out during tender process prior to the beginning of the construction.

(3) Construction

The construction is divided into two phases, taking into consideration of the priorities determined from the economic evaluation results. The rehabilitation program, however, should complete in a short period. The construction of Phase-I and Phase-II is recommended to be carried out simultaneously.

Fig. 13.1 TENTATIVE IMPLEMENTATION SCHEDULE



13.3 Construction Phase and Package

The bridges to be rehabilitated are widely scattered in Luzon, samar, and Leyte islands. as such, the rehabilitation program covering all of these bridges is remarkably important in terms of both scale and financial requirement. Therefore, in order to ensure effective implementation for getting the expected economic and financial benefits from the project, it is recommendable to realize the rehabilitation program by phases. The phasing is determined on the basis of the economic evaluation results, construction packages, existence of detouring roads and traffic volume. The Phase-I covers the area designated for first priority implementation, while the Phase-II involves the area of lesser importance.

13.4 Fund Requirement

The total fund requirement broken down into foreign and local components is shown in Section 11.5. It was estimated at 907.20 million pesos, at August 1988 price level, consisting of a foreign currency component 612.90 million pesos and a local currency component of 294.30 million pesos.

As discussed in the financial analysis, it is recommended to seek financial assistance from a foreign country or an international financing institution for project implementation. Negotiation for getting loans to cover the foreign currency portion of 612.90 million pesos should be made during the period from 1990 to 1994. The local currency portion amounting 294.30 million pesos should be made available by the Government.

The annual fund requirement broken down into foreign and local currency portions is shown below.

Unit: Peso x 10^6

Description	1990	1991	1992	1993	1994	Amount
1. Construction Cost						
F/C portion	-	41.3	160.3	173.6	51.2	426.4
L/C portion	-	19.2	74.3	80.4	23.7	197.6
Sub-total	-	60.5	234.6	254.0	74.9	624.0
2. Engineering Cost						
F/C portion	21.3	4.1	16.1	17.4	5.1	64.0
L/C portion	9.9	1.9	7.4	8.0	2.4	29.6
Sub-total	31.2	6.0	23.5	25.4	7.5	93.6
3. Land Acquisition Cost						
F/C portion	-	-	-	-	-	-
L/C portion	8.2	-	-	-	-	8.2
Sub-total	8.2	-	-	-	-	8.2
4. Contingencies						
F/C portion	4.3	11.7	45.3	46.7	14.5	122.5
L/C portion	3.6	5.5	21.0	22.1	6.7	58.9
Sub-total	7.9	17.2	66.3	68.8	21.2	181.4
5. Grand Total	47.3	83.8	324.4	348.2	103.5	907.2
F/C portion	25.6	57.2	221.7	237.7	70.7	612.9
L/C portion	21.7	26.6	102.7	110.5	32.8	294.3

Note: F/C - Foreign Currency Portion
L/C - Local Currency Portion

13.5 Additional Engineering Studies Required

The required additional engineering studies cover the following items.

(1) Traffic Study

- Review and updating of the traffic study in the feasibility study on rehabilitation and maintenance of bridges along arterial roads, especially on traffic forecasts

(2) Investigation of the Existing Conditions of Bridges

- Survey of deterioration and damages of bridges

(3) Topographic Survey

- Detailed surveys of the bridge sites which are necessary for design of rehabilitation works

(4) Material Sources Survey

- Identification of sources of borrow, aggregates and other materials which are necessary for construction works

(5) Geological and Hydrological Surveys

- Geological survey of bridge foundation
- Collection and analysis of meteorological data
- Review of flood control analysis

(6) Detailed Design for Bridge Rehabilitation

- Review of current bridge design criteria
- Determination of criteria for bridge rehabilitation design
- Design of the rehabilitation works including study on detour during construction

- Preparation of engineering drawings, key plan, general view showing the rehabilitation works proposed, details of rehabilitation works, drawings of temporary works, execution sequence, detours, etc., as necessary.

(7) Cost Estimate

- Price analysis classified in labor, materials, equipment, tax, overhead, profit, etc.
- Breakdown of foreign and local currency portions
- Financing schedule

(8) Study and Proposal for Execution of Construction Works

- Division of road sections/spots into appropriate sizes under each contract
- Study of construction schedule
- Study of use of materials and equipment
- Study of construction methods

(9) Preparation of Tender Documents for Civil Works

- Instructions to bidders
- Form of contract
- General conditions of contract
- Special provisions of contract
- Technical specifications
- Bill of quantities
- Drawings
- Pre-qualification documents
- Tender documents for international bidding for materials and/or equipment to be procured from abroad, if necessary

(10) Review of Present Road and Bridge Maintenance System

- Organization
- Present maintenance operation system
- Financial and budgeting aspect

- Management information system
- Workshop and equipment
- Other relevant matters

13.6 Construction Management and Organization

The Executing Agency for the Project is DPWH, the Agency that is responsible for planning, design, construction and maintenance of the national road network of the country. DPWH is also responsible for design and construction of ports, public buildings and water supply infrastructure as well as construction of airport facilities such as runways, taxiways, aprons and terminal buildings.

The present organizational setup of DPWH was promulgated under the Executive Order No. 710 dated July 27, 1981 which actually merged the Ministry of Public Works and the Ministry of Public Highways into one agency. DWPH is headed by the Secretary who is assisted by six Undersecretaries and six Assistant Secretaries. At the Department proper, it has six service offices in change of planning, finance and management, administration, legal matters, manpower development, and accounts and allied services. There are five staff bureaus which basically provide general policy direction and technical services relevant to the implementation of projects, including the Bureau of Design, Bureau of Construction, Bureau of Maintenance, Bureau of Equipment and the Bureau of Materials and Quality Control. A brief description of the functions of the aforementioned bureaus is given below.

(1) Bureau of Construction provides technical services on construction, rehabilitation, betterment, and the improvement of infrastructure facilities;

(2) Bureau of Design undertakes project development, engineering surveys, and design of infrastructure facilities;

