社会開発調査部報告書

No. 52

GOVERNMENT OF MALAYSIA
MINISTRY OF WORKS
PUBLIC WORKS DEPARTMENT

THE STUDY ON THE MAINTENANCE AND REHABILITATION OF BRIDGES IN MALAYSIA

FINAL REPORT

VOLUME II

MAIN TEXT

JAPAN INTERNATIONAL COOPERATION AGENCY

GOVERNMENT OF MALAYSIA
MINISTRY OF WORKS
PUBLIC WORKS DEPARTMENT

THE STUDY ON THE MAINTENANCE AND REHABILITATION OF BRIDGES IN MALAYSIA

FINAL REPORT

VOLUME II

MAIN TEXT

DECEMBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

CURRENCY EQUIVALENTS
(As of 31 December 1991)

Currency Unit - Ringgit (M$)
M$ 1.00 =US$ 0.366=Yen 45.862

PREFACE

In response to a request from the Government of Malaysia, the Government of Japan decided to conduct the study on the Maintenance and Rehabilitation of Bridges in Malaysia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Malaysia a study team headed by Mr. Hisashi OHSHIMA from Nippon Koei Co., Ltd., three times between September 1990 and October 1992.

The team held discussions with officials concerned of the Government of Malaysia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

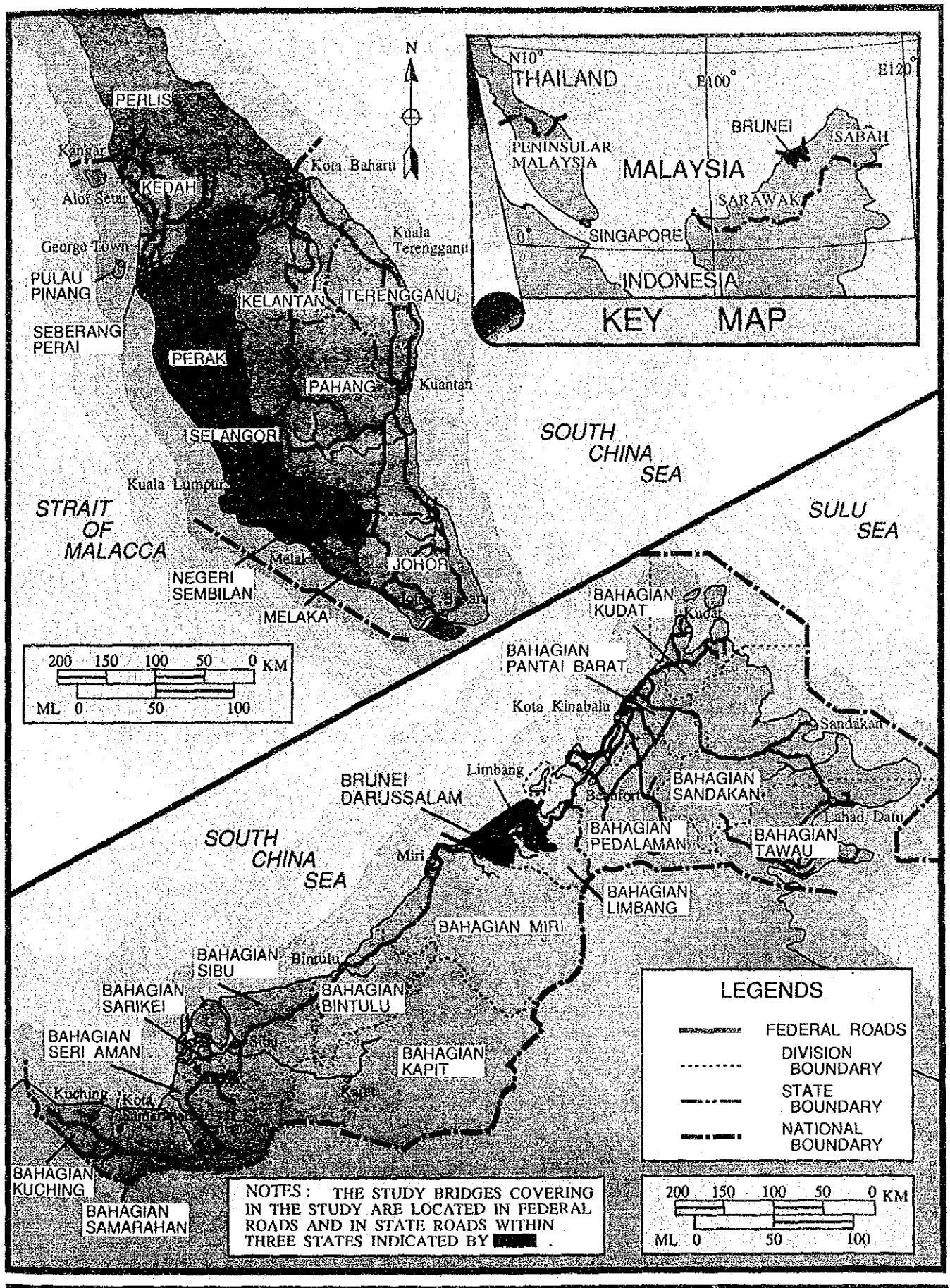
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

December 1992

Kensuke Yanagiya

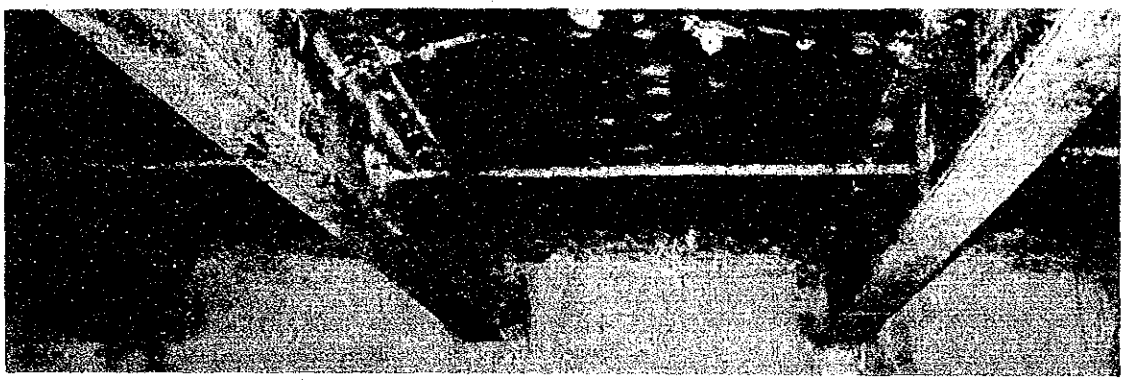
Kensuke Yanagiya
President
Japan International Cooperation Agency



