CHAPTER 3 EXISTING CONDITION OF BRIDGES AND STATUS OF BRIDGE MAINTENANCE

3.1 Outline of Bridges in Costa Rica

The total length of the road network in Costa Rica is approximately 35,000 km and some of it consists of international trunk roads (e.g., the Pan-American Highway). Land transport accounts for a vast majority of the total transport in Central America due to it being much more cost effective than either air or marine modes of travel. Therefore, strengthening and improving the road network is crucial for regional development. In addition, some trunk roads have no alternative routes due to topographical constraints. Therefore, negative social and economic impacts will be enormous for not only Costa Rica but also for the whole of Central America if these roads are not improved and well maintained.

On the other hand, most of the current bridges, which are total of 1,330, on the national highway suffer from damage due to a lack of maintenance work and rehabilitation. Moreover, natural disasters such as floods and earthquakes frequently strike the country just like Japan.

Costa Rica's National Highway has 3 categories classified as following:

- Class 1 : Route No 1 to 100
- Class 2 : Route No. 101 to 300
- Class 3 : Route No. 301 and over

MOPT has made a Bridge Inventory for every national highway routes and recorded each location, length, width, river name, traffic Volume and type of bridges. However, the information for the bridges in the bridge inventory data are not enough for the maintenance or management of bridges. For example, the types of bridges are recorded as only "Concrete" or "Steel". Therefore, it is impossible to understand detailed information for the bridges such as structure type and number of spans of bridges. CONAVI, which is in charge of making the budget and decisions for maintenance and rehabilitation of bridges, does no have its own bridge inventory data, and uses the data from MOPT.

According to this inventory and information kept in MOPT, the outlines of bridges on national highway in Costa Rica are the followings:

- About 81 percent of the bridges on national highway roads are concrete bridge types.
- In Class 1 road, the maximum length of a Bridge is 790 m located on route 18.
- The range of bridge length on the Class 1 is from 10 m to 200 m and the distribution of lengths of bridges is wider than other classes.
- In Class 2 road, the maximum length of a Bridge is 198 m located on Route 237.
- The lengths of the bridges on Class 2 and Class 3 roads are mostly less than 50 m.
- The widths of the bridges are from 5 m to 10 m wide and are mostly more than 7 m.
- The widths of the bridges do not depend on their classes of road.

Table 3.1.1 shows the outline of bridges in study route and Figure 3.1.1 and Figure 3.1.2 shows the distribution of width and length of each class road in Costa Rica.

Table 3.1.1. Number of Bridges in Study Route

Route	Concrete	Steel	Wood	No Bridge	Total (Study Bridges)
1	67 (4)	15 (4)	0	0	82 (8)
2	69 (3)	8 (5)	0	0	77 (8)
4	45 (1)	5 (1)	0	1	51 (3)
32	57 (8)	1 (1)	0	0	57 (9)
218	3 (1)	1 (0)	0	0	4 (1)
Others	843	134	72	10	1,059 (0)
Total	1,084 (17)	163 (12)	72	11	1,330 (29)

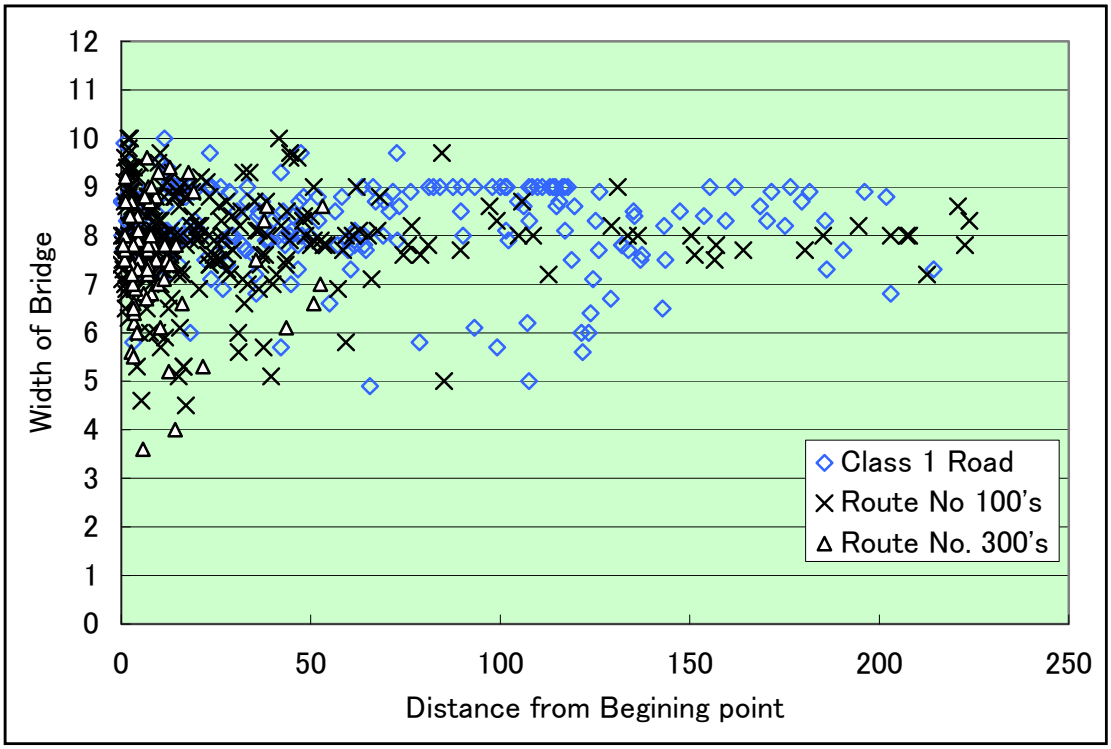


Figure 3.1.1. Distribution of Bridge Width

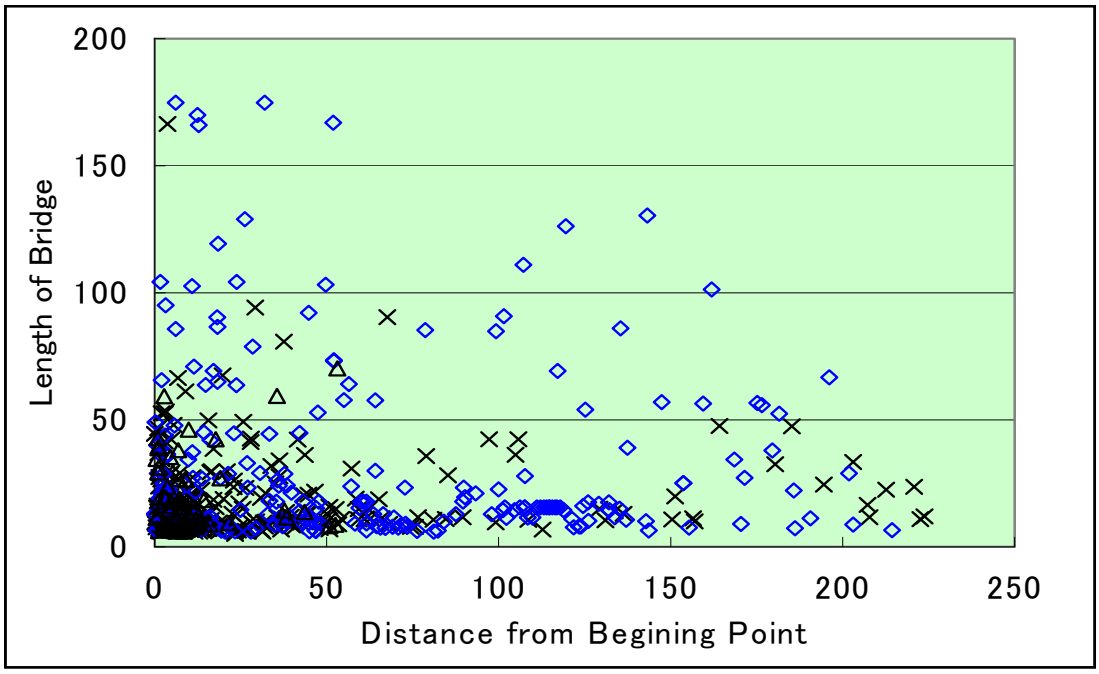


Figure 3.1.2. Distribution of Bridge Length

3.2 Bridge Design Standards

The American Association of State Highway and Transportation Officials (AASHTO) is adopted for the bridge design standard for the bridges on the national highway roads in Costa Rica. The design criteria for the bridges are as follows.

3.2.1 Design Load

1) Dead Load

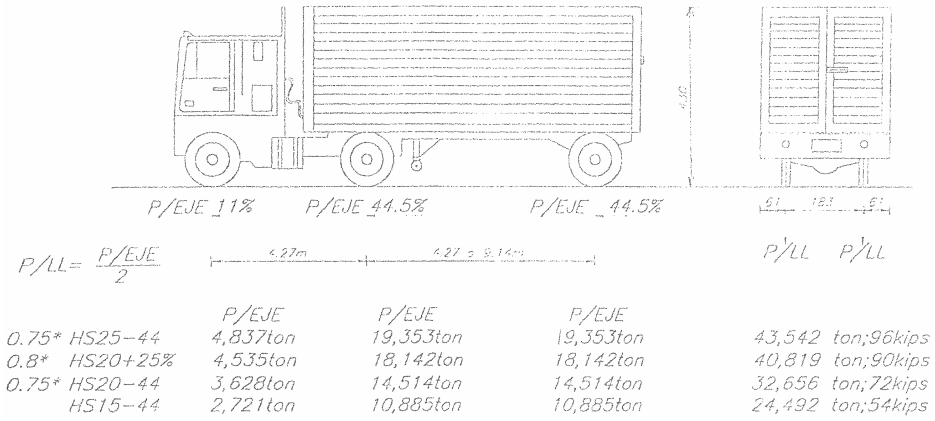
Table 3.2.1. Dead Load

Material	Weight (kN/m^3)
Steel	77.00
Reinforced Concrete	23.54
Plain Concrete	23.00
Asphalt	18.64

2) Live Load

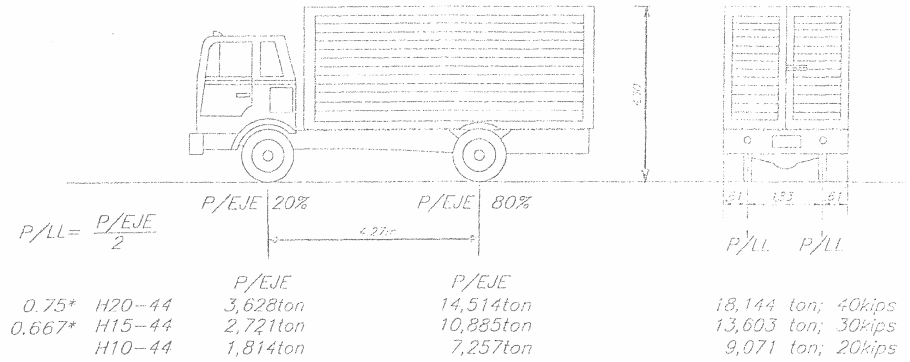
Principal Line : HS20 and HS20+25%
Local Line : HS15

The highway live load on the roadways of bridges or incidental structures shall consist of standard trucks or lane loads that are equivalent to truck trains. Two systems of loadings are applied; the H loadings and the HS loadings- the HS load are heavier than the corresponding H loadings. The criteria for the live load is available on the article 3.7 of AASHTO. Actually in Costa Rica the live loads of bridges have been incremented twenty five percent due to an agreement between the governments of Central America permit the increment of truck's load.



	P/EJE	P/EJE	P/EJE	
0.75* HS25-44	4,837ton	19,353ton	19,353ton	43,542 ton;96kips
0.8* HS20+25%	4,535ton	18,142ton	18,142ton	40,819 ton;90kips
0.75* HS20-44	3,628ton	14,514ton	14,514ton	32,656 ton;72kips
HS15-44	2,721ton	10,885ton	10,885ton	24,492 ton;54kips

Figure 3.2.1. Standard HS Trucks (Costa Rica)



	P/EJE	P/EJE	
0.75* H20-44	3,628ton	14,514ton	18,144 ton; 40kips
0.667* H15-44	2,721ton	10,885ton	13,603 ton; 30kips
H10-44	1,814ton	7,257ton	9,071 ton; 20kips

Figure 3.2.2 Standard H Trucks (Costa Rica)

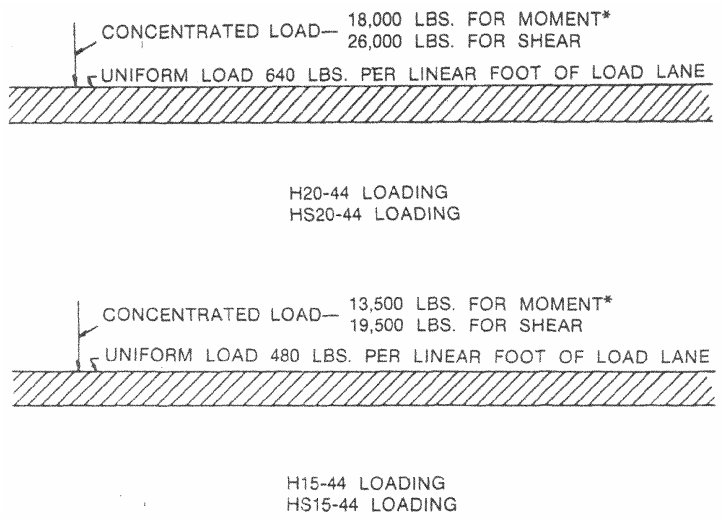


Figure 3.2.3. Lane Loading (AASHTO)

3) Impact

The amount of the impact allowance or increment is expressed as a fraction of the live load stress, and shall be determined by the formula:

$$I = \frac{50}{L + 125}$$

in which, I = impact fraction (maximum 30 percent);
L= length in feet of the portion of the span that is loaded to produce the maximum stress in the member.

4) Wind

The bridges are designed with article 3.15 of the AASHTO, the forces and loads given herein are for a base wind velocity of 100 miles per hour. The wind load shall consist of moving uniformly distributed loads to the exposed area of the structure. The exposed area shall be the sum of the areas of all members, including floor system and railing, as seen in elevation at 90 degrees to the longitudinal axis of the structure. Furthermore in Costa Rica, the rules from the Urban Code are only available for all type of construction except bridges, transmission lines and other because its structural concepts require a specific analysis to consider forces of the type of air elastic vibrations. The Urban Code has the wind load for structures designed in front of the sea or in the city

5) Earthquake

Costa Rica is one of the countries where the earthquakes often occur. Some of the buildings and bridges have damaged by the earthquakes. A seismic force is one of the important factors for the design of structures such as buildings, bridges and other structures in Costa Rica. So they have a Seismic Code that gives the rules, recommendations and construction practices in order to design the seismic-resistance buildings. However, this Seismic Code can be applied only for buildings and not for bridges.

The Standard Specifications of American Association of State Highway and Transportation Officials (AASHTO) have been applied for the seismic design of bridges. The seismic forces are considered as elastic in the code of AASHTO. To apply the formulas for bridge seismic design from AASHTO it is required to make some conversions of the seismic forces. To obtain the coefficient of seismic acceleration (A), AASHTO uses contour maps of elastic acceleration values, in the Costa Rican case there is a top-effective acceleration table for each specific zone which is found in the Table 2.2 of the Seismic Code of Costa Rica., which is divided with the value of γ in Table 3.22.1A of the AASHTO code. Therefore the value of the coefficient of Seismic Acceleration used in AASHTO is obtained for a Load Factor design.

6) Collision

Collision Load has not been considered. Only their railings are designed for the primary purpose to contain the average vehicle using the structure, so the collision is already considered.

7) Thermal

Normally Costa Rica doesn't have extreme changes of temperature, but it has been considered the typical design conditions in the sideways with constructions joints and in the superstructure with the expansion joints. In case of very important structures special studies are required to considered thermal conditions.

8) Combination Load

The formulas from the table 3.22.1A of the Standard Specifications for Highways Bridges of the AASHTO have been applied.

Table 3.2.2. Table of Coefficients γ and β (AASHTO :Table 3.22.1A)

COL. No.		1	2	3	3A	4	5	6	7	8	9	10	11	12	13	14	
Group		γ	β Factors														
			D	$(L+I)_n$	$(L+I)_p$	CF	E	B	SF	W	WL	LF	R+S+T	EQ	ICE	%	
Service Load	I	1.0	1	1	0	1	β_E	1	1	0	0	0	0	0	0	100	
	IA	1.0	1	2	0	0	0	0	0	0	0	0	0	0	0	150	
	IB	1.0	1	0	1	1	β_E	1	1	0	0	0	0	0	0	**	
	II	1.0	1	0	0	0	1	1	1	1	0	0	0	0	0	125	
	III	1.0	1	1	0	1	β_E	1	1	0.3	1	1	0	0	0	125	
	IV	1.0	1	1	0	1	β_E	1	1	0	0	0	1	0	0	125	
	V	1.0	1	0	0	0	1	1	1	1	0	0	1	0	0	140	
	VI	1.0	1	1	0	1	β_E	1	1	0.3	1	1	1	0	0	140	
	VII	1.0	1	0	0	0	1	1	1	0	0	0	0	1	0	133	
	VIII	1.0	1	1	0	1	1	1	1	0	0	0	0	0	1	140	
	IX	1.0	1	0	0	0	1	1	1	1	0	0	0	0	1	150	
	X	1.0	1	1	0	0	β_E	0	0	0	0	0	0	0	0	100	Culvert
Load Factor Desing	I	1.3	β_D	1,67*	0	1.0	β_E	1	1	0	0	0	0	0	0	Not Applicable	
	IA	1.3	β_D	2.20	0	0	0	0	0	0	0	0	0	0	0		
	IB	1.3	β_D	0	1	1.0	β_E	1	1	0	0	0	0	0	0		
	II	1.3	β_D	0	0	0	β_E	1	1	1	0	0	0	0	0		
	III	1.3	β_D	1	0	1	β_E	1	1	0.3	1	1	0	0	0		
	IV	1.3	β_D	1	0	1	β_E	1	1	0	0	0	1	0	0		
	V	1.25	β_D	0	0	0	β_E	1	1	1	0	0	1	0	0		
	VI	1.25	β_D	1	0	1	β_E	1	1	0.3	1	1	1	0	0		
	VII	1.3	β_D	0	0	0	β_E	1	1	0	0	0	0	1	0		
	VIII	1.3	β_D	1	0	1	β_E	1	1	0	0	0	0	0	1		
	IX	1.20	β_D	0	0	0	β_E	1	1	1	0	0	0	0	1		
	X	1.30	1	1.67	0	0	β_E	0	0	0	0	0	0	0	0		Culvert

(L+I)n Live Load plus impact for AASHTO Highway H or HS loading
(L+I)p Live load plus impact consistent with the overload criteri of the operation agency

3.2.2 Other Condition

1) Width

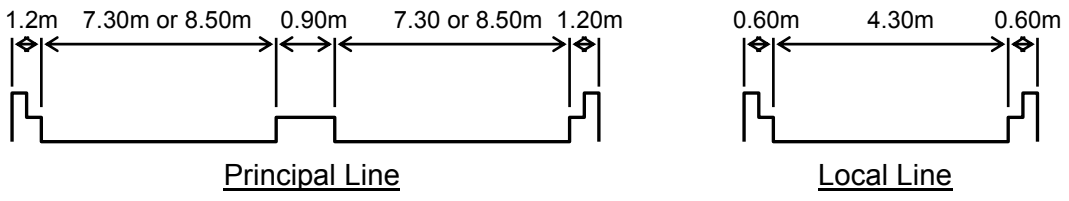


Figure 3.2.4. Road Width

2) Structure Clearance

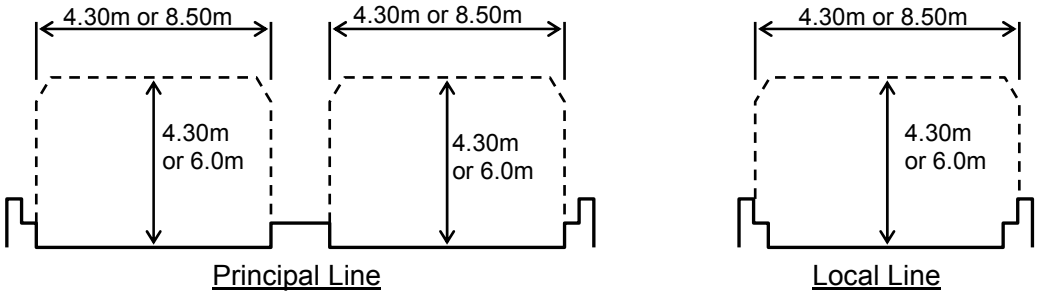


Figure 3.2.5. Structure Clearance

3) Clearance under the Girder

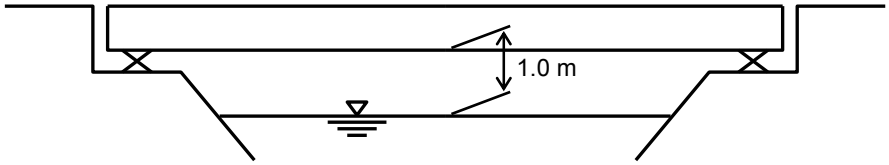


Figure 3.2.6. Clearance under the Girder

4) Material

(1) Steel

Table 3.2.3. Standard of Steel

Designation	M270 Grade 36 (lb/in^2)	M270 Grade 50 (lb/in^2)
Minimum Tensile Strength, Fu	58,000	65,000
Minimum Yield Point or Minimum Yield Strength, Fy	36,000	50,000

(2) Concrete

Table 3.2.4. Standard of Concrete

C:A:P	fc (kg/cm^2)	Cement (kg)	Sand (m^3)	Gravel (m^3)	A/C	Water (L)
1:3:6	105	219.0	0.486	0.972	0.83	20.4
1:2.5:5	140	255.0	0.472	0.944	0.80	19.6
1:2:4	175	306.0	0.456	0.912	0.71	17.0
1:1.5:3	210	382.5	0.427	0.854	0.65	15.7
1:1:2	245	510.0	0.378	0.756	0.58	14.0

Note, C: Cement, A: Sand, P: Gravel

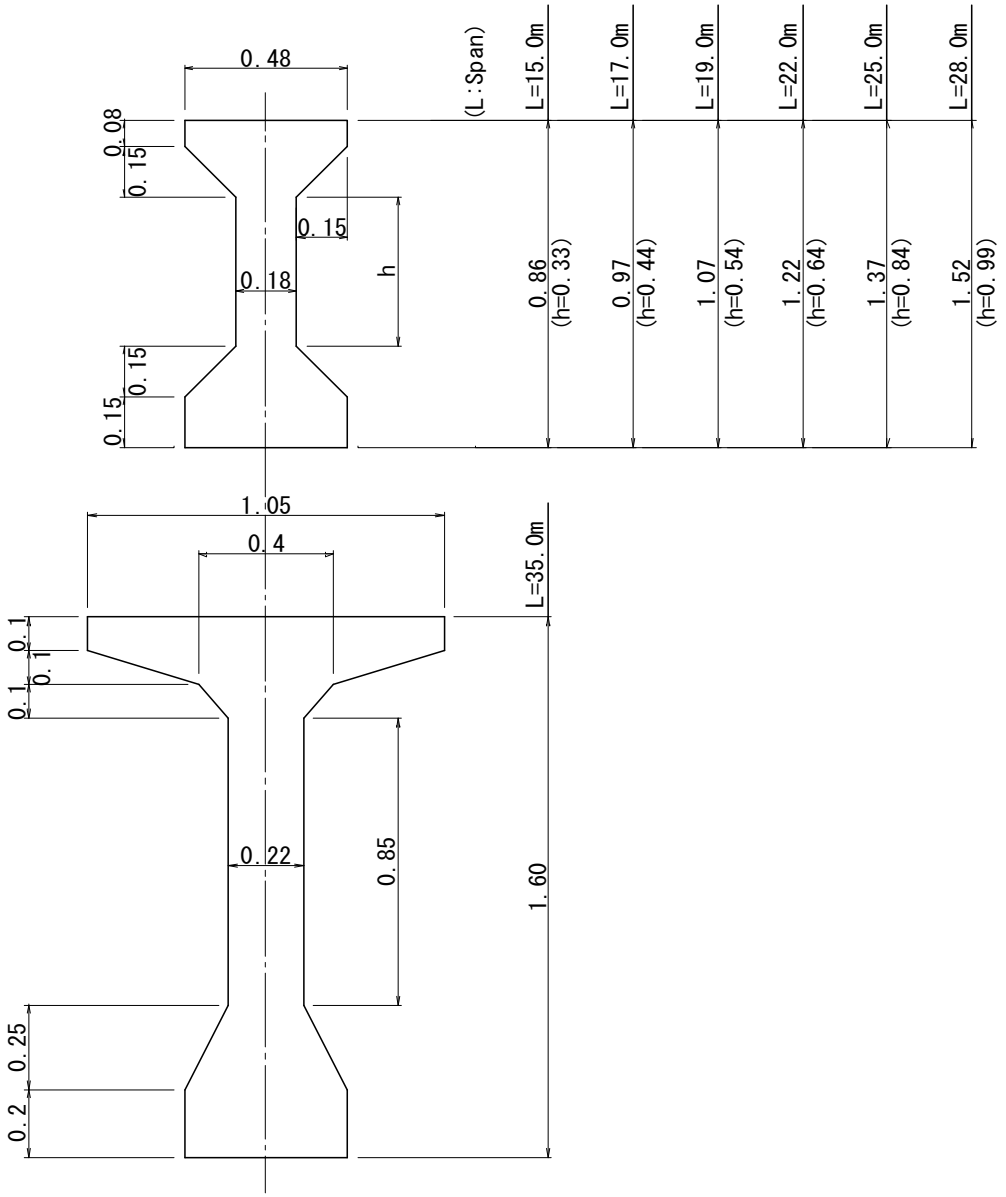


Figure 3.2.7. PCI Standard Bridge Beams (Costa Rica)

(3) Others

The Department of Bridges of the Ministry of Public Works and Transport (MOPT) is almost fifty years; it was founded by the support of American Association of State Highway Officials. Today the majority of design practices are conserved and followed, actually our bridge designs are based on the specifications of that association, for example the current design manual is the Standard Specifications for Highway Bridges 17th Edition-2002.

Inside their design practices it is common to have some standard drawings available for superstructures of different spans and types, for example superstructure like truss, concrete girder, steel I-beam. The same case occurred with the substructures for example standards for massive abutments, wing-walls are available. When they have special conditions, these drawings must be changed with the respective calculations from the design engineer.

Furthermore of the typical process of the structural analysis and design, their common practice is to make an exhausted process of revisions of the final drawings of the specific bridge project. This process consists in a revision of the design and quantities between the design engineer and the revision engineer.

The consultancy to other institutions of the Republic of Costa Rica is part of their job, this consists on the revisions and designs of construction drawings, and inspections of bridges in all the country.

3.3 Bridge Maintenance

3.3.1 Organization for Construction and Maintenance of Bridges

MOPT is in charge of formulating basic policies and executing the construction and maintenance of the national road network as well as bridges through CONAVI or the National Concessions Council (Consejo Nacional de Concesiones-CNC). CONAVI is in charge of the overhaul and maintenance of the existing national road network including bridges, while CNC promotes the new concession scheme for highways and bridges thereon. Besides, the construction and maintenance of roads and bridges at Cantonal (regional) level has been supported through the MOPT-KFW program with the technical assistance of the German Agency for Technical Co-operation (Gesellschaft fr Technische Zusammenarbeit, GTZ) and based on the participatory approach involving the communities.

The number of staff and workers of MOPT is approximately 4,000, and the bridge department under the Division of the Public Works, has 18 staff members and workers is in charge of the technical assistance to the construction and maintenance of bridges. However, there are only 3 qualified professional engineers in the department who can offer the technical services for the bridge design.

The number of staff members and workers of CONAVI is 353 at present, and 145 staff members and workers in the Department of Road Conservation are in charge of the maintenance of the national road network. There are 29 professional engineers in the Department of Road Conservation, and out of those engineers, 28 engineers are contract-based local staff who are inspecting the national road network. Since CONAVI does not have any department in charge of the maintenance of bridges, it receives technical assistance from the bridge department of MOPT. In addition, CONAVI annually receives the priorities of the construction and rehabilitation of the national road network and bridges based on the recommendations of the department of planning of MOPT. However, due to the limitation of the budget, CONAVI is not able to complete all the recommended construction and rehabilitation programs.

Presently, MOPT bids out the construction, overhaul and maintenance of the national road network and bridges to private local and foreign construction companies. The projects are tendered by CONAVI through the government procurement system, and those tenders are announced in the official newspaper *La Gaceta*. The Government of Costa Rica created the Public Works Concession Law, which came into effect in May 1998. This Concession Law is intended to offer the operating concessions for the construction and maintenance of the

national road network including bridges.

For the maintenance and repair of highways and bridges, the Government of Costa Rica also created in 1998 a special tax of 15 percent on the fuel to generate the necessary resources to accomplish this task. CONAVI counts on the income from the special tax, plus toll collection, to undertake the maintenance and repair program of roads and bridges, and it does not depend on the government's annual budget. CONAVI is presently developing bid specifications for the construction and the overhauling of existing roads and bridges, such as the enlargement and modernization of the San Jose-San Ramon highway project (74 km), the Braulio Carrillo highway project San Jose-Guapiles-Limon (200 km), the Radial Zapote Curridabat/Florencio del Castillo highway (22 km), and the Radial Heredia project (7 km).

3.3.2 Bridge Maintenance System in Costa Rica

The Bridge Management System (BMS) in MOPT was established under the project donated by France and was modified by the Planning Department in MOPT in 1988. The CONAVI does not have his own bridge maintenance system and uses the bridge inspection data of BMS in MOPT.

However, the BMS is used mostly for making the Bridge Inventory and only the inspection sheet and the evaluation method described in the BMS are applied for Routine Inspection of bridges on the national roads. The evaluation results are arranged as the maintenance programme, which lists bridges in the order of damaged degree, by the Planning Department of MOPT. This maintenance programme is handed over to CONAVI as the plan of bridge repairing and rehabilitation.

The Department of Planning in MOPT executes the Routine Inspection of bridges on national roads since 10 years ago with the help of four inspectors as one of the parts of the road's facilities when they check the roads. These inspectors are civil engineers and they are not bridge engineering specialists. However, the inspection items listed in the inspection sheets of the BMS request to make rankings of damages for each part of the bridge structure based on the evaluations of the bridge structure engineer.