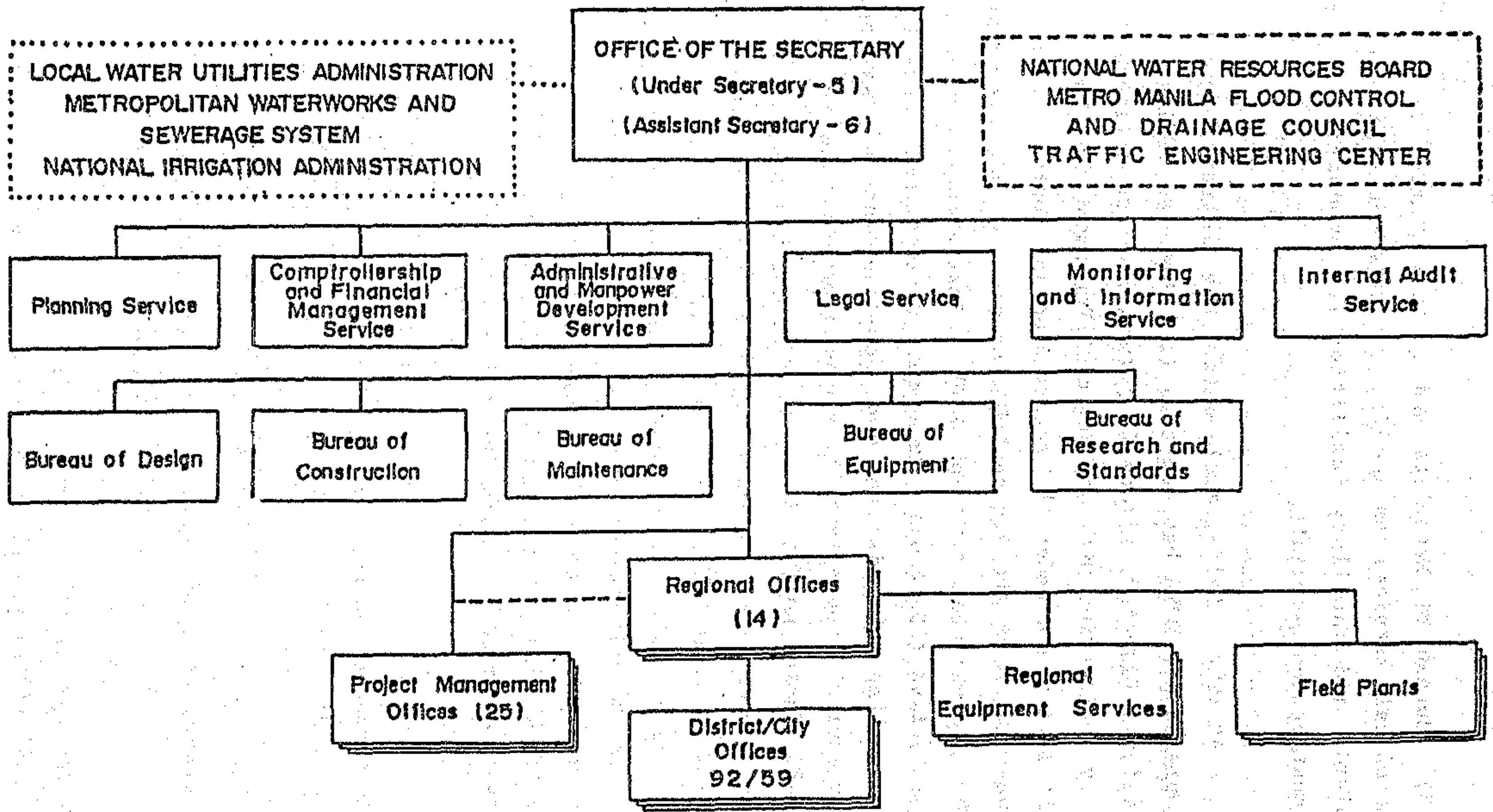
(3) Bureau of Equipment provides technical services on management of construction and maintenance equipment and ancillary facilities;

(4) Bureau of Maintenance provides technical services on maintenance and repair of infrastructure facilities, and

(5) Bureau of Materials and Quality Control provides research and technical services on quality control and management of materials, plants and ancillary facilities for production and processing of construction materials.

At the field level where the infrastructure projects are implemented, DPWH has fourteen (14) Regional Offices each headed by a Regional Director, ninety four (94) District Offices, fifty five (55) City Engineering Offices, Regional Equipment Centers and Field Plants. The latter are under the supervision and control and/or administrative supervision of the Regional Director concerned. These offices serve as the implementing arms of DPWH. Furthermore, there are at present twenty-five (25) Project Management Offices (PMO) which have the task of overseeing the design and construction of national projects, particularly the externally financed projects including those under the OECF. (Refer to Fig. 13.2)

Fig. 13.2 ORGANIZATION CHART OF DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS



CHAPTER 14

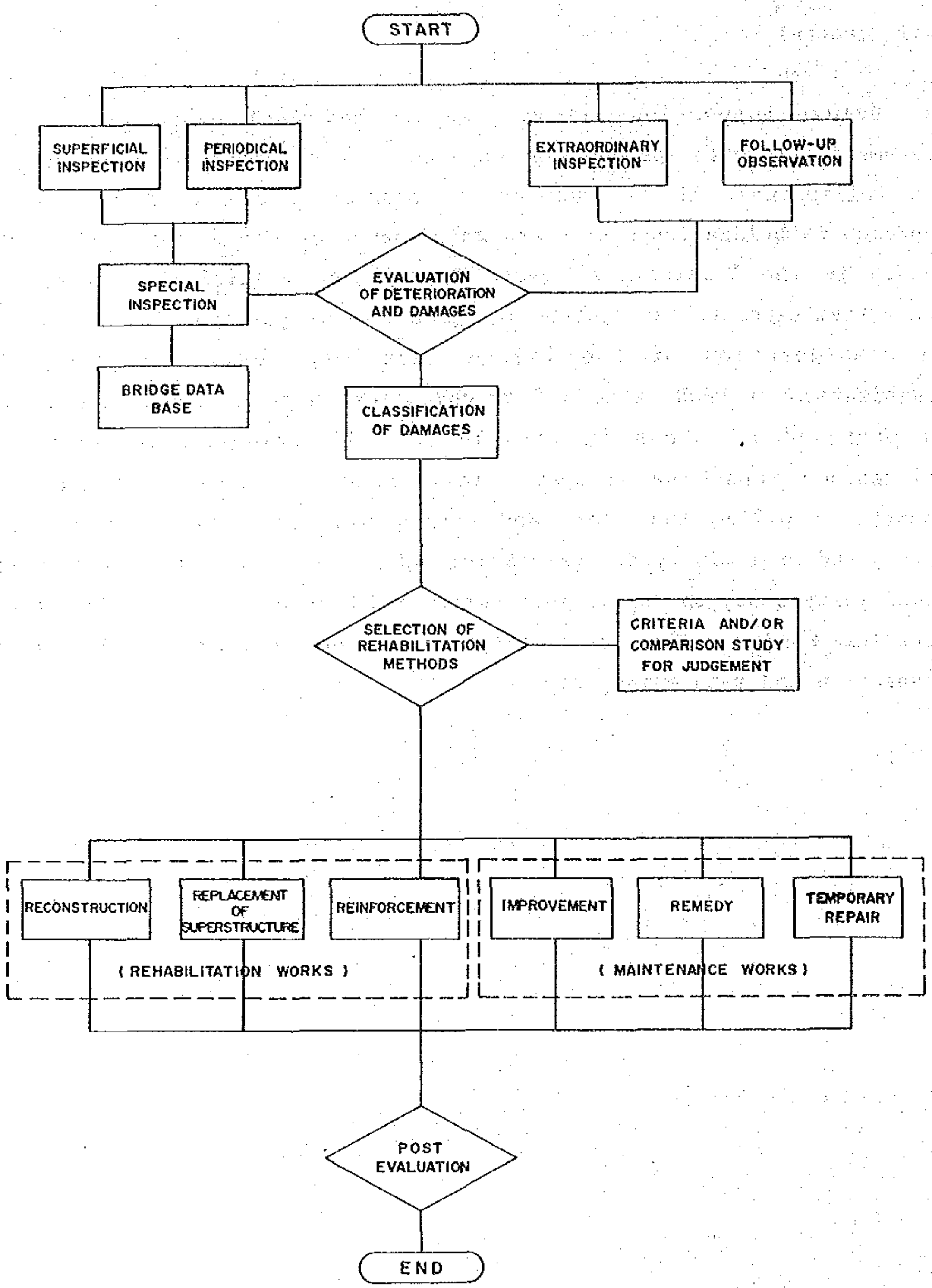
PREPARATION OF AN APPROACH
ON BRIDGE INSPECTION AND MAINTENANCE REPORT

CHAPTER 14 PREPARATION OF AN APPROACH ON BRIDGE INSPECTION AND MAINTENANCE REPORT

14.1 General

Bridge inspection and maintenance have not been carried out systematically with appropriate inspection and maintenance guidelines in the Philippines. It is required to prepare a report presenting an approach to bridge inspection and maintenance at the present and in the future in the Feasibility Study. Through the Feasibility Study, the study team examined the systematic process of inspection and maintenance in consideration of the bridge features, design standard and organization of DPWH, etc. A flow chart for inspection and maintenance is proposed as shown in Fig. 14.1. The bridge inspection and maintenance report was prepared in a separate volume from the main report, compiling the ideas and method used in visual and detailed survey and preliminary design carried out by the JICA study team in the Feasibility Study on the Rehabilitation and Maintenance of Bridges along Arterial Roads. This chapter presents the summary of the bridge inspection and maintenance report.

Fig.14.1 FLOW CHART DIAGRAM FOR INSPECTION AND MAINTENANCE



14.2 Bridge Inspection

Bridge inspection is a starting point of bridge management and will be done periodically for ensuring safety and minimizing interruption of traffic. When damage or deterioration is apparent, the inspection should be made specially to research its causes and to establish an assessment and rating of bridges for programming rehabilitation and repair works. It is particularly necessary that the inspection is made continuously for follow-up in the case of old bridges no longer adopted to modern traffic conditions and whose materials have deteriorated as a result of weathering.

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

According to the bridge inspection described above, the main purposes are as follows;

1) to identify the actual and potential damage and deterioration of the bridge at the earliest possible stage.

2) to provide an assurance that the bridge is structurally safe and provide an urgent preventing method when a damage requiring urgent repair is apparent.

3) to record systematically and periodically the state of bridges in computerized data base.

4) to provide the necessary information on maintenance, repair, replacement and reconstruction of bridges.

5) to provide a feedback of information to designers, contractors and anyone who are interested in bridge data.

14.2.1 Inspection Classification and Frequency

The classification and frequency of inspection can be identified in terms of degree of skill that is required in the inspection procedure and in terms of governmental organization that is divided into a national organization, a regional subdivision such as a province and a local organization such as a district or city office.

The inspections in this inspection and maintenance report are broadly classified into (1) superficial inspection, (2) periodical inspection, (3) special inspection and (4) extraordinary inspection. The broad categories of each bridge inspection are described below.

(1) Superficial Inspection

A superficial inspection is carried out by highway maintenance personnel (team) who have a good practical knowledge of road structures, but not necessarily trained in bridge inspection in each district or city office. This inspection is not to be made regularly and will usually occur as the opportunity arises such as during cleaning or routine road or bridge maintenance. Any adverse condition should be reported to the Region Office without delay, but the absence or defects are not necessary to be recorded.

(2) Periodical Inspection

A periodical inspection is divided into two categories referred to as general and major inspections defined by frequency and intensity. The general inspection is made by a trained inspector under the supervision of a bridge engineer in each Region Office. This inspection is carried out periodically at interval of one year to provide assurance that the bridge is safe for traffic and is usually made by visual examination by means of standard instrumented aids on and under the bridge against a prepared inventory sheet and check lists. The major inspection is made more intensively by a special inspection team organized under the Bureau of Maintenance which is composed specially of trained bridge engineers and will require close examination using special access facilities or inspection mobile. The major inspection is carried out at interval of five years to update records in the data base and to make a rating and assessment of current bridge conditions against a prepared inventory sheet.

(3) Special Inspection

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

(4) Extraordinary Inspection

An extraordinary inspection is made in connection with occurrence of extraordinary collapse such as explosion made by guerrilla, by army force. This inspection is to get information on damages of the bridge and safety circumstances and to report to the Regional Office with photographs.

14.2.2 Inspection Procedure

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

14.2.3 Documentation on Bridges

Bridge documentation contains basic information on bridges in order to give data for planning operations and feedback for designers, contractors and maintainers of the bridges. Bridge documentation consists of bridge inventory and data base (data check, renewal of data and data retrieval). The initial function of bridge documentation is to have a complete and accurate record of each bridge and to store the records into the computer data base which was carried out by the JICA Feasibility Study Team in 1988. However, it is still requested that the bridge inventory, data check, renewal of data base will be periodically carried out by the Special Inspection Team.

(1) Bridge Inventory

The system of bridge inventory contains three inventory sheets: Inventory Sheet No.1 is summary list of the existing bridges to be inspected, Inventory Sheet No. 2 covers the relevant bridge data items and Inventory Sheet No. 3 covers the degree of deterioration and damage of the existing structures as shown in APPENDIX 4.1. The guidelines and key points of inspection to be carried out to a uniform standard are prepared considering the characteristics of the damaged bridges on the arterial roads.

(2) Bridge Data Base

The bridge data base stored more than 50 items of data (in a disc) concerning 742 bridges on the arterial roads in the computer used in DPWH. The bridge management system (BRIDAMAS) is developed as the backbone of bridge documentation in order to maintain and manage necessary bridge data systematically for making decisions on engineering, economic and policy matters and easy retrieval and updating. The detailed functions and procedures are described in Section 13.

(3) Updating and Correction of Data

The initial data base was developed by the JICA Study Team with the data collected as of 1988. However, it can not continuously remain new by itself the data should be updated and corrected periodically to give the latest information for planners, designers, contractors and maintainers. The updating and correction of data will be carried out by staffs of the Inventory Division in the Bureau of Maintenance based on the results of the Periodical Inspection or the Special Inspection. The procedure of updating and of correction bridge data will be basically made as follows:

a) When scheduling periodical inspection, the inspectors are requested to have the Inspection Sheet No. 2 and No. 3 which were made in the last periodical inspection and to update data and revise ratings.

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

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

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

e) Updated and corrected bridge data are stored in BRIDAMAS under the control of the Inventory Division in the Bureau of Maintenance.

(4) Control of the Data Base

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

14.2.4 Rating of Bridge

Rating of bridges is carried out in two stages; the first stage is assessment by visual inspection in periodical inspection and the second stage is assessment by non-destructive tests undertaken in order to determine the compliance of physical, chemical, mechanical properties in the special inspection.