LOCATION MAP

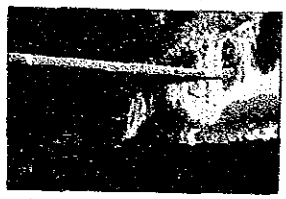
Photos of Typical Construction Type and Defects

1. Steel Beam with Buckle Plate Bridge (SBB)



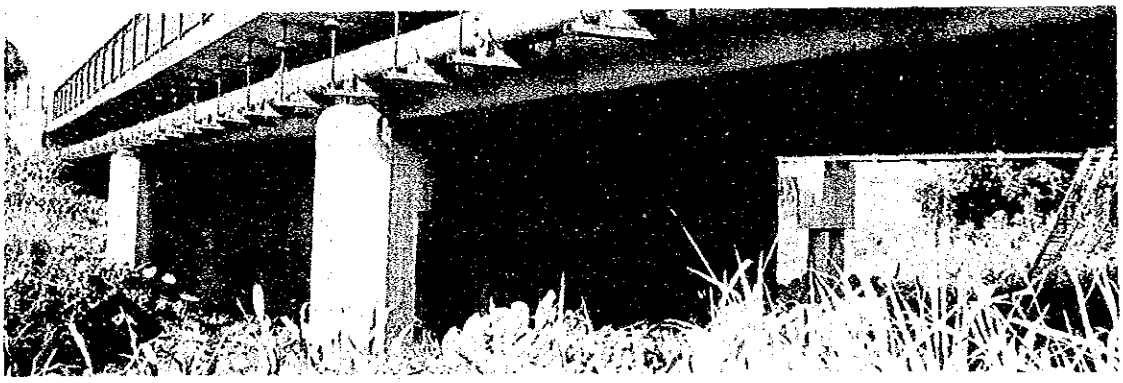
Cross Section

Lamination of Lower Flange



Corrosion of Web Plate and Sediment Accumulation on Lower Flange

2. Steel Beam with Concrete Deck Slab Bridge (SBC)



General View

Paint Deterioration

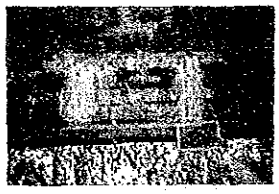
Two-Way Cracks on Deck Slab Soffit

Photos of Typical Construction Type and Defects

3. Reinforced Concrete Beam Bridge (RCB)

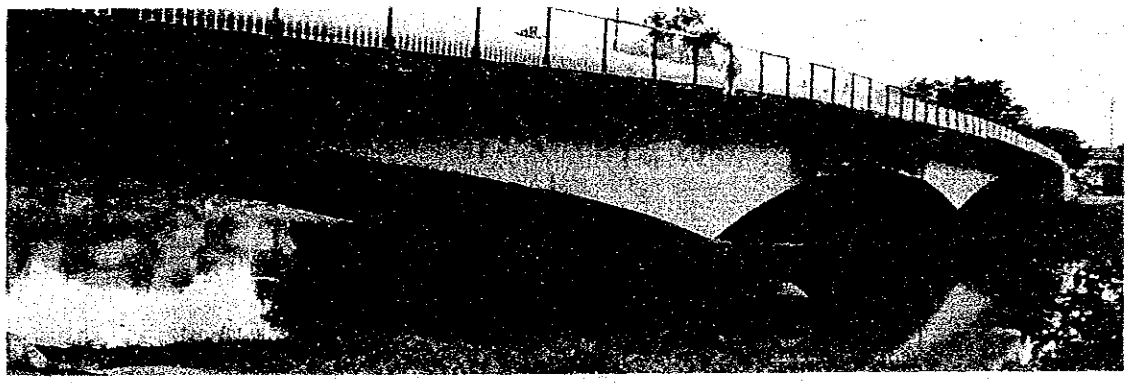
General View

Flaking and Rebar Exposure

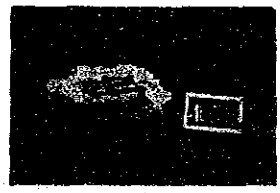


Free Lime

4. Reinforced Concrete Slab Bridge (RCS)



General View



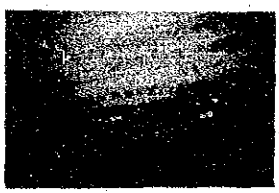
Flaking and Rebar Exposure

Water Leakage and Flaking

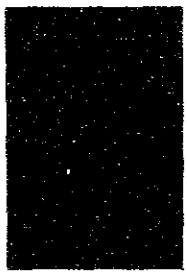
Photos of Typical Construction Type and Defects

5. Precast Reinforced Concrete Beam Bridge (PRB)

General View



Free Lime and Water Leakage between Beams

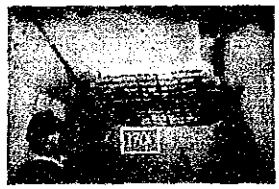


Flaking and Rebar Exposure

6. Prestressed Concrete Beam Bridge (PCB)

General View

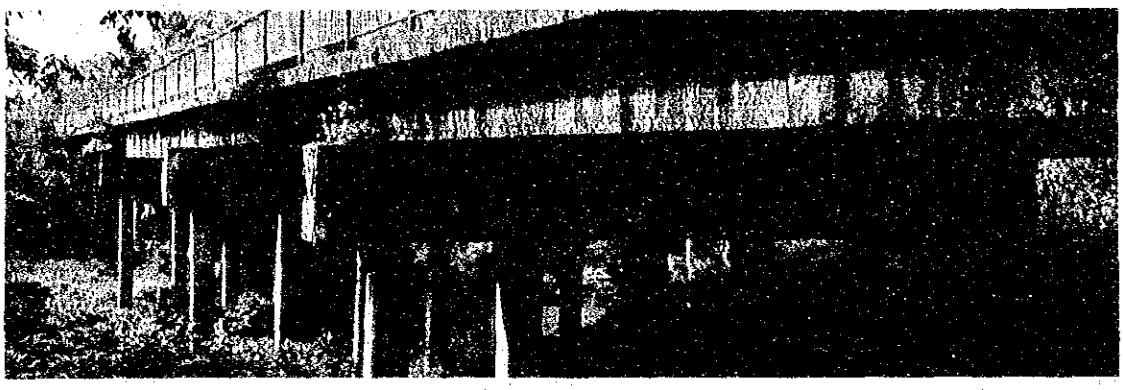
Exposed P.C. Tendon on Beam Web



Reber Exposure on Deck Soffit

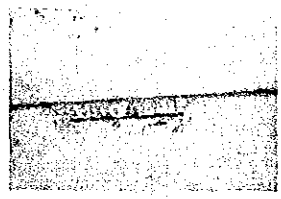
Photos of Typical Construction Type and Defects