The Detailed Inspection of bridges are executed by the Department of Bridges Design in MOPT based on their original inspection method, when they are requested from local governments or CONAVI to make a plan for repairing or reinforcing bridges.

1) Routine Inspection

The routine inspection has as an objective to determine the physical condition of the structures. Inspections have been done regularly with the purpose to have up to date the bridge inventories and prepare the maintenance programs.

The inspection and the evaluation have been carried out by the inspector in the Department of Planning of MOPT. The inspectors consist of 4 civil engineers and the assistance of qualified personnel. The decisions to repair, replace, or abandon the structure will be reported by the inspector based on their inspection result (evaluation and comment). The data of bridge inventory are kept in the server of MOPT and updated after inspection results are reported.

Every MOPT member can access to this server by LAN (Local Area Network) system and confirm the inventory. Each bridge is inspected around once per year every three years and its inventory is updated.

According to BMS manual the Bridge Maintenance System consist of three Main Modules, which are Data Module, Action Module and Historical Module and inspection item are shown in Table 3.2.1. At the present, the Data Module, which contains a general inventory of the bridges, is updated regularly and qualifies the bridges according to the physical state.

In this Data Module the state of each of the bridges in the inventory can be consulted, these consultations can be done according to Route, Region, Zone, and Section.

Table 3.3.1. Inspection Item

River bed	Undermining
	Sedimentation
	Vegetation
	Channel Change
	Protections
Substructure	Piles
	Defences
	Undermining Protection
	Abutments
	Anchor
	Footing
Superstructure	Main Members
	Secondary Members and Bracings
	Supports
	Public Service Installation
	Deck ,Deck Slab
	Sidewalks and railings
Miscellaneous	Accesses
	Ligthing
	Signs

Bridges are divided in two main parts, superstructure and substructure. These two basic parts can be divided in structural members, which at the same time are subdivided in each one of its components.

The general procedure to evaluate the bridge conditions would be to fill a number of evaluations for each element or component of the main unities. These points of each evaluation for a bridge are summed up, and the mean point of them is considered to be the point of evaluation of the bridge for the comparison with other bridges. Relationship between number of evaluation and the condition of members are shown Table 3.3.2.

Table 3.3.2. Number of Evaluation and Condition of Members

Evaluation	Description
9	New Condition
8	Good condition, no need of repairs
7	Small repairs by the Maintenance team.
6	Major Repair by the Maintenance Team.
5	Major Repair by contract or by the Maintenance Team
4	Minimum conditions to support the present transit and the immediate rehabilitation to keep it in service are needed.
3	Inadequate to support heavy loads. Requires shutting down the truck transit
2	Inadequate to support live loads of any class. It requires the total shutting of transit.
1	Repairable Bridge, if opening it to transit is desired.
0	Bridge Conditions do not admit any repairs. Danger of Immediate Collapse.

2) Detailed Inspection

The Detailed inspection has been executed by Department of Bridges Design. When they received a request from local government or CONAVI the engineer of Department of Bridges Design has investigated the bridge and recommended the countermeasure.

After that MOPT explains the condition of the requested bridge to local government and the local government judges countermeasure for damaged bridge on MOPT's recommendation and their budget.

The engineer has inspected the damaged bridge, which was requested from the local government by visual inspection using the BRIDGE INSPECTION SHEET.

According to the BRIDGE INSPECTION SHEET, the engineer should inspect six (6) items, which consist of more than twenty (20) parts and commented each part.

Inspection item and parts were shown in Table 3.3.3.

Table 3.3.3. (1) Item of Detailed Inspection

A. DIMENSIONS	B.MATERIALS	C. RIVER / INFERIOR WAY	D. ABUTMENTS:
1. Skew of the bridge: 2. Sidewalk width: 3.Clear width between curbs: (Traffic lane) 4.Clear width between railings: 5.Distance between Abutments: 6.Spanp length: 7.Vertical clearance in the Bridge entrance: 8. Vertical clearance in the inferior portal: 9.Vertical Roadway level in Bridge entrance: 10.Vertical Roadway level in Bridge exit: 11.Normal Water level: 12.Maximum assumed water level: 13.Minimum superstructure level: 14.Asphalt pavement thickness: 15.Length of approach slab in bridge entrance: 16.Length of approach slab in bridge exit: 17.Width of approach slab in bridge entrance: 18.Width of approach slab in bridge exit: 19.Length of the right railing in bridge entrance: 20.Length of the right railing in bridge exit: 21.Length of the left railing in bridge entrance: 22.Length of the left railing in bridge exit: 23.Slab thickness: 24.Shear Key: 25.Support length: 26.Minimum support length:	1.Railings 2.Floor 3.Truss 4.Girder 5.Crossbeam: 6.Abutments: 7.Piers: 8.Curbs: 9.Piles: 10.Pavement: 11.Railings ends: 12.Access Pavement: 13.Transverse Beams:	1. Scour: 2. Erosion in the bank: 3.Sedimentation 4.Vegatation 5.Change of the flow: 6.Protection of the banks: 7.Inferior way:	1.People living there: 2.Scour: 3.Settlement: 4.Piles: 5.Defenses 6.Stone facing: 7.Gabion: 8.Wingwalls: 9.Gravity Abutments: 10.Cracking: 11.Corrosion in the steel: 12.Corrosion in the concrete 13.Rotten wood 14.Paint 15.Damage by collision 16.Drainage: 17.Anchor bolts 18.Bearing Plate: 19.Beam Ledge: 20.Back wall: 21.Superstructure embedded in the Abutment: 22.Exposed web wall: 23.Shear Keys:

Table 3.3.3. (2) Item of Detailed Inspection

E. PIERS:	F. SUPERESTRUCTURE:		G. ACCESS:
1.Scour 2.Settlement: 3.Piles: 4.Defenses 5.Corrosion in the steel: 6.Corrosion of the concrete: 7.Rotten wood: 8.Paint: 9.Anchor bolts: 10.Bearing plate: 11.Beam Ledge: 12.Step of the Piers Caps: 13.Columna Cracked: 14.Girder cracked: 15.Angle of attack between flow and pier: 16.Exposed web wall: 17.Damage by collision:	**1.Truss: Pony,Acrow. U:S:S: angles** 2. Simple Spans: 3.Continuos Span: 4.Slab: 5.chute beams: 6. T Beams: 7.Arch: 8.Timber Truss: 9.Expantion joints: 10.Diaphragms: 11.Lower chord 12.Upper chord 13.Transversal beams 14.Cleam Bearings 15.Corrosion in the Bearings: 16.Elastomeric Bearing: 17.Portals in the Bridge entrance: 18.Internal portals: 19.Upper chord: 20.Lower chord: 21.Conexions: 22.Rivet or Bolts: 23.Welding: 24.Corrosión del acero 25.Anchorage 26.Towers 27.Cables 28.Fall-line carrier: 29, Rotten wood: 30.Concret cracked 31.Slab	**32.Floor:** 33.Damage by collision 34.Deflection under load: 35.Vibration under load: 36.Paint: 37.Alignment of the member 38.Public service installation: Water pipe: Electrical Cables Phone cables duct: 39.Curbs: 40.Sidewalks: 41.Railings: 42.Cleam drainage: 43.Put drainage ducts: 44.Water filtration: 45.Pavement condition: 46.Illumination 47.Traffic Signals	1.Pavements 2.Backfill Settement: 3.Joints 4.Finishing railings: 5.Alignment: 6.Scour: 7.Sank access:

CHAPTER 4 CAPACITY GAP ASSESSMENT

4.1 Objectives and Procedures of Capacity Gap Assessment

Capacity gap assessment is defined as a process through which the stakeholders confirm their goals, map their existing capacities and identify the gaps between their available capacities and those needed to meet their goals. A successful capacity assessment exercise requires the full involvement of the stakeholders in a consultative process. The major objective of the capacity gap assessment is to comprehensively evaluate the quantitative and qualitative gap between the ideal situation and the status quo in terms of the bridge maintenance for the purpose of identifying the bottleneck against the ideal bridge maintenance system. The image of the capacity gap assessment is illustrated as below.

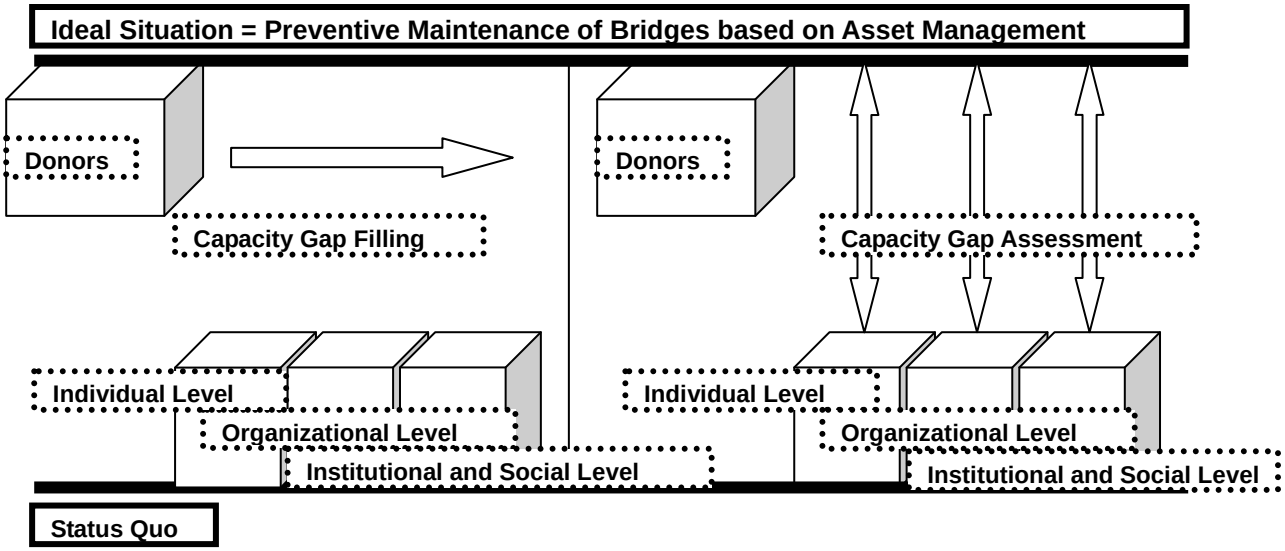


Figure 4.1.1. Image Illustration of Capacity Gap Assessment (Individual Level)

The full-scale capacity gap assessment was jointly conducted with counterpart officials of MOPT and CONAVI. The major objective of the full-scale capacity gap assessment is to evaluate the quantitative and qualitative gap between the ideal situation and the present situation in terms of the bridge maintenance, thereby identifying the bottleneck against the ideal bridge maintenance system.

The ideal bridge maintenance system derives from a sort of preventive maintenance of bridges based on the concept of *"Asset Management"* which is an overall and strategic management system for social infrastructure to keep the maintenance service level satisfactory and to maximize the benefits of users under the limited budget. In other words, *"Asset Management"* represents a holistic and systematic approach to asset preservation which ensures maximum service performance at minimum life-cycle costs.

The procedures for the capacity gap assessment include the following 6 steps.

- Designing capacity gap assessment score sheets
- Interviews and collection of data/information from relevant stakeholders
- Preliminary assessment of capacity gaps
- Full-scale assessment of capacity gaps

- PCM (Project Cycle Management) analysis including the problem analysis and the objective analysis to solve the bottleneck against the ideal bridge management
- Formulation of basic policies and action plans including the PDMs (Project Design Matrix) of the required module projects for the ideal bridge management

Stakeholders to be interviewed in the capacity gap assessment include a wide range of individuals and organizations related to inspection, diagnosis, operation of BMS, planning and implementation of the bridge maintenance and rehabilitation. The qualitative and quantitative degree of the gap between the required capacity and the present capacity at individual, organizational, institutional and social levels was comprehensively assessed by using 5-grade score sheets. Those 5-grade score sheets for the capacity gap assessment were designed so as to evaluate the degree of the gap.

Capacities at the individual level include relevant officials' i) knowledge and practical skills/experiences for inspection, diagnosis, operation of BMS, planning and implementation of repair and rehabilitation, and ii) management and responsiveness for preventive bridge maintenance.

Table 4.1.1. Capacity Gap Assessment Score Sheet (Individual Level)

No.		Items	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
1		Relevant officials' knowledge and practical skills/experiences					
	1-a	Knowledge and skills/practical experiences for inspection and diagnosis					
	1-b	Knowledge and skills/practical experiences for operation and management of BMS					
	1-c	Knowledge and skills/practical experiences for planning of repair and rehabilitation					
	1-d	Knowledge and skills/practical experiences for cost estimates, bidding and supervision					
	1-e	Knowledge and skills/practical experiences for environmental consideration					
2		Relevant officials' managerial skills and responsiveness for bridge maintenance					
	2-a	Planning and management capacity for budget control					
	2-b	Planning and managerial capacity for human resources					
	2-c	Short-term and long-term planning for bridge maintenance					
	2-d	Communication capacity for regular activities					
	2-e	Understanding on preventive maintenance and responsible mind for bridge maintenance					

Note: Grade 1 = Far from the required level, Grade 2 = Limited level, Grade 3 = Satisfactory not up to the required level, Grade 4 = Satisfactory to a certain level, Grade 5 = Completely satisfactory level

Capacities at the organizational level include i) organizational performance (functions, number of qualified staff, decision-making mechanism, coordination abilities, incentive system, personnel management, etc.), ii) financial and outsourcing system (amount and allocation of budget for bridge maintenance and rehabilitation, and contracting system for bridge maintenance and rehabilitation), and iii) physical and intellectual assets for bridge maintenance and rehabilitation.

Table 4.1.2. Capacity Gap Assessment Score Sheet (Organizational Level)

No.		Items	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
3		Organizational functions and performance					
	3-a	Organizational structure for bridge maintenance					
	3-b	Balanced demarcation of responsibilities and functions and mechanisms at the central and provincial levels					
	3-c	Overall organizational functions such as decision-making mechanism					
	3-d	Number of qualified staff and personnel management					
	3-e	Personnel Incentive system for qualified staff					
4		Financial resources and outsourcing system					
	4-a	Amount and allocation of recurrent and indirect cost for bridge maintenance					
	4-b	Amount and allocation of direct maintenance and rehabilitation cost					
	4-c	Outsourcing and contracting system					
	4-d	Standards for cost estimates and technical specifications for outsourcing					
	4-e	Capacity level of private sector					
5		Physical and intellectual assets					
	5-a	Physical assets for bridge maintenance and rehabilitation (inspection equipment, repair facilities, etc.)					
	5-b	Physical assets for regular activities (office equipment, etc.)					
	5-c	Intellectual assets for bridge maintenance and rehabilitation (Manuals and database)					
	5-d	BMS and other software for bridge maintenance					
	5-e	Technical standards for bridge maintenance					

Note: Grade 1 = Far from the required level, Grade 2 = Limited level, Grade 3 = Satisfactory not up to the required level, Grade 4 = Satisfactory to a certain level, Grade 5 = Completely satisfactory level

Capacities at the institutional and social levels include i) existence of policies, laws, regulations and standards for preventive maintenance of bridges, and ii) social understanding of preventive maintenance of bridges and knowledge management.

Table 4.1.3. Capacity Gap Assessment Score Sheet (Institutional and Social Level)

No.		Items	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
6		Existence of policies, laws, regulations and standards for preventive maintenance of bridges					
	6-a	Understanding and awareness of preventive maintenance of bridges among politicians and high-ranking officials					
	6-b	Understanding and awareness of preventive maintenance of bridges among financial and planning authorities					
	6-c	Enforcement of laws, regulations and standards on inspection and diagnosis for bridges					
	6-d	Enforcement of laws, regulations and standards on design for bridges					
	6-e	Enforcement of laws, regulations and standards on traffic control for bridges					
7		Social understanding and awareness of preventive maintenance of bridges and knowledge management					
	7-a	Understanding of preventive maintenance of bridges among academic circles					
	7-b	Understanding of preventive maintenance of bridges among ordinary citizens and drivers					
	7-c	Partnership on domestic exchange of technical information between public sector and private sector					
	7-d	Partnership on domestic exchange of technical information between public sector and academic circle					
	7-e	Partnership and collaboration on overseas exchange of technical information					

Note: Grade 1 = Far from the required level, Grade 2 = Limited level, Grade 3 = Satisfactory not up to the required level, Grade 4 = Satisfactory to a certain level, Grade 5 = Completely satisfactory level

4.2 Results of Full-scale Capacity Gap Assessment

4.2.1 Governmental Organizations

1) MOPT and Its Relevant Departments

The MOPT is in charge of formulating basic policies and executing the construction and maintenance of the national road network as well as bridges through CONAVI and CNC. MOPT plays a central role for the technical services in the field of the construction and maintenance of national roads and bridges thereon. Since CONAVI does not have professional bridge engineers, the Bridge Department, which belongs to the direction of public works of MOPT, is only organization in a position to provide technical services on bridge designing, while the direction of planning, which directly belongs to the Minister, is in charge of maintaining the database for bridges.

The Bridge Department of MOPT is composed of 18 staff and workers, and, out of these staff and workers, there are only one senior bridge engineer and 3 bridge engineers who have expertise in the field of the bridge engineering. Those engineers are providing technical services to CONAVI on ad-hoc basis, when CONAVI requests the preliminary design of bridges for biddings to the private sector in case of large-scale projects and the full-scale design of bridges in case of small-scale projects. When special inspections of bridges are needed, the Bridge Department will dispatch the team of engineers and topographers to the sites on demand basis.

Table 4.2.1. List of Staff in Bridge Department

No.	Position	Responsibility	Years Working at MOPT
1	Department Chief	Supervising	15
2	Design Engineer	Structural Design	8
3	Design Engineer	Structural Design	6
4	Design Engineer	Structural Design	3
5	Draftsman	Auto CAD Operator	30
6	Draftsman	Auto CAD Operator	16
7	Draftsman	Auto CAD Operator	4
8	Draftsman	Auto CAD Operator	3
9	Technician	Preliminary Design	34
10	Technician	Preliminary Design	16
11	Technician	Preliminary Design	4
12	Chief Topographer	Topography Group	33
13	Topographer	Topography Group	17
14	Topographer	Topography Group	26
15	Topographer	Topography Group	15
16	Topographer	Topography Group	26
17	Secretary	Office Coordination	19
18	Miscellaneous	Mail Delivery and Cleaning	1

Source: MOPT, Bridge Department

The total budget of MOPT for the financial year 2005 is 102,776 million Colones, and the budget allocated for the Bridge Department occupies only 0.95% of all. The salaries for staff and workers occupy 92.2% of the total budget of the Bridge Department, and there are almost no financial resources for the regular inspection activities for bridges on the national highway network.

Table 4.2.2. Budget of MOPT for FY 2005

Organization	Budget for FY 2005 (million Colones)	%
MOPT Total	102,776	100.0
Division of Public Works	11,267	11.0
Bridge Department	148	0.95

Source: MOPT, Financial Department

Table 4.2.3. Budget of Bridge Department Budget for FY 2005

Item	Budget for FY 2005 (thousand Colones)	%
Bridge Department Total	148,049	100.0
Salaries	136,441	92.2
Trip Expenses for Inspection	1,967	1.3
Others	9,641	6.5

Source: MOPT, Bridge Department

Salaries for staff and workers of MOPT are not generally linked with individual capacities and efficiency, and the annual increase in the basic salary is fixed regardless of capacity of each staff and worker. For example, the average annual increase in the basic salary from the financial year 2005 to 2006 approximately stands at 1.94% for MOPT officials. The below table shows examples of the level of salaries for the financial year 2005.

Table 4.2.4. Level of Salaries for MOPT Officials (FY 2005)

No.	Organization	Class	Estimated Basic Monthly Salary 2005 (Colones)	Level (Office Worker = 100)
1	MOPT	Senior Professional Staff	292,850	235.9
2	MOPT	Professional Staff	236,250	190.3
3	MOPT	Technical Professional Staff	184,050	148.2
4	MOPT	Professional Staff	131,350	105.8
5	MOPT	Office Worker	124,150	100.0

Source: Personnel Department of MOPT, 2005

While there are considerable training opportunities for the existing road management system such as SPEM and SIGVI provided by MOPT, there are almost no training opportunities in the field of bridge maintenance such as the operation of BMS. As a result, understanding and awareness of the concept of preventive maintenance of bridges such as *"Asset Management"* and *"Life Cycle Cost"* is not enough among the officials of the Bridge Department of MOPT.

Table 4.2.5. Road-related Training Programme by MOPT (2005)

No.	Road-related Training Programme by MOPT	No. of Training Programmes	Duration
1	Road Maintenance and Preservation	2	35 hours
2	Auto CAD	1	30 hours
3	SPEM	47	844 hours
4	SIGVI	1	16 hours
	Total	51	925 hours

Source: Human Resources Development Department of MOPT, 2005

Table 4.2.6. Availability of Intellectual Assets for Bridge Maintenance and Understanding of Preventive Maintenance by Officials of Bridge Department of MOPT

No.	Item	Availability and Understanding
1	Availability of SAP	Available
2	Availability of Auto CAD	Available
3	Availability of Shummit Hammer	Not Available
4	Understanding on Asset Management	Not Understand
5	Understanding on Life Cycle Cost	Not Understand

Source: Results of Interviews with Private Contractors

2) CONAVI

Law No. 7798 of the Creation of CONAVI in May 1998 stipulates the responsibilities and functions of CONAVI who is in charge of regulating the construction and conservation of the national road network and bridges. The law also refers to a wide range of repair and rehabilitative activities such as i) conservation, ii) routine maintenance, iii) periodical maintenance, iv) improvement, and v) rehabilitation which cover the national road network and bridges, although the bridge maintenance is a minor part of those activities for CONAVI.

The Direction of Road Conservation of CONAVI is in charge of programming, coordinating and supervising of the construction, rehabilitation and maintenance of the national road network, including supervising and managing the contracts with the private sector. More specifically, the missions of the Direction of Road Conservation include:

- to propose programmes of the construction and conservation of the national road network; including the budget, equipment and human resources required to accomplish the programme;
- to prepare technical specifications for specific projects under the programmes;
- to periodically inspect roads and bridges on the national road network;
- to execute the road and bridge maintenance on the national road network including the emergency rehabilitations; and
- to verify and control the quality of the asphalt mix to be used on the national road network

The below table shows the list of staff for the Direction of Road Conservation. There are contracted-based 28 professional engineers and 94 technical staff in the regional offices of CONAVI, and they are engaged in the regular inspection of the national road network. However, due to the fact that they have no expertise in the field of the inspection and maintenance of bridges, there are insufficient inspection activities on bridges by CONAVI.

Table 4.2.7. Direction of Road Conservation of CONAVI

No.	Personnel	CONAVI	Seconded from MOPT	Contract-based	Total
1	Department Chief				
2	Executive	1			1
3	Professional Staff	1		28	29
4	Technical Staff			94	94
5	Administrative Staff			19	19
6	Workers	1			1
Total		3		141	145

Source: Estructura Basia del Plan Annual Operativo 2006

Meanwhile, the Direction of Engineering of CONAVI is responsible for the technical assistance to the Direction of Road Conservation, elaborating the bidding specifications for periodical maintenance, rehabilitation and construction of roads and bridges. More specifically, its principal functions are:

- To make bidding preparations for periodical, improvement, rehabilitation, reconstruction, amplification and new construction of roads, bridges, intersections and other road engineering projects;
- To make bidding preparations for contracting engineering consultants such as transport planning, geotechnical engineering, hydrological studies, environmental studies and others; and
- To provide technical assistance for the evaluation in bidding processes for designing, supervision, construction, and geotechnical studies on roads and bridges.

There are only 6 professional engineers whose main expertise is the construction and conservation of roads.

Table 4.2.8. Direction of Engineering of CONAVI

No.	Personnel	CONAVI	Seconded from MOPT	Contract-based	Total
1	Department Chief				
2	Executive	2			2
3	Professional Staff	6			6
4	Technical Staff				
5	Administrative Staff	1		1	2
6	Workers	1			1
Total		10		1	11

Source: Estructura Basia del Plan Annual Operativo 2006

The Direction of Works is responsible for coordinating, administering and supervising rehabilitation, reconstruction and new construction works in the national road network, having 9 professional, 38 technical and 4 administrative staff seconded from MOPT.

Table 4.2.9. Direction of Works of CONAVI

No.	Personnel	CONAVI	Seconded from MOPT	Contract-based	Total
1	Department Chief				
2	Executive	2			2
3	Professional Staff		9		9
4	Technical Staff		38	2	40
5	Administrative Staff	1	4	4	9
6	Workers	1	9	0	10
Total		4	60	6	70

Source: Estructura Basia del Plan Annual Operativo 2006

According to *the Law No. 8114 and Decree No. 30263-MOPT in July 2001*, 30% of the fuel tax is distributed to the construction and maintenance of the road network of Costa Rica in the following way.

Out of the total value of the transferred fuel tax, 25% is allocated for the construction and

maintenance of the Cantonal road network which is being supported by the KFW-GTZ programme, 72% is for the construction and maintenance of the national highway network, and 3% is for the technical assistance to CONAVI by the National Laboratory of Materials and Structural Models (LANAMME). However, CONAVI recently complains that the Ministry of Finance allocates only half of the amount which it has the right to be allocated.

The total budget of CONAVI for the financial year 2006 is projected at 38,021 million Colones, and 34.0% of the total budget is allocated for the conservation of roads and bridges. Only 9.0% of the construction and conservation budget for roads and bridges is allocated for the rehabilitation of bridges, and almost nothing is allocated for the regular inspection activities of bridges. The annual programme for the construction and maintenance of roads and bridges recommended by the Direction of Planning of MOPT does not fully consider the financial limit of CONAVI. At the same time, in 2005, the actual revenue from the transferred value of the fuel tax directed for CONAVI stood at only 50.9% of what the Ministry of Finance should provide for CONAVI.

Table 4.2.10. Budget of CONAVI for FY 2006

Item	Total Budget for FY 2006	Administration (Programme 1)	Road and Bridge Conservation (Programme 2)	Road and Bridge Construction (Programme 3)	Toll Road Construction (Programme 4)
Million Colones	38,021	1,365	12,912	17,914	5,830
%	100.0	3.6	34.0	47.1	15.3

Source: Estructura Basia del Plan Annual Operativo 2006

Salaries for staff and workers of CONAVI stand at the same level as MOPT, and are also not generally linked with individual capacities and efficiency. The annual increase in the basic salary is also fixed regardless of capacity of each staff and worker. For example, the average annual increase in the basic salary from the financial year 2005 to 2006 approximately stands at 1.94% for CONAVI officials. The below table shows examples of the level of salaries for the financial year 2005.

Table 4.2.11. Level of Salaries for CONAVI Officials (FY 2005)

No.	Organization	Class	Estimated Basic Monthly Salary 2005 (Colones)	Level (Office Worker = 100)
1	CONAVI	Senior Professional Staff	292,850	235.9
2	CONAVI	Professional Staff	236,250	190.3
3	CONAVI	Technical Professional Staff	184,050	148.2
4	CONAVI	Professional Staff	131,350	105.8
5	CONAVI	Office Worker	124,150	100.0

Source: Personnel Department of MOPT, 2005

While there are considerable training opportunities in the field of project management and implementation provided by CONAVI, there are almost no training opportunities in the field of bridge maintenance such as the operation of BMS. As a result, understanding and awareness of the concept of preventive maintenance such as *"Asset Management"* and *"Life Cycle Cost"* is not sufficient among the officials of the bridge department of CONAVI.

Table 4.2.12. Training Programme by CONAVI (2005)

No.	Training Programme by CONAVI	Duration	Timing
1	Project Management 1	40 hours	2005 February
2	Project Management 2	40 hours	2005 April
3	Planning and Supervision and Road Projects	20 hours	2005 May
4	Project Implementation	16 hours	2005 June
5	Laws for Roads	8 hours	2005 October

Source: CONAVI 2005

Table 4.2.13. Understanding of Preventive Maintenance by Officials of CONAVI

No.	Item	Understanding
1	Understanding on Asset Management	Not Understand
2	Understanding on Life Cycle Cost	Not Understand

Source: Results of Interviews with Private Contractors

3) Institutional Framework for MOPT and CONAVI

There are a wide range of institutional framework such as laws, regulations, standards and manuals in terms of design and maintenance standards for roads and bridges. However, due to the insufficient domestic institutional framework as well as its enforcement, officials of MOPT and CONAVI regularly refer to the international framework such as AASHTO and SIECA.

For example, the Bridge Department of MOPT is frequently requested to give technical assistances to CONAVI who has no professional and qualified staff in the field of the bridge engineering, and the officials of the Bridge Department refer to the international design standard such as *"Standard Specifications for Highway Bridges 17th Edition, 2002"* published by American Association of State Highway and Transport Officials (AASHTO). They also refer to *"Central American Manuals for Specifications of Regional Bridges and Roads Construction, 2003"* compiled by SIECA.

Table 4.2.14. Institutional Framework for Road and Bridge Maintenance

No.	Organization	Level	Law No.	Year
1	Law of Public Roads	National Law	Law 7494	1995
2	Law of Road Administration	National Law	Law 7762	1998
3	Law of MOPT Creation	National Law	No.27099-MOPT	1998
4	Law of CONAVI Creation	National Law	Law 7798	1998
5	Central American Manual for Road Maintenance	SIECA Manual	SIECA	2000
6	Manual of Inventory of Bridges	Internal Manual	Federico Gamboa	2000

Table 4.2.15. Institutional Framework for Road Design

No.	Organization	Level	Law No.	Year
1	Policy on Geometric Design of Highways	Standard	USA-AASHTO	1994
2	Central American Manual for Pavement Design	Manual	SIECA-USAID	2002
3	Rules for Geometric Design of Regional Roads	Standard	SIECA	2004
4	Manual for Geometric Design of Roads	Manual	MOPT	1977
5	General Specifications for Construction of Roads and Bridges CR-77	Regulation	MOPT	1977
6	Central American Manuals for Specifications of Regional Bridges and Roads Construction	Manual	SIECA	2001

Table 4.2.16. Institutional Framework for Bridge Design

No.	Organization	Level	Law No.	Year
1	Specifications of Highway Bridges	National Law	USA-AASHTO	2002
2	Specifications of Highway Bridges LRFD	Standard	USA-AASHTO	2003
3	General Specifications for Construction of Roads and Bridges CR-77	Regulation	MOPT	1977
4	Central American Manuals for Specifications of Regional Bridges and Roads Construction	Manual	SIECA	2001

In addition to these design standards for roads and bridges, there are a couple of laws and regulations for procurement of goods and services for the maintenance and construction of roads and bridges. *"Law of Administrative Contracts 1995"* stipulates procedures for activities contracts between public institutions and private companies.