In the periodical inspection, a fairly experienced bridge inspector may be able to accomplish a satisfactory visual assessment by naked eye. However, the experienced bridge inspector is obviously limited in charge of the periodical inspection in the Region Office. It is therefore considered that the visual assessment in periodical inspection is reasonably reliable and effective only when supplemented by the judgment of Engineers in the Special Inspection Team. Inspectors in periodical inspection carry out a rating evaluation of the degree of structural deterioration including potential dangers to be brought about by the river condition, local scouring, meandering and sedimentation in accordance with the Inspection Sheet No. 3 and guidelines and key-points. Based on their own judgment on the extend of structural deterioration, the bridges comprising 16 *components (inspection items)* are rated A, B or C in accordance with the technical criteria stated in Tables 6.1 to 6.3.

14.2.5 Means of Access

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

(1) Bridge Inspection Vehicles

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

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

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

- unuseful for truss bridges because the vehicle is only designed for deck bridges
- traffic interruption caused by the operation of inspection vehicle because its outriggers may obstruct traffic on two-lane bridges.
- the need to train specialists in operation of inspection vehicle ensuring safety for inspection personnel and costly initial investment.

(2) Scaffolding

Another possible and proper access to all or specific damaged structures can be the installation of scaffoldings. It is likely to be restricted to special occasions in the case of no appropriate method from the economic viewpoint as well as for other reasons such as time consumption.

(3) Means of Access under Water

There is sometimes need for inspection of parts of structures or foundations under water. One of possible means of access under water is the use of television cameras with remote control brought into the proper position by a diver with advice from inspector.

14.2.6 Inspection Tools and Equipment

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

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

It is recognized that a number of reliable equipment techniques and method have been developed to suit the need of assessing movements, strains, forces, strength, quality, etc. To describe testing procedures of all the various testing equipment, it would be beyond the objective of the Main report.

14.3 Bridge Maintenance and Rehabilitation

Bridge maintenance and rehabilitation were selected by a simple but important method considered or envisaged on the bridge inspection along the arterial roads in the JICA Feasibility Study. Detailed maintenance and rehabilitation methods well-known and established in the world are therefore not given. The maintenance and rehabilitation method in further detail or additional informations regarding the specific bridges are referred to the AASHTO MANUAL FOR BRIDGE MAINTENANCE 1976, or other equivalent manuals.

In this Study, the bridge maintenance and rehabilitation are classified as below:

Ordinary Maintenance:	Ordinary maintenance is established for the recurring maintenance, depending on the type of bridge structure and operating condition (traffic climate, etc.) to prevent defects.
Rehabilitation :	Specialized maintenance is to repair or replace and reconstruct the bridge based on the results of Periodical or Special Inspection.

14.3.1 Scope of Ordinary Maintenance

The scope of maintenance, which is ordinarily carried out by each region offices, is listed below considering the personnel in charge of maintenance of bridges along the arterial roads.

- Simple clearing of carriageways, footpaths, joints, drains, shoes, expansion joint, gutters, etc., by hand and removal of foreign materials such as trash, mud or vegetation.
- Small restoration of concrete structure, slab and railing, to be carried out with mortar or concrete.
- Small restoration of slope protection (stone masonry or stone pitching) replacement of missing stones, sealing and repairs with mortar.
- Prevention of local scouring around piers and abutment with spone placing in dry season.
- Localized painting operations to protect against corrosion.
- Lubrication and greasing of bearing shoes.
- Repair of drainage system.

14.3.2 Instances of Rehabilitation Method

The following sixteen instances of rehabilitation method are prepared based on the study of Rehabilitation and Maintenance of Bridges Along Arterial Roads. It is expected that the rehabilitation methods introduced here will be more effective by applied also to similar planning and execution of the other existing bridges in the Philippines. The instances of rehabilitation method mainly consist of deterioration and damages, causes, application, procedure. The rehabilitation methods listed up as instances are presented particularly in Section 10.7.

(1) Reconstruction
(2) Replacement of Superstructure
(3) Replacement of Deck Slab
(4) Reinforcement of Deck Slab
(5) Additional Sidewalk
(6) Widening of Girder Bridge
(7) Extension of Approach Span
(8) Reinforcing Concrete Beam and/or Deck Slab
(9) Link Slab
(10) Widening Pier Cap/Bearing Bed
(11) Reinforcement of Substructure
(12) Protection of Pier Foundation
(13) Slope Protection/River Bank
(14) Foot Protection
(15) River Bed Protection
(16) Groyne

14.4 Organization of Bridge Inspection and Maintenance

DPWH is divided into five Bureaus. The Bureau of Maintenance, which is directly under the supervision and control of the Secretary, is responsible for the overall inspection and maintenance policy. The Bureau of Maintenance provides direct communication and contact with the Regional Offices and also provides technical assistance and guidance for efficient and economical implementation of the maintenance functions of the Department. Inspection and maintenance of infrastructures such as not only bridges but also roads, portworks, river control, buildings, etc., are a primary function of the Bureau of Maintenance.

The Bureau of Maintenance is composed of the following five Divisions:

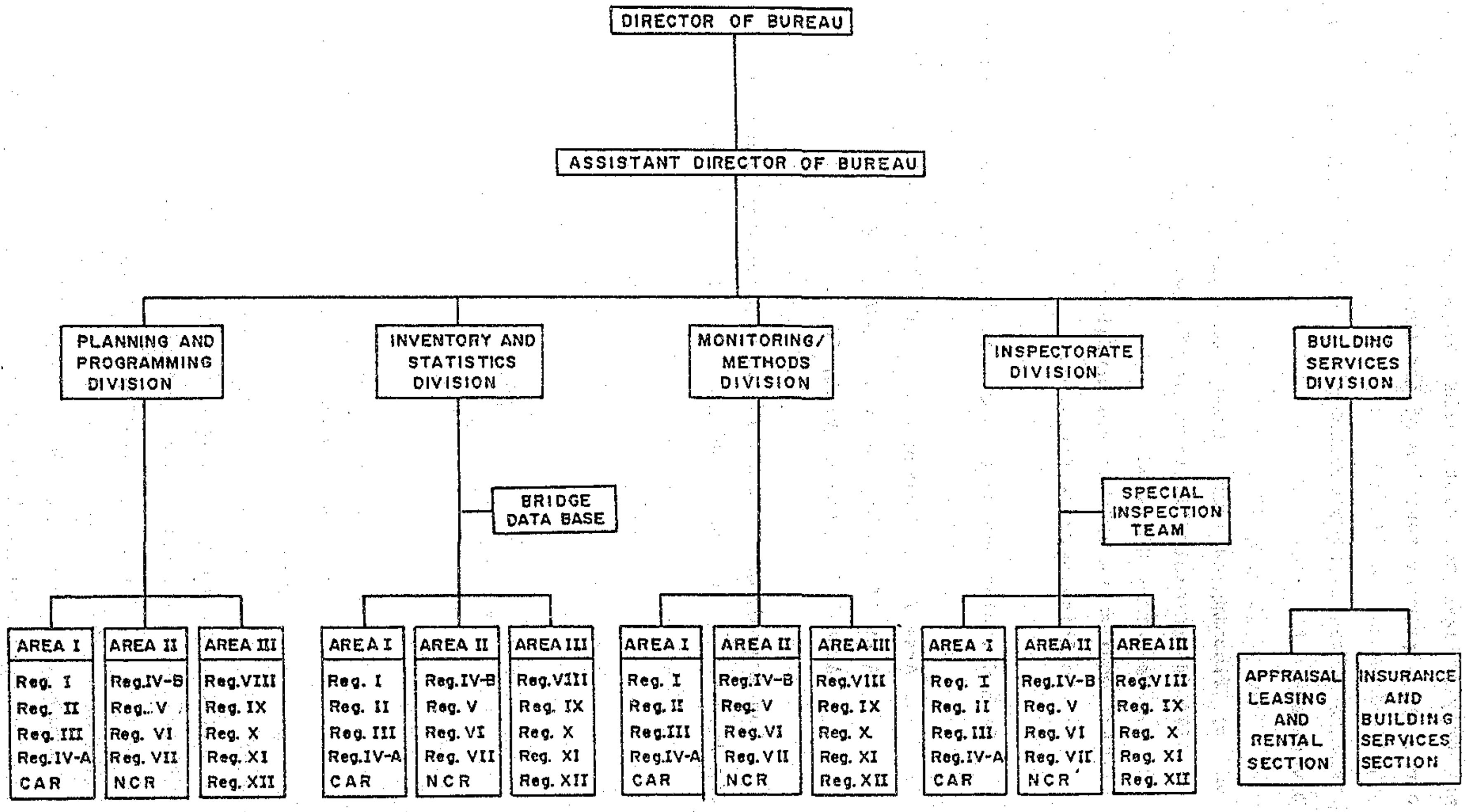
1) Planning and Programming Division
2) Inspectorate Division
3) Inventory Division
4) Monitoring and Methods Division
5) Building Service Division

Each division has three sections divided into areas (regions)

Area I	:	Region I, II, III, IV-A & CAR
Area II	:	Region IV-B, V, VI, VII & NCR
Area III	:	Region VIII, IX, X, XI & XII

The Organization Chart of the Bureau of Maintenance is shown in Fig.14.2.

Fig. 14.2 ORGANIZATION CHART OF BUREAU OF MAINTENANCE



14.4.1 Organization of Inspection and Maintenance Operation

(1) Superficial Inspection

Superficial Inspection is carried out by the District or City Office which is then responsible for a smaller number of bridges located in the district or city. It has the advantage of having more intimate knowledge on the bridge conditions and cutting down inspection time. The bridge conditions are reported to the Regional Office based on the results of the Superficial Inspection.

(2) Periodical Inspection

Periodical Inspection is carried out by the Regional Office is then responsible for bridges located in the region area. The Periodical Inspection can be planned to be simple and efficiently based on the guidelines and key points. The results of Periodical Inspection and the rating of structure damages are reported to the Bureau of Maintenance. If the damages would need more detailed inspection and better use of specialized inspection equipment, the Regional Office requests the Bureau of Maintenance to dispatch a Special Inspection Team.

(3) Special Inspection

Special Inspection is carried out by the Special Inspection Team belonging to the Inspectorate Division in the Bureau of Maintenance. However, the Special Inspection Team does not, at present, exist as a team with particular specialties and not operate with the use of specialized equipment, although such a function should be organized in the Inspectorate Division. The Special Inspection's duties are to evaluate and assess severe damages discovered in the Periodical Inspection and disasters caused after cyclone, flood and earthquake upon request from the Regional Office or by direct order from DPWH.

(4) Data Base

The Bridge Data Base was developed by the JICA Study Team with the inventory data collected and stored in a personal computer the Inventory and Statistics Division,under Bureau of Maintenance. The data base will be operated and updated by the control of the Inventory and Statistics Division. The data to be updated are obtained from the Periodical Inspection and Special Inspection and are checked, reviewed and verified by the Inspectorate Division. The updated bridge data base will be available for the Regional Offices if they have computer and devices compatible to those of the Inventory and Statistics Division with a 5.25 inch FDD.

(5) Ordinary Maintenance

Ordinary maintenance is carried out by the District or City Office according to the results of the Superficial Inspection or by orders from the Regional Office. When damages or deterioration are discovered during the Periodical Inspection and can be still recovered, ordinary maintenance is carried out. The ordinary maintenance should be therefore done in close cooperation with the Superficial and Periodical Inspection teams.

(6) Rehabilitation

Rehabilitation cannot in most cases be performed by the existing personnel of the District Office and Regional Office, because the rehabilitation works require large expenditures and equipment with appropriate size and of various types. The rehabilitation of bridges should be carried out by contractors with appropriate equipment under the contract basis. The Regional Office prepares a rehabilitation program based on the Periodical Inspection and the Special Inspection if necessary and submits the program to the Bureau of Maintenance for approval. The Bureau of Maintenance checks and evaluates the rehabilitation program and prepares annual budget for the maintenance and rehabilitation projects and then submit with comprehensive appraisal to DPWH for decision making. The procedures of rehabilitation program such as data collection, comparative study, detailed design, tendering and construction supervision are mainly carried out by the Regional Office with the approval of DPWH.

The above five operations are to be carried out in accordance with the relationship among DPWH, the Bureau of Maintenance, the Regional Office and the District or City Office. A Schematic Flow Chart is shown in Fig. 14.3.

14.4.2 Training of Bridge Inspection and Maintenance Personnel

DPWH has not formalized the training system for bridge inspection and maintenance personnel but recognized the needs for initial training of inspectors and maintainers for identification of the actual and potential damages of the existing bridges. Training program should be drawn up in consideration of the organization of DPWH, the number of staffs available and the level of techniques required. The training program is envisaged to be at two levels.