7. Pretensioned Inverted Tee Beam Bridge (IT)



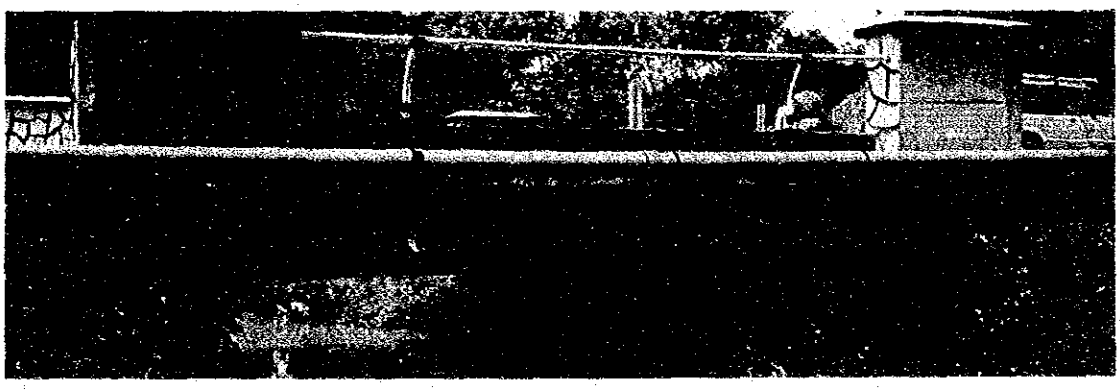
General View

Free Lime and Water Leakage between Beams



Exposed P.C. Tendon on Beam Soffit

8. Encased Steel Beam Bridge (SBE)



General View

Exposed Lower Flange of Steel Beam

Flaking and Rebar Exposure on Deck Soffit

Photos of Typical Construction Type and Defects

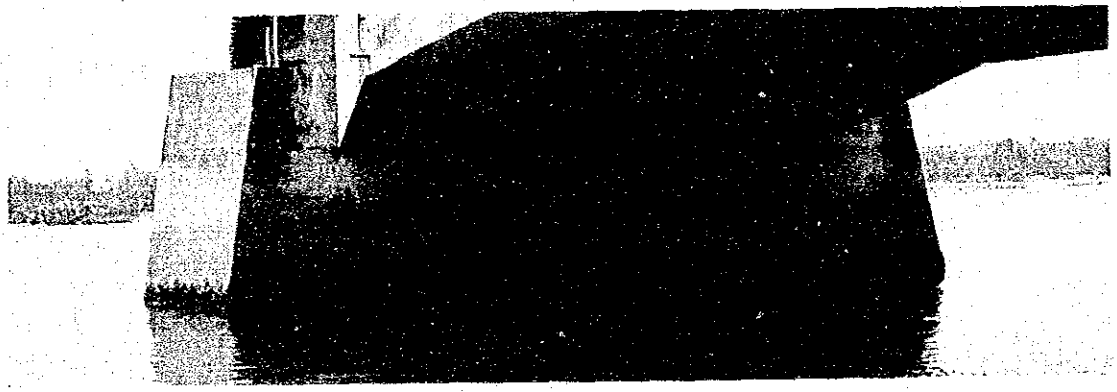
9. Pile Bent Type Abutment and Pier

General View

Abrasion due to Acid Attack

Longitudinal Cracks on Pier Column

10. Wall Type Pier



General View

Flaking and Rebar Exposure

Vertical Crack on Wall

PRINCIPAL EXECUTIVE SUMMARY

PART A: OUTLINE OF THE STUDY

In response to the request from the Government of Malaysia (GOM), the Government of Japan (GOJ) decided to conduct the Study on the Maintenance and Rehabilitation of Bridges in Malaysia (the Study). Accordingly, the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programs of GOJ, organized a Study Team to implement the Study. The Study Team was dispatched to Malaysia in September 1990 and the Study officially commenced with the submission of the Inception Report. After twenty seven months, the Study was completed in December 1992 with the submission of the Final Report and the Bridge Inspection, Maintenance and Rehabilitation Manual.

The principal objectives of the Study are twofold:(1) To develop a systematic maintenance and rehabilitation program for bridges in Peninsular Malaysia, and (2) To establish a manual for inspection, maintenance and rehabilitation work covering all the typical bridges in Malaysia.

The Study covered 216 Federal bridges located along the Federal roads in Peninsular Malaysia with condition rating given by the National Axle Load Study (NALS) as 3 (defined as bridge with significant defect), 4 (in structurally dangerous condition) or study category of Substandard Axle Load (SSAL). The Study also included 30 selected Federal bridges in Sabah and Sarawak and 40 selected State bridges in the States of Perak, Selangor, and Negeri Sembilan with the aim of conducting visual inspection and reflecting the inspection results into the Manual.

In the Study, an extensive data collection exercise and field survey were carried out and the main field surveys undertaken were as follows:

- Visual inspection for 100 bridges consisting of 95 selected out of the above 216 bridges and 5 special bridges selected by GOM, and for 70 bridges selected by GOM which made up of 30 Federal bridges in Sabah and Sarawak, and 40 State bridges as mentioned above. Visual inspection carried out at each bridge site involved measurement survey, field interviews, damage condition rating, photographing, and assessment of possible rehabilitation plans.

- Detailed structural survey for 20 bridges consisting of 17 bridges out of the 95 selected bridges, 1 bridge out of the five special bridges and one bridge each in Sabah and Sarawak from the 30 bridges inspected. The detailed structural survey included topographic survey, subsoil and water investigation, and river hydrological survey. In addition to these field surveys, full scale bridge loading tests were carried out for a total of five spans at three different bridge sites.

- Supplemental bridge survey was also carried out for a total of 199 bridges since NALS did not cover the quantitative damage data of these bridges, as originally anticipated. These bridges consisted of 121 bridges which were discarded for the visual inspection and 78 bridges which were visually inspected but discarded for the detailed structural survey. The purpose of the supplemental survey was to obtain the bridge data for planning maintenance and rehabilitation programs covering all the study bridges, i.e. to measure the extent of damage, to identify rehabilitation method, and to estimate the work quantity. In the supplemental bridge survey, it was found that 11 study bridges have been replaced and 2 study bridges have no defects. Thus, the total number of the 216 study bridges was reduced to 203 bridges.

Based on the information collected through the above field survey, assessment works for the study bridges were carried out from structural, functional and hydraulic viewpoints to identify and diagnose all defects so that suitable rehabilitation methods can be selected to effectively rectify the cause of the defects.

Assessment from the structural viewpoint is divided into two categories; one is material deterioration and the other is load carrying capacity. The material deterioration assessment was carried out through the visual inspection, while the assessment of load carrying capacity was carried out through structural analysis for only 20 representative bridges to identify which structural member is inadequate or adequate in carrying "Long Term Axle Load (LTAL)" loading. The results of the structural analytic assessment for the respective bridge types were used to estimate adequacy of the load carrying capacity of structural members in the remaining same bridge types.