Table 4.2.17. Institutional Framework for Procurement Regulations

No.	Organization	Level	Law No.	Year
1	Law of Administrative Contracts	National Law	Law 7494	1995
2	Public Works Concession Law	National Law	Law 7762	1998
3	Regulations on Organization and Procedures for CONAVI	CONAVI Internal Regulation	No.27099-MOPT	1998

In addition to these laws and regulations, there is a *"Manual for Process, Procedures and Products of CONAVI, 2003"* which specifies the following practical procedures for the procurement contracts by CONAVI.

- Acquisition and contract procedures
- Formulation and management of contracts
- Planning and budgetary process
- Technical development process and quality control
- Environmental process
- Internal audit process
- Legal process
- Finance administrative process

More specifically, the regulations on public biddings and direct contracts in accordance with the CONAVI's contract amount are as shown below, indicating that the public bidding is required for a contract whose amount is more than 111,200 thousand Colones.

Table 4.2.18. Regulations on Public Bidding and Direct Contract by CONAVI

No.	Type of Contract	Conditions on CONAVI's Contract Amount
1	Public Bidding	More than Colones 111,200 thousand
2	Limited Bidding through Long List	Colones 17,800 thousand to 111,200 thousand
3	Limited Bidding through Short List	Colones 8,900 thousand to 17,800 thousand
4	Special Direct Contract	Less than Colones 8,900 thousand

4) National Concessions Council (CNC)

The National Concessions Council (CNC) is in charge of procedures for concession projects such as highways, bridges, railways, ports and airports. The Government of Costa Rica enacted *the Public Works Concession Law in May 1998*, and the Concession Law offers the protocols on operating concessions for the construction and administration of these infrastructures. The Government of Costa Rica has traditionally maintained monopoly control over essential public utilities such as transportation services. However, recently, there has been a trend to move away from this monopoly structure and allow the private sector to participate in specific areas of public infrastructure projects for periods of 20 to 25 years.

More specifically, *the Regulations for Private Initiative Projects of Public Work Concession on Public Service, Decree No. 31836 of MOPT*, define more detailed procedures for the process of concession projects. The regulations contain the general criteria of works, work procedures and other conditions which concessionaries must obey as obligations.

In accordance with the above regulations, a concession contract is subject to stipulate the concessionaries' obligations to maintain, rehabilitate and repair the constructed roads and bridges as part of the contract. However, there are almost no detailed procedures for the maintenance activities such as inspections in the contract. More specifically, the regulations include the following 4 steps with a series of activities. It is often criticized that these procedures are delayed due to slower processing of documents.

a) First Stage
- To coordinate the idea of a concession project
- To conduct a feasibility study in terms of technical, economical, financial and environmental points of views
- To start pre-qualification process

b) Second Stage
- To prepare bidding documents
- To approve and publish bidding process

c) Third Stage
- To evaluate bidding
- To award and formalize bidding

d) Forth Stage
- To supervise the awarded works under construction
- To start the operation of a concession project

5) Other Governmental Organizations

As the financial authority of the Government of Costa Rica, the Ministry of Finance (MOF) is in a position to coordinate and control the budget for a wide range of the public spending and investment. Although MOF negotiates with each line ministry for the ceiling of the budget of the respective ministry due to the chronic shortage of the revenue, MOF does not request MOPT to specify the breakdown of the budget. MOF is not well aware of the preventive maintenance of roads and bridges based on the concept of *"Asset Management"*, and does not pay special attentions to the maintenance and rehabilitation of roads and bridges.

The Ministry of National Planning (MIDEPLAN) coordinates the formulation of the 5-year National Development Plan for the transport sector, *"Plan de Trabajo 2002-2006"*, as a fundamental strategy for the construction and conservation of roads and bridges.

For the national road network under the responsibility of CONAVI, there are, at present, 13 road conservation contracts including the maintenance of the 4,400 km of the national road network with an asphalt surface. Out of the 7,437.0 km of the national road network, 47% (approximately 3,510.2 km) are in bad shape, and 38% of them (approximately 2,814.8 km) are in regular state, only 15% of them are found in good shape.

In the Plan, it is projected that CONAVI continues to provide the maintenance of 4,200 km of asphalted roads. The investment program includes the strategic national highway such as the Atlantic Corridor (Los Chiles-Chilamate). Lower priorities are given to the maintenance of bridges due to the limitation of the budget. For the year 2002 to 2006, it is projected that CONAVI will rehabilitate 31 bridges on the national road network which are not in line with the recommendations and priorities by the Direction of Planning of MOPT.

However, when MIDEPLAN coordinates the National Development Plan for the transport sector, it does not recognize the concept of *"Preventive Maintenance"*, mainly paying attentions to the construction of new roads. Furthermore, understanding and awareness of the concept of *"Asset Management"* and *"Life Cycle Cost"* is not sufficient among the officials of MOF and MIDEPLAN.

Table 4.2.19. Understanding of Preventive Maintenance by Officials of MOF and MIDEPLAN

No.	Item	MOF	MIDEPLAN
1	Understanding on Preventive Maintenance	Not Understand	Not Understand
2	Understanding on Asset Management	Not Understand	Not Understand
3	Understanding on Life Cycle Cost	Not Understand	Not Understand

Source: Results of Interviews with MOF and MIDEPLAN

4.2.2 Academic and Research Organizations

1) University of Costa Rica and Affiliated Research Organizations

The University of Costa Rica has a couple of affiliated research organizations in the field of civil engineering. The National Laboratory of Materials and Structural Models (LANAMME), which is subsidized by 3% value of the fuel tax, is one of the most important organizations.

The function of LANAMME is i) technical audits of road and bridge construction projects, ii) the biannual evaluation of the national road network, iii) the annual evaluation of roads and bridges in concessions, iv) modernization of the specification's manual, v) technical advice to MOPT and, vi) holding a series of seminars on the civil engineering. LANAMME is an academic institution with researchers whose academic backgrounds are various expertises in the field of civil engineering, and it has only few bridge engineers who developed their carriers in foreign universities. Furthermore, the University of Costa Rica does not have any course for bridge engineering.

While there are considerable training opportunities for civil engineering provided by LANNAME, there have been almost no training opportunities in the field of bridge maintenance such as the operation of BMS. The below table shows the summary of the recent training programme by LANAMME. Understanding and awareness of the concept of preventive maintenance of bridges such as *"Asset Management"* and *"Life Cycle Cost"* is limited to few engineers whose are specialized in bridge engineering. Nevertheless, LANAMME recently held a comprehensive seminar in the field of bridge maintenance, recognizing the importance of the concept of *"Asset Management"*. LANNAME invited a seminar lecturer from Columbia, and the seminar included a series of workshops as well as practical OJT-based training for the bridge maintenance.

Table 4.2.20. Training Programme by LANNAME (2005)

No.	Training Programme by LANAMME	Duration	Timing
1	Bridge Engineering	35 hours	2005 February
2	Vulnerability of Roads	30 hours	2005 April
3	Management of Roads	35 hours	2005 May
4	Road Auditing	4 hours	2005 June
5	Laws for Roads	8 hours	2005 October

Source: LANNAME 2005

Table 4.2.21. Availability of Intellectual Assets for Bridge Maintenance and Understanding of Preventive Maintenance by LANNAME Bridge Engineers

No.	Item	LANNAME Bridge Engineer
1	Availability of SAP	Available
2	Availability of Auto CAD	Available
3	Availability of Shummit Hammer	Not Available
4	Understanding on Asset Management	Understand
5	Understanding on Life Cycle Cost	Understand

Source: Results of Interviews with LANNAME

2) Association of Engineers

CFIA (Costa Rica Federation of Engineers and Architects) is the largest association for the registered engineers in Costa Rica, and the association is composed of 3,250 civil engineers, 2,000 consulting engineers, 2,000 architects, 2,000 topographic engineers, 3,250 electrical and mechanical engineers, respectively. The association provides those members with a wide range of opportunities such as seminars and training programmes for obtaining knowledge and experiences in the field of the civil engineering. However, at this moment, there are no specific training programmes for the bridge engineering due to the shortage of resource persons.

In the community of Costa Rican civil engineers, there are few professionals with the designing and maintenance of bridges who are well aware of the importance of the concept of *"Preventive Maintenance"* such as *"Asset Management"* and *"Life Cycle Cost"*.

Table 4.2.22. Availability of Intellectual Assets for Bridge Maintenance and Understanding of Preventive Maintenance by CFIA Member Engineers

No.	Item	CFIA Member Engineers
1	Availability of SAP	Available
2	Availability of Auto CAD	Available
3	Availability of Shummit Hammer	Not Available
4	Understanding on Asset Management	Not Understand
5	Understanding on Life Cycle Cost	Not Understand

Source: Results of Interviews with CFIA

4.2.3 Private Sector

1) Private Companies

There are approximately 10 large domestic contractors as well as consulting companies which participate in the tenders arranged by CONAVI for the construction of roads and bridges. Some of them also participate in the concession projects prepared by CNC for the construction of new roads and highways. The below figure illustrates the typical career development for bridge engineers, indicating that it takes approximately 15 years to develop a bridge engineer after employing a university graduate from the faculty of engineering.

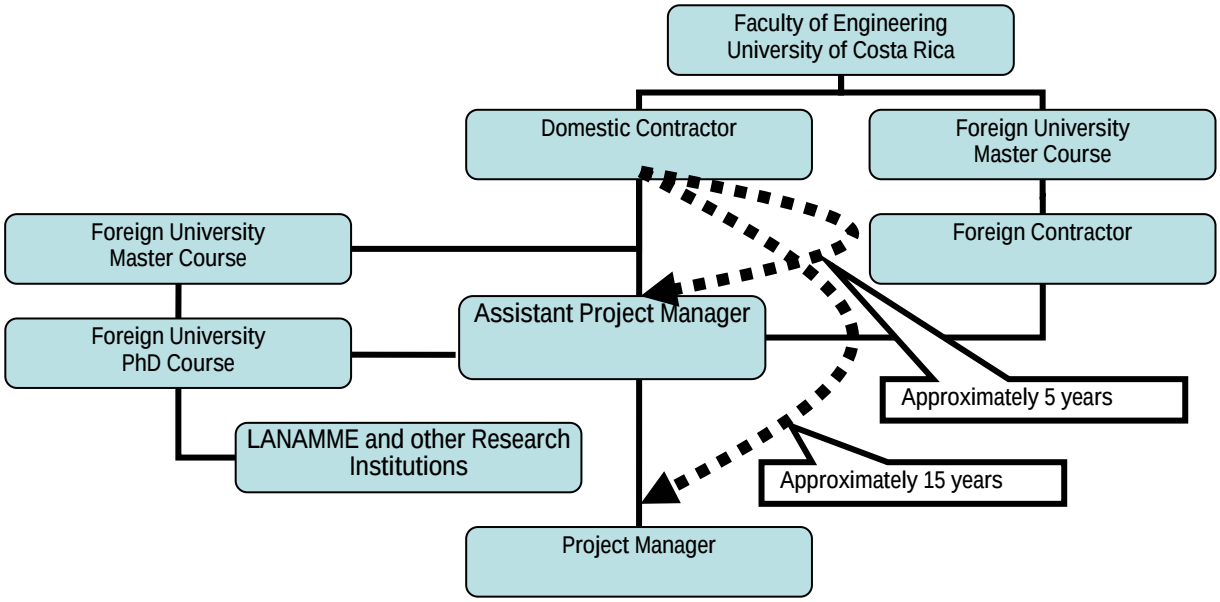


Figure 4.2.1. Possible Career Development for Bridge Engineers

Although those companies have a lot of civil engineers in the field of the road construction and maintenance, there are few bridge engineers who can design bridges based on structural calculations. Those private companies usually employ graduates of the Faculty of

Engineering of the University of Costa Rica, and provide them with opportunities to work with senior bridge engineers so that they can obtain the experiences on the job training basis. Normally, it will take approximately 15 years of experiences to become a professional bridge engineer at the project manager level. Understanding of the concept of preventive maintenance of bridges such as *"Asset Management"* and *"Life Cycle Cost"* is not sufficient among engineers of domestic contractors compared with those of foreign contractors.

Table 4.2.23. Availability of Intellectual Assets for Bridge Maintenance and Understanding of Preventive Maintenance by Domestic and Foreign Contractors

No.	Item	Domestic Contractors	Foreign Contractors
1	Availability of SAP	Available	Available
2	Availability of Auto CAD	Available	Available
3	Availability of Shummit Hammer	Not Available	Available
4	Understanding on Asset Management	Not Understand	Understand
5	Understanding on Life Cycle Cost	Not Understand	Understand

Source: Results of Interviews with Private Contractors

2) Truckers and Drivers

Truckers and drivers are also important stakeholders as users of bridges. The Costa Rican Chamber of United Transporters (CCTU) is a typical non-profit association for truckers. The association has more than 3,000 member transporting companies. More than 80% of their cargos are transported by the member truckers on the inter-American highway.

Meanwhile, there are a couple of domestic laws and regulations for the traffic control with regard to the use of bridges such as the regulations on the maximum allowable weights and lengths for trucks and containers. Nevertheless, the enforcement of these regulations is not effective in Costa Rica. In spite of the Central American Weight and Dimensions Agreement agreed under SIECA and the regulations set by MOPT, there are many cases that their trucks and containers are frequently overloaded. For example, although the weight limit for a two-axle truck is regulated at 39 ton in Costa Rica, rucks with over 40-ton of weights frequently pass through the bridges on the national road network. Those truckers are not well aware that their trucks and containers would give damages to roads and bridges, since they have only information on the regulation from *La Gaceta*. Likewise, they do not usually regard the traffic regulations as well as the maintenance of bridges as important.

Table 4.2.24. Institutional Framework for Traffic Regulations

No.	Organization	Level	Law No.	Year
1	Law of Traffic on Public Road	National Law	Law 7331	2004
2	Law of National Committee on Traffic Security	National Law	Law 8413	2005
3	Regulations on Weights and Dimensions of Heavy Vehicles	Regulation	No. 31363	2000
4	Central American Manual for Use of Traffic Control	SIECA Manual		2005

Table 4.2.25. Maximum Allowable Weight and Lengths for Trucks

Type No.	Truck Type	Axes Configuration	No. of Axles	No. of Wheels	Maximum Allowable Weight (ton)	Maximum Allowable Length (m)
T2-S1	Truck with Semi-wagon	1S-1D-1D	3	10	26.0	21.00
T2-S2	Truck with Semi-wagon	1S-1D-2D	4	14	32.5	21.00
T2-S3	Truck with Semi-wagon	1S-1D-3D	5	18	39.0	21.00
T2-S1-2	Truck with Semi-wagon	1S-1D-1D-2D	5	18	42.5	21.00
T3-S1	Truck with Semi-wagon	1S-2D-1D	4	14	32.5	21.00
T3-S2	Truck with Semi-wagon	1S-2D-2D	5	18	39.0	21.00
T3-S3	Truck with Semi-wagon	1S-2D-3D	6	22	45.5	21.00
T3-S1-2	Truck with Semi-wagon	1S-2D-1D-2D	6	22	49.0	21.00
C2-R1	Truck with Double Trailer	1S-1D-1D	3	10	26.0	21.00
C2-R2	Truck with Double Trailer	1S-1D-1D-1D	4	14	36.0	21.00
C3-R1	Truck with Double Trailer	1S-2D-1D	4	14	32.5	21.00
C3-R2	Truck with Double Trailer	1S-2S-1D-1D	5	18	42.5	21.00
C3-R3	Truck with Double Trailer	1S-2D-1D-2D	6	22	49.0	21.00
C4-R1	Truck with Double Trailer	2S-2D-1D	5	16	39.5	21.00
C4-R1	Truck with Double Trailer	1S-3D-1D	5	18	39.0	21.00
C4-R2	Truck with Double Trailer	2S-2D-1D-1D	6	20	49.5	21.00
C4-R2	Truck with Double Trailer	1S-3D-1D-1D	6	22	49.0	21.00
C4-R3	Truck with Double Trailer	2S-2D-1D-2D	7	24	56.0	21.00
C4-R3	Truck with Double Trailer	1S-3D-1D-2D	7	26	55.5	21.00

Source: SIECA Regulations for Road Traffic

Note: S=Simple Axel, D=Double Axel

4.2.4 International Framework

The Plan Puebla Panama (PPP) is a USD 10 billion infrastructure, utility and commercial integration program affecting the nine southern states of Mexico, Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica and Panama, and it is a package of 28 separate "mega-projects" which will promote the regional integration. PPP includes an initiative to create a Mesoamerican network of highways known as RICAM. The network, which is largely based on existing roads, comprises two main corridors on the Atlantic and the Pacific and a series of complementary routes. Two major corridors are to be built, running roughly from the Texas-Mexico border, around the Gulf of Mexico.

RICAM seeks to increase internal and external regional economic links by improving the integration corridors and harmonizing transportation rules and regulations. In order to promote the integration, the region's transportation and public works ministers established a Technical Commission of the Road Initiative. The IDB (Inter-American Development Bank), CABEI (Central American Bank of Economic Integration) and SIECA (Secretary of Central American Economic Integration), the regional banking institutions and the system for the regional economic integration, provide the support for this commission.

SIECA formulated "Master Plan for Regional Transportation for the 2001-2010 Decade" which is the basis for strengthening and organizing the development of the transportation sector in the Central America. In addition to this basic master plan, SIECA also created the international standards and manuals for the road construction and maintenance such as *"The Central American Standard for Geometrical Design of Regional Roads in 2004"* and *"The Central American Catalogue and Repair Manual for Damage to Road Pavement in 2000"* in

order to provide member countries with the common knowledge in the field of the road construction and maintenance.

MOPT of Costa Rica is in charge of the executive commissioner of the Road Initiative of PPP, and this initiative includes i) construction, rehabilitation, and improvement of RICAM, ii) modernization of customs and border passes, and iii) harmonization of regulations and technical standards of the transport sector. Nevertheless, the coordination for the maintenance of bridges is less active than that for highways.

4.3 Summary of Results of Full-scale Capacity Gap Assessment

Based on a series of interviews with a wide range of stakeholders, the results of the preliminary assessment of the capacities at the individual, organizational, institutional and social levels are summarized as below.

1) Individual Level

The individual-level capacities refer to relevant officials' i) knowledge and practical skills/experiences for inspection, diagnosis, operation of BMS, planning and implementation of repair and rehabilitation, and ii) management and responsiveness for preventive bridge maintenance. The full-scale assessment results by the 5-grade score sheets as well as the major findings at this level are shown below.

Table 4.3.1. Results of Capacity Gap Assessment Score Sheet (Individual Level)

No.		Items	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
1		Relevant officials' knowledge and practical skills/experiences					
	1-a	Knowledge and skills/practical experiences for inspection and diagnosis		●			
	1-b	Knowledge and skills/practical experiences for operation and management of BMS			●		
	1-c	Knowledge and skills/practical experiences for planning of repair and reinforcement		●			
	1-d	Knowledge and skills/practical experiences for cost estimates, bidding and supervision		●			
	1-e	Knowledge and skills/practical experiences for environmental consideration		●			
2		Relevant officials' managerial skills for and responsiveness bridge maintenance					
	2-a	Planning and management capacity for budget control		●			
	2-b	Planning and managerial capacity for human resources		●			
	2-c	Short-term and long-term planning for bridge maintenance		●			
	2-d	Communication capacity for regular activities		●			
	2-e	Understanding on preventive maintenance and responsible mind for bridge maintenance			●		

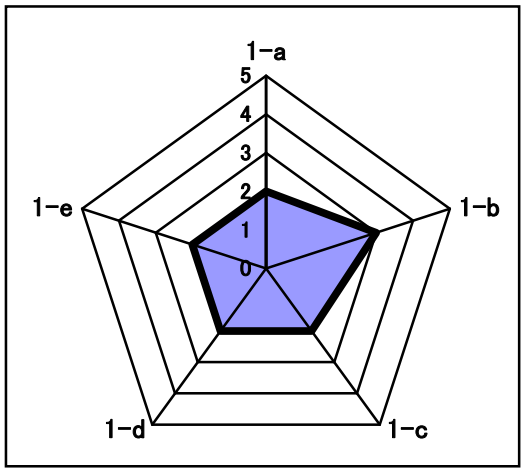


Figure 4.3.1. Rader Chart for Individual-level Capacity (1)

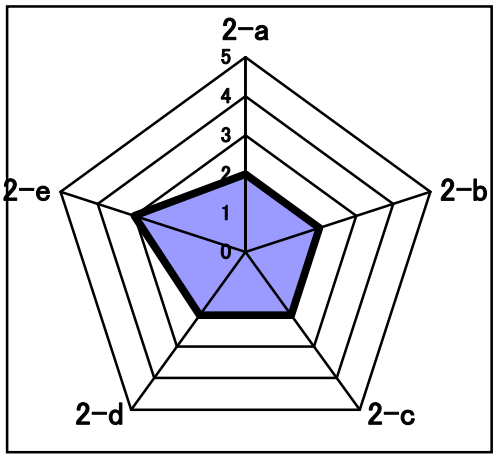


Figure 4.3.2. Rader Chart for Individual-level Capacity (2)

(a) Although the bridge department of MOPT has a few bridge engineers, they do not have sufficient knowledge and experiences in terms of bridge maintenance practices such as inspection, diagnosis, operation of BMS, planning and implementation of repair and rehabilitation of bridges.
(b) CONAVI does not have any qualified bridge engineer, although it employs contract-based

local civil engineers for the bridge inspection activities.

(c) There are insufficient number of qualified professional inspectors in both MOPT and CONAVI, although the Planning Direction of MOPT is updating the existing bridge database.

(d) Officials of both planning and financial authorities are not well aware of significance of the preventive maintenance of bridges based on the concept of *"Asset Management"*.

(e) Although some researchers of affiliated research organizations of University of Costa Rica understand significance of the preventive maintenance of bridges, other officials of the public sector as well as staff of the private sector are not well aware of its importance.

(f) Although some foreign contractors have several trained bridge engineers, the level of engineers of domestic contractors does not reach to the required level.

2) Organizational Level

The organizational-level capacities refer to i) organizational performance (functions, number of qualified staff, decision-making mechanism, coordination abilities, incentive system, personnel management, etc.), ii) financial and outsourcing system (amount and allocation of budget for bridge maintenance and rehabilitation, and contracting system for bridge maintenance and rehabilitation), and iii) physical and intellectual assets for bridge maintenance and rehabilitation. The full-scale assessment results by the 5-grade score sheets as well as the major findings at this level are shown below.

Table 4.3.2. Results of Capacity Gap Assessment Score Sheet (Organizational Level)

No.		Items	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
3		Organizational functions and performance					
	3-a	Organizational structure for bridge maintenance		●			
	3-b	Balanced demarcation of responsibilities and functions and mechanisms at the central and provincial levels		●			
	3-c	Overall organizational functions such as decision-making mechanism and coordination ability		●			
	3-d	Number of qualified staff and personnel management		●			
	3-e	Personnel Incentive system for qualified staff	●				
4		Financial resources and outsourcing system					
	4-a	Amount and allocation of recurrent and indirect cost for bridge maintenance		●			
	4-b	Amount and allocation of direct maintenance and rehabilitation cost	●				
	4-c	Outsourcing and contracting system		●			
	4-d	Standards for cost estimates and technical specifications for outsourcing		●			
	4-e	Capacity level of private sector			●		
5		Physical and intellectual assets					
	5-a	Physical assets for bridge maintenance and rehabilitation (inspection equipment, repair facilities, etc.)	●				
	5-b	Physical assets for regular activities (office equipment, etc.)		●			
	5-c	Intellectual assets for bridge maintenance and rehabilitation (Manuals and database)		●			
	5-d	BMS and other software for bridge maintenance			●		
	5-e	Technical standards for bridge maintenance		●			

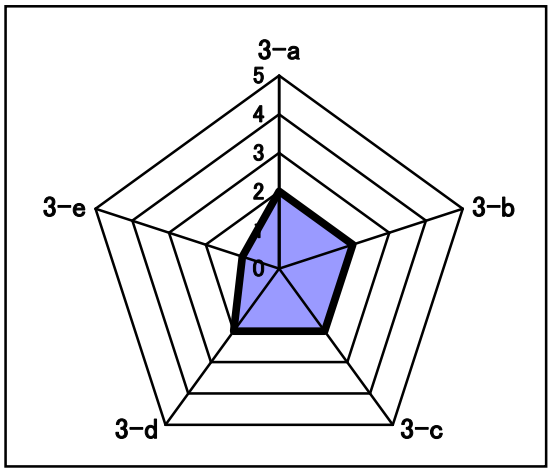


Figure 4.3.3. Rader Chart for Organizational-level Capacity (1)

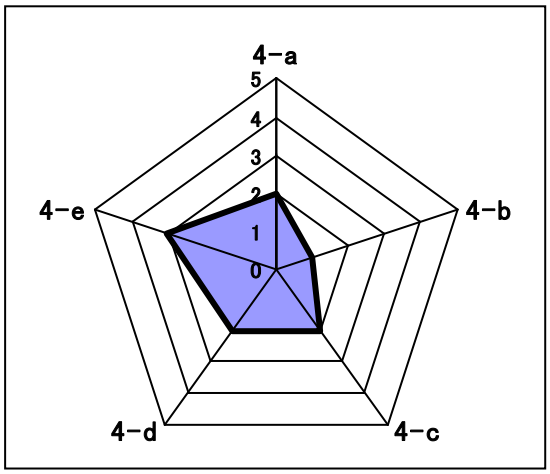


Figure 4.3.4. Rader Chart for Organizational-level Capacity (2)

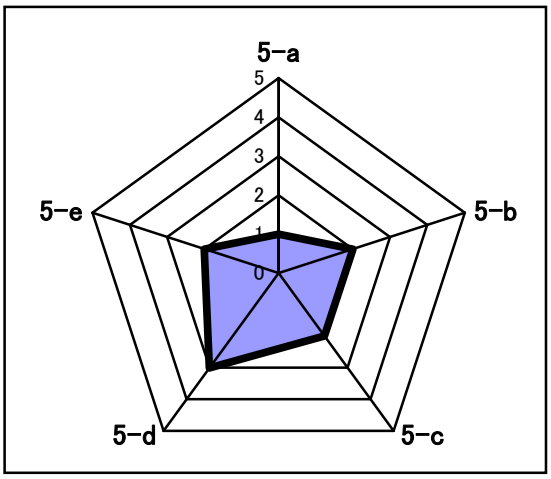


Figure 4.3.5. Rader Chart for Organizational-level Capacity (3)

(a) There are no systematic and comprehensive bridge inspection systems in both MOPT and CONAVI, and the inspection of bridges is basically conducted only on ad-hoc basis.

(b) The budget for the maintenance of bridges is not sufficiently allocated for both MOPT and CONAVI, compared with the construction and maintenance of roads.

(c) The regional offices of MOPT and CONAVI do not have enough financial resources for the regular inspection activities.

(d) The standards for the diagnosis of damages of bridges as well as the inspection manuals are not sufficiently prepared, although the bridge department is updating the bridge data in the existing bridge database. In addition, there is lack of the required equipment for the bridge inspection activities.

(e) In the concession system for the maintenance of roads and bridges, CONAVI and CNC do not specify the detailed maintenance activities of bridges by concession companies.

(f) There is lack of opportunities for the training of bridge engineers and inspectors of MOPT and CONAVI.

3) Institutional and Social Level

Capacities at the institutional and social levels include i) existence of policies, laws, regulations and standards for preventive maintenance of bridges, and ii) social understanding of preventive maintenance of bridges and knowledge management. The full-scale assessment results by the 5-grade score sheets as well as the major findings at this level are shown below.

Table 4.3.3. Results of Capacity Gap Assessment Score Sheet (Institutional and Social Level)

No.		Items	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
6		Existence of policies, laws, regulations and standards for preventive maintenance of bridges					
	6-a	Understanding and awareness of preventive maintenance of bridges among politicians and high-ranking officials	●				
	6-b	Understanding and awareness of preventive maintenance of bridges among financial and planning authorities		●			
	6-c	Existence and enforcement of laws, regulations and standards on inspection and diagnosis for bridges		●			
	6-d	Existence and enforcement of laws, regulations and standards on design for bridges		●			
	6-e	Existence and enforcement of laws, regulations and standards on traffic control for bridges		●			
7		Social understanding and awareness of preventive maintenance of bridges and knowledge management					
	7-a	Understanding and awareness of preventive maintenance of bridges among academic circles		●			
	7-b	Understanding and awareness of preventive maintenance of bridges among ordinary citizens and drivers	●				
	7-c	Partnership and collaboration on domestic exchange of technical information between public sector and private sector		●			
	7-d	Partnership and collaboration on domestic exchange of technical information between public sector and academic circle		●			
	7-e	Partnership and collaboration on overseas exchange of technical information		●			

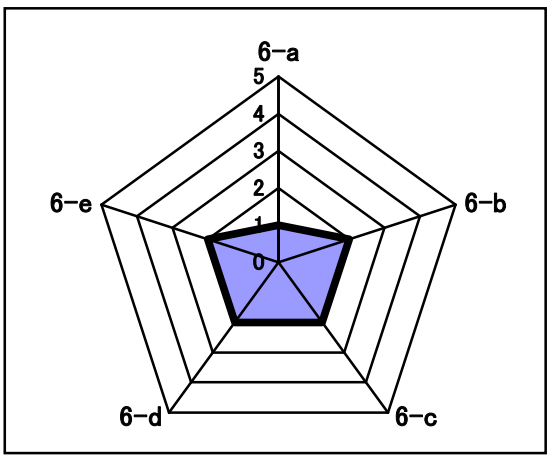


Figure 4.3.6. Rader Chart for Institutional-level Capacity

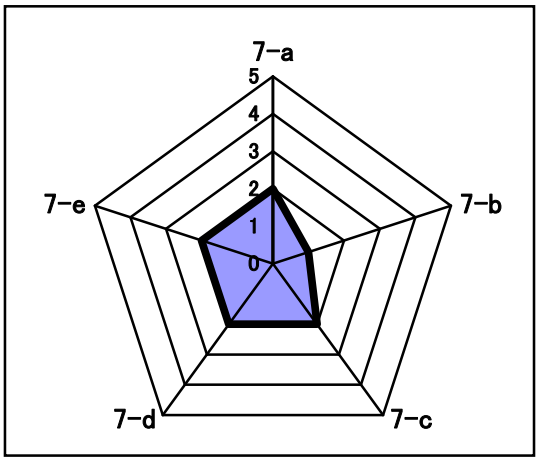


Figure 4.3.7. Rader Chart for Social-level Capacity

(a) There is no political commitment to the maintenance of bridges based on the concept of *"Asset Management"*.