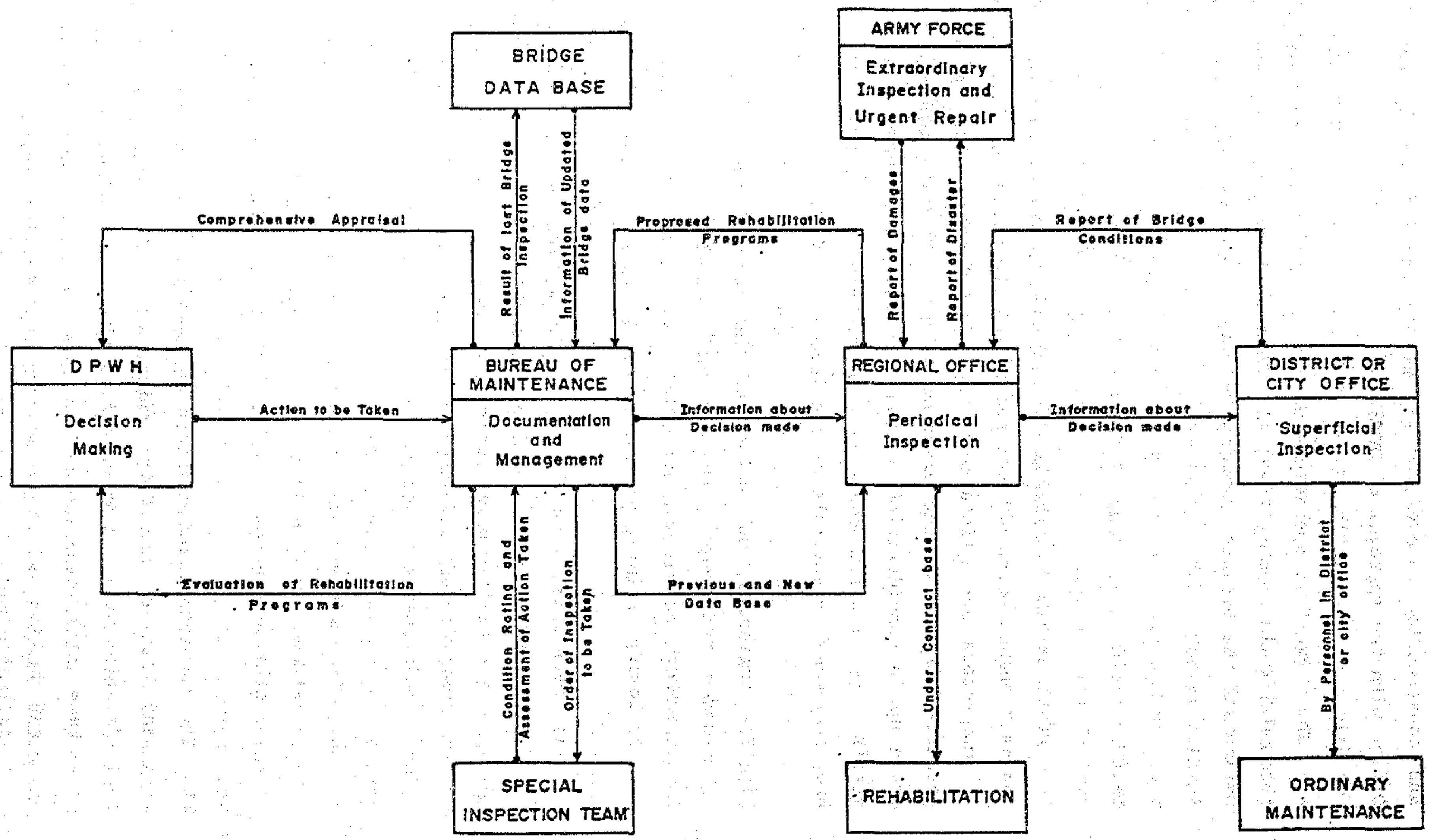
1) The engineers, who belong to the Special Inspection Team, have to get and keep up-to-date their knowledge on the testing techniques, materials and maintenance procedures. The following training program is available and valuable to them:

    a) DPWH invites specialists on inspection and maintenance to give lectures to them including practical on-the-job training. The specialists will train the special inspection team to be experienced and capable of undertaking the inspection and maintenance by itself.

    b) The engineers in the Special Inspection Team should be sent to attend special lectures or seminars to be held in Japan or other countries to update and improve their knowledge.

2) The inspectors and maintainers, who belong to the Regional Office and District and City Office, will make rating of damages or deterioration and often use equipment and materials on which they have little experience. Therefore, practical courses to be carried out by trained engineers in the Special Inspection Team are desirable for all inspection and maintenance team members.

Fig. 14.3 SCHEMATIC FLOW CHART OF BRIDGE INSPECTION AND MAINTENANCE/DECISION MAKING



CHAPTER 15

ESTABLISHMENT OF BRIDGE DATA BASE

CHAPTER 15 ESTABLISHMENT OF BRIDGE DATA BASE

15.1 General

The Bridge Data Management System (BRIDAMAS) intends to manage the data of individual bridges by the use of personal computers. The main purposes are as follows:

(1) To maintain necessary bridge data systematically for easy retrieval and update

(2) To prepare planning basis required for engineering and management work of bridge maintenance and improvement with minimal efforts and maximum efficiency.

In designing the system, the following factors were taken into consideration, i.e. to facilitate the user's convenience for input and retrieval of data by designing a simple system, to facilitate better understanding of users by incorporating a graphics function, and to facilitate update or renewal of bridge data, when and where necessary.