The bridge functional assessment was carried out in terms of traffic capacity, pedestrian flow capacity, and bridge opening capacity. Traffic capacity of each study bridge was evaluated by means of comparison between the calculated total service flow rate in both directions and the present total traffic volume at traffic count station near the bridge obtained from "Traffic Volume Malaysia". Pedestrian flow capacity on each study bridge was also evaluated based on whether a bridge without sidewalks is located in an urban area or not or its proximity with public facilities such as schools, hospitals, mosques, and other landmarks to the bridge. Bridge opening capacity was also assessed to determine whether it can accommodate flood runoff discharge through interview surveys with residents living near the bridge site and also based on the flood information collected from each Drainage & Irrigation Department (DID) District office.

The assessment from hydraulic viewpoint for each study bridge was carried out through the visual inspection to identify flood marks and local scouring/bank erosion locations, to confirm the main water course and to evaluate whether the riverbed is rising or lowering. Furthermore, hydrological analysis for the selected major bridges was also carried out to theoretically estimate the magnitude of floods, the flow capacity of the river at bridge site and the flood level at the bridge site.

Based on diagnosis of all the defects identified through the above exercises such as structural, functional and hydraulic assessments, suitable rehabilitation methods were selected for each defective member or each defective bridge. Accordingly, the work quantity of each rehabilitation method was estimated on a bridge by bridge basis.

The rehabilitation methods selected in the Study were broadly divided into three categories; structural, functional and hydraulic. The structural rehabilitation work is to rectify a deteriorated bridge member or to strengthen a bridge member which has inadequate load carrying capacity, while the functional rehabilitation work is to improve the bridge function by widening carriageways, adding sidewalks, or raising bridge grades. The hydraulic rehabilitation method is mainly to protect river banks or river beds in the vicinity of abutments and river piers.

To estimate the project cost, which was broadly divided into direct cost and indirect cost, the multiplier factors for indirect cost items such as engineering, land acquisition, administration, and contingency were first assessed and determined referring to similar projects. Secondly, the unit price of each rehabilitation method was analyzed to estimate the direct construction cost. The project cost of each study bridge was then estimated by multiplying the estimated work quantity and the corresponding unit price analyzed. The total project cost covering the 203 study bridges was estimated at M$58.148 million.

The economic evaluation followed the project cost estimate. The trends model was applied to project the traffic volume based on the traffic count data available in "Traffic Volume Malaysia 1998", while the estimated project cost was converted to economic cost by using the authorized average conversion factor (CF) of related works published by the "Economic Planning Unit". The tangible benefits accrued from the bridge rehabilitation and considered in this Study are three categories; (1) saving in vehicle operation cost due to a reduction of traffic flow interruption period, (2) saving in vehicle operation cost due to an increase of vehicle speed, and (3) saving of maintenance cost between "with" and "without" project cases.

The economic evaluation was carried out using three parameters; Benefit/Cost Ratio (B/C), Net Present Value (NPV) and Internal Rate of Return (IRR),and assuming a project life of 20 years starting from 1994. The results indicated that the benefit which is mostly derived from the reduction of the traffic interruption period due to bridge failure is large enough as compared to the cost with a benefit cost ratio of 6.75 and an internal rate of return of 58 % as a whole project. Furthermore, the economic evaluation of individual study bridge revealed that the 197 study bridges, or 97 % of the 203 study bridges, are economically viable in 1994. The 6 remaining bridges are also substantially feasible in 1999 due to enhancing an internal rate of return by retarding the rehabilitation for 5 years.

PART B : CONCLUSION

B-1 Necessity of Bridge Maintenance and Rehabilitation

The growth of the transport and communication sector, especially the road network in the road transport subsector, has been playing an important part in the national growth and economic expansion of the country. On the road network, bridges are key elements because of their strategic location and the adverse consequences when their capacity is impaired.

Out of the 216 study bridges, 34 (15.7%) were constructed before 1945 and 180 (83.3%) were built between 1946 and 1974. On the type of construction, 76 (35.2%) are steel beam buckle plate (SBB) bridges which have major structural and maintenance problems. Hence, the aging and inadequate load carrying capacity of these bridges are one of the most potential problems. Moreover, the rapid growth of total traffic volume and increase in the traffic loads require bridge widening and an increase in the bridge load carrying capacity. To make matters worse as revealed in the Study, river water and air pollution have aggravated deterioration of the bridge materials due to chemical attack, chloride attack as well as carbonation.

In order to prevent the adverse consequences such as a loss of traffic safety and a reduction of structural safety, and to avoid an increase of the Government expenditure for bridge replacement, there is clearly a need to carry out bridge maintenance and rehabilitation in Malaysia as a matter of urgency.

B-2 Implementation of the Project

Based on the preliminary rehabilitation design and the economic evaluation carried out in the Study, it was concluded that all the study bridges are technically and economically viable and the implementation of a bridge rehabilitation project covering all the bridges should be carried out within the earliest possible time, in conforming with the Government policy emphasized in the "Sixth Malaysia Plan 1991-1995". The total project cost covering 203 bridges amounts to M$ 58.148 million, December 1991 price levels, as shown below:

Cost Item	Million M$
Construction Cost	45.428
Engineering Cost	4.543
Administration Cost	1.363
Contingency	6.814
Total	58.148

PART C : RECOMMENDATIONS

C-1 Project Implementation

It is recommended that the bridge maintenance and rehabilitation covering a total of 203 bridges, defined as "A Project", shall be implemented based on the following reasons:

(i) All of the study bridges have suffered various distresses or damages and some of them are in critical condition;
(ii) Those bridges can be improved by mainly using standard rehabilitation or strengthening techniques;
(iii) The economic evaluation results indicate that the project is economically highly feasible;
(iv) The Government of Malaysia, presumably, has enough financial capability to prepare the total project cost.

With consideration of the Government's financial arrangement capability as well as urgency of the project implementation, the following key aspects are recommended.

(i) The project covering 203 bridges shall be divided into five packages;
(ii) The construction of the first package shall be commenced in early 1994; and
(iii) In principle, each package shall be completed within one Malaysian fiscal year and the project be completed by the end of 1998.

C-2 Technical and Institutional Recommendation

(1) Need to Eliminate Design and Construction Deficiencies in New Bridges

The study results revealed that various deficiencies observed in the study bridges included the deficiencies due to improper bridge design and construction. It is, therefore, obvious that these deficiencies should be eliminated in new bridge design and construction, otherwise the workload of the maintenance and rehabilitation will never be reduced in the future.

In order to eliminate those deficiencies, the following measures should be taken;

- Standard design of appropriate types of superstructures covering span length from 10m to 40m and typical design of several types of substructures shall be established, and application of these standard design shall be institutionalized nation wide.