(b) Although there are regulations for the payload capacities for trucks based on the international transportation framework such as PPP and SIECA, there are a lot of trucks and containers which are overloaded.

(c) Understanding of the concept of *"Asset Management"* as well as "*preventive maintenance"* is not enough among the society, since ordinary citizens are not so much interested in the maintenance of existing bridges.

(d) There are insufficient opportunities for the collaboration between the public sector and the private sector to develop the bridge maintenance and rehabilitation technologies.

4.4 Core Problem and Problems Analysis

"Problem Analysis" is a method for graphically displaying the problematic environment related to the matter of issues. The analysis lays problems out in a cause and effect tree with roots and branches showing relationships between problems. Roots represent causative factors and branches represent consequent effects. One problem in a tree is one of the causes of the problem located above as well as the effect of the problem located beneath.

Based on the interview results and the analysis of the 5-grade score assessment sheets, the full-scale problem analysis using PCM (Project Cycle Management) method was conducted. For example, the core problem of *"Inappropriate Bridge Maintenance"* is derived from i) insufficient bridge maintenance capacity, ii) weak organizational structure on bridge maintenance, iii) insufficient budget for bridge maintenance, iv) insufficient enforcement of laws, regulations and standards, and v) insufficient knowledge management on bridge maintenance. More detailed problem trees showing major causes of the core problem are illustrated as below in consultations with the counterparts using the full-scale PCM method.

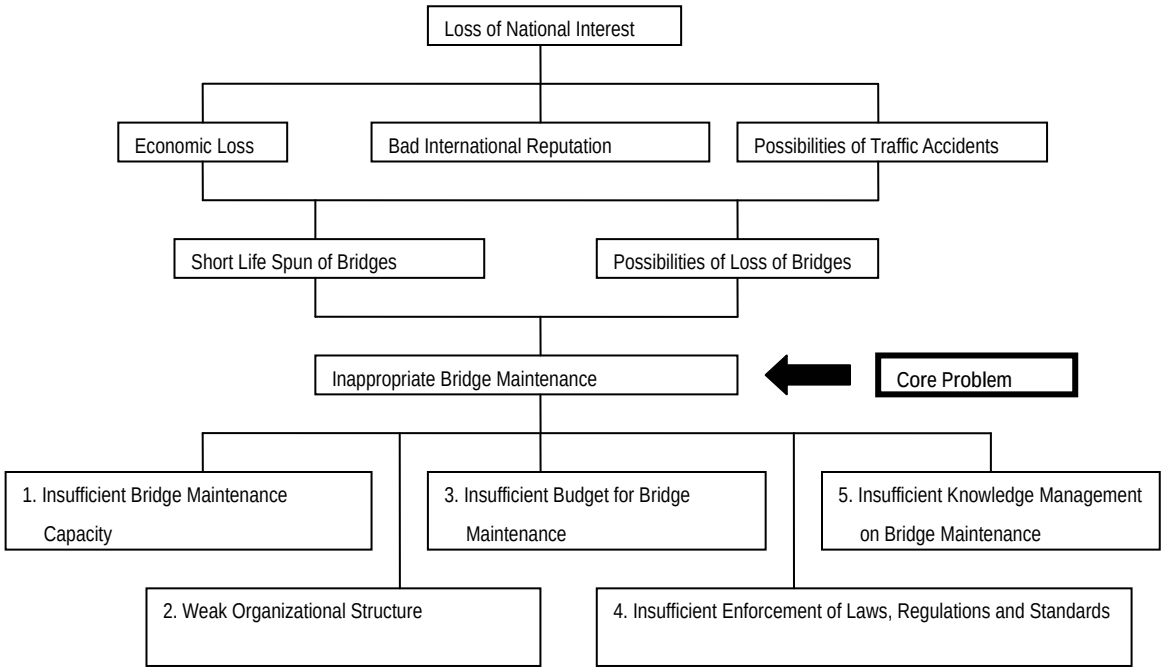


Figure 4.4.1. Overall Problem Tree

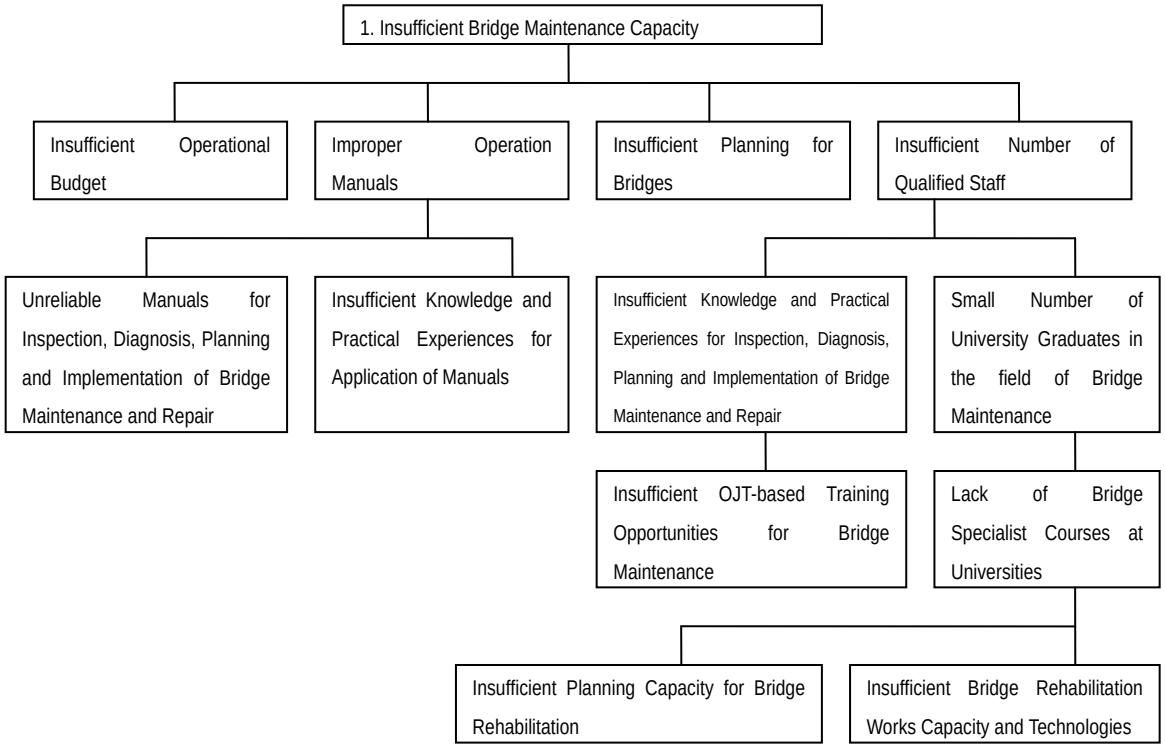


Figure 4.4.2. Problem Tree for Insufficient Bridge Maintenance Capacity

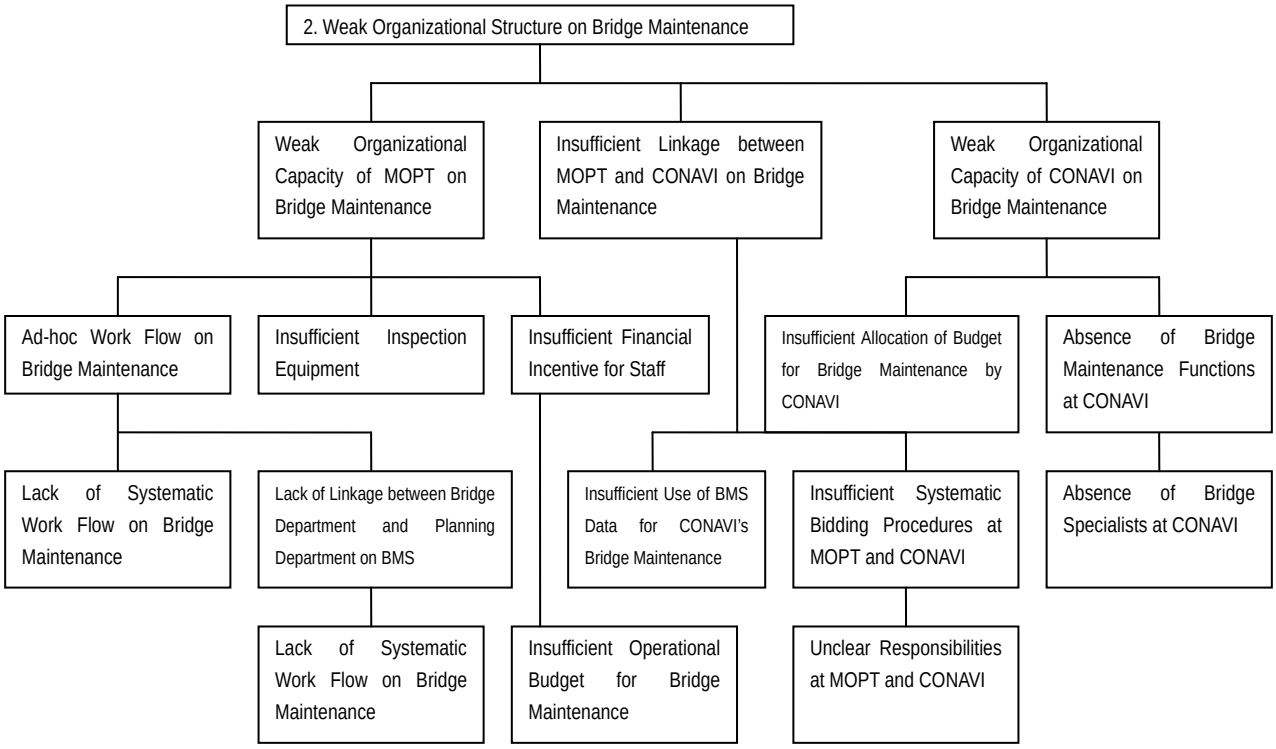


Figure 4.4.3. Problem Tree for Weak Organizational Structure on Bridge Maintenance

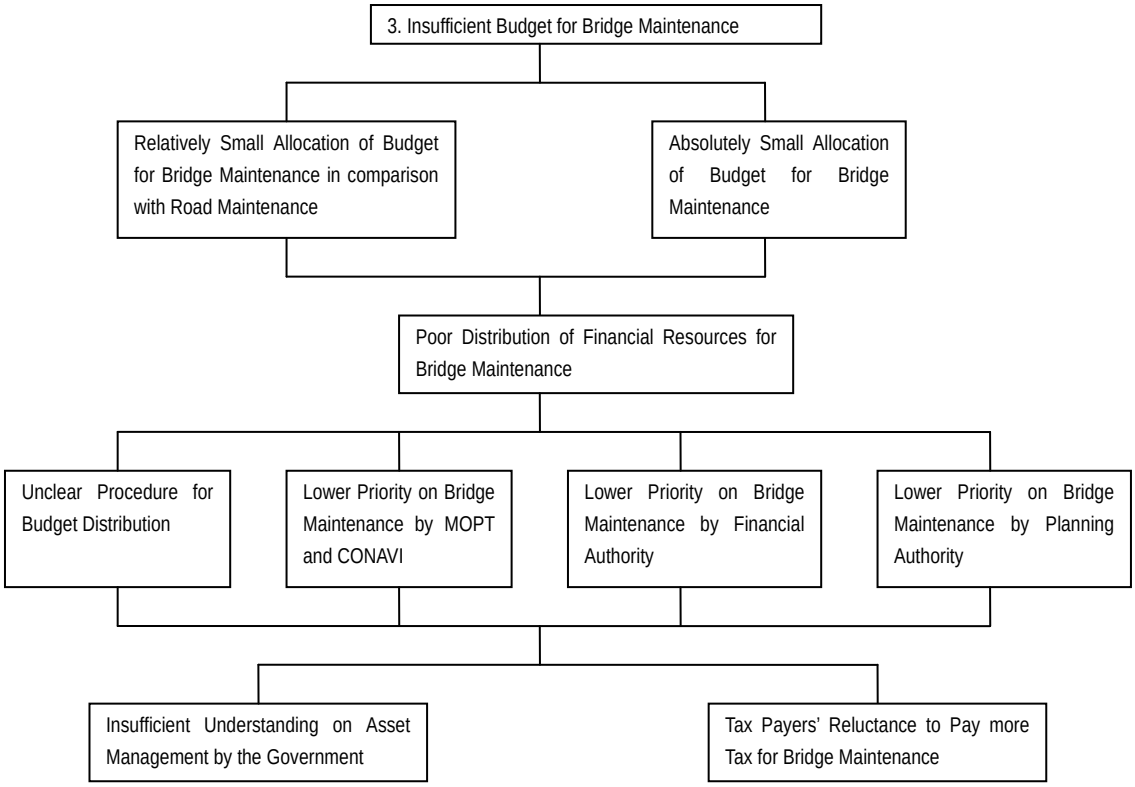


Figure 4.4.4. Problem Tree for Insufficient Budget for Bridge Maintenance

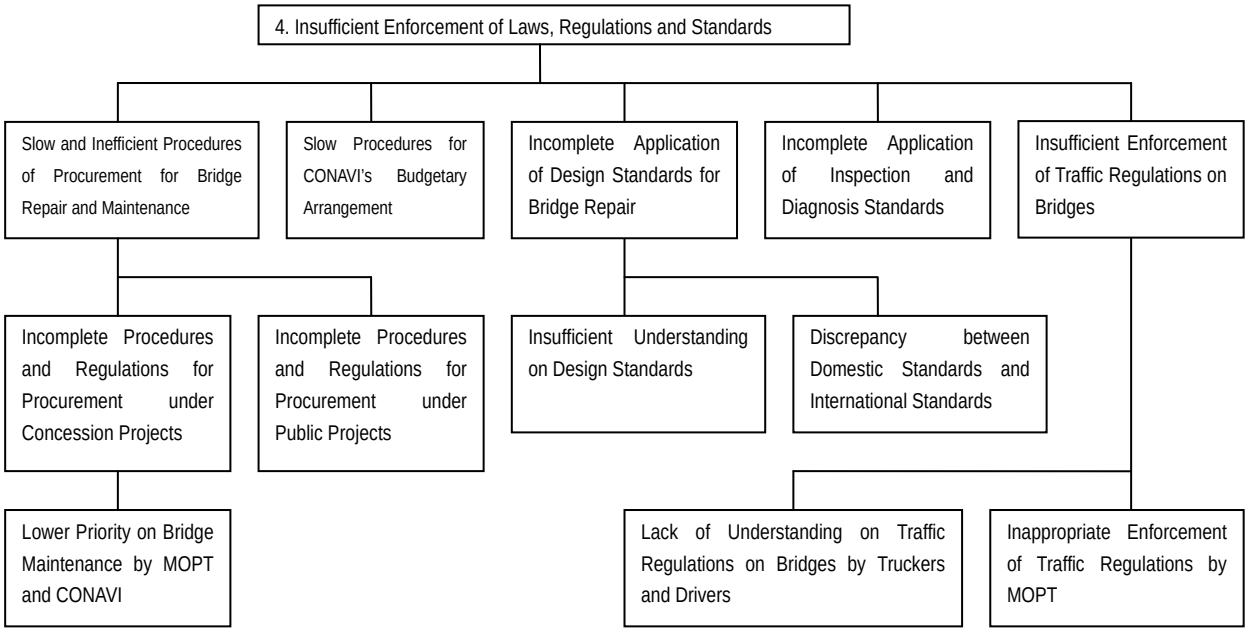


Figure 4.4.5. Problem Tree for Enforcement of Laws, Regulations and Standards

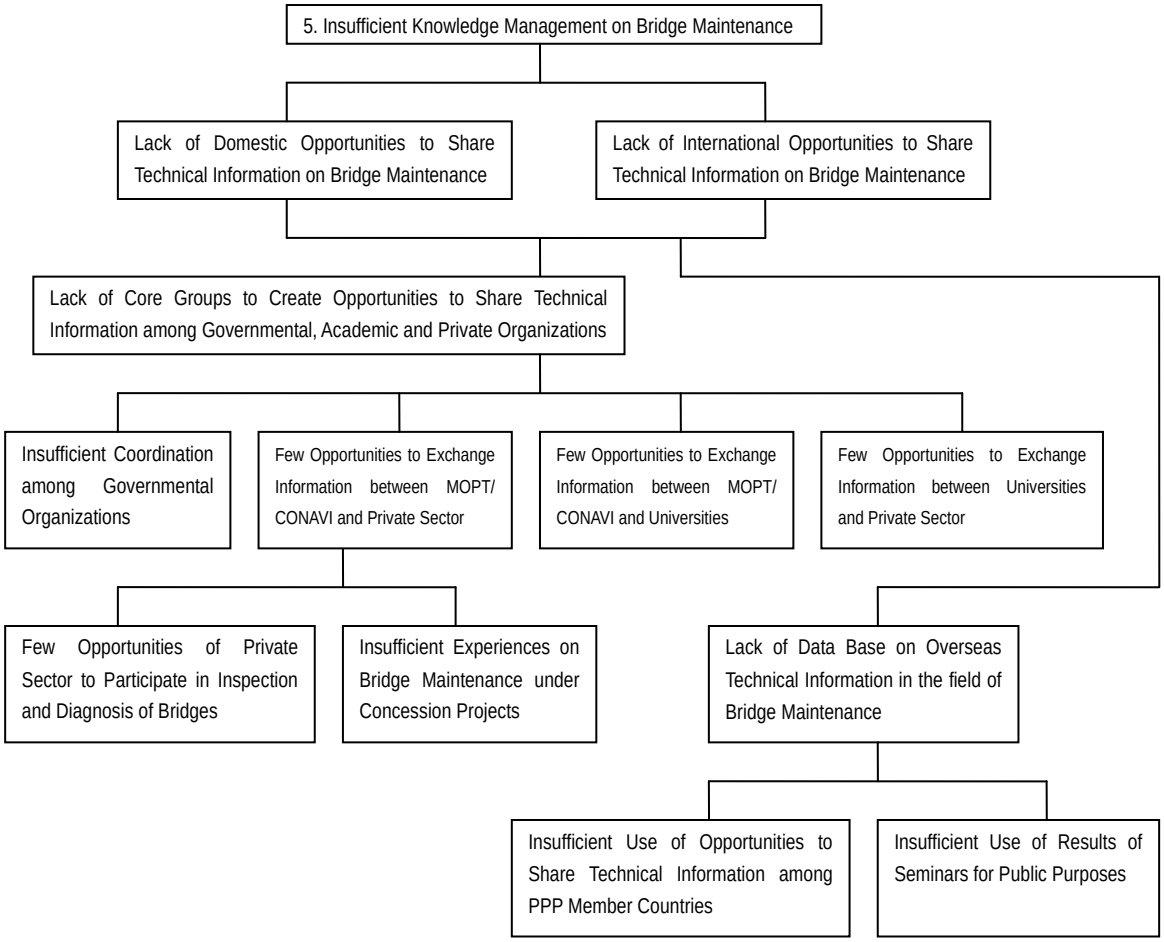


Figure 4.4.6. Problem Tree for Insufficient Knowledge Management on Bridge Maintenance

In order to solve these problems, 13 proto-type modular projects are identified as per Chapter 5. The detailed contents of these modular projects are specified in Chapter 5 through the process of the full-scale PCM analysis including a) problem analysis, b) objective analysis, and c) formulation of PDM (Project Design Matrix) of the identified modular projects.

CHAPTER 5 BASIC POLICIES FOR CAPACITY DEVELOPMENT

5.1 Basic Approaches and Policies for Capacity Development

Following the problem analysis in Chapter 4, the objective analysis, which converts negative present situations described in "a problem tree" into a positive future situation by rewording problems into their solutions, was conducted. The objective analysis illustrates a desirable future situation which would be attained after problems have been solved.

It has been concluded in Chapter 4 that the core problem of *"Inappropriate Bridge Maintenance"* is derived from i) insufficient bridge maintenance capacity, ii) weak organizational structure on bridge maintenance, iii) insufficient budget for bridge maintenance, iv) insufficient enforcement of laws, regulations and standards, and v) insufficient knowledge management on bridge maintenance.

The objective analysis lays the objectives out in *"a means and ends tree"* with roots and branches showing relationships between objectives. One objective in a tree is one of the means of the objective located above as well as the end of the objectives located beneath. In other words, the logic formulates an objective tree is "if-then" logic, which means that if the lower level objectives are accomplished out, then the upper level objectives would be achieved.

On the other hand, the alternative analysis is a process to identify project components and possible alternative options for the solution of the identified problems. Since an objective tree is created using means and ends relationships thus establishing a hierarchy of objectives, several branches generate groups showing prototypes of module projects.

In summary, the alternative analysis generates i) maintenance capacity improvement approach, ii) organizational capacity improvement approach, iii) policy change approach, iv) institutional enforcement improvement approach, v) users advocacy approach, and vi) overseas technical cooperation approach. These alternative approaches would lead to proto-type 13 modular projects.

Table 5.1.1. Alternative Basic Approaches for Bridge Maintenance

Basic Approach	Prototype for Modular Project	Level
Maintenance Capacity Improvement Approach	Individual Capacity Improvement Project for Bridge Inspection and Diagnosis	Individual
	Individual Capacity Improvement Project for BMS Operation and Priority Selection of Bridge Maintenance	Individual
	Individual Capacity Improvement Project for Planning and Implementation of Bridge Rehabilitation	Individual
	Human Resources Development Project for Bridge Maintenance	Individual
Organizational Capacity Improvement Approach	Organization Strengthening Project of Bridge Department of MOPT	Organizational
	Organization Setting-up Project of Bridge Department of CONAVI	Organizational
	Knowledge Management Promotion Project among Public, Private and Academic Sectors	Organizational
Policy Change Approach	Asset Management Policy Introduction Project for Financial and Planning Authority	Institutional (Policy)
Institutional Enforcement Improvement Approach	Enforcement Improvement Project for Procurement Procedures and Regulations	Institutional
	Enforcement Improvement Project for Technical Regulations and Design Standards	Institutional
Users Advocacy Approach	Bridge Users Advocacy and Campaign Project for Asset Management and Traffic Safety	Social
	Tax Payers Advocacy and Campaign Project for Asset Management	Social
Overseas Technical Cooperation Approach	Overseas Information Exchange Project for Bridge Maintenance	Social (International)

Based on the above alternative basic approaches to be identified, the following basic policies for the comprehensive bridge management are proposed. The relevant objective analysis is illustrated as per Figure 5.1.1.

(a) The basic approach for the bridge maintenance should be switched from *"ad-hoc basis maintenance"* to *"preventive maintenance"* which derives from the concept of *"asset management"* for bridges. Since the present budget for the maintenance of bridges remains minimum, the concept of the well-planned *"life cycle cost"* should be incorporated into the planning and budgetary arrangement of the maintenance of bridges. The strong political commitment to the optimum allocation of financial resources for the bridge maintenance is critical in order to secure the required budget based on the concept of *"preventive maintenance"*.

(b) The maintenance of bridges should be managed not simply by the improvement of bridge maintenance technologies and training of individual engineers but by the comprehensive bridge maintenance improvement through the modular projects in terms of individual, organizational, institutional and social levels of capacities.

(c) The ambiguous responsibilities, functions and missions of relevant departments of MOPT and CONAVI should be clarified, thereby strengthening the institutional capacities of those departments for both organizations. The functions of the bridge department of

MOPT should be strengthened in the field of i) formulation of basic strategies, ii) allocation of budget, iii) operation of BMS, iv) prioritization of maintenance and repair of bridges, and v) planning of maintenance and repair of bridges. On the other hand, the bridge–related section of CONAVI should be created under the Direction of Road Conservation in cooperation with the Direction of Engineering and the Direction of Works. The core bridge management group, which consists of the representatives of relevant organizations, should be established as a transient institution to the newly created bridge-related section of CONAVI.

(d) The ad-hoc work flow for the bridge maintenance should be standardized with a proper manual for the bridge maintenance, thereby streamlining the functions of relevant departments of MOPT and CONAVI.

(e) A wide range of human resources development programmes in the field of bridge management should be designed taking into account that:

i) the main target of the training programmes should be staff of the bridge maintenance core group;
ii) training of road engineers, especially OJT (on-the-job training) in the field of the bridge maintenance should be promoted in order to make maximum use of the current human resources in MOPT and CONAVI; and
iii) training of technical staff, contract-based technical staff of the Direction of Road Conservation of CONAVI, should be emphasized.

(f) A wide range of collaborations in the field of human resources development and technical information exchange among MOPT, CONAVI, research organizations and private companies should be promoted.

(g) Effective enforcement of laws, standards, regulations in the field of bridge maintenance, bridge designing, procurement *procedures* and traffic control should be significantly improved so as to upgrade capacities at the institutional level.

(h) The optimum budget for the maintenance of bridges should be achieved through:

i) the most effective and allocation of the budget for the bridge maintenance within the realistic budgetary limit;
ii) reasonable reallocation of the budget from new construction projects to maintenance works; and
iii) reasonable reallocation of the budget from road maintenance works to bridge maintenance works.

(i) Advocacy for users and tax payers on the bridge maintenance as well as the technical cooperation with overseas countries such as PPP member countries should be implemented for the purpose of socially and internationally extending the concept of *"Preventive Maintenance"* and *"Asset Management"*.

(j) Sustainability of the bridge maintenance even after the completion of the Study is critical. In other words, "exit strategy" after the completion of the Study should be clarified in such ways as:

i) sustainable budget for the bridge maintenance in the longer term;
ii) visualized management of the identified modular projects though the plan of operations; and
iii) monitoring on the identified modular projects by using verifiable indicators.