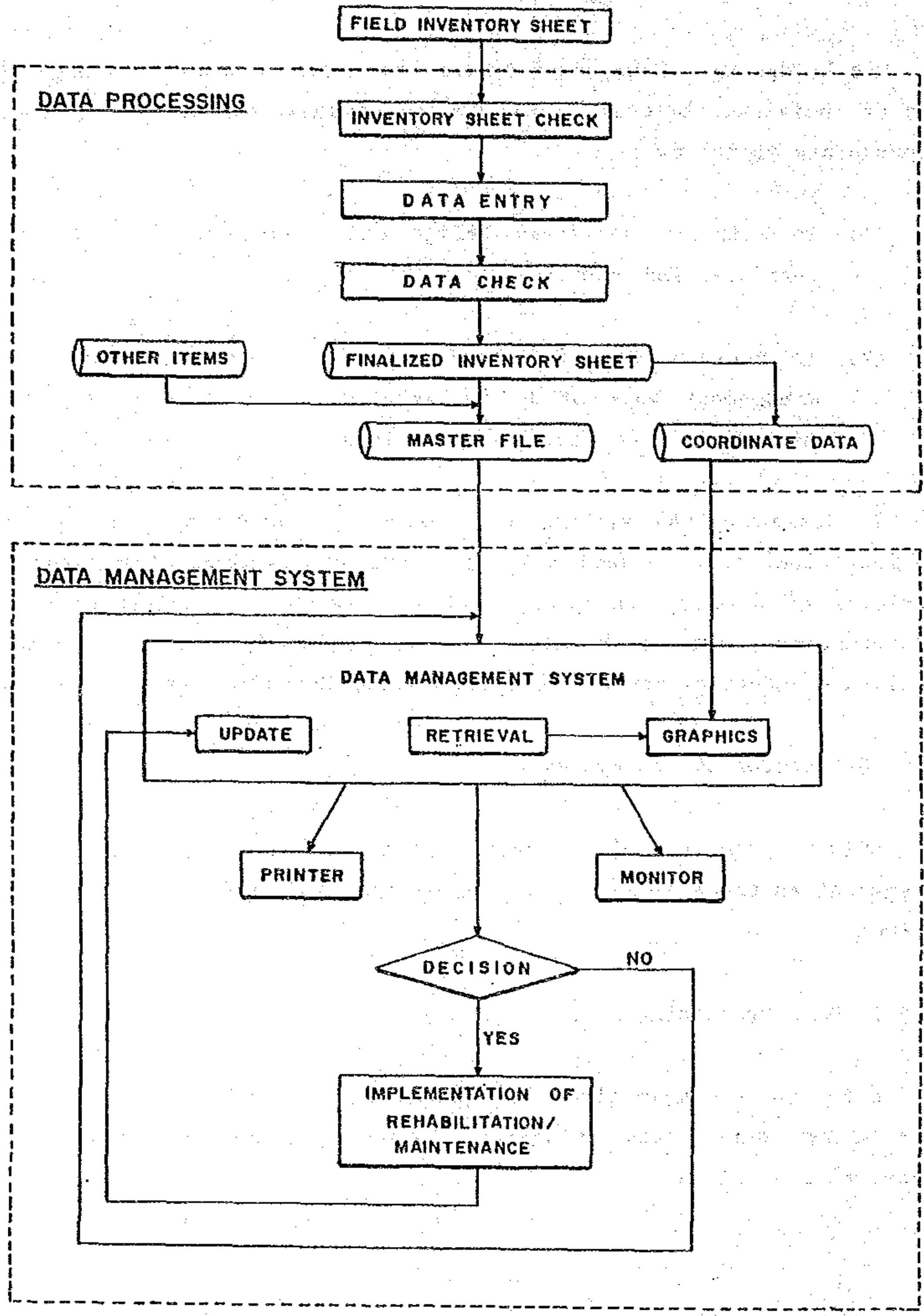
15.2 Structures of the System

BRIDAMAS consists of two major functions: data processing and data management as shown in Fig. 15.1. They are described more in detail as follows:

15.2.1 Data Processing

Data Processing involves five processes i.e. inventory sheet check, data entry, data check, finalized inventory sheet and master file. (Refer to Fig. 15.1)

Fig. 15.1 FLOW CHART PROGRAM OF BRIDGE DATA MANAGEMENT SYSTEM



(1) Inventory Sheet Check: This is to add a serial number to each sheet and check if the Inventory Sheet No. 1, 2 and 3 (Refer to APPENDIX 15.1) exist, to check the Bridge No. within the given range, and to check the Bridge Name if it is not blank.

(2) Data Entry: This is executed by using program soft (dBase III Plus) to avoid input error and to facilitate retrieval. This is to determine the name, type, and width by item, to create data base file and screen, and to prepare data entry.

(3) Data Check: This is executed in order to check the data for the following items: summary table which includes important items and complete data table which includes all data items.

(4) Others: Other existing related data have been separately prepared for adding to master file and graphics, i.e. maintenance record (improvement year etc.) and coordinates of the bridge and boundary of the island (mapping).

15.2.2 Data Management

Data Management System involves three sub-systems, i.e., Update, Retrieval, and Graphics.

(1) Update: This has five functions which can be selected from the menu. The menu is shown as follows:

Update System

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

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

- Summary Table
- Bridge Structure Table (Type, Length, Width, etc.)
- Rating Table by item of inventory
- List of Bridges by Construction Year

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

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

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

- Selection of the color is available on the grouped bridges, then the user can select different colors by group.

15.3 Computer Devices Being Utilized

The following computer, devices and memory system are used for BRIDAMAS:

- Computer : IBM PC compatible with CPU 80286 (AT)
- Hard Disc: 40 Mega
- FDD : 5 1/4 inch 1.2 Mega, 360K
- Memory : 1 Mega
- Printer : EPSON LQ 2500 +

15.4 Current and Scheduled Activities

All data related to each of the 742 bridges obtained from the study have been inputted. The format will further be revised after the use of the data is more specifically determined based on the discussion with DPWH. It is planned to prepare the graphic program as part of the system of the location map for all 742 bridges and the structural figures of a sample bridge for demonstration.

Relations between the sequential number for data entry and the station from the origin in Manila are shown in APPENDIX 15.1

Necessary Operation Manual was prepared and transferring was also conducted for DPWH officials to familiarize with the Bridge Data Base on the working and mechanics of the system.

The Operation Manual includes the following contents.

(1) Bridge Data Base Management System Menu

(2) Bridge Data Update System

- View a bridge record
- Print a bridge record
- Change an existing bridge record
- Add a new bridge record
- Delete a bridge record
- Exit from the Update System

(3) Bridge Data Retrieval System

- Print the Sheet 1
- Print the Sheet 2
- Retrieve the Item
- Retrieve and Get the new Item
- Exit from the Retrieval System

(4) Graphics

- Draw the graphics
- Choose the Item for graphics
- Transfer the data from dBASE to ASCII
- Exit from the graphics

CHAPTER 16

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 16 CONCLUSIONS AND RECOMMENDATIONS

16.1 General

The conclusions and recommendations were made after thorough evaluation of the study results i.e. the technical, socio-economic and traffic aspects, future management procedures and methods of maintenance and rehabilitation of the bridges in the Philippines, and the establishment of priorities for implementing the rehabilitation project.

16.2 Importance of Rehabilitation of the Existing Bridges

The Pan-Philippine Highway and the Manila North Road are important arteries in the highway network of the Republic of the Philippines. These highways link the four major islands of Luzon, Samar, Leyte and Mindanao. Restoration of the said highway was carried out from 1946 to 1948 with financial assistance from the U.S. Public Works Department. Further, upgrading the highway over its entire length including the bridges was carried out from 1969 to 1979 with financial assistance from the Japanese Government through the OECF.

However, the bridge structures have deteriorated rapidly due to the increase in traffic volume, heavy loads and low design standard. Steel structures such as I-beams and trusses are already rusty or heavily corroded due to inadequate maintenance. The river banks are eroded and recently a bridge collapsed due to the movement of the pier by river flood. Due to the above mentioned serious deterioration and damages on the existing bridges, urgent rehabilitation activities is required.

Without any urgent rehabilitation actions to avoid further development of deterioration and damages of the existing bridges, their rehabilitation will become increasingly costly. Moreover, traffic interruptions will seriously disturb the community activities due to the collapse or washing-out of bridges.

Therefore, the rehabilitation works for the bridges along arterial roads in the Republic of the Philippines are important and of higher priority. It is clear that the rehabilitation of the existing bridges will help to maintain its value and give great impetus to the economic development of the Philippines.

16.3 Conclusions and Recommendations

16.3.1 Assessment of the Existing Bridges

Assessment of the existing bridges was carried out based on the degree of structural deterioration and damages, potential danger in the river and socio-economic conditions. Out of the 742 bridges which were inspected, 52 bridges were selected for urgent rehabilitation. These 52 bridges were classified into three categories: reconstruction (12 bridges), replacement of superstructure (13) and repair (27). The selected 52 bridges are recommended to be rehabilitated by applying 16 rehabilitation methods. The other bridges which do not require urgent improvement are recommended to be inspected and maintained by systematic method.