- In new bridge planning, bridge type selection, span arrangement, determination of total bridge length and finish grade shall be carefully examined, especially from river hydrological and hydraulic viewpoints.

- A comprehensive bridge design manual including construction details and erection /construction methods shall be prepared.

- The Bridge Unit in JKR should be given the authority to review and to approve all the bridge designs under JKR jurisdiction.

- The JKR's management and supervision team for bridge construction should be strengthened and pay more attention to quality control of the work.

(2) Need to Establish a Solid Organization for Bridge Management and to Implement Systematic Bridge Inspection, Maintenance, and Rehabilitation

As stressed in Part B: Conclusion, there is clearly a need to carry out systematic bridge inspection, maintenance, and rehabilitation which are only part of a broad panoply of the measures from the moment a bridge is opened to traffic. A successful bridge inspection, maintenance, and rehabilitation, however, will to a considerable extent rely on the organizational, managerial, and training aspects of the operation. Therefore, the followings are recommended:

- The Bridge Unit in JKR should be given the authority to oversee all the activities related to bridge inspection, maintenance and rehabilitation and be responsible for bridge management under JKR jurisdiction.

- The State JKR should be responsible for management of the rehabilitation work, while each District Office is responsible for implementation of superficial and periodical bridge inspection and routine bridge maintenance.

- All the inspection results and the maintenance and rehabilitation records should be centralized in the JKR Bridge Management System.

- To enhance the JKR engineers and technician's capability which in turn directly affects the quality of work, a professional training should be carried out periodically.

- Qualified Bridge Inspectors Registration should be introduced in the national bridge inspection system so that they can maintain a professional mind.

- Frequent personnel turnovers must be avoided, so that working on a bridge inspection and maintenance team does not become merely a stepping stone to another job.

- A bridge inspection, maintenance, and rehabilitation budget should be separately allocated from the road maintenance.

MAIN TEXT - VOLUME II

TABLE OF CONTENTS

MAIN TEXT - VOLUME II

LIST OF FIGURES

MAIN TEXT - VOLUME II

LIST OF TABLES

LIST OF APPENDICES

(A Separate Volume)

ABBREVIATION

(In Alphabetical Order)

AADT	Annual Average Daily Traffic
AAR	Alkali Aggregate Reaction
APP.	Approximately
BCR	Benefit Cost Ratio
BMS	Bridge Management System
BOX	Box Culvert
BS	British Standard
CIRIA	Construction Industry Research and Information Association
CPs	Certified Plans
Co.,Ltd	Company Limited
DID	Drainage and Irrigation Department
DRG	Drawing
DSS	Detail Structural Survey Drawing
EPU	Economic Planning Unit
EDM	Electronic Distance Meter
EUDL	Equivalent Uniformly Distributed Load
GOJ	Government of Japan
GOM	Government of Malaysia
HPU	Highway Planning Unit
HR	Hour
IRR	Internal Rate of Return
ISO	International Organisation Standardisation
IT	Inverted-Tee Beam
JICA	Japan International Cooperation Agency
JKR	Jabatan Kerja Raya
JSCE	Japan Society of Civil Engineering
KEL	Knife Edge Load
Kg.	Kampung
Km	Kilometer
km2	Square Kilometer
KN/m	Kilo Newton per Meter
LTAL	Long Term Axle Load
P.C.	Prestressed Concrete
PCB	Prestressed Concrete Beam
PRB	Precast Reinforced Beam

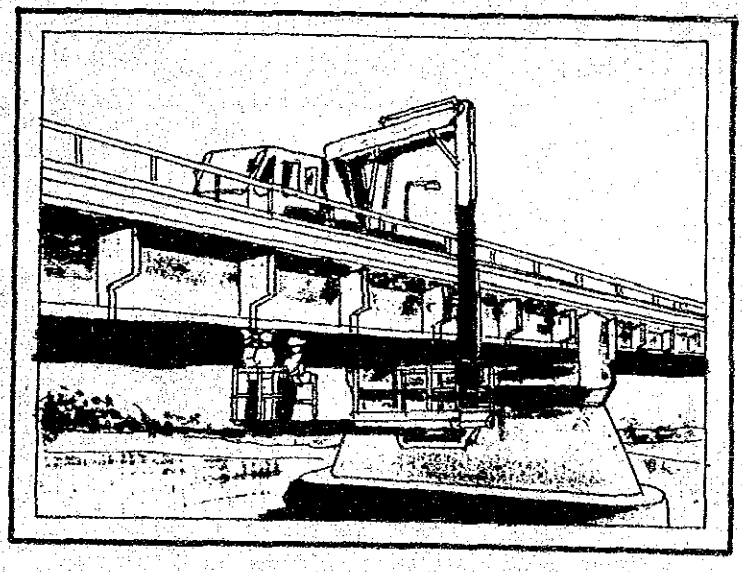
m^3/sec	Cubicmeter per second
MOT	Ministry of Transport
MTAL	Medium Term Axle Load
N/mm	Newton Per Milimeter
N/sq.mm	Newton Per Square Milimeter
NALS	National Axle Load Study
NPV	Net Present Value
NR	Natural Rubber
OECD	Organization of Economic Cooperation and Development
R.C.	Reinforced Concrete
RCB	Reinforced Concrete Beam
RCS	Reinforced Concrete Slab
RRLC	Reserved Residual Loading Capacity
SBB	Steel Beam Buckle Plate
SBC	Steel Beam Concrete Slab
SBE	Steel Beam Encased
SBG	Steel Box Girder
SBR	Styrene Butadience Rubber
SPT	Standard Penetration Test
SSAL	Substandard Axle Load
SRPC	Sulphate Resisting Portland Cement
S/W	Scope of Work
SHV	Special Heavy Vehicle
STD	Standard
SV	Special Vehicle
TBMs	Temporary Benchmarks
UDL	Uniformly Distributed Load
UK	United Kingdom
UPV	Ultrasonic Pulse Velocity
VOC	Vehicle Operating Cost
VPD	Vehicle Per Day

ABBREVIATIONS FOR MEASUREMENTS

mm	millimeter
cm	centimeter
m	meter
km	kilometer
mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
cm^3	cubic centimeter
m^3	cubic meter
kg	kilogram
ton	metric ton
N	newton (9.80655 N = 1 kgf)
KN	kilo newton
t.m	ton meter (1 t.m = 9.30665 kN.m)
kN.m	kilo newton meter
kgf/cm^2	kilogram (force) per square centimeter ($1\ kgf/cm^2 = 10{,}000$ Pa = 10 KPa)
N/mm^2	Newton per square milimeter ($1\ N/mm^2 = 1{,}000{,}000$ Pa = 1 Mpa)
Pa	pascal ($1\ Pa = 1\ N/m^2$)
KPa	kilo pascal
MPa	mega pascal ($1\ MPa = 10.197\ kgf/cm^2$)
V	velocity
A	area
L	length
r	radius of gyration
psi	pounds per square inch ($1\ psi = 0.07031\ kgf/cm^2$)
°C	degree centigrade
%	percent
m/s	meter per second
sec	second
M$	Malaysian Ringgit

CHAPTER 1

INTRODUCTION



CHAPTER 1

INTRODUCTION

1.1 Project Background

The growth of the transport and communication sector, especially the road network in the road transport sub-sector, is supporting the national growth and economic expansion of Malaysia.