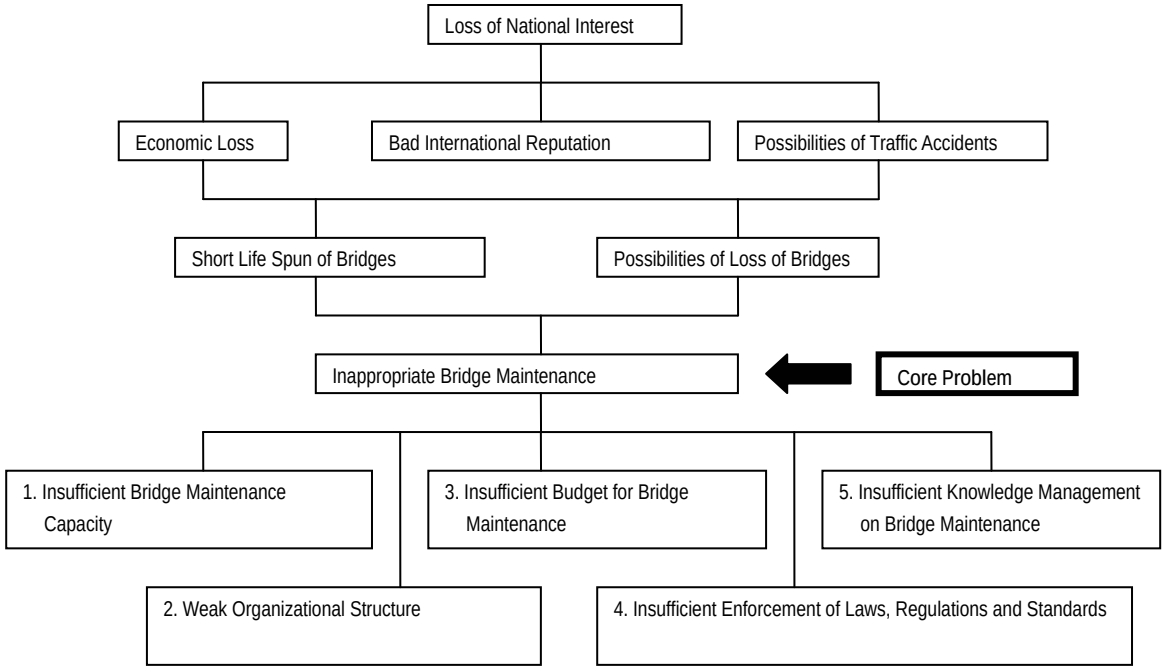
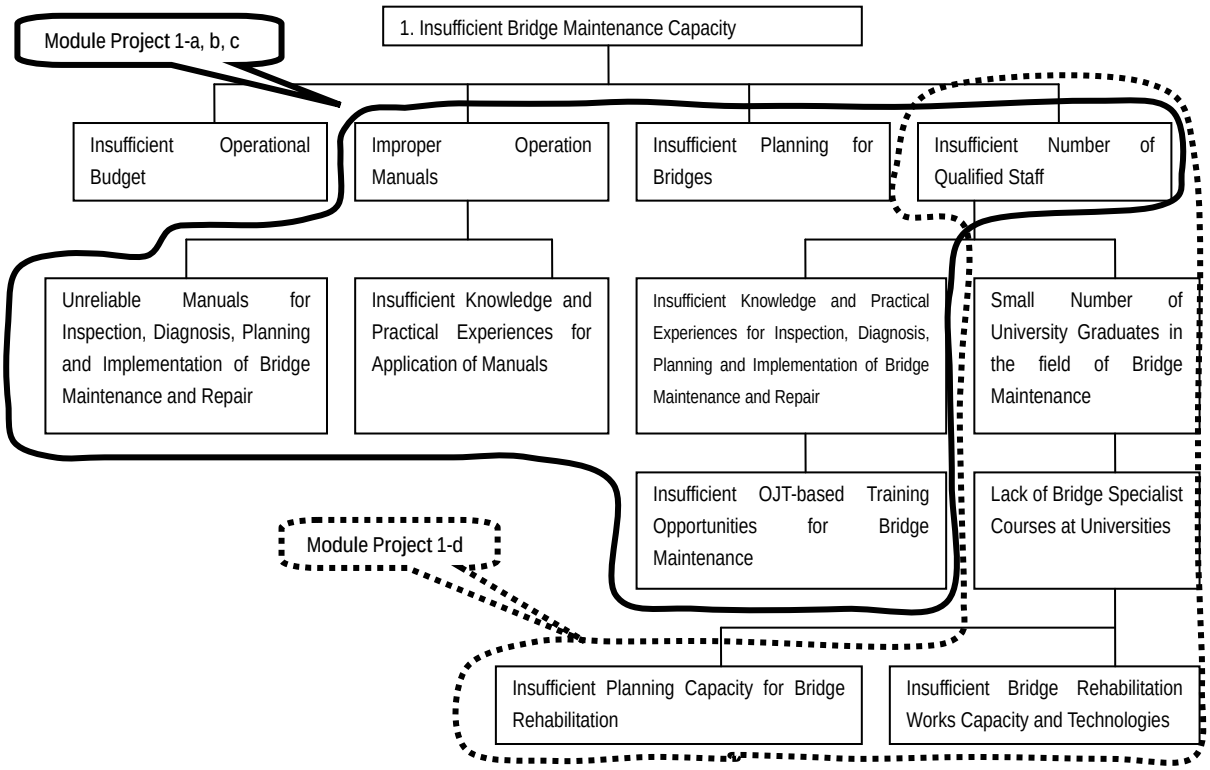
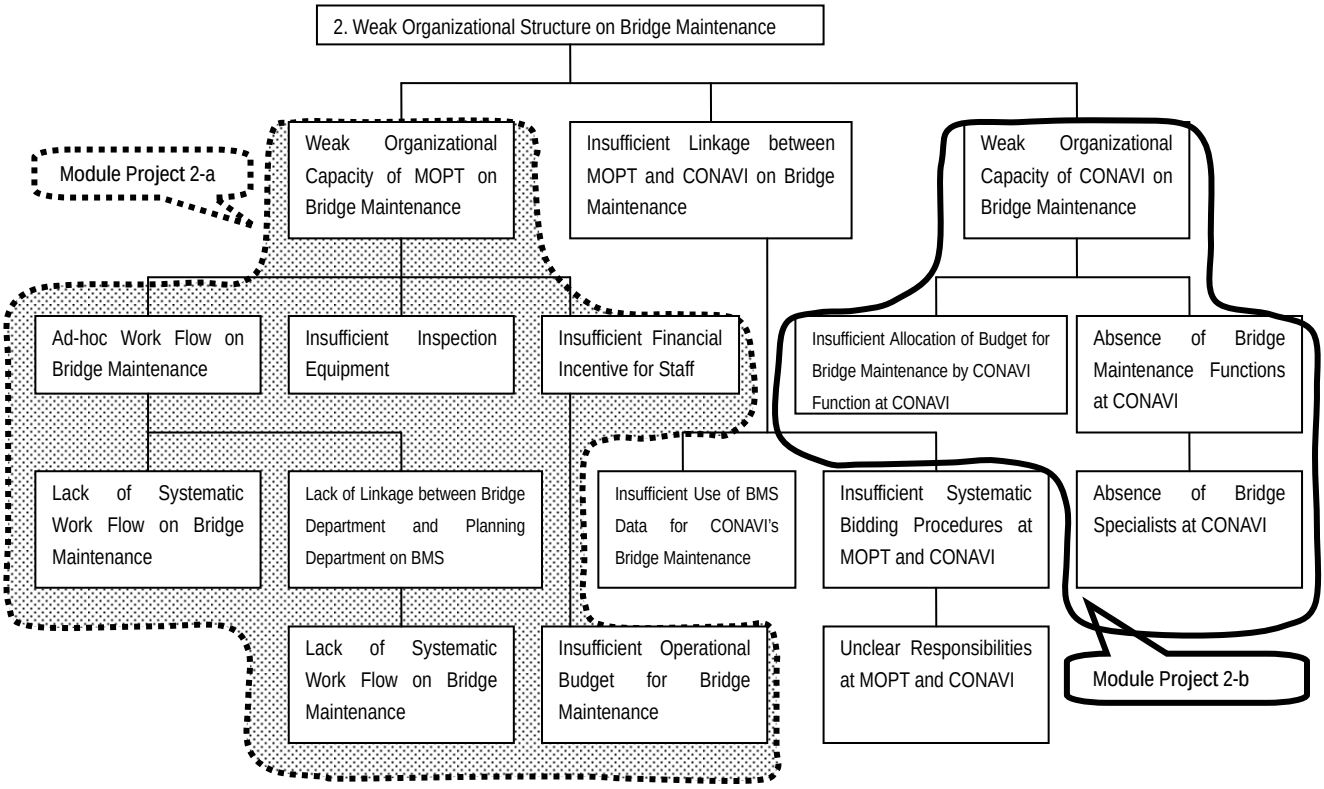
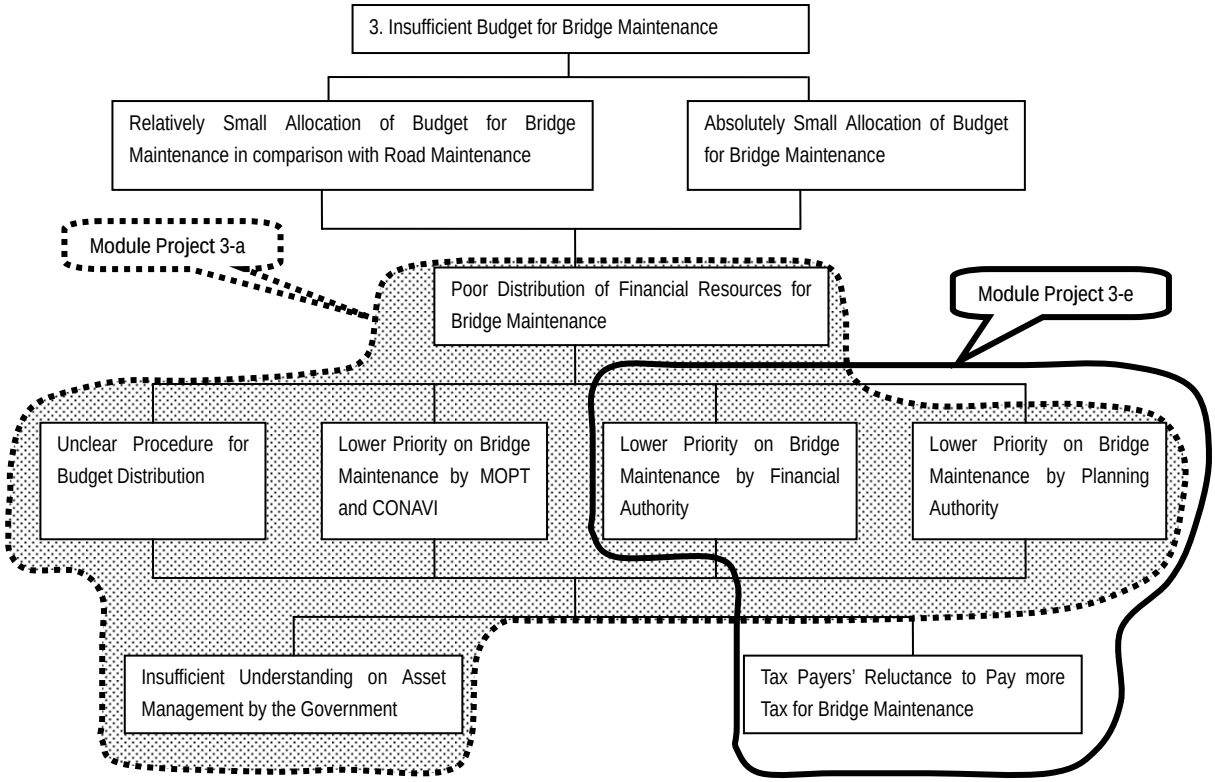


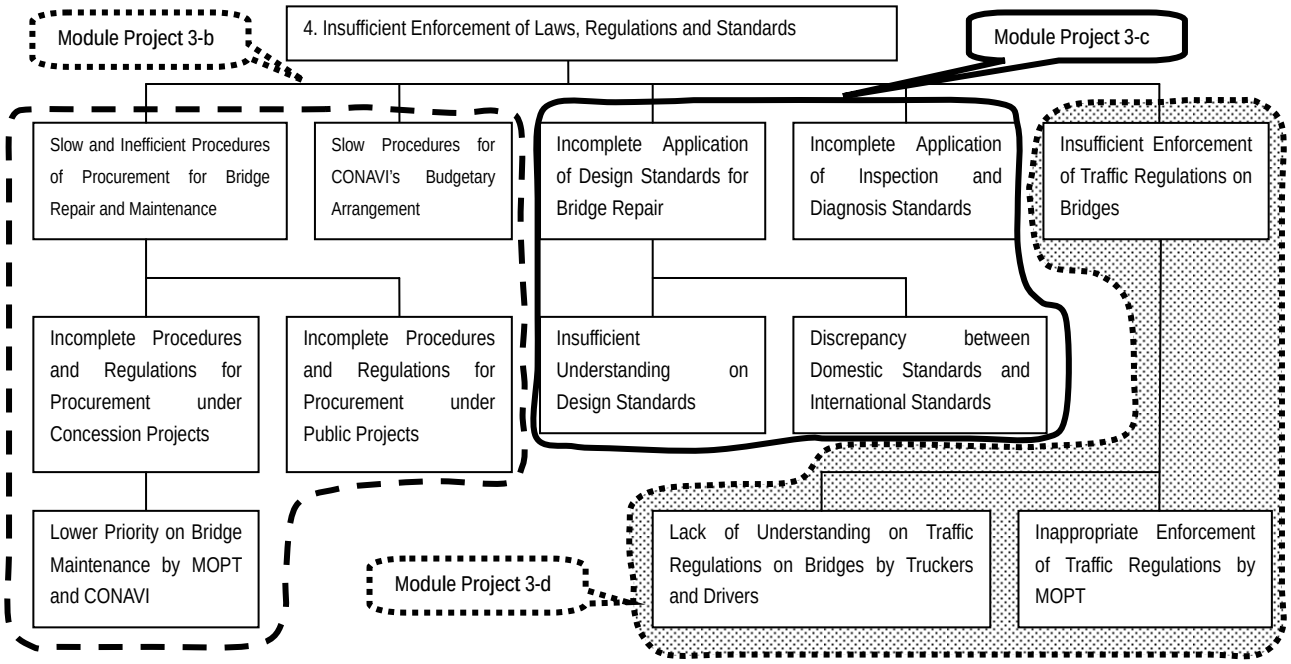
Figure 5.1.1 Overall Problem Tree and Alternative Approaches

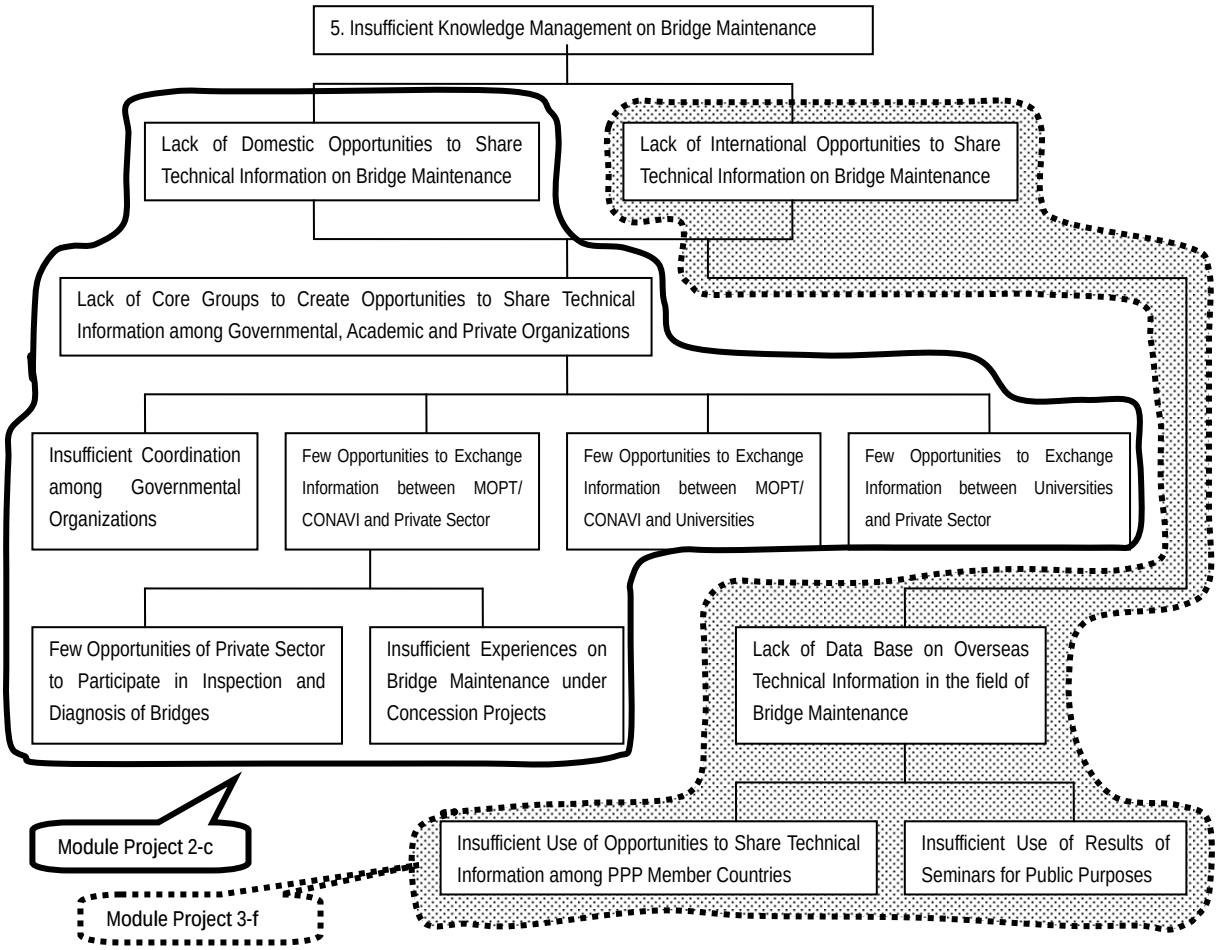
Note: Alternative approaches for each cause of the core problem are as shown below.




2. Weak Organizational Structure on Bridge Maintenance
Module Project 2-a
Weak Organizational Capacity of MOPT on Bridge Maintenance
Insufficient Linkage between MOPT and CONAVI on Bridge Maintenance
Weak Organizational Capacity of CONAVI on Bridge Maintenance
Ad-hoc Work Flow on Bridge Maintenance
Insufficient Inspection Equipment
Insufficient Financial Incentive for Staff
Insufficient Allocation of Budget for Bridge Maintenance by CONAVI Function at CONAVI
Absence of Bridge Maintenance Functions at CONAVI
Lack of Systematic Work Flow on Bridge Maintenance
Lack of Linkage between Bridge Department and Planning Department on BMS
Insufficient Use of BMS Data for CONAVI's Bridge Maintenance
Insufficient Systematic Bidding Procedures at MOPT and CONAVI
Absence of Bridge Specialists at CONAVI
Lack of Systematic Work Flow on Bridge Maintenance
Insufficient Operational Budget for Bridge Maintenance
Unclear Responsibilities at MOPT and CONAVI
Module Project 2-b


3. Insufficient Budget for Bridge Maintenance
Relatively Small Allocation of Budget for Bridge Maintenance in comparison with Road Maintenance
Absolutely Small Allocation of Budget for Bridge Maintenance
Module Project 3-a
Poor Distribution of Financial Resources for Bridge Maintenance
Module Project 3-e
Unclear Procedure for Budget Distribution
Lower Priority on Bridge Maintenance by MOPT and CONAVI
Lower Priority on Bridge Maintenance by Financial Authority
Lower Priority on Bridge Maintenance by Planning Authority
Insufficient Understanding on Asset Management by the Government
Tax Payers' Reluctance to Pay more Tax for Bridge Maintenance


Module Project 3-b
4. Insufficient Enforcement of Laws, Regulations and Standards
Module Project 3-c
Slow and Inefficient Procedures of Procurement for Bridge Repair and Maintenance
Slow Procedures for CONAVI's Budgetary Arrangement
Incomplete Application of Design Standards for Bridge Repair
Incomplete Application of Inspection and Diagnosis Standards
Insufficient Enforcement of Traffic Regulations on Bridges
Incomplete Procedures and Regulations for Procurement under Concession Projects
Incomplete Procedures and Regulations for Procurement under Public Projects
Insufficient Understanding on Design Standards
Discrepancy between Domestic Standards and International Standards
Lower Priority on Bridge Maintenance by MOPT and CONAVI
Module Project 3-d
Lack of Understanding on Traffic Regulations on Bridges by Truckers and Drivers
Inappropriate Enforcement of Traffic Regulations by MOPT


5. Insufficient Knowledge Management on Bridge Maintenance
Lack of Domestic Opportunities to Share Technical Information on Bridge Maintenance
Lack of International Opportunities to Share Technical Information on Bridge Maintenance
Lack of Core Groups to Create Opportunities to Share Technical Information among Governmental, Academic and Private Organizations
Insufficient Coordination among Governmental Organizations
Few Opportunities to Exchange Information between MOPT/ CONAVI and Private Sector
Few Opportunities to Exchange Information between MOPT/ CONAVI and Universities
Few Opportunities to Exchange Information between Universities and Private Sector
Few Opportunities of Private Sector to Participate in Inspection and Diagnosis of Bridges
Insufficient Experiences on Bridge Maintenance under Concession Projects
Lack of Data Base on Overseas Technical Information in the field of Bridge Maintenance
Module Project 2-c
Module Project 3-f
Insufficient Use of Opportunities to Share Technical Information among PPP Member Countries
Insufficient Use of Results of Seminars for Public Purposes

5.2 Proto-type Modular Projects for Capacity Development

Based on the alternative approaches derived from the alternative analysis under the PCM method, 13 proto-type modular projects are identified. At the individual level, the following 4 modular projects are identified so as to remove the individual-level bottlenecks.

Table 5.2.1. Preliminary List of Modular Projects (Individual Level)

PDM No.	Name of Modular Project	Outline of Modular Project	Level
1-a	Individual Capacity Improvement Project for Bridge Inspection and Diagnosis	To significantly improve engineers' capacity of MOPT and CONAVI in the field of inspection and diagnosis.	Individual
1-b	Individual Capacity Improvement Project for BMS Operation and Priority Selection of Bridge Maintenance	To significantly improve engineers' capacity of MOPT and CONAVI in the field of BMS operation and priority selection of bridge maintenance	Individual
1-c	Individual Capacity Improvement Project for Planning and Implementation of Bridge Rehabilitation	To significantly improve engineers' capacity of MOPT and CONAVI in the field of planning and implementation of bridge rehabilitation	Individual
1-d	Human Resources Development Project for Bridge Maintenance	To secure sufficient number of qualified human resources in the field of bridge maintenance on a longer-term basis	Individual

At the organizational level, the following 3 modular projects are identified so as to remove the organizational-level bottlenecks.

Table 5.2.2. Preliminary List of Modular Projects (Organizational Level)

PDM No.	Name of Modular Project	Outline of Modular Project	Level
2-a	Organization Strengthening Project of Bridge Department of MOPT	To significantly improve functions and performance of the bridge department of MOPT	Organizational
2-b	Organization Setting-up Project of Bridge Department of CONAVI	To effectively and substantially set up the function of the new bridge department of CONAVI	Organizational
2-c	Knowledge Management Promotion Project among Public, Private and Academic Sectors	To promote the knowledge and information sharing on the bridge maintenance among public, private and academic sectors	Organizational

At the institutional and social levels, the following 6 modular projects are identified so as to remove the institutional/social-level bottlenecks.

Table 5.2.3. Preliminary List of Modular Projects (Institutional and Social Level)

PDM No.	Name of Modular Project	Outline of Modular Project	Level
3-a	Asset Management Policy Introduction Project for Financial and Planning Authority	To incorporate the concept of *"asset management" and "preventive maintenance"* into the budgetary and planning process of the government	Institutional (Policy)
3-b	Enforcement Improvement Project for Procurement Procedures, Regulations and Standards	To significantly improve the enforcement of procurement procedures, regulations and technical standards under direct contracts	Institutional
3-c	Enforcement Improvement Project for Technical Regulations and Design Standards	To significantly improve the enforcement of technical regulations and design standards under direct and concession contracts	Institutional
3-d	Bridge Users Advocacy and Campaign Project for Asset Management and Traffic Safety	To significantly improve the understanding of bridge users such as truckers and other drivers on *"asset management" and "preventive maintenance"* of bridges	Social (Domestic)
3-e	Tax Payers Advocacy and Campaign Project for Asset Management	To significantly improve the understanding of tax payers on *"asset management" and "preventive maintenance"* of bridges	Social (Domestic)
3-f	Overseas Information Exchange Project for Bridge Maintenance	To extend the concept of *"asset management" and "preventive maintenance"* of bridges toward the regional society such as PPP member countries	Social (International)

CHAPTER 6 IMPLEMENTATION OF CAPACITY DEVELOPMENT FOR A COMPREHENSIVE BRIDGE MAINTENANCE PROGRAM

6.1 Basic Methodologies and Procedures

6.1.1 Program Approach as Basic Methodology for Implementation of Capacity Development

Through a wide range of the capacity gap assessment activities for the improvement of the comprehensive bridge maintenance system, basic policies for the capacity development have been formulated, thereby identifying 13 proto-type modular projects at individual, organizational, institutional and social capacity levels. However, these basic policies for the capacity development are so conceptual that officials of MOPT and CONAVI would find it difficult to explore a proper operational methodology and procedures to actually implement these 13 proto-type modular projects.

It is acknowledged that ***"project approach"*** based on a single project alone does not comprehensively solve the bridge maintenance system. Since ***"program approach"*** is the process of managing a portfolio of multiple inter-dependent projects, the approach can be used for the management of the identified multiple modular projects. The program approach provides the capacity development with an operational common platform to implement these modular projects. Although the capacity development acts as a cardinal pre-condition to maximize the sustainability of the nation-wide bridge maintenance performance, the implementation of each proto-type modular project alone would not be successful in implementing the capacity development.

"Program management" provides a program approach with a layer focusing on selecting the best combination and sequences of the identified modular projects. In other words, a program approach requires a program management method so as to actually manage the identified modular projects. However, the program approach for the capacity development must have a customized or tailored-made approach specifically designed for the capacity development.

6.1.2 Integration of Modular Projects for Capacity Development

Thirteen proto-type modular projects identified in Chapter 5 are integrated into 5 full-scale modular projects, taking into account the similarity of each proto-type modular project. Consequently, the cluster of 5 integrated full-scale modular projects is regarded as the bridge maintenance program so as to comprehensively develop a wide range of capacities in the field of the bridge maintenance. The road map for the capacity development is also designed by integrating these 5 modular projects to provide the snapshot for the combination of these integrated modular projects, thereby illustrating a clear-cut route to achieve the ideal bridge maintenance. Table 6.1.1. shows the list of the integrated modular projects together with the original proto-type modular projects.

Table 6.1.1. List of 5 Integrated Modular Projects

Proto-type Modular Project No.		Contents of Integrated Modular Projects	Integrated Modular Project No.
Integrated Modular Project 1 (MP-1: Individual Capacity Building Project for MOPT and COMAVI)			Project Design Matrix (PDM-1)
	1-a	Individual Capacity Improvement Project for Inspection and Diagnosis	
	1-b	Individual Capacity Improvement Project for BMS Operation, Priority Selection and Rehabilitation Planning of Bridges	
	1-c	Individual Capacity Improvement Project for Implementation of Rehabilitation of Bridges	
Integrated Modular Project 2 (MP-2: Institutional Building Project for MOPT and CONAVI)			Project Design Matrix (PDM-2)
	2-a	Organization Strengthening Project for Direction of Bridges of MOPT	
	2-b	Organization Strengthening Project for New Bridge-related Department of CONAVI	
Integrated Modular Project 3 (MP-3: Long-term Human Resources Development and Technical Exchange Project)			Project Design Matrix (PDM-3)
	1-d	Long-term Human Resources Development Project	
	2-c	Public-Private-Academic Technical Exchange Project	
	3-f	PPP Countries Technical Exchange Project	
Integrated Modular Project 4 (MP-4: Regulation and Standards Improvement Project)			Project Design Matrix (PDM-4)
	3-b	Technical Regulations and Design Standards Improvement Project	
	3-c	Procurement Regulations and Procedures Improvement Project	
Integrated Modular Project 5 (MP-5: Promotion of Public Relations and Advocacy Project)			Project Design Matrix (PDM-5)
	3-a	Asset Management Advocacy Project for Financial and Planning Authorities	
	3-d	Bridge Users Public Relations and Advocacy Project	
	3-e	Tax Payers Public Relations and Advocacy Project	

6.1.3 Establishment of BMCG and Working Groups

As a main supporting body for the implementation of the capacity development to comprehensively improve the bridge maintenance activities of MOPT and CONAVI, “Bridge Maintenance Consulting Group (BMCG)” which consists of representatives from various organizations was established. The main functions of the BMCG are described as below, and the relationship between 5 working groups and 5 integrated modular projects is shown in Table 6.1.2.

(a) The BMCG should function as an advisory and consulting body to help strengthen the institutional capacity of the newly established direction of bridges of MOPT and create the bridge-related department of CONAVI.

(b) The ad-hoc work flow for the bridge maintenance activities should be standardized by streamlining demarcations of responsibilities between MOPT and CONAVI.

(c) The BMCG consists of the secretariat and 5 working groups, and members of the BMCG including representatives of the following organizations.

i) Direction of Bridges of MOPT

ii) Direction of Planning of MOPT
iii) Direction of Planning and Evaluation of CONAVI
iv) National Concession Committee
v) University of Costa Rica and Other Universities
vi) LANNAME and Other Affiliated Research Organizations
vii) Association of Engineers
viii) Representatives of Truck Companies Association
ix) Representative of Contractors Association

(d) *"Plan of Operations"* for the PDMs should be shared among all the members of the BMCG in order to visualize them as an effective management tool.

Table 6.1.2. 5 Groups for BMCG and Related Modular Projects

WG No.	Working Group	Related Modular Projects
WG-1	Working Group for Individual Capacity Building	Modular Project 1
WG-2	Working Group for Institutional Building of MOPT and CONAVI	Modular Project 2
WG-3	Working Group for Long-term Human Resources Development	Modular Project 3
WG-4	Working Group for Improvement of Laws, Regulations and Standards	Modular Project 4
WG-5	Working Group for Promotion of Public Relations	Modular Project 5

The responsibility assignment of the members of the BMCG for each working group is also tabulated as per Table 6.1.3.

Table 6.1.3. Proposed Responsibility Assignment for Working Groups of BMCG

Member	WG1	WG2	WG3	WG4	WG5
MOPT, Direction of Bridges	●	●	●	●	●
MOPT, Direction of Planning	●	●	●		●
CONAVI	●	●	●	●	●
MIDEPLAN		●			●
Ministry of Finance		●			●
National Concession Committee				●	
University of Costa Rica and Other Universities	●		●	●	
LANAMME	●		●	●	
Engineering Association			●	●	
Contractors Association (Private Sector)			●	●	
Truck Association				●	●

Note : ● = Member of WG

6.1.4 Basic Schedule for Capacity Development

The basic time frame required for implementing the capacity development initiative to meet targets of modular projects takes longer period. It might be noted that complicated and multi-modular capacity development projects take many years to implement. It might take approximately 5 years in addition to one-year preparation period to complete the capacity development with 5 integrated modular projects in the field of the bridge maintenance. Based on this recognition, the implementation period for 5 integrated modular projects will substantially start from the financial year 2007 and complete in the financial year 2012, while the financial year 2007 is regarded as the preparation period.

6.1.5 Key Drivers for Capacity Development

Ownership, motivation and incentive are identified as key inter-related ingredients of successful capacity development activities in addition to tangible aspects such as skills, financial resources and organizational structures. Strong ownership was identified as one of the most fundamental attributes to assure sustainability of the capacity development.

Incentives play an important part in mobilizing and making use of existing capacities. Monetary and non-monetary forms of incentives contributes to enhancing the stakeholders' willingness to improve the capacities by ensuring that effective capacity is translated into good performance of individuals, organizations and societies. Table 6.1.4. indicates the non-monetary and invisible incentives for the BMCG members. These non-monetary incentives will be the most effective key driver among various factors surrounding the capacity development process.

Table 6.1.4. Incentives for BMCG Members

Members	Incentives
MOPT and CONAVI	To establish the comprehensive bridge maintenance system for the national highway network
Ministry of Finance and MIDEPLAN	To efficiently use the national financial resources through the preventive maintenance of bridges
National Concession Committee	To establish the efficient procurement procedures under the concession system
Universities and Research Organizations	To establish new bridge-related courses at Universities
Truck Companies Association	To enjoy safer traffic
Contractors Association	To expand new outsourcing market for bridge maintenance and rehabilitation

6.2 Project Design Matrix, Work Breakdown Structure and Plan of Operation

6.2.1 Project Design Matrix

The outline of each modular project is expressed in the form of PDM (Project Design Matrix) which is a four-by-four matrix to lay out a project design, and each box in the PDM contains the following specific information on 5 integrated modular projects. The PDMs for 5 integrated modular projects are as per Table 6.2.1. to Table 6.2.5.

(a) ***Narrative Summary*** refers to the hierarchy of objectives and makes the distinction between program strategy ***(Overall Goal)***, project impacts ***(Project Purpose)***, project deliverables ***(Outputs)*** and the key activities ***(Activities)***.
(b) ***Objectively Verifiable Indicators*** identifies the performance indicators which define quantity, quality and time for each objective.
(c) ***Means of Verification*** refers to the data sources for objectively verifiable indicators.
(d) ***Important Assumptions*** describes the other conditions on which each modular project depends for its success.
(e) ***Pre-conditions*** indicate prerequisites for the starting a modular project or implementing the activities.
(f) ***Inputs*** are required for implementation of the activities are listed in the bottom box in the second column.