The economic feasibility of the selected 52 bridges was assessed and analyzed based on the Internal Rate of Return (IRR) and Net Present Value (NPV). IRRs of the selected 52 bridges are more than 22.5 % per individual bridge and 55.7 % in total.

16.3.2 For Implementation of Rehabilitation Program

The rehabilitation program for the bridges along the Manila North Road and the Pan-Philippine Highway, consisting of 52 bridges, involves reconstruction, replacement of superstructure and repair. The total project cost is 907,276 x 10^3 Pesos, consisting of foreign portion of ,958 x 10^3, local portion of 203,687 x 10^3 and tax of 90,631 x 10^3. For effective and prompt implementation of urgent rehabilitation, the phasing strategy for implementation is adopted based on the priority results of economic evaluation and consideration of construction packages.

(1) Economic indicators were calculated by individual bridge, by route section and by region. IRRs of the bridges are low due to their high construction costs in the above analyses. The bridges to be reconstructed, however, are given higher priority because of their narrow width and low loading capacity. Moreover their structures have seriously deteriorated and damaged widely on the bridge structures. Those bridges may cause traffic interruptions and consequently give seriously obstructd normal social and economic activities.

(2) To effectively implement the rehabilitation program, priority must be considered according to the results of economic evaluation, phased and packages systems based on the construction size, existence of detouring roads and traffic volume. The high priority for the rehabilitation should be given to the sections of Manila to Matnog and Manila to Bayombong (La Union) on the Pan-Philippine Highway and Manila to Bauang on the Manila North Road, as shown in Fig. 16.1.

(3) The desirable overall project implementation period has been scheduled as 4 years and 6 months from the detailed engineering to the completion of the construction. the detailed engineering period will be one and a half (1.5) years and the overall construction period is three (3) years with Phase-I of 3 years and Phase-II of 2 years.

16.3.3 For Future Inspection and Maintenance

Inspection and maintenance of the existing bridges including the 52 bridges in the rehabilitation program are necessary and important tasks of DPWH. Application of the results such as Inspection and Maintenance Report and bridge data base is recommended to enhance effectiveness of management by DPWH. Establishment of special team and program of educating staff for the specialists are also recommended.

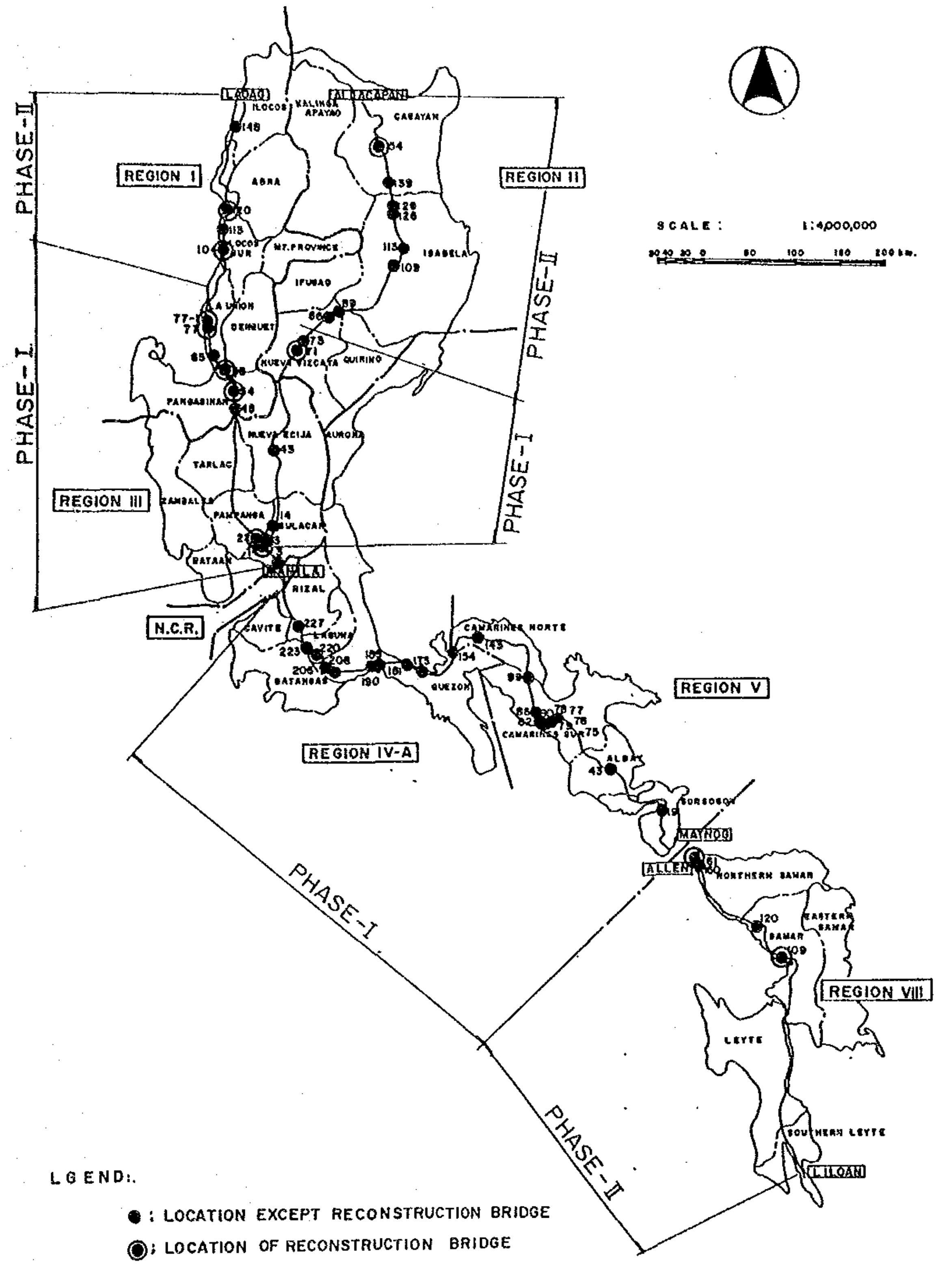
(1) The guidelines and recommendations on mesures to be applied for existing bridges have been treated in the Inspection and Maintenance Report covering inspection, maintenance and the

executing organization. Since the report has been carefully prepared considering the present situation in the Philippines, the application of the study results in the report is expected to greatly enhance effectiveness of the DPWH's management.

(2) Bridge data base is computerized for the 742 existing bridges on an easy-retrieval system and its utilization is highly recommended for the effective performance of inspection and maintenance by DPWH.

(3) It is recommended that a special inspection team be established to evaluate bridge damages and to judge the necessity of rehabilitation with up-to-date techniques of the bridge inspection. For early establishment of the special inspection team, an education program (lectures by a inspection specialist, seminars or practical on-the-job training) for staff participating in the special inspection team should be implementated as soon as possible. *Procurement of inspection equipment is also recommended* to improve the level of inspection techniques in parallel with the the establishment of special team.

Fig. 16.1 PHASING SYSTEM FOR REHABILITATION BRIDGES



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