In the late 19th century a proper road network did not exist, only primitive roads in the form of bridle paths and bullock cart tracks exist in Peninsular Malaysia. Rapid development of roads began in the early 1900s with the development of the rubber industry as where more roads had to be built to link the rubber production centers to major towns and ports. In 1913 about 3,000km of metaled road had been constructed. The development of roads, which serves tin and rubber industry, continued until mid 1950s. In 1957 Malaysia achieved its independence and the Government of Malaysia (hereinafter called "GOM") changes its policy to diversify its economy and to reduce its dependence on the world market for tin and rubber. Since then Malaysia has experienced tremendous economic growth. In 1966 GOM introduced the first 5 year plan where more emphasis was put towards providing a larger and better road network. As at 1988 a total of about 40,600km of paved roads and approximately 4,500 bridges[1]had been built.

With the existence of better roads and rapid economic growth, the number of vehicles has increased very rapidly. The average rate of increase in the number of vehicles registered in Malaysia is about 10.7% annually. Traffic census carried out in 1988 revealed that about 16% of the vehicles on Federal Roads consisted of medium and heavy lorries while buses made up of 2.4% of the traffic.[2] Annual average daily traffic on some stretches of Federal Roads is as high as 101,500 vehicles per day. A sharp increase in the volume of traffic and overloading together with introduction of large scale and heavier vehicles have caused many roads to be inadequate in capacity and in need of frequent maintenance.

---

1. Data Source : MALAYSIAN ROAD, General Information 1990

2. Data Source: Annual Statistical Bulletin 1988

Realizing the need for a rational transport policy, GOM carried out a National Axle Load Study (hereinafter called "NALS") in 1985. Phase I of the study was completed in 1987 while Phase II of the study has also been completed in 1991. The aim of the study was to review the present trucking industry so that a more economical system of road transportation could be established. In order to carry out the study a knowledge on the strength and general structural condition of all the bridges in the study roads was necessary. The old bridge inventory of Federal Roads was produced from 1972 to 1974 and it was partially updated in 1978. This old inventory was found to be incomplete as quite a number of smaller bridges were not recorded adequately and the inventory was not regularly updated. Since the old inventory was incomplete, inspection and data gathering exercise for all the bridges on Federal Roads included in the study had to be carried out by NALS. A new bridge inventory and bridge cards for each bridge located on the study roads were then produced by NALS.

During phase I & II of NALS it was discovered that quite a number of bridges had been in distress either due to overloading, deficient structural members, deteriorated bridge parts, and improper maintenance practice. Some of the bridges had been found to have deteriorated beyond economic repair while a significant number of bridges require urgent maintenance and rehabilitation. The study also revealed that the current maintenance practice, such as excessive overlaying of premix on bridge deck and "non-designed" bridge modification, is detrimental to the "structure". NALS recommended to GOM various action to be taken with regard to bridges. The most significant recommendations were:-

- The Bridge Unit should be given the authority to oversee the engineering design and detailing of all works and to centralize the bridge management.

- The bridges identified as being in an unsafe condition (rating as "5") and some bridges which have been rated as substandard axle load (SSAL) carrying capacity should be replaced as a matter of urgency.

- The many bridges suffering significant defects (rating as "3") and identified as being in a dangerous condition (rating as "4") or SSAL should be upgraded before they become structurally deficient.

- All new bridges should be designed to the recommended bridge loading standard which is the basis of the Long Term Axle Load Policy.

- A regular system of inspecting bridges should be established.

To this end, GOM gave high priority to the bridge maintenance and rehabilitation and the establishment of systematic bridge inspection. The Public Works Department (translated as Jabatan Kerja Raya into Malay which is abbreviated to JKR) representing GOM responded to part of the recommendation by taking the following steps:

- Setting up a Bridge Management Section in the Bridge Unit of JKR.

- Development and establishment of a Bridge Management System (hereinafter call "BMS")

- Replacement of the bridges rated as "5" and some bridges which had been rated as SSAL.

1.2 Study Background and Objectives

Recognizing the necessity to "strengthen" BMS and the importance of maintenance and rehabilitation works of bridges in Malaysia, GOM requested the Government of Japan (hereinafter called "GOJ") to provide assistance for a study for this purpose. In response to the request of GOM, GOJ decided to conduct the Study on the Maintenance and Rehabilitation of Bridges in Malaysia and entrusted the Study to the Japan International Cooperation Agency (hereinafter called "JICA"), the official agency responsible for the implementation of technical cooperation programs of GOJ.

Accordingly, JICA dispatched a preliminary study team headed by Mr. Isamu Takuwa to Malaysia from 13th February 1990 to 24th February 1990. The agreement on the Scope of Work for the Study (hereinafter called "S/W") was signed between the Economic Planning Unit (hereinafter called "EPU") representing GOM and JICA on 23rd February 1990. Subsequently JICA organized an advisory committee and a study team in August 1990 to conduct the Study. The Study Team was then dispatched to Malaysia on 6th September 1990.

The principle objectives of the Study are two fold:-

1) To develop a systematic maintenance and rehabilitation program for bridges in Peninsular Malaysia.

2) To establish a manual of inspection, maintenance, and rehabilitation work covering all the typical bridges in Malaysia.

In addition to the above, the Study includes providing practical training to JKR counterparts in field inspection techniques, bridge loading test and assessment techniques on the required maintenance and rehabilitation method for various types of defective structural members.

1.3 Scope of the Study

The Study covers all the bridges located along the federal roads on the Peninsular with condition rating 3, 4, or study category of SSAL (Substandard Axle Load) by NALS, the 30 selected federal bridges in Sabah and Sarawak and the 40 selected bridges in the States of Perak, Selangor, and Negeri Sembilan.

The Study on the federal bridges on the Peninsular includes the following:

- To collect and to review available data and related information.
- To conduct visual inspection covering a maximum of 100 typical bridges.
- To conduct detailed survey of a maximum of 20 typical bridges including loading test for a maximum of 5 bridges and to carry out preliminary rehabilitation design.
- To prepare rehabilitation and maintenance program with cost estimate and economic analysis for all bridges rated 3, 4 or SSAL by NALS.
- To reflect the above study results into a bridge inspection, maintenance and rehabilitation manual.