Table 6.2.1. Preliminary Project Design Matrix (Modular Project 1)

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal: All the bridges on the national highway network will be sustainably maintained and repaired in the long run by the trained and qualified MOPT and CONAVI staff.	By the end of the financial year 2012, all the bridges on the national highway network will be rotationally maintained and repaired in 5 years (350 bridges per annum) by the trained and qualified MOPT and CONAVI staff.	Bridge Inventory Data on BMS	The training of the ample number of the qualified staff in the relevant expertise is regarded as one of priority areas of the bridge maintenance in Costa Rica.
Project Purpose: 1. All the bridges on the national highway network will be maintained and repaired by the ample number of the qualified staff of MOPT and CONAVI who have the following appropriate expertise. 1. Inspection of Bridges, 2. BMS Management, 3. Diagnosis and Priority Selection, 4. Repair Planning, 5. Repair Works	By the end of the financial year 2012, all the bridges on the national highway network will be maintained and repaired by the ample number of the qualified staff of MOPT and CONAVI who have the following appropriate expertise. 1. Inspection of Bridges, 2. BMS Management, 3. Diagnosis and Priority Selection, 4. Repair Planning, 5. Repair Works	Bridge Inspection Records and Bridge Repair Records	Through the full operations of the trained staff, maintenance and repair works of all the bridges will be rotationally implemented.
Outcome: 1. The ample number of the qualified staff of MOPT and CONAVI who have the following appropriate expertise will be trained. 1. Inspection of Bridges, 2. BMS Management, 3. Diagnosis and Priority Selection, 4. Repair Planning, 5. Repair Works	By the end of the financial year 2012, the required number of the qualified staff of MOPT and CONAVI will be trained in accordance with the plan of operations in the following expertise. 1. Inspection of Bridges, 2. BMS Management, 3. Diagnosis and Priority Selection, 4. Repair Planning, 5. Repair Works	Work Records and Progress Reports of the Working Group 1 (WG-1)	The trained staff will be actually assigned to MOPT and CONAVI, and will keep in full operations.
Activities: The details of activities are as per the attached Work Breakdown Structure (WBS) for MP-1	Input : The details of input are as per the attached plan of operations (PO) for the Modular Project 1 (MP-1).		The candidates for the qualified staff with the relevant expertise will participate in the training opportunities. Pre-Conditions : 1. The budget and staff for the working group 1 (WG-1) will be guaranteed starting from the financial year 2008 in order to cover the WBS under the MP-1

Table 6.2.2. Preliminary Project Design Matrix (Modular Project 2)

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal: All the bridges on the national highway network will be maintained and repaired under the proper organization of MOPT and CONAVI.	By the end of the financial year 2012, 100 percent of bridges on the national highway network will be regularly maintained and repaired under the improved organization of MOPT and CONAVI.	Maintenance and Repair Records in BMS	The organization as well as the budget for new bridge-related organizations of MOPT and CONAVI is regarded as one of priority areas of the bridge maintenance in Costa Rica.
Project Purpose: 1. The existing bridge design department of MOPT will be transformed into the new direction of bridges to appropriately support the bridge maintenance activities in accordance with the recommended organizational and budgetary structure. 2. The new bridge-related department of CONAVI will be established to appropriately support the bridge maintenance activities in accordance with the recommended organizational and budgetary structure.	1. By the end of the financial year 2012, the existing organizational and budgetary level of the bridge design department of MOPT will reach to the same level as the recommended organizational and budgetary structure. 2. By the end of the financial year 2012, the organizational and budgetary level of the new bridge-related department of CONAVI will reach to the same level as the recommended organizational and budgetary structure.	Work Records of New Direction of Bridges of MOPT and New Department of Bridges of CONAVI	The improved organization as well as the budget for new bridge-related organization will actually function for bridge maintenance activities.
Outcome : The following activities will be implemented to establish optimum and workable performance of new bridge-related organizations of MOPT and CONAVI. 1. To streamline responsibilities and clarify workflows, 2. To improve organizational structure, 3. To secure optimum staffing, 4. To secure optimum budget	By the end of the financial year 2007, streamlining responsibilities and clarifying workflows of new bridge-related organizations of MOPT and CONAVI will be completed so as to apply for the optimum staff and budget.	1. Organization Chart for New Bridge-related Organizations of MOPT and CONAVI, 2. Staff List and Terms of Reference for New Bridge-related Organizations of MOPT and CONAVI, 3. Budgetary Documents for New Bridge-related Organizations of MOPT and CONAVI	The proposed responsibilities as well as workflows of the new bridge-related organizations of MOPT and CONAVI will be materialized with the actual organizational and budgetary commitment.
Activities: The details of activities are as per the attached Work Breakdown Structure (WBS) for MP-2	Input : The details of input are as per the attached plan of operations (PO) for the Modular Project 2 (MP-2).		The existing bridge-related organizations of MOPT and CONAVI will be transformed into new organizations. Pre-Conditions : 1. The budget and staff for the working group 2 (WG-2) will be guaranteed starting from the financial year 2008 in order to cover the WBS under the MP-2

Table 6.2.3. Preliminary Project Design Matrix (Modular Project 3)

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal: The maintenance of all the bridges on the national highway network will be supported by the long-term supply of experts and knowledge shares among various stakeholders.	By the end of the financial year 2012, the candidates for the trained and qualified MOPT and CONAVI staff who are in charge of all the bridges on the national highway network will be selected from the graduates from 3 universities of Costa Rica	Bridge Inventory Data on BMS	The long-term supply of human resources in the field of bridge construction and maintenance through universities as well as the knowledge share among relevant stakeholders is regarded as one of priority areas of the bridge maintenance in Costa Rica.
Project Purpose: 1. The sufficient number of university graduates in the field of bridge construction and maintenance will be secured. 2. A wide range of technological information in the field of bridge maintenance will be frequently exchanged and shared among the public-private-academic circle. 3. A wide range of technological information in the field of bridge maintenance will be frequently exchanged and shared among the PPP countries.	1. By the end of the financial year 2012, 3 universities of Costa Rica will have 10 new graduates in the field of bridge construction and maintenance. 2. By the end of the financial year 2012, more than 80 percent of the new technological information will be exchanged and shared among the public-private-academic circle. 3. By the end of the financial year 2012, more than 80 percent of the new technological information will be exchanged and shared among PPP member countries.	1. List of Graduates from New Courses at Universities, 2. Database of Shared Technological Information among Public-Private-Academic Circle, 3. Database of Shared Technological Information among PPP Member Countries	1. The new university graduates in the field of bridge construction and maintenance will be continuously employed by MOPT, CONAVI, and the private sector. 2. The shared technological information will be effectively utilized for the improvement of bridge maintenance activities.
Outcome: 1. New courses in the field of bridge constuction and maintenance in several universities will be established, 2. Regular meetings and ad-hoc seminars will be held to exchange and share the latest technological information in the field of bridge maintenance.	1. By the end of the financial year 2011, three universities of Costa Rica will have new courses in the field of bridge construction and maintenance. 2. From the financial year 2008 to 2012, at least, one regular meeting as well as one ad-hoc seminar among the public-private-academic circle for the knowledge share will be annually held. 3. From the financial year 2008 to 2012, at least, one regular meeting as well as one ad-hoc seminar among PPP member countries for the knowledge share will be annually held.	1. List of Courses at Universities, 2. Progress Reports and Work Records of Public-Private-Academic Seminars, 3. Progress Reports and Work Records of PPP Seminars	1. The new courses at universities will be able to have graduates in the field of bridge construction and maintenance. 2. The participants for a series of seminars will fully exchange and share useful technological information.
Activities: The details of activities are as per the attached Work Breakdown Structure (WBS) for MP-3	Input : The details of input are as per the attached plan of operations (PO) for the Modular Project 3 (MP-3).		1. The new courses at universities will be actually financed by the government. 2. Relevant stakeholders will actually participate in a series of seminars.

Table 6.2.4. Preliminary Project Design Matrix (Modular Project 4)

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal: All the bridges on the national highway network will be maintained and repaired under proper guidelines, regulations, standards and manuals.	By the end of the financial year 2012, 100 percent of bridges on the national highway network will be regularly maintained and repaired under the improved guidelines, regulations, standards and manuals.	Maintenance and Repair Records in BMS	The preparation of relevant guidelines, regulations, standards and manuals is regarded as one of priority areas of the bridge maintenance in Costa Rica.
Project Purpose: 1. A wide range of guidelines, regulations, standards and manuals for bridge maintenance practices, together with their applications and operations, will be significantly improved. 2. A wide range of guidelines, regulations, standards and manuals for procurement procedures of MOPT, CONAVI and CNC, including concession procedures, will be significantly improved. 3. The regulations and their operations in the field of traffic safety on bridges will be significantly improved.	By the end of the financial year 2012, 100 percent of guidelines, regulations, standards and manuals related to bridge maintenance practices, procurement procedures and traffic safety, together with their applications and operations, will be improved up to the international level.	List of Guidelines, Regulations, Standards and Manuals related to Bridge Maintenance Practices, Procurement Procedures and Traffic Safety on Bridges	The improved guidelines, regulations, standards and manuals will be actually function for the use of trained staff.
Outcome : The following proper and workable guidelines, regulations, standards and manuals will be prepared. 1. Bridge Inspection Manual, 2.BMS Operation Manual, 3. Guidelines for Bridge Maintenance, 4. Bridge Design Standards, 5. Regulations for Bridge Maintenance, 6. Guidelines for Procurement Procedures by MOPT, CONAVI and CNC, 7. Regulations on Traffic Safety on Bridges	By the end of the financial year 2012, the following documents will be prepared In accordance with the plan of operations. 1. Bridge Inspection Manual, 2.BMS Operation Manual, 3. Guidelines for Bridge Maintenance, 4. Bridge Design Standards, 5. Regulations for Bridge Maintenance, 6. Guidelines for Procurement Procedures by MOPT, CONAVI and CNC, 7. Regulations on Traffic Safety on Bridges	Work Records and Progress Reports of the Working Group 4 (WG-4)	The improvements of guidelines, regulations, standards and manuals are officially reflected on all the documents.
Activities: The details of activities are as per the attached Work Breakdown Structure (WBS) for MP-4	Input : The details of input are as per the attached plan of operations (PO) for the Modular Project 4 (MP-4).		The existing guidelines, regulations, standards and manuals are streamlined for their reviews.
			Pre-Conditions : 1. The budget and staff for the working group 4 (WG-4) will be guaranteed starting from the financial year 2008 in order to cover the WBS under the MP-4

Table 6.2.5. Preliminary Project Design Matrix (Modular Project 5)

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal: All the bridges on the national highway network will be periodically maintained and repaired under understandings of relevant stakeholders on the importance of bridge maintenance as well as asset management.	By the end of the financial year 2012, 100 percent of bridges on the national highway network will be periodically maintained and repaired under understandings of relevant stakeholders on the importance of bridge maintenance as well as asset management.	Maintenance and Repair Records in BMS	The advocacy as well as public relations is regarded as one of priority areas of the bridge maintenance in Costa Rica.
Project Purpose: 1. Understanding of the government officials on the bridge maintenance in terms of asset management will be promoted. 2. Understanding of bridge users and taxpayers on the bridge maintenance in terms of asset management will be significantly promoted.	1. By the end of the financial year 2012, 80 percent of financial and planning officials of relevant ministries as well as MOPT/CONAVI will understand the importance of asset management. 2. By the end of the financial year 2012, 80 percent of bridge users as well as taxpayers will understand the importance of bridge maintenance.	1. Survey on Understanding by Financial and Planning Officials, 2. Survey on Understanding by Bridge Users and Taxpayers	The understanding on asset management as well as safety regulations by government officials, bridge users and taxpayers will lead to the better bridge maintenance in Costa Rica.
Outcome : 1. Sufficient number of officials of the Ministry of Finance and the Ministry of National Planning will be educated through a series of seminars on asset management. 2. Sufficient number of financial and planning officials of MOPT and CONAVI will be educated through a series of seminars on asset management. 3. Sufficient number of bridge users and tax payers will be educated through a wide range of public relations activities on understanding of bridge maintenance and safety regulations.	1. By the end of the financial year 2012, 10 officials of the Ministry of Finance and the Ministry of National Planning will annually participate in a series of seminars on asset management. 2. By the end of the financial year 2012, a considerable number of bridge users and taxpayers will continuously be advocated through a wide range of public relation activities in the field of bridge maintenance.	1. Attendance List of Seminars, 2. Number and Target List of Public Relation Activities	The participants in a series of seminars as well as the targetted bridge users and taxpayers will fully understand their contents.
Activities: The details of activities are as per the attached Work Breakdown Structure (WBS) for MP-5	Input : The details of input are as per the attached plan of operations (PO) for the Modular Project 5 (MP-5).		Candidates for participants in a series of seminars as well as the targeted bridge users and taxpayers will positively participate in those activities.
			Pre-Conditions : 1. The budget and staff for the working group 5 (WG-5) will be guaranteed starting from the financial year 2008 in order to cover the WBS under the MP-5

6.2.2 WBS for Integrated Modular Projects

Activities specified in each PDM are broken down into more manageable packages of work, which is called Work Breakdown Structure (WBS). A WBS is a deliverable-oriented hierarchical decomposition which defines all the works to be accomplished during each modular project. Being a critical document of the project scope, a WBS serves as the basis for planning of a modular project. More concretely, a WBS is a very common and critical project management tool. The preliminary WBSs for 5 integrated modular projects under each working group of the BMCG are as per Table 6.2.6. to Table 6.2.19, and the full-scale WBSs will be formulated in the course of a series of the BMCG meetings held in the financial year 2007.

a) Working Group 1

The major missions of the working group 1 (WG-1) are: i) to train sufficient number of qualified inspectors of bridges; ii) to train sufficient number of qualified staff for BMS management, diagnosis and priority selection of bridges; iii) to train sufficient number of qualified staff for rehabilitation and reinforcement planning of bridges; and iv) to train sufficient number of qualified staff for rehabilitation and reinforcement implementation of bridges. The preliminary WBS for the modular project 1 (MP-1) is as per Table 6.2.6. to Table 6.2.9.

Table 6.2.6. Preliminary WBS for Modular Project 1 (Task 1)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
1-1	To have a series of seminars for inspection of bridges	1-1-a	To plan contents and programs of seminars
		1-1-b	To select appropriate lecturers for seminars
		1-1-c	To prepare materials for seminars
		1-1-d	To prepare logistic arrangements for seminars
		1-1-e	To hold a series of seminars
1-2	To prepare a proper inspection manual	1-2-a	To make a proper inspection sheet
		1-2-b	To compile a proper inspection manual
1-3	To have a series of on-the-job training (OJT) for inspection of bridges	1-3-a	To plan contents and programs of the OJT
		1-3-b	To select appropriate trainers for the OJT
		1-3-c	To prepare equipment for the OJT
		1-3-d	To prepare logistic arrangements for the OJT
		1-3-e	To hold a series of the OJT
1-4	To set up a proper qualification system for inspectors	1-4-a	To set up a grading system for inspectors
		1-4-b	To categorize inspectors into qualification grades

Table 6.2.7. Preliminary WBS for Modular Project 1 (Task 2)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
2-1	To have a series of seminars for BMS management	2-1-a	To plan contents and programs of seminars
		2-1-b	To select appropriate lecturers for seminars
		2-1-c	To prepare materials for seminars
		2-1-d	To prepare logistic arrangements for seminars
		2-1-e	To hold a series of seminars
2-2	To prepare a proper BMS manual	2-2-a	To make a proper BMS system
		2-2-b	To compile a proper BMS operation manual
2-3	To have a series of on-the-job training (OJT) for BMS management	2-3-a	To plan contents and programs of the OJT
		2-3-b	To select appropriate trainers for the OJT
		2-3-c	To prepare materials for the OJT
		2-3-d	To prepare logistic arrangements for the OJT
		2-3-e	To hold a series of the OJT

Table 6.2.8. Preliminary WBS for Modular Project 1 (Task 3)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
3-1	To have a series of seminars for rehabilitation and reinforcement planning	3-1-a	To plan contents and programs of seminars
		3-1-b	To select appropriate lecturers for seminars
		3-1-c	To prepare materials for seminars
		3-1-d	To prepare logistic arrangements for seminars
		3-1-e	To hold a series of seminars
3-2	To prepare a proper planning guideline for rehabilitation and reinforcement planning	3-2-a	To make a proper guidelines for diagnosis and priority selection
		3-2-b	To make a proper guidelines for planning
3-3	To have a series of on-the-job training (OJT) for rehabilitation and reinforcement planning	3-3-a	To plan contents and programs of the OJT
		3-3-b	To select appropriate trainers for the OJT
		3-3-c	To prepare materials for the OJT
		3-3-d	To prepare logistic arrangements for the OJT
		3-3-e	To hold a series of the OJT

Table 6.2.9. Preliminary WBS for Modular Project 1 (Task 4)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
4-1	To have a series of seminars for rehabilitation and reinforcement works	4-1-a	To plan contents and programs of seminars
		4-1-b	To select appropriate lecturers for seminars
		4-1-c	To prepare materials for seminars
		4-1-d	To prepare logistic arrangements for seminars
		4-1-e	To hold a series of seminars
4-2	To prepare a proper guideline for rehabilitation and reinforcement works	4-2-a	To make a proper guidelines for rehabilitation and reinforcement works
4-3	To have a series of on-the-job training (OJT) for rehabilitation and reinforcement works	4-3-a	To plan contents and programs of the OJT
		4-3-b	To select appropriate trainers for the OJT
		4-3-c	To prepare materials for the OJT
		4-3-d	To prepare logistic arrangements for the OJT
		4-3-e	To hold a series of the OJT

b) Working Group 2

The major missions of the working group 2 (WG-2) are: i) to establish the optimum and workable organization structure of the direction of bridges of MOPT; ii) to establish the optimum and workable organization structure of the new department of the bridge constriction of CONAVI. The preliminary WBS for the modular project 2 (MP-2) is as per Table 6.2.10. to Table 6.2.11.

Table 6.2.10. Preliminary WBS for Modular Project 2 (Task 1)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
1-1	To streamline responsibilities of new direction of bridges	1-1-a	To review existing responsibilities of bridge design department of MOPT
		1-1-b	To fix responsibilities of new direction of bridges
1-2	To clarify workflows of new direction of bridges	1-2-a	To review existing workflows of bridge design department
		1-2-b	To fix workflows of new direction of bridges
1-3	To improve organizational structure of new direction of bridges	1-3-a	To review existing organizational structure of bridge design department
		1-3-b	To create organizational structure of new direction of bridges
1-4	To secure optimum staffing for new direction of bridges	1-4-a	To review existing staffing of bridge design department
		1-4-b	To apply for additional staffing of new direction of bridges
1-5	To secure optimum budget for new direction of bridges	1-5-a	To review existing budget of bridge design department
		1-5-b	To apply for the required budget of new direction of bridges

Table 6.2.11. Preliminary WBS for Modular Project 2 (Task 2)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
2-1	To streamline responsibilities of bridge-related organization of CONAVI	2-1-a	To review existing responsibilities of bridge-related organization of CONAVI
		2-1-b	To fix responsibilities of new department of bridges
2-2	To clarify workflows of new department of bridges	2-2-a	To review existing workflows of existing bridge-related organization
		2-2-b	To fix workflows of new department of bridges
2-3	To improve organizational structure of new department of bridges	2-3-a	To review existing organizational structure of existing bridge-related organization
		2-3-b	To create organizational structure of new department of bridges
2-4	To secure optimum staffing for new department of bridges	2-4-a	To review existing staffing of bridge-related organization
		2-4-b	To apply for additional staffing of new department of bridges
2-5	To secure optimum budget for new department of bridges	2-5-a	To review existing budget of bridge-related organization
		2-5-b	To apply for the required budget of new department of bridges

c) Working Group 3

The major missions of the working group 3 (WG-3) are: i) to establish new courses for bridge construction and maintenance in universities; ii) to promote technical cooperation among public-private-academic circles in the field of bridge maintenance; and iii) to promote technical cooperation among PPP countries in the field of bridge maintenance. The preliminary WBS for the modular project 3 (MP-3) is as per Table 6.2.12. to Table 6.2.14.

Table 6.2.12. Preliminary WBS for Modular Project 3 (Task 1)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
1-1	To establish new courses for bridge construction	1-1-a	To design course programs for bridge construction
		1-1-b	To select course directors and lecturers
		1-1-c	To negotiate and assign course directors and lecturers
		1-1-d	To design detailed contents of courses
		1-1-e	To select and compile text books and materials
		1-1-f	To prepare software and equipment
		1-1-g	To prepare logistic arrangements
		1-1-h	To handle and proceed applications for admissions
		1-1-i	To run new courses for bridge construction
1-2	To establish new courses for bridge maintenance	1-2-a	To design course programs for bridge engineering
		1-2-b	To select course directors and lecturers
		1-2-c	To negotiate and assign course directors and lecturers
		1-2-d	To design detailed contents of courses
		1-2-e	To select and compile text books and materials
		1-2-f	To prepare software and equipment
		1-2-g	To prepare logistic arrangements
		1-2-h	To handle and proceed applications for admissions
		1-2-i	To run new courses for bridge maintenance

Table 6.2.13. Preliminary WBS for Modular Project 3 (Task 2)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
2-1	To hold opportunities to exchange and share new technologies among the public-private-academic circle in the field of bridge engineering and maintenance	2-1-a	To hold regular meetings among the public-private-academic circle to exchange and share the latest technical information in the field of bridge engineering and maintenance
		2-1-b	To hold ad-hoc seminars among the public-private-academic circle for the latest technical information in the field bridge engineering and maintenance
		2-1-c	To formulate and update technical database for bridge engineering and maintenance to be shared among the public-private-academic circle
		2-1-d	To implement staff exchange program among the public-private-academic circles

Table 6.2.14. Preliminary WBS for Modular Project 3 (Task 3)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
3-1	To hold opportunities to exchange and share new technologies among the PPP countries in the field of bridge engineering and maintenance	3-1-a	To hold regular meetings among PPP countries to exchange and share the latest technical information in the field of bridge engineering and maintenance
		3-1-b	To hold ad-hoc seminars among PPP countries for the latest technical information in the field bridge engineering and maintenance
		3-1-c	To formulate and update technical database for bridge engineering and maintenance to be shared among PPP countries
		3-1-d	To implement staff exchange program among PPP countries

d) Working Group 4

The major missions of the working group 1 (WG-1) are: i) to improve guidelines, standards and manuals for bridge maintenance practices for MOPT and CONAVI; ii) to improve guidelines, standards and manuals for procurement practices of MOPT, CONAVI and CNC; and iii) to improve regulations and their operations in the field of traffic safety on bridges. The preliminary WBS for the modular project 4 (MP-4) is as per Table 6.2.15. to Table 6.2.17.

Table 6.2.15. Preliminary WBS for Modular Project 4 (Task 1)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
1-1	To improve inspection manual	1-1-a	To review a existing inspection manual
		1-1-b	To compile a new inspection manual
1-2	To improve BMS operation manual	1-2-a	To review a existing BMS operation manual
		1-2-b	To compile a new BMS operation manual
1-3	To improve guidelines for bridge rehabilitation and reinforcement planning	1-3-a	To review existing guidelines for bridge rehabilitation and reinforcement planning
		1-3-b	To compile new guidelines for bridge rehabilitation and reinforcement planning
1-4	To improve bridge design standards	1-4-a	To review existing international bridge design standards
		1-4-b	To review existing regional bridge design standards
		1-4-c	To review existing domestic bridge design standards
		1-4-d	To compile new bridge design standards
1-5	To improve regulations for bridge maintenance practices	1-5-a	To review regulations for bridge maintenance practices
		1-5-b	To compile new regulations for bridge maintenance practices

Table 6.2.16. Preliminary WBS for Modular Project 4 (Task 2)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
2-1	To improve guidelines for procurement guidelines and procedures by MOPT	2-1-a	To review existing procurement guidelines by MOPT
		2-1-b	To review an existing procurement procedure manual by MOPT
		2-1-c	To compile new procurement guidelines by MOPT
		2-1-d	To compile a new procurement procedure manual by MOPT
2-2	To improve guidelines for procurement guidelines and procedures by CONAVI	2-2-a	To review existing procurement guidelines by CONAVI
		2-2-b	To review an existing procurement procedure manual by CONAVI
		2-2-c	To compile new procurement guidelines by CONAVI
		2-2-d	To compile a new procurement procedure manual by CONAVI
2-3	To improve guidelines for concession guidelines and procedures by CNC	2-3-a	To review existing concession guidelines by CNC
		2-3-b	To review an existing concession procedure manual by CNC
		2-3-c	To compile new concession guidelines by CNC
		2-3-d	To compile a concession procedure manual by CNC
		2-3-e	To develop a model contract format for efficient bridge maintenance operation

Table 6.2.17. Preliminary WBS for Modular Project 4 (Task 3)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
3-1	To improve regulations for traffic safety on bridges	3-1-a	To review existing payload regulations on bridges by MOPT
		3-1-b	To review existing other traffic regulations on bridges by MOPT
		3-1-c	To compile new payload regulations on bridges by MOPT
		3-1-d	To compile new other traffic regulations on bridges by MOPT
3-2	To improve operations for traffic safety on bridges	3-2-a	To review existing operations for payload regulations on bridges by MOPT
		3-2-b	To review existing operations for other traffic regulations on bridges by MOPT
		3-2-c	To enforce improved operations for payload regulations on bridges by MOPT
		3-2-d	To enforce improved operations for other traffic regulations on bridges by MOPT

e) Working Group 5

The major missions of the working group 5 (WG-5) are: i) to promote understandings of "Bridge Maintenance" and "Asset Management" by officials of planning and financial authorities; ii) to promote understandings of "Bridge Maintenance" and "Asset Management" by bridge users and tax payers. The preliminary WBS for the modular project 5 (MP-5) is as per Table 6.2.18. to Table 6.2.19.

Table 6.2.18. Preliminary WBS for Modular Project 5 (Task 1)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
1-1	To advocate planning and financial officials of MH and MIDEPLAN through a series of seminars on asset management	1-1-a	To plan contents and programs of seminars
		1-1-b	To select appropriate lecturers for seminars
		1-1-c	To prepare materials for seminars
		1-1-d	To prepare logistic arrangements for seminars
		1-1-e	To hold a series of seminars
		1-1-f	To share results of seminars with other ministries in charge of public investment
1-2	To advocate planning and financial officials of MOPT and CONAVI through a series of seminars on asset management	1-2-a	To plan contents and programs of seminars
		1-2-b	To select appropriate lecturers for seminars
		1-2-c	To prepare materials for seminars
		1-2-d	To prepare logistic arrangements for seminars
		1-2-e	To hold a series of seminars
		1-2-f	To share results of seminars with other departments of MOPT and CONAVI

Table 6.2.19. Preliminary WBS for Modular Project 5 (Task 2)

Task No.	Task	Preliminary WBS No.	Preliminary WBS
2-1	To promote public relations with bridge users and taxpayers through understanding of bridge maintenance	2-1-a	To make the contents of bridge maintenance for MOPT/CONVAI website
		2-1-b	To upload and update the contents of bridge maintenance in MOPT and CONAVI
		2-1-c	To make leaflets on bridge maintenance for bridge users and taxpayers
		2-1-d	To distribute leaflets to bridge users and taxpayers
		2-1-e	To plan "bridge maintenance month" campaign on news papers
		2-1-f	To make articles for "bridge maintenance month" campaign on news papers
		2-1-g	To implement "bridge maintenance month" campaign on news paper advertisement.
		2-1-h	To plan press tours on bridge maintenance
		2-1-i	To implement press tours on bridge maintenance
		2-1-j	To plan introduction videos on bridge maintenance
		2-1-k	To make introduction video on bridge maintenance
		2-1-l	To televise introduction video on TV programs
2-2	To advocate bridge users for safety regulations	2-2-a	To make leaflets on safety regulations for bridge users
		2-2-b	To distribute leaflets on safety regulations to bridge users
		2-2-c	To utilize leaflets on "safety traffic week" campaign.
2-3	To educate students through understanding of bridge maintenance	2-3-a	To plan "bridge photo contest" in selected schools
		2-3-b	To implement "bridge photo contest" in selected schools

6.2.3 Plan of Operations

A full-scale Plan of Operations (PO) is a detailed project implementation plan containing various project management factors including scope, time, human resource, quality, procurement and cost. The full-scale PO including the following contents will be formulated in consultation with each working group of the BMCG.

a) ***Activities*** are the list of detailed activities which are equivalent to the WBS.
b) ***Expected results*** are performance indicators of the activities.

c) ***Time schedule*** is a calendar bar chart which provides time estimates, sequence of activities over time and the precedence relationships.
d) ***Person in charge*** is a responsible person with supervisory authority over a set of activities.
e) ***Implementers*** are human resources or team assignments for implementing the activities.
f) ***Materials and equipment*** are resources input to implement activities and their procurement schedule.
g) ***Budget and expenditure*** defines the allocation and disbursement of budget for a set of activities.

Out of these factors, ***"time schedule"***, ***"implementers"*** and ***"budget/expenditure"*** are integral part of the PO. The preliminary POs for 5 integrated modular projects including these factors are formulated in accordance with the contents of each PDM, while the full-scale PO will be formulated in consultation with the members of the BMCG during the financial year 2007 in order to request the budget required for the capacity development.

The project time management, which is a subset of project management including the processes required to ensure timely completion of the project, is related to ***"time schedule"***. In the preliminary POs, the quarterly time schedule from the financial year 2007 to 2012 is specified.

The project cost management, which refers to process ensuring that a project is completed on time and within budget, is related to ***"budget and expenditure"***. In the preliminary POs, WBS-wise ***Cost Breakdown Structure (CBS)*** as well as ***Budget Breakdown Structure (BBS)*** for each modular project is specified.

Responsibility assignment matrix (RAM), which is known as a linear responsibility chart and can be used to show who is responsible for each WBS, is related to ***"implementers"***. In the preliminary POs, the simple RAM is specified so as to ensure that the scopes' of components assigned to the members of the BMCG become clear.

WBS No.	Work Breakdown Structure (WBS)	Input Unit	Quantity	Unit Cost (USD)	Cost Breakdown (USD)	Responsibility Assignment Matrix (RAM)	Budget Breakdown (USD)
Task 1-1: To have a series of seminars for inspectors							
1-1-a	To plan contents and programs of seminars				0	MOPT/CONAVI	
1-1-b	To select appropriate lecturers for seminars	Lecturer	8	500	4,000	MOPT/CONAVI	
1-1-c	To prepare materials for seminars	Set	1	1,000	1,000	MOPT/CONAVI	
1-1-d	To prepare logistics arrangements for seminars	Set	1	500	500	MOPT/CONAVI	
1-1-e	To hold a series of seminars	Seminar	4	1,000	4,000	MOPT/CONAVI	
Task 1-2: To prepare a proper inspection manual							
1-2-a	To make a proper inspecion sheet	to be separately arranged				MOPT/CONAVI	
1-2-b	To compile a proper inspection manual	to be separately arranged				MOPT/CONAVI	
Task 1-3: To have a series of on -the-job training for inspectors							
1-3-a	To plan contents and programs of the OJT				0	MOPT/CONAVI	
1-3-b	To select appropriate trainers for the OJT	Lecturer	8	500	4,000	MOPT/CONAVI	
1-3-c	To prepare equipment for the OJT	Set	1	2,000	2,000	MOPT/CONAVI	
1-3-d	To prepare logistic arrangements for the OJT	Set	1	1,000	1,000	MOPT/CONAVI	
1-3-e	To hold a series of the OJT	Seminar	4	2,000	8,000	MOPT/CONAVI	
Task 1-4: To set up a proper qualification system for inspectors							
1-4-a	To set up a grading system for inspectors	to be separately arranged				MOPT/CONAVI	
1-4-b	To categorize inspectors into qualification grades	to be separately arranged				MOPT/CONAVI	
Task 2-1: To have a series of seminars for BMS management							
2-1-a	To plan contents and programs of seminars				0	MOPT/CONAVI	
2-1-b	To select appropriate lecturers for seminars	Lecturer	8	500	4,000	MOPT/CONAVI	
2-1-c	To prepare materials for seminars	Set	1	1,000	1,000	MOPT/CONAVI	
2-1-d	To prepare logistics arrangements for seminars	Set	1	500	500	MOPT/CONAVI	
2-1-e	To hold a series of seminars	Seminar	4	1,000	4,000	MOPT/CONAVI	
Task 2-2: To prepare a proper BMS manual							
2-2-a	To make a proper BMS system	to be separately arranged				MOPT/CONAVI	
2-2-b	To compile a proper BMS operation manual	to be separately arranged				MOPT/CONAVI	
Task 2-3: To have a series of on-the-job training for BMS Management							
2-3-a	To plan contents and programs of the OJT				0	MOPT/CONAVI	
2-3-b	To select appropriate trainers for the OJT	Lecturer	8	500	4,000	MOPT/CONAVI	
2-3-c	To prepare equipment for the OJT	Set	1	2,000	2,000	MOPT/CONAVI	
2-3-d	To prepare logistic arrangements for the OJT	Set	1	1,000	1,000	MOPT/CONAVI	
2-3-e	To hold a series of the OJT	Seminar	4	2,000	8,000	MOPT/CONAVI	
Task 3-1: To have a series of seminars for repair planning							
3-1-a	To plan contents and programs of seminars				0	MOPT/CONAVI	
3-1-b	To select appropriate lecturers for seminars	Lecturer	8	500	4,000	MOPT/CONAVI	
3-1-c	To prepare materials for seminars	Set	1	1,000	1,000	MOPT/CONAVI	
3-1-d	To prepare logistics arrangements for seminars	Set	1	500	500	MOPT/CONAVI	
3-1-e	To hold a series of seminars	Seminar	4	1,000	4,000	MOPT/CONAVI	
Task 3-2: To prepare proper guidelines for repair planning							
3-2-a	To make proper guidelines for diagnosis and priority selection	to be separately arranged				MOPT/CONAVI	
3-2-b	To mak proper guidelines for repair planning	to be separately arranged				MOPT/CONAVI	
Task 3-3: To have a series of on-the-job training for repair planning							
3-3-a	To plan contents and programs of the OJT				0	MOPT/CONAVI	
3-3-b	To select appropriate trainers for the OJT	Lecturer	8	500	4,000	MOPT/CONAVI	
3-3-c	To prepare equipment for the OJT	Set	1	2,000	2,000	MOPT/CONAVI	
3-3-d	To prepare logistic arrangements for the OJT	Set	1	1,000	1,000	MOPT/CONAVI	
3-3-e	To hold a series of the OJT	Seminar	4	2,000	8,000	MOPT/CONAVI	
Task 4-1: To have a series of seminars for repair works							
4-1-a	To plan contents and programs of seminars				0	MOPT/CONAVI	
4-1-b	To select appropriate lecturers for seminars	Lecturer	8	500	4,000	MOPT/CONAVI	
4-1-c	To prepare materials for seminars	Set	1	1,000	1,000	MOPT/CONAVI	
4-1-d	To prepare logistics arrangements for seminars	Set	1	500	500	MOPT/CONAVI	
4-1-e	To hold a series of seminars	Seminar	4	1,000	4,000	MOPT/CONAVI	
Task 4-2: To prepare proper guidelines for repair works							
4-2-a	To make aproper guidelines for repair works	to be separately arranged				MOPT/CONAVI	
Task 4-3: To have a series of on-the-job training for repair works							
4-3-a	To plan contents and programs of the OJT				0	MOPT/CONAVI	
4-3-b	To select appropriate trainers for the OJT	Lecturer	8	500	4,000	MOPT/CONAVI	
4-3-c	To prepare equipment for the OJT	Set	1	2,000	2,000	MOPT/CONAVI	
4-3-d	To prepare logistic arrangements for the OJT	Set	1	1,000	1,000	MOPT/CONAVI	
4-3-e	To hold a series of the OJT	Seminar	4	2,000	8,000	MOPT/CONAVI	

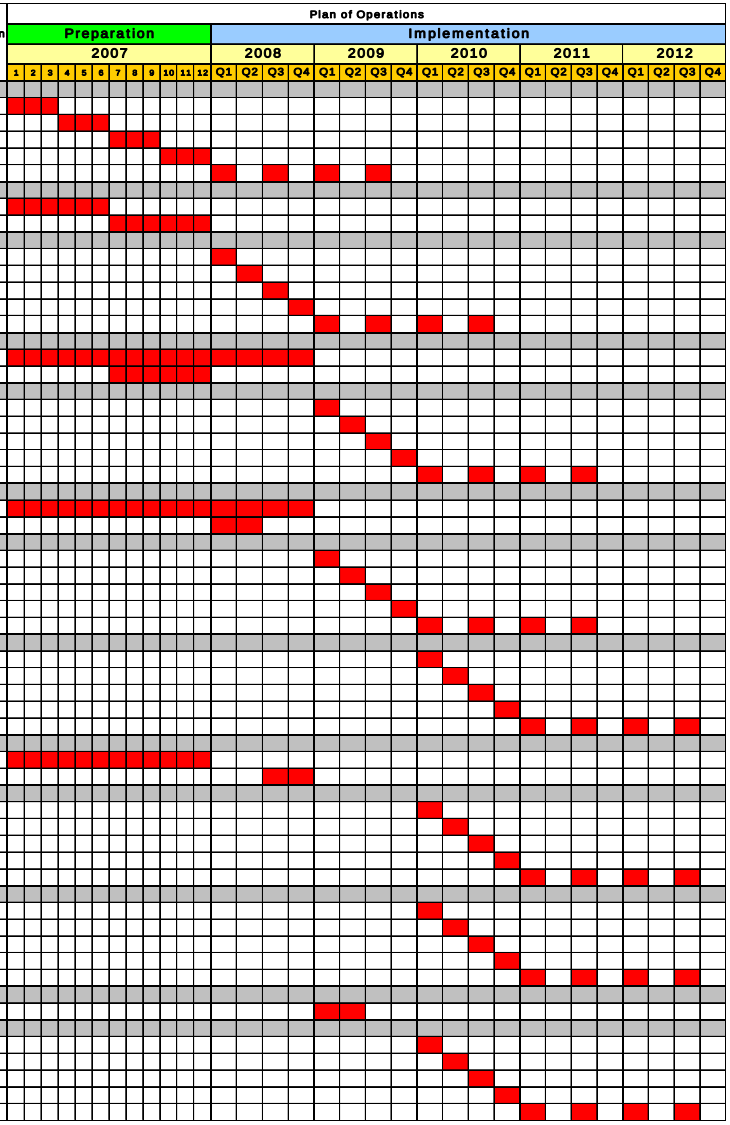


Figure 6.2.1. Preliminary Plan of Operations for Modular Project 1

WBS No.	Work Breakdown Structure (WBS)	Input Unit	Quantity	Unit Cost (USD)	Cost Breakdown (USD)	Responsibility Assignment Matrix (RAM)	Budget Breakdown (USD)	Plan of Operations
								Preparation: 2007 (1–12) / Implementation: 2008 Q1–Q4, 2009 Q1–Q4, 2010 Q1–Q4, 2011 Q1–Q4, 2012 Q1–Q4
Task 1-1: To streamline responsibilities of new direction of bridges of MOPT								
1-1-a	To review existing responsibilities of bridge design department of MOPT				0	MOPT/CONAVI		
1-1-b	To fix responsibilities of new direction of bridges				0	MOPT/CONAVI		
Task1-2: To clarify workflows of new direction of bridges of MOPT								
1-2-a	To review existing workflows of bridge design department of MOPT				0	MOPT/CONAVI		
1-2-b	To fix workflows of new direction of bridges				0	MOPT/CONAVI		
Task 1-3: To improve organizational structure of new direction of bridges of MOPT								
1-3-a	To review existing organizational structure of bridge design department				0	MOPT/CONAVI		
1-3-b	To create organizational structure of new direction of bridges				0	MOPT/CONAVI		
Task1-4: To secure optimum staffing for new direction of bridges of MOPT								
1-4-a	To review existing staffing of bridge design department				0	MOPT/CONAVI		
1-4-b	To apply for additional satffing of new direction of bridges	to be separately arranged				MOPT/CONAVI		
Task 1-5: To secure optimum budget for new direction of bridges of MOPT								
1-5-a	To review existing budget of bridge design department				0	MOPT/CONAVI		
1-5-b	To apply for the required budget of new direction of bridges	to be separately arranged				MOPT/CONAVI		
Task 2-1: To streamline responsibilities of new bridge department of CONAVI								
1-1-a	To review existing responsibilities of bridge-related department of CONAVI				0	MOPT/CONAVI		
1-1-b	To fix responsibilities of new bridge department of CONAVI				0	MOPT/CONAVI		
Task 2-2: To clarify workflows of new bridge department of CONAVI								
1-2-a	To review existing workflows of bridge-related department of CONAVI				0	MOPT/CONAVI		
1-2-b	To fix workflows of new bridge department of CONAVI				0	MOPT/CONAVI		
Task 2-3: To improve organizational structure of new bridge department of CONAVI								
1-3-a	To review existing organizational structure of bridge-related department of CONAVI				0	MOPT/CONAVI		
1-3-b	To create organizational structure of new bridge department of CONAVI				0	MOPT/CONAVI		
Task 2-4: To secure optimum staffing for new bridge department of CONAVI								
1-4-a	To review existing staffing of bridge-related department of CONAVI				0	MOPT/CONAVI		
1-4-b	To apply for additional staffing of new bridge department of CONAVI	to be separately arranged				MOPT/CONAVI		
Task 2-5: To secure optimum budget for new bridge department of bridges								
1-5-a	To review existing budget of bridge -related department of CONAVI				0	MOPT/CONAVI		
1-5-b	To apply for the required budget of new bridge department of CONAVI	to be separately arranged				MOPT/CONAVI		

Figure 6.2.2. Preliminary Plan of Operations for Modular Project 2

WBS No.	Work Breakdown Structure (WBS)	Input Unit	Quantity	Unit Cost (USD)	Cost Breakdown (USD)	Responsibility Assignment Matrix (RAM)	Budget Breakdown (USD)	Plan of Operations
								Preparation: 2007 (1–12) / Implementation: 2008 Q1–Q4, 2009 Q1–Q4, 2010 Q1–Q4, 2011 Q1–Q4, 2012 Q1–Q4
Task 1-1: To establish new courses for bridge construction								
1-1-a	To design course programs for bridge construction					UCR/LANNAME		
1-1-b	To select course directors and lecturers					UCR/LANNAME		
1-1-c	To negotiate and assign course directors and lecturers	Lecturer	3	15,000	45,000	UCR/LANNAME		
1-1-d	To design detailed contents of courses					UCR/LANNAME		
1-1-e	To select and compile text books and materials	Set	1	5,000	5,000	UCR/LANNAME		
1-1-f	To prepare software and equipment	Set	1	10,000	10,000	UCR/LANNAME		
1-1-g	To prepare logistic arrangements	Set	1	3,000	3,000	UCR/LANNAME		
1-1-h	To handle and proceed applications for admissions	Time	1	2,000	2,000	UCR/LANNAME		
1-1-i	To run new courses for bridge construction	Time	1	5,000	5,000	UCR/LANNAME		
Task 1-2: To establish new courses for bridge maintenance								
1-2-a	To design course programs for bridge maintenance					UCR/LANNAME		
1-2-b	To select course directors and lecturers					UCR/LANNAME		
1-2-c	To negotiate and assign course directors and lecturers	Lecturer	2	15,000	30,000	UCR/LANNAME		
1-2-d	To design detailed contents of courses					UCR/LANNAME		
1-2-e	To select and compile text books and materials	Set	1	5,000	5,000	UCR/LANNAME		
1-2-f	To prepare software and equipment	Set	1	5,000	5,000	UCR/LANNAME		
1-2-g	To prepare logistic arrangements	Set	1	3,000	3,000	UCR/LANNAME		
1-2-h	To handle and proceed applications for admissions	Time	1	2,000	2,000	UCR/LANNAME		
1-2-i	To run new courses for bridge maintenance	Time	1	5,000	5,000	UCR/LANNAME		
Task 2-1: To hold opportunities to exchange and share new technologies among the public-private-academic circle in the field of brdige engineering and maintenance								
2-1-a	To hold regular meetings among the public-private-academic cricle to exchange and share the latest technical information in the field of bridge engineering and maintenance	Time	5			MOPT/CONAVI		
2-1-b	To hold ad-hoc seminars among the public-private-academic circle for the latest technical information in the field of bridge maintenance and maintenance	Time	5			MOPT/CONAVI		
2-1-c	To formulate and update technical database for bridge engineering and maintenance to be shared among the public-private-academic circle	Database	1			MOPT/CONAVI		
2-1-d	To implement staff exchange program among the public-private-academic circle	Time	5			MOPT/CONAVI		
Task 3-1: To hold opportunities to exchange and share new technologies among PPP countries in the field of brdige engineering and maintenance								
3-1-a	To hold regular meetings among PPP countries to exchange and share the latest technical information in the field of bridge engineering and maintenance	Time	5			MOPT/CONAVI		
3-1-b	To hold ad-hoc seminars among PPP countries for the latest technical information in the field of bridge maintenance and maintenance	Time	5			MOPT/CONAVI		
3-1-c	To formulate and update technical database for bridge engineering and maintenance to be shared among PPP countries	Database	1			MOPT/CONAVI		
3-1-d	To implement staff exchange program among PPP countries	Time	5			MOPT/CONAVI		

Figure 6.2.3. Preliminary Plan of Operations for Modular Project 3

WBS No.	Work Breakdown Structure (WBS)	Input Unit	Quantity	Unit Cost (USD)	Cost Breakdown (USD)	Responsibility Assignment Matrix (RAM)	Budget Breakdown (USD)	Plan of Operations
								Preparation: 2007 (1–12) / Implementation: 2008 Q1–Q4, 2009 Q1–Q4, 2010 Q1–Q4, 2011 Q1–Q4, 2012 Q1–Q4
Task 1-1: To improve inspection manual								
1-1-a	To review an existing inspection manual							
1-1-b	To compile a new inspection manual	Set	1	500	500	MOPT/CONAVI		
Task 1-2: To review an existing BMS operation manual								
1-2-a	To review an existing BMS operation manual					MOPT/CONAVI		
1-2-b	To compile a new BMS operation manual	Set	1	1,000	1,000			
Task 1-3: To improve guidelines for repair planning								
1-3-a	To review existing guidelines for repair planning					MOPT/CONAVI		
1-3-b	To compile new guidelines for repair planning	Set	1	500	500			
Task 1-4: To improve bridge design standards								
1-4-a	To review existing intenational bridge design standards					MOPT/CONAVI		
1-4-b	To review existing regional bridge design standards					MOPT/CONAVI		
1-4-c	To review existing domestic bridge design standards					MOPT/CONAVI		
1-4-d	To compile new bridge design standards	Set	1	1,000	1,000	MOPT/CONAVI		
Task 1-5: To improve regulations for bridge maintenance practices								
1-5-a	To review regulations for bridge maintenance practices					MOPT/CONAVI		
1-5-b	To compile new regulations for bridge maintenance practices	Set	1	500	500	MOPT/CONAVI		
Task 2-1: To improve gudilines for procurement procedures by MOPT								
2-1-a	To review existing procurement guidelines by MOPT					MOPT		
2-1-b	To review an existing procurement procedure manual by MOPT					MOPT		
2-1-c	To compile new procurement guidelines by MOPT	Set	1	500	500	MOPT		
2-1-d	To compile a new procurement procedure manual by MOPT	Set	1	500	500	MOPT		
Task 2-2: To improve gudilines for procurement procedures by CONAVI								
2-2-a	To review existing procurement guidelines by CONAVI					CONAVI		
2-2-b	To review an existing procurement procedure manual by CONAVI					CONAVI		
2-2-c	To compile new procurement guidelines by CONAVI	Set	1	500	500	CONAVI		
2-2-d	To compile a new procurement procedure manual by CONAVI	Set	1	500	500	CONAVI		
Task 2-3: To improve gudilines for concession procedures by CNC								
2-3-a	To review existing concession guidelines by CNC					CNC		
2-3-b	To review an existing concession procedure manual by CNC					CNC		
2-3-c	To compile new concession guidelines by CNC	Set	1	500	500	CNC		
2-3-d	To compile a new concession procedure manual by CNC	Set	1	500	500	CNC		
2-3-e	To develop a model contract format for efficient bridge maintenance operation	Set	1	200	200	CNC		
Task 3-1: To improve regulations for traffic safety on bridges								
3-1-a	To review existing payload regulations on bridges by MOPT					MOPT		
3-1-b	To review existing other traffic regulations on bridges by MOPT					MOPT		
3-1-c	To compile new payload regulations on bridges by MOPT	Set	1	500	500	MOPT		
3-1-d	To compile new other traffic regulations on bridges by MOPT	Set	1	500	500	MOPT		
Task 3-2: To improve operations for traffic safety on bridges								
3-2-a	To review existing payload operations on bridges by MOPT					MOPT		
3-2-b	To review existing other traffic operations on bridges by MOPT					MOPT		
3-2-c	To compile new payload operations on bridges by MOPT	Set	1	500	500	MOPT		
3-2-d	To compile new other traffic operations on bridges by MOPT	Set	1	500	500	MOPT		

Figure 6.2.4. Preliminary Plan of Operations for Modular Project 4

WBS No.	Work Breakdown Structure (WBS)	Input Unit	Quantity	Unit Cost (USD)	Cost Breakdown (USD)	Responsibility Assignment Matrix (RAM)	Budget Breakdown (USD)	Plan of Operations
								Preparation: 2007 (1–12); Implementation: 2008 Q1–Q4, 2009 Q1–Q4, 2010 Q1–Q4, 2011 Q1–Q4, 2012 Q1–Q4
Task 1-1: To advocate planning and financial officials of MH and MIDEPLAN through a series of seminars on asset management								
1-1-a	To plan contents and programs of seminars				0	MOPT/CONAVI, MH, MIDEPLAN		
1-1-b	To select appropriate lecturers for seminars	Lecturer	12	500	6,000	MOPT/CONAVI, MH, MIDEPLAN		
1-1-c	To prepare materials for seminars	Set	1	1,000	1,000	MOPT/CONAVI, MH, MIDEPLAN		
1-1-d	To prepare logistic arrangements for seminars	Set	1	500	500	MOPT/CONAVI, MH, MIDEPLAN		
1-1-e	To hold a series of seminars	Time	6	500	3,000	MOPT/CONAVI, MH, MIDEPLAN		
1-1-f	To share results of seminars with other ministries in charge of public investment				0	MOPT/CONAVI, MH, MIDEPLAN		
Task 1-2: To advocate planning and financial officials of MOPT and CONAVI through a series of seminars on asset management								
1-2-a	To plan contents and programs of seminars				0	MOPT/CONAVI		
1-2-b	To select appropriate lecturers for seminars	Lecturer	12	500	6,000	MOPT/CONAVI		
1-2-c	To prepare materials for seminars	Set	1	1,000	1,000	MOPT/CONAVI		
1-2-d	To prepare logistic arrangements for seminars	Set	1	500	500	MOPT/CONAVI		
1-2-e	To hold a series of seminars	Time	6	500	3,000	MOPT/CONAVI		
1-2-f	To share results of seminars with other departments of MOPT and CONAVI				0	MOPT/CONAVI		
Task 2-1: To promote public relations with bridge users and taxpayers through understading of bridge maintenance								
2-1-a	To make the contents of bridge maintenance for MOPT/CONAVI website	Set	1	1,000	1,000	MOPT/CONAVI		
2-1-b	To upload and update the contents of bridge maintenance in MOPT and CONAVI website					MOPT/CONAVI		
2-1-c	To make leaflets on bridge maintenance for bridge users and taxpayers	Set	1	3,000	3,000	MOPT/CONAVI		
2-1-d	To distribute leaflets to bridge users and taxpayers				0	MOPT/CONAVI		
2-1-e	To plan "bridge maintenance month" campaign on news papers				0	MOPT/CONAVI		
2-1-f	To make articles for "bridge maintenance month" campaign on news paper advertisement	Set	1	1,000	1,000	MOPT/CONAVI		
2-1-g	To implement "bridge maintenance month" campaign on news paper advertisement	Time	3	1,000	3,000	MOPT/CONAVI		
2-1-h	To plan press tours on bridge maintenance				0	MOPT/CONAVI		
2-1-i	To implement press tours on bridge maintenance	Time	1	1,000	1,000	MOPT/CONAVI		
2-1-j	To plan introduction videos on bridge maintenance				0	MOPT/CONAVI		
2-1-k	To make introduction videos on bridge maintenance	Set	1	3,000	3,000	MOPT/CONAVI		
2-1-l	To televise introduction videos on TV programs	Time	12	500	6,000	MOPT/CONAVI		
Task 2-2: To advocate bridge users for safety regulations								
2-2-a	To make leaflets on safety regulations for bridge users	Set	1	1,000	1,000	MOPT/CONAVI		
2-2-b	To distribute leaflets on safety regulations for bridge users				0	MOPT/CONAVI		
2-2-c	To utilize leaflets on "safety traffic week" campaign				0	MOPT/CONAVI		
Task 2-3: To educate students through understanding of bridge maintenance								
2-3-a	To plan "bridge photo contest" in selected schools				0	MOPT/CONAVI		
2-3-b	To implement "bridge photo contest" in selected schools	Time	1	1	1,000	MOPT/CONAVI		

Figure 6.2.5. Preliminary Plan of Operations for Modular Project 5

6.3 Institutional Reform and Budgetary Arrangement as Pre-conditions for Capacity Development

6.3.1 Basic Concepts for Institutional Reform

The institutional reform for the bridge-related organizations of MOPT and CONAVI is an integral part of the pre-conditions for the capacity development, and the reform is included in the modular project 2 (MP-2). The capacity gap assessment was started from the so-called ***"entry point"*** which is the initial target for the assessment, creating a strong momentum for changing the current institution. A typical entry point is often found at the organizational level, when the capacity gap assessment is carried out. The entry point in this study is the bridge design department of MOPT which is subject to be promoted to the direction of bridges. There are two basic concepts for the institutional reform; ***"zooming-in"*** and ***"zooming out"*** from the entry point.

Zooming-in from the entry point allows stakeholders to look more closely at the capacity dimensions of existing organizations, thereby focusing on the institutional reform of the direction of bridges of MOPT as well as the new bridge-related department of CONAVI. The zoomed-in examination of these existing organizations would provide the basic layer for the capacity development. On the other hand, ***zooming-out*** from the entry point would shift from narrow examinations to broader collaboration in order to create the institutional basis for the BMCG.

6.3.2 Institutional Reform of Bridge-related Organizations of MOPT and CONAVI

It is theoretically acknowledged that there are mainly 3 organization models such as ***functional organization***, ***project-type organization*** and ***matrix-type organization***. These models are referred to as proto-type organizational structures of the newly established direction of bridges of MOPT and the department of bridge construction of CONAVI, when the institutional reforms of these organizations are planned.

A ***functional organization*** is a hierarchical organization model in which missions and tasks are divided among groups with different functional managers who concentrate on their fields of expertise. In this model, the ownership is also shared among different functional managers.

On the other hand, a ***project-type organization*** is the antithesis of a functional organization. A project-type organization in the field of the bridge maintenance is defined as the team which is composed of task-force members, under one project manager, covering administration, inspection, planning, designing, system management, construction, and other areas. Since the staff under the project-type organization can concentrate on their within the team, it is possible to respond to changing requirements in a timely manner. Although resource costs are generally higher for a project-type organization as the organization must have sufficient expertise to assign full-time to different project simultaneously.

Matrix-type organization combines the concept of a functional organization with that of a project-type organization. Most organizations fall somewhere between the fully functional and fully project-type organizational structure.

It should be noted that the current bridge design department of MOPT is subject to be upgraded to the new direction of bridges from the financial year 2007, and this strong institutional momentum should be utilized at maximum to obtain ample financial and human resources. Meanwhile, CONAVI is planning to set up the new bridge-related department although its detailed organizational structure still remains unclear.

The ultimate goal of the institutional reform is to establish the regular and proper maintenance system of the nation-wide 1350 bridges on the national highway network by streamlining the functions of MOPT and CONAVI as well as selecting the optimum organizational model. In order to achieve this ultimate goal, the ideal organizational structure to properly maintain the current number of bridges based on the following conditions.

(i) The ideal organizational level should be achieved within 5 years based on the step-by-step improvement of the current organizational structure.
(ii) The functions of the bridge maintenance practices are streamlined between MOPT and CONAVI.
(iii) The direction of bridges of MOPT will be responsible for the upstream of the bridge maintenance such as inspection and planning, while the proposed bridge construction department of CONAVI will be responsible for the downstream such as rehabilitation and repairs.
(iv) The scheduled inspection of 350 bridges on the primary and secondary level highway network will be conducted in every 5 years in the rotating manner. (Figure 6.3.1 indicates the target number of bridges to be periodically inspected.)
(v) The detailed inspection as well as the rehabilitation and reinforcement of 50 bridges will be carried out in every 5 years.
(vi) The bridges which are seriously damaged and urgently rehabilitated will be treated within 5 years.

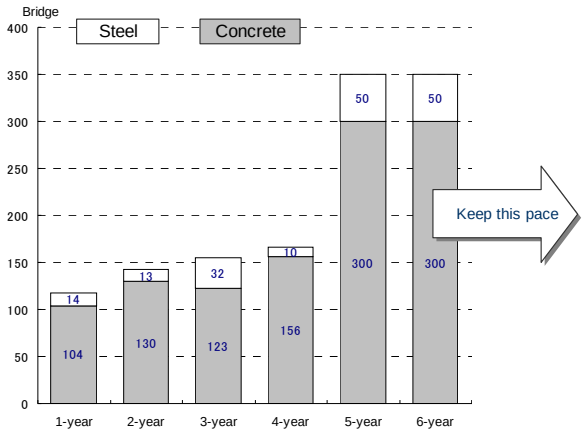


Figure 6.3.1. Target Number of Bridges to be Periodically Inspected

As a result, the staffing and organization to be required for the new bridge-related organizations of MOPT and CONAVI is proposed as below.

a) Direction of Bridges of MOPT

As a primary entry point of the capacity gap assessment and the core member of the BMCG, the bridge design department of MOPT is subject to be promoted to the direction of bridges from the financial year 2007. Taking advantage of this strong momentum, the ideal organizational structure as well as the number of staff required for the proposed organization is estimated. A project-type organization which consists of 6 departments and regional offices headed by a director is proposed. The total number of the required staff and workers is calculated at 36 in the financial year 2008 and at 58 in the financial year 2012, respectively. The list of the required staff for the direction of bridges of MOPT is as per Table 6.3.1, and

the proposed organizational structure is as illustrated by Figure 6.3.2. to Figure 6.3.4, respectively.