The Study on the federal bridges in Sabah and Sarawak includes the following:-

- To conduct visual inspections to over a maximum of 15 bridges in Sabah and a maximum of 15 bridges in Sarawak and to prepare visual inspection reports,
- To conduct detailed survey of a few selected bridges and to carry out preliminary rehabilitation design, and
- To reflect the result of inspection and design into a bridge inspection, maintenance and rehabilitation manual.

The purposes of the Study on State bridges on the Peninsular are to introduce field inspection techniques and inspection recording methods and to recommend required maintenance and rehabilitation work for each bridge. The study includes the following:-

- To conduct visual inspection covering a maximum of 40 bridges in the State of Perak (10), Selangor (20), and Negeri Sembilan (10) and to prepare visual inspection reports and
- To reflect the inspection results into a bridge inspection, maintenance, and rehabilitation manual.

1.4 Work Flow and Major Work Items

The Study was broadly divided into three main phases: Phase I - Visual Inspection and Selection of 20 Representative Bridges, Phase II - Detailed Engineering Survey and Preparation of Implementation Program and Phase III - Submission of the Draft Final Report and completion of Final Report. Each main phase was further subdivided into two stages which

involve work in Malaysia and Japan, which is indicated by the suffix (A) and (B) respectively.

Main work items during each phase are summarized as follows:

- o Phase I (A) Study : Selection of 100 bridges and Visual Inspection
- o Phase I (B) Study : Setting of Evaluation Criteria and Selection of 20 bridges
- o Phase II (A) Study : Detailed Survey, Preliminary Design, and Planning of Maintenance & Rehabilitation Work
- o Phase II (B) Study : Cost Estimate, Economic Evaluation, and Implementation Programming
- o Phase III (A) Study : Preparation of Draft Manual and Draft Final Report
- o Phase III (B) Study : Completion and submission of Final Report and Manual

The flow chart of the work program and the interrelations of the above main work items are depicted in Figure 1-1.

The number of study bridges at each phase and the relationship between the above work items and the bridge categories consisting of the federal bridges in the Peninsular, the federal bridge in Sabah and Sarawak, and the state bridges are shown in Figure 1-2.

1.5 Study Organization

To facilitate and ensure the smooth conduct of the Study, GOM set up a Steering Committee chaired by the Director of Infrastructure and Utilities Section in the Economic Planning Unit (EPU) and a Technical Committee led by the Director of Roads Branch in the Public Works Department (JKR).

The Public Works Department acted as the counterpart agency to the Study Team and also as a coordination body between the Government Agencies concerned. A Counterpart Team comprising five members from the Bridge Unit in JKR was formed headed by the Senior Assistant Director of the Bridge Unit.

On the other hand, JICA organized an Advisory Committee consisting of three members who provided advice and guidance to ensure proper execution of the Study, and a Study Team comprising nine specialists headed by Mr. Hisashi Ohshima of Nippon Koei Co., Ltd., Team Leader, to carry out the Study on the Maintenance and Rehabilitation of Bridges in Malaysia.

Figure 1-1 Work Flow Diagram of the Study

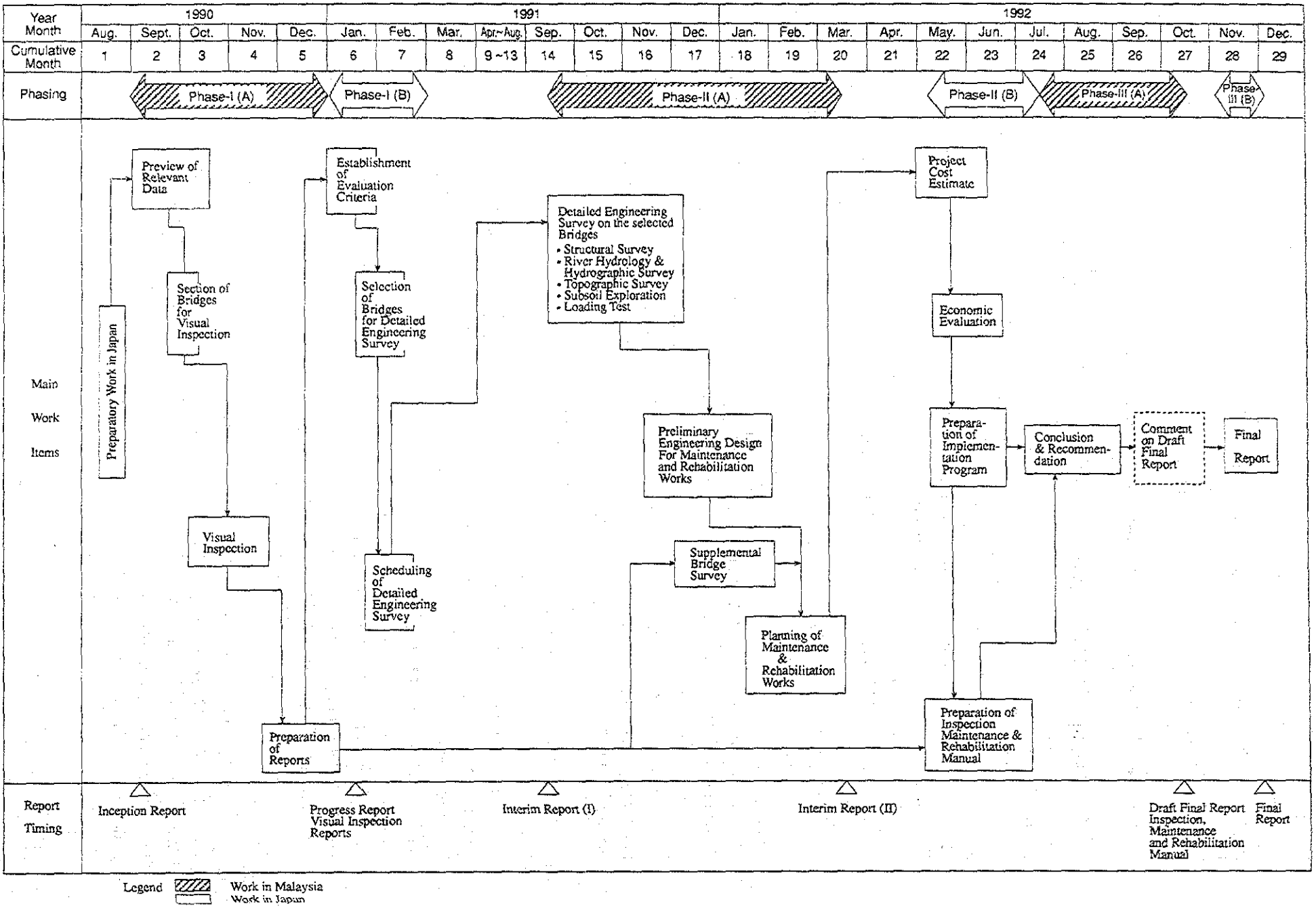
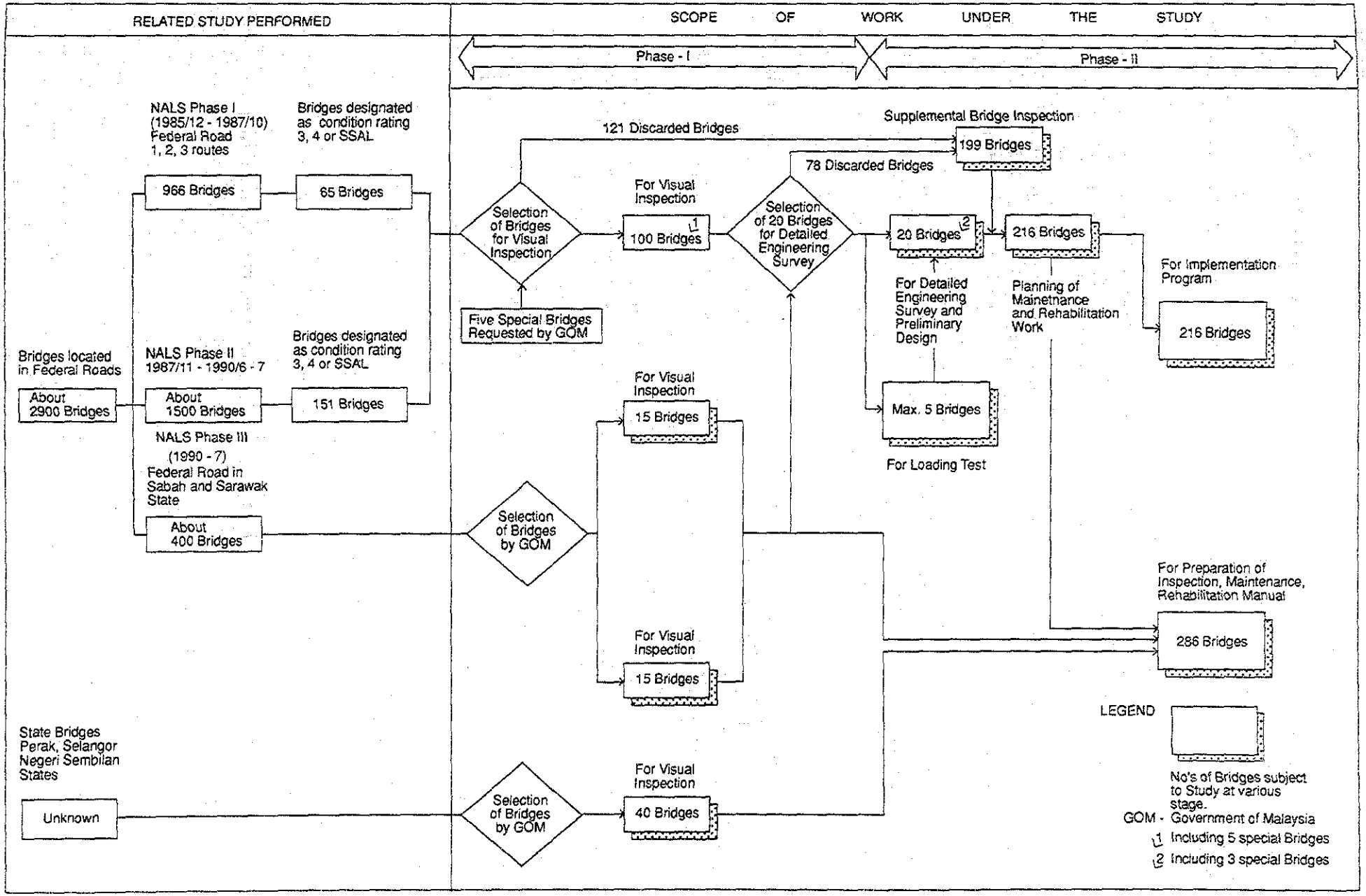
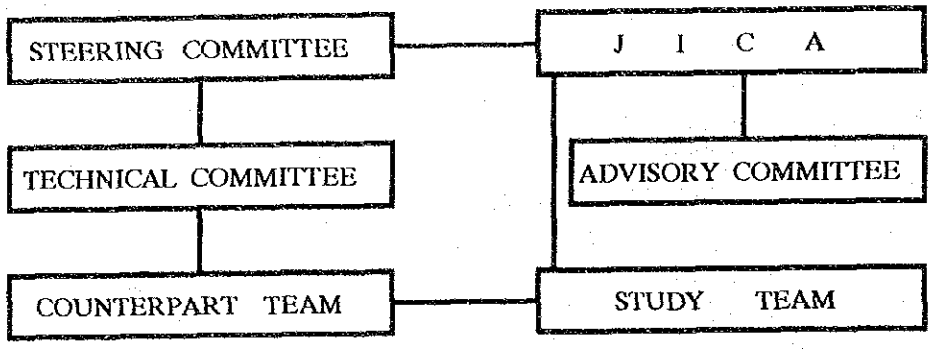


Figure 1-2 No's of Bridges at Various Stages of the Study



The interrelationships between the above mentioned Committees and Teams are shown in Figure 1-3.

Figure 1-3 Study Organization



Members of the Steering Committee, Technical Committee, Counterpart Team, JICA, Advisory Committee, and Study Team are listed in Appendix-A.

1.6 Composition of Final Report

The final report contains summarized findings and recommendation, followed by the results of all the works carried out including field survey, all the structural assessment, cost estimates, and economic evaluation.

The final report consists of four volumes as listed below:

Volume I	Executive Summary
Volume II	Main Text
Volume III	Appendixes
Volume IV	Drawings

In addition to the above, a bridge inspection, maintenance and rehabilitation manual was prepared as a separate booklet and submitted to GOM.

1.7 Major Meetings Held

During the whole study period, the following major meetings were held in Malaysia and the minutes of each meeting is attached in Appendix-B.

	Meeting	Date	Main Subjects
The First	Technical Committee	September 10, 1990	The Inception Report
The First	Steering Committee	September 12, 1990	The Inception Report
The Second	Technical Committee	December 18, 1990	The Progress Report & Visual Inspection Report
The Third	Technical Committee	September 19, 1991	The Interim Report (I)
The Second	Steering Committee	September 23, 1991	The Interim Report (I)
The Fourth	Technical Committee	March 7, 1992	The Interim Report (II)
The Third	Steering Committee	March 11, 1992	The Interim Report (II)
The Fifth	Technical Committee	October 6, 1992	Draft Final Report & Manual
The Fourth	Steering Committee	October 9, 1992	Draft Final Report & Manual