Table 6.3.1. Staff Required for Direction of Bridges of MOPT

Organization / Position		FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Director		1	1	1	1	1
Deputy Director		0	0	1	1	1
Department of Administration	Manager	0	1	1	1	1
	Secretary	0	1	1	1	1
	Staff	0	0	1	1	2
	Sub Total	0	2	3	3	4
Department of Planning	Manager	0	1	1	1	1
	Chief Planner	0	0	1	1	1
	Budgetary Officer	0	1	1	1	2
	Coordinator	0	1	1	1	2
	Public Relations Officer	0	0	0	1	1
	Sub Total	0	3	4	5	7
Department of Design	Manager	1	1	1	1	1
	Chief Engineer	0	0	1	2	2
	Engineer	3	4	4	4	6
	CAD Operator	2	2	2	2	2
	Others	11	11	11	11	11
	Sub Total	17	18	19	20	22
Department of Inspection	Manager	1	1	1	1	1
	Chief Inspector	0	0	0	1	1
	Inspector	1	1	1	1	2
	Technical Staff	0	0	1	1	1
	Sub Total	2	2	3	4	5
Department of System	Manager	1	1	1	1	1
	Chief System Engineer	0	0	0	1	1
	System Engineer	1	1	1	1	1
	Staff	0	0	1	1	2
	Sub Total	2	2	3	4	5
Department of Bridge Construction	Manager	1	1	1	1	1
	Chief Engineer	2	2	2	2	2
	Engineer	5	5	5	5	5
	Sub Total	8	8	8	8	8
Headquarter Total	Total	29	35	40	44	51
Regional Office Total	Technical Staff	7	7	7	7	7
	Sub Total	7	7	7	7	7
MOPT Grand Total	Grand Total	36	42	47	51	58

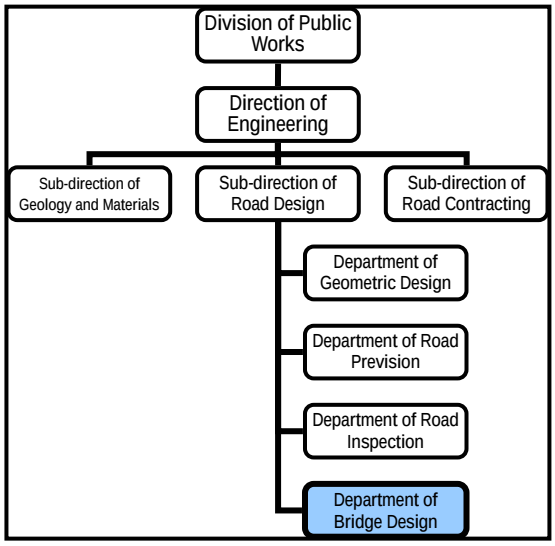


Figure 6.3.2 Organizational Structure of Current Bridge Design Department of MOPT in 2006

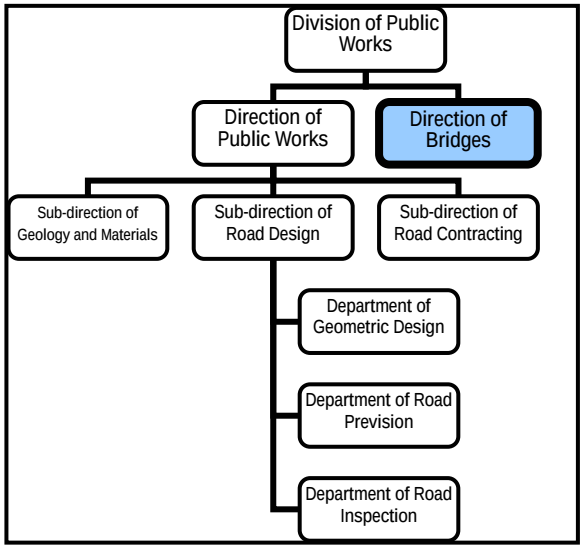


Figure 6.3.3 Organizational Structure of Upgraded Direction of Bridges of MOPT in 2007

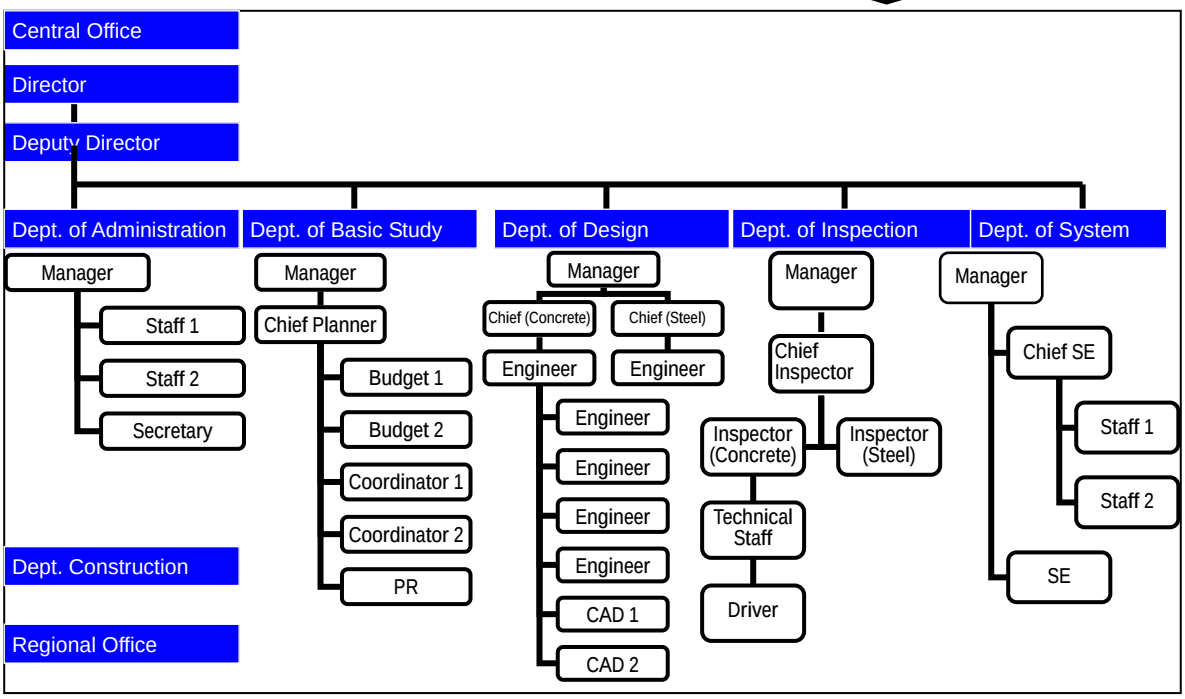


Figure 6.3.4. Proposed Organizational Structure of Direction of Bridges of MOPT

b) New Department of Bridge Conservation of CONAVI

Juxtaposed with the direction of bridges of MOPT, the ideal organizational structure as well as the number of staff required for the proposed department of bridge conservation of CONAVI together with its regional offices is estimated. The total number of the required staff should be increased to 14 in the financial year 2008 from 38 in the financial year 2012. The list of the required staff by kind is as per Table 6.3.2, and the proposed organizational structure for the new department of bridge conservation of CONAVI is as per Figure 6.3.5. to

Figure 6.3.7.

Table 6.3.2. Staff Required for Department of Bridge Conservation of CONAVI

Organization / Position		FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
Department of Bridge Construction	Manager	1	1	1	1	1
	Chief Cost Estimator	0	0	1	1	1
	Chief Construction Planner	0	0	1	1	1
	Chief Procurement Officer	1	1	1	1	1
	Chief Supervisor	0	1	1	1	1
	Cost Estimator	1	1	1	1	1
	Construction Planner	0	1	1	1	1
	Staff	1	1	1	1	2
	Technical Staff	0	0	1	1	1
	Sub Total	4	6	9	9	10
Regional Office Total	Supervisor	7	7	10	12	14
	Staff	3	5	7	10	14
	Sub Total	10	12	17	22	28
Grand Total	Grand Total	14	18	26	31	38

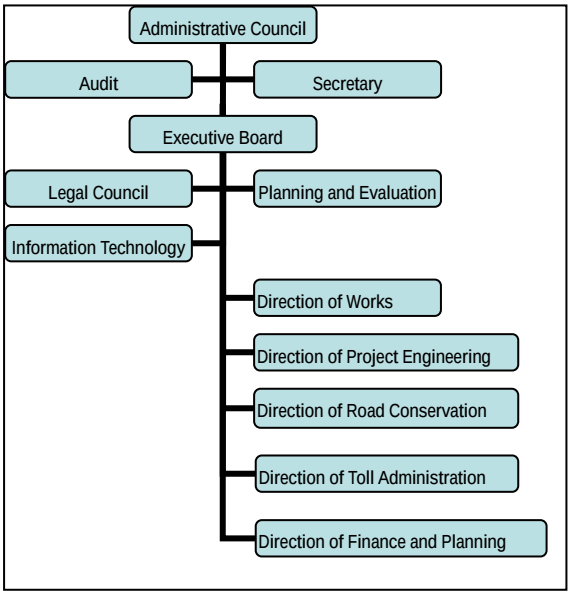


Figure 6.3.5. Organizational Structure of Current CONAVI in 2006

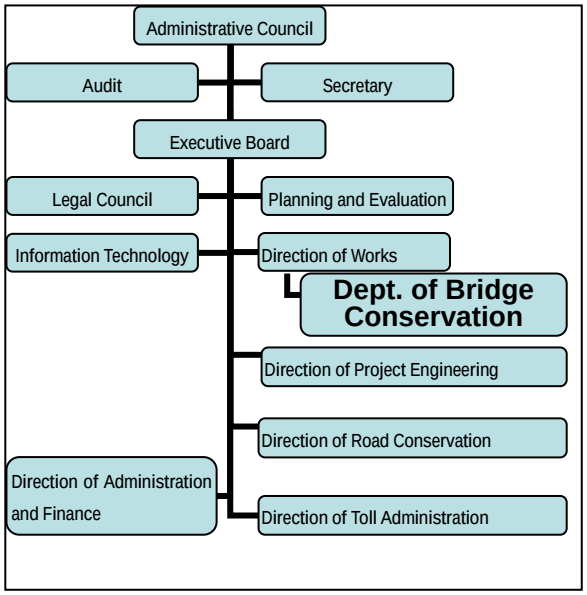


Figure 6.3.6. Organizational Structure of CONAVI in 2007

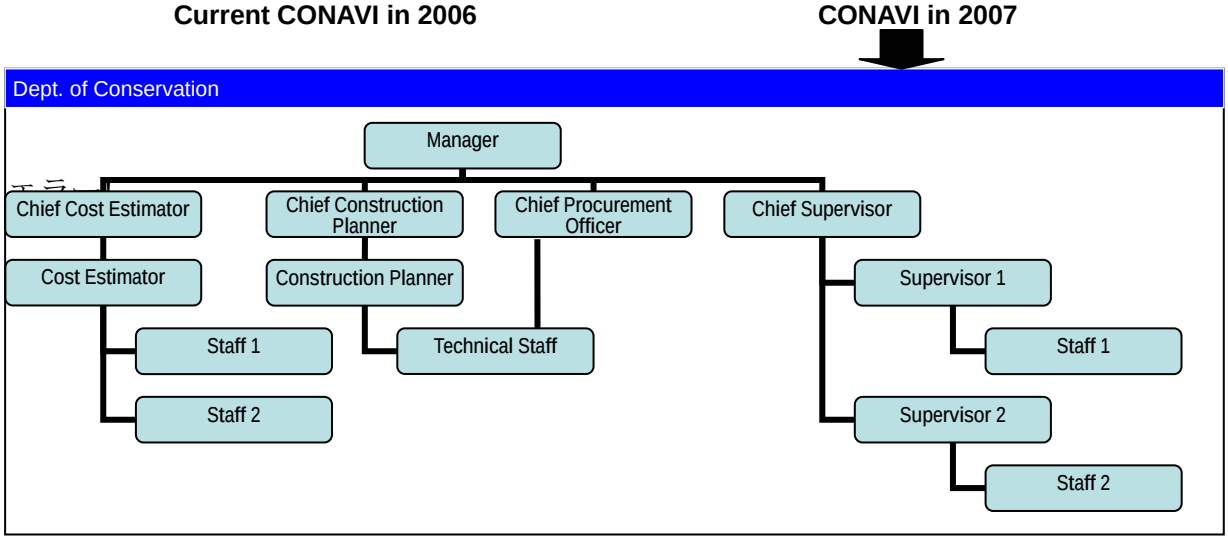


Figure 6.3.7. Proposed Organizational Structure of New Department of Bridge Conservation of CONAVI

6.3.3 Institutional Building of BMCG

The members of the BMCG will play key roles for the full-scale planning and implementation of the identified modular projects. In general, in order to establish a multi-member consulting group like the BMCG, a new project office which is composed of a wide range of project officers is established. However, unlike the organizational structure of the direction of bridges of MOPT and the planned department of bridge construction of CONAVI, the BMCG requires the ***Matrix-type organization*** where all the members report to both the secretariat of the BMCG and managers of each member organizations. While the members of the BMCG is normally engaged in the original works of the member organizations, the member organizations of the BMCG will be require to render strong back-stop services to the BMCG.

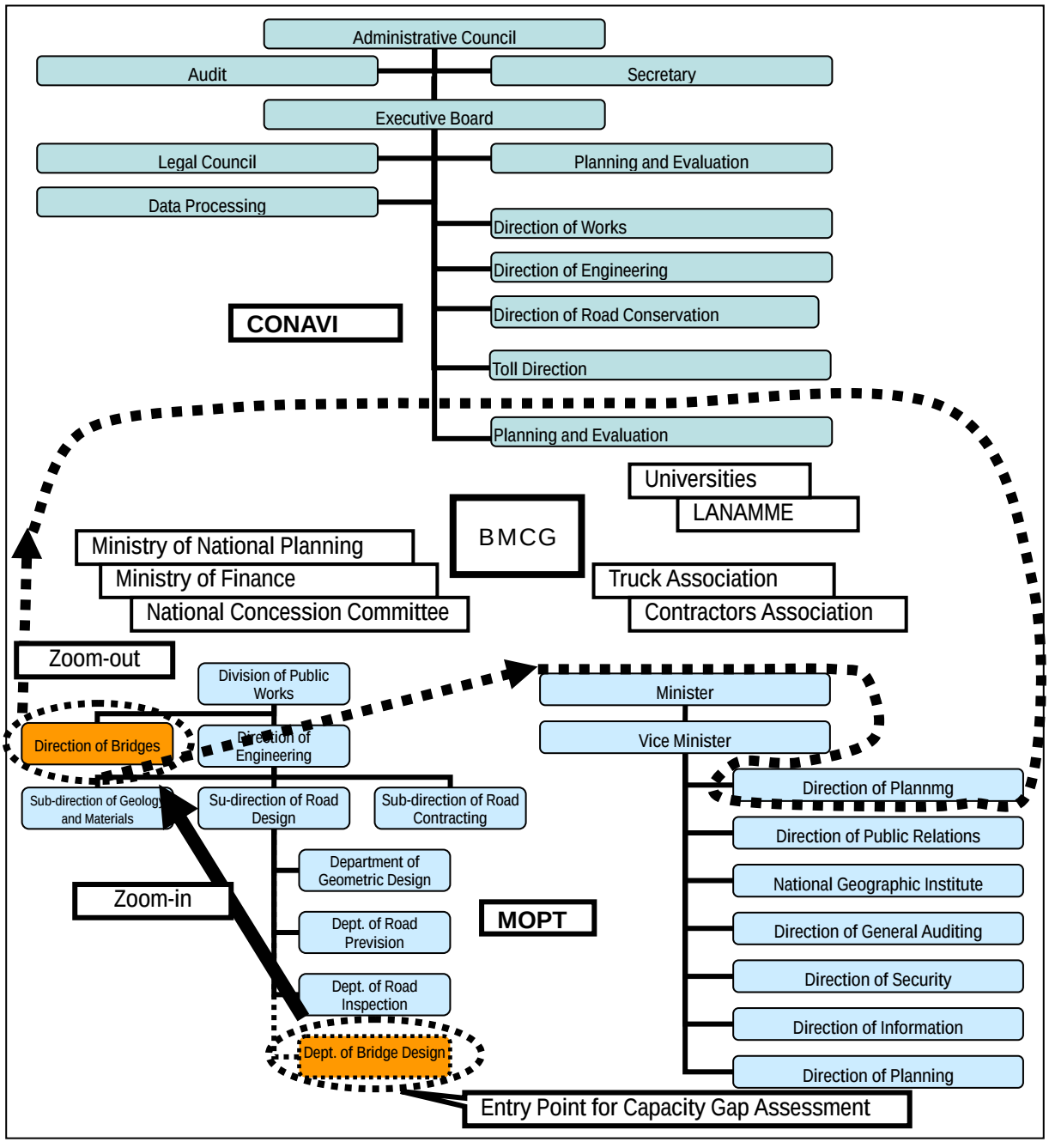


Figure 6.3.8. Image of Position of BMCG

6.3.4 Budgetary Arrangement

Based on the required number of staff as well as the proposed organizational structure, the required budget for the direction of bridges of MOPT and the proposed department of bridge conservation of CONAVI is estimated to verify their financial sustainability. The total budget required for the basic organizational operation of the direction of bridges of MOPT is estimated at 369,650 thousand Colones for the financial year 2008. On the other hand, the total budget for the organizational operation cost for the new department of bridge conservation is estimated at 2,257,900 thousand Colones for the financial year 2008. These costs are related to the implementation of the modular project 2 (MP-2).

Table 6.3.3. Requirements of Budget for Organizational Cost for Bridge Maintenance

(Unit: Thousand Colones)

Cost Item / Financial Year		FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
MOPT	Direct Cost	151,200	173,900	192,900	209,400	236,100
	Indirect Cost	30,240	34,780	38,580	41,880	47,220
	Sub Total	181,440	208,680	231,480	251,280	283,320
CONAVI	Direct Cost	112,400	137,900	194,100	233,600	283,000
	Indirect Cost	22,480	27,580	38,820	46,720	56,600
	Sub Total	134,880	165,480	232,920	280,320	339,600
TOTAL		316,320	374,160	464,400	531,600	622,920

Table 6.3.4. Requirements of Budget for Total Cost for Bridge Maintenance

(Unit: Thousand Colones)

Cost Item / Financial Year		FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
MOPT	Cost for Organization	181,440	208,680	231,480	251,280	283,320
	Periodical Inspection	3,658	4,433	4,805	5,146	10,850
	Detailed Inspection	4,032	4,536	6,552	6,552	8,400
	Equipment and Facilities	180,520	30,020	19,520	20,520	48,270
	Sub Total	369,650	247,669	262,357	283,498	350,840
CONAVI	Cost for Organization	134,880	165,480	232,920	280,320	339,600
	Rehabilitation Works	1,895,000	1,895,000	2,220,000	2,220,000	3,630,000
	Equipment and Facilities	228,020	5,520	46,020	6,270	118,520
	Sub Total	2,257,900	2,066,000	2,498,940	2,506,590	4,088,120
TOTAL		2,627,550	2,313,669	2,761,297	2,790,088	4,438,960

The budget for the direction of bridges requested by MOPT for the financial year 2007 is summarized as per Table 6.3.5. According to this budget request, MOPT is allocating the budget total operating cost excluding construction costs is estimated at 277,690 Thousand Colones, which is only 75.1 percent of the total budget required for the basic organizational operation of the direction of bridges of MOPT. There are several options to fill the gap such as i) downsizing the maintenance target of bridges, ii) postponing the target year, iii) requesting the donor supports, etc.

Table 6.3.5. Requested Budget for Direction of Bridges of MOPT for Financial Year 2007

(Unit: Thousand Colones)

Cost Item	2007 Requested Budget for Direction of Bridges of MOPT	Description
Personnel Cost	96,000	19 Staff
Administration Cost	5,590	
Design and Technical Assistance Cost	120,600	
Detailed Inspection Cost	24,900	Periodical and Detailed Inspection
Facilities and Equipment	30,600	
Total Operating Cost Excluding Construction Costs	277,690	

On the other hand, the requested budget for CONAVI for the financial year 2007 is summarized as per Table 6.3.6. Since approximately 9.0 percent of the road construction and conservation budget is presently allocated for the construction, maintenance and rehabilitation of bridges on the national highway network, the estimated allocation for bridges in the financial year 2007 would be estimated at 6,331,250 Thousand Colones. However, the majority of this amount is new constructions of bridges which does not include sufficient budget for the maintenance and rehabilitation of bridges. Therefore, the present budget will not satisfy the required budget which is estimated at 4,438,960 Thousand Colones in the financial year 2012.

Table 6.3.6. Requested Budget for CONAVI for Financial Year 2007

(Unit: Thousand Colones)

Item	Total	Administration	Road Conservation	Road Construction	Operation Cost and Investment
Remuneration	1,794,860	791,573	60,107	620,226	322,954
Services	37,847,687	805,749	30,653,550	2,942,313	3,446,075
Material and Supplies	2,150,796	153,121	1,836,333	83,196	78,146
Interest and Commission	0	0	0	0	0
Consumer Durables	34,488,801	363,586	2,137,240	30,498,650	1,489,325
Transferences	54,000	12,000	3,000	30,000	9,000
Transferences of Capital	1,482,606	0	1,482,606	0	0
Total	77,818,750	2,126,029	36,172,836	34,174,385	5,345,500

6.4 Monitoring and Evaluation of Capacity Development

6.4.1 Basic Concepts for Monitoring and Evaluation

The outcomes of the capacity development through the implementation of 5 integrated modular projects are required to be constantly given feedbacks to MOPT and CONAVI to ensure that the process is on course and achieving results. The process must also be totally transparent to all the stakeholders so that the results of monitoring activities are reflected in the process of the capacity development.

Monitoring and evaluation is a complicated assessment of capacities involving qualitative rather than quantitative performance indicators. Benchmarks as performance indicators for monitoring and evaluation will be developed for the continuous feedbacks to the capacity development activities. In other words, since the capacity development is a continuous process from ***learning by doing***, the evaluation as well as the reassessment of the capacities is absolutely required.

6.4.2 Monitoring for Activities during the Study Period

The initial monitoring results in each modular project during the study period together with the relevant performance indicators are shown as Table 6.4.1. The evaluations on these performance indicators are as below, and the results of the evaluations at the early stage of the capacity development are rather satisfactory in terms of the individual capacity level. Since the inputs during the study period focus on the human resources development, especially trial inputs such as a comprehensive evaluation based on the human resources development activities, the monitoring and evaluation is mainly related to the individual capacity level.

a) Human resources development activities through 4 workshops on capacity development as well as 4 technical seminars on bridge maintenance technologies are continuously held during the course of the study, and the majority of the participants fully understand the contents of the workshops and seminars.
b) The training of 4 officials through the mission to Chili as well as the training of 2 officials in Japan greatly contributes to the basis of the capacity development targeting the officials of MOPT and CONAVI which are entry points of the capacity gap assessment.
c) Through the activities of drafting the manuals and guidelines, the degree of the understanding by the MOPT and CONAVI officials are considerably satisfactory, although there still remain the requirements for the improvement of actual operational skills based on more practical on-the-job basis training opportunities.
d) Since the PPP regional seminar will function as the strong commitment to the capacity development activities by MOPT and CONAVI, the results of the seminar will further deepen the individual capacity level of the officials of MOPT and CONAVI.
e) A wide range of public relation activities are carried out, and the consensus on the importance of the bridge maintenance has been further improved, thereby taxpayers are willing to pay for the financial resources.

Table 6.4.1. Performance Indicators in Monitoring

Modular Project	Performance Indicator	Explanatory Notes for Performance Indicator	Achievement of Target	
			Performance Targets	Results
MP-1	Technical Seminar	a) Theory and practice for bridge inventory and regular inspection	Participants including 4 engineers of the bridge design department of MOPT fully understand the contents of the seminar..	Satisfactory
		b) Theory and Practice for Rehabilitation and Reinforcement Planning	Participants including 4 engineers of the bridge design department of MOPT fully understand the contents of the seminar..	Satisfactory
		c) Theory and Practice for Rehabilitation and Reinforcement Design practice	Participants including 4 engineers of the bridge design department of MOPT fully understand the contents of the seminar..	Satisfactory
		d) Theory & Practical Operation For Bridge Management System (BMS)	Participants including 4 engineers of the bridge design department of MOPT fully understand the contents of the seminar..	Satisfactory
	Training in Chili	a) Theory and practice for bridge inventory and regular inspection	4 officials fully understand the contents of the training..	Understood by 4 Officials
	Training in Japan	a) Theory and practice for bridge inventory and regular inspection	2 officials fully understand the contents of the training.	Understood by 2 Officials
MP-2	Institution Building of MOPT	a) Drafting Organization Chart,	The ideal organization chart for the direction of bridges is drafted.	Drafted
	Institution Building of CONAVI	a) Drafting Organization Chart	The ideal organization chart for the new department of bridge construction is drafted.	Drafted
	Manuals and Guidelines	a) Inspection Manual	Drafted, 4 engineers of the bridge design department fully understand the outline of the manual	Completed
		b) BMS Operation Manual	Drafted, 4 engineers of the bridge design department fully understand the outline of the manual	Completed
		c) AHP Manual for Priority Selection	Drafted, 4 engineers of the bridge design department fully understand the outline of the manual	Completed
		d) Guidelines for Rehabilitation Planning and Implementation	Drafted, 4 engineers of the bridge design department fully understand the outline of the guidelines	Completed
MP-3	Regional Seminar	a) PPP Regional Seminars	50 relevant participants including 14 officials of other PPP member countries will fully understand the contents of the seminar.	Will be understood
MP-4	List up of Laws, Regulations and Standards	a) Technical Standards	4 technical standards are listed.	Listed
		b) Procurement Regulations	3 regulations are listed.	Listed
		c) Traffic Safety Regulations and Standards	All the regulations and standards are listed.	Listed
MP-5	Public Relations	a) Creation of Web Site for Public Relations	The web site for the study is created.	Created
		b) Press Kit for PPP Seminar	70 sets of press kit s for PPP seminars are prepared.	Prepared

6.4.3 Monitoring for Institutional Level during the Study Period

The target institutional levels of the capacity development are described as below, and the image of each target level is as per Figure 6.4.1.

(a) *Level 1* is the institutional level in which the organization depends on the capacities of individual staff and workers.

(b) *Level 2* is the institutional level in which the work flow of the organization is standardized by compiling manuals, thereby efficiency of the organization is significantly improved.

(c) *Level 3* is the institutional level in which each module project is managed under the

project management concept.

(d) *Level 4* is the institutional level in which each module project is comprehensively managed under the programme management concept.

(e) *Level 5* is the institutional level in which all the stakeholders fully understand the mission, modular projects, PDMs and WBSs under the programme management concept.

Based on the above benchmarks for the level of the institutional capacity as well as the following observations, the current institutional level is evaluated at between Target 1 and Target 2, reflecting the recent momentum towards the institutional reform of MOPT and CONAVI.

i) The bridge design department of MOPT is subject to be promoted to the direction of bridges from the financial year 2007, and there is a momentum that the bridge maintenance will not depend only on individual capacities but will be managed through the systematic institutional capacity. The study is proposing the details of the direction of bridges of MOPT.
ii) Although CONAVI is planning to establish the bridge-related department, the details of the department still remains unspecified by CONAVI. The study is proposing the details of the department of bridge construction of CONAVI.
iii) A wide range of manuals and guidelines in the field of the bridge maintenance are being drafted so as to standardize the workflows of MOPT and CONAVI.
iv) The BMCG is being established as a key consulting institution to bring about the synergy effect through integrating the individual capacities of the relevant organizations.

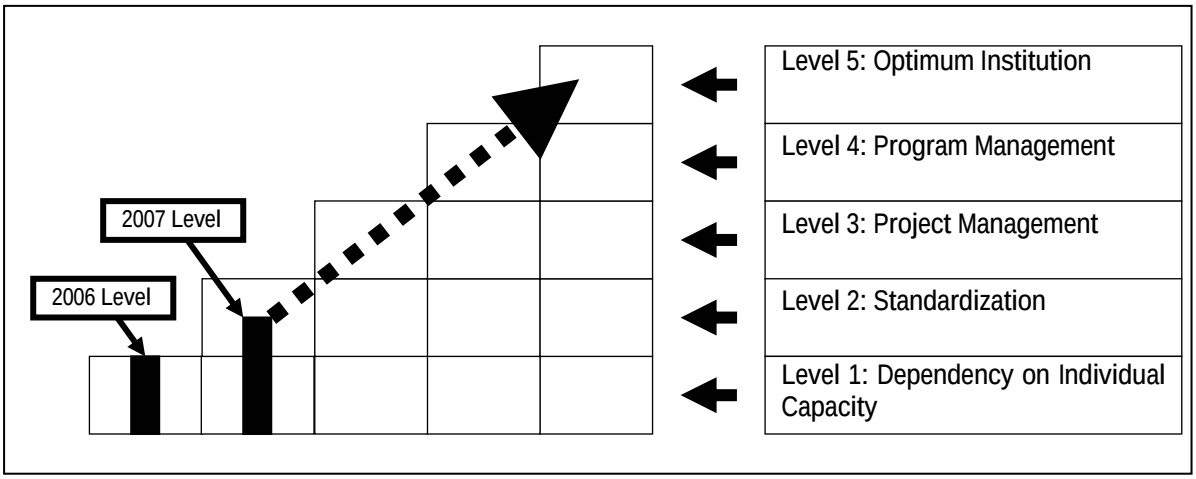


Figure 6.4.1. Target Institutional Level of Capacity Development

6.4.4 Monitoring during Implementation of Capacity Development

During the implementation of the capacity development through 5 integrated modular projects, the monitoring and evaluation activities targeting 5 integrated modular projects will be carried out. All the modular projects will be monitored under the full-scale monitoring system, and Table 6.4.2. to Table 6.4.6. indicate monitoring plans for 5 integrated modular projects.

Table 6.4.2. Monitoring Plan for Modular Project 1

Monitoring Activities		Project Purpose	Output
Objectively Verifiable Indicators		By the end of the financial year 2012, all the bridges on the national highway network will be maintained and repaired by the ample number of the qualified staff of MOPT and CONAVI who have the following appropriate expertise. 1. Inspection of Bridges, 2. BMS Management, 3. Diagnosis and Priority Selection, 4. Repair Planning, 5. Repair Works The required number of the qualified staff by expertise is as per Table 6.1.1.	By the end of the financial year 2012, the required number of the qualified staff of MOPT and CONAVI will be trained in accordance with the plan of operations in the following expertise. 1. Inspection of Bridges, 2. BMS Management, 3. Diagnosis and Priority Selection, 4. Repair Planning, 5. Repair Works The required number of the qualified staff by expertise is as per Table 6.1.1.
Means of Verifications		Bridge Inspection Records and Bridge Repair Records	Work Records and Progress Reports of Working Group 1 (WG-1)
Data Collection	Collector	MOPT, Direction of Bridges	Working Group 1 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 1 (MP-1)	Monitoring Report of Working Group 1 (WG-1)
Aggregation	Aggregator	MOPT, Direction of Bridges	Working Group 1 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 1 (MP-1)	Monitoring Report of Working Group 1 (WG-1)

Table 6.4.3. Monitoring Plan for Modular Project 2

Monitoring Activities		Project Purpose	Output
Objectively Verifiable Indicators		By the end of the financial year 2012, all the bridges on the national highway network will be maintained and repaired by the ample number of the qualified staff of MOPT and CONAVI who have the following appropriate expertise. 1. Inspection of Bridges, 2. BMS Management, 3. Diagnosis and Priority Selection, 4. Repair Planning, 5. Repair Works The required number of the qualified staff by expertise is as per Table 6.1.1.	By the end of the financial year 2007, streamlining responsibilities and clarifying workflows of new bridge-related organizations of MOPT and CONAVI will be completed so as to apply for the optimum staff and budget.
Means of Verifications		Work Records of New Direction of Bridges of MOPT and New Department of Bridges of CONAVI	1. Organization Chart for New Bridge-related Organizations of MOPT and CONAVI, 2. Staff List and Terms of Reference for New Bridge-related Organizations of MOPT and CONAVI, 3. Budgetary Documents for New Bridge-related Organizations of MOPT and CONAVI
Data Collection	Collector	MOPT, Direction of Bridges	Working Group 2 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 2 (MP-2)	Monitoring Report of Working Group 2 (WG-2)
Aggregation	Aggregator	MOPT, Direction of Bridges	Working Group 1 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 2 (MP-2)	Monitoring Report of Working Group 2 (WG-2)

Table 6.4.4. Monitoring Plan for Modular Project 3

Monitoring Activities		Project Purpose	Output
Objectively Verifiable Indicators		1. By the end of the financial year 2012, three universities of Costa Rica will have 10 new graduates in the field of bridge construction and maintenance. 2. By the end of the financial year 2012, more than 80 percent of the new technological information will be exchanged and shared among the public-private-academic circle. 3. By the end of the financial year 2012, more than 80 percent of the new technological information will be exchanged and shared among PPP member countries.	1. By the end of the financial year 2011, three universities of Costa Rica will have new courses in the field of bridge construction and maintenance. 2. From the financial year 2008 to 2012, at least, one regular meeting as well as one ad-hoc seminar among the public-private-academic circle for the knowledge share will be annually held. 3. From the financial year 2008 to 2012, at least, one regular meeting as well as one ad-hoc seminar among PPP member countries for the knowledge share will be annually held.
Means of Verifications		1. List of Graduates from New Courses at Universities, 2. Database of Shared Technological Information among Public-Private-Academic Circle, 3. Database of Shared Technological Information among PPP Member Countries	1. List of Courses at Universities, 2. Progress Reports and Work Records of Public-Private-Academic Seminars, 3. Progress Reports and Work Records of PPP Seminars
Data Collection	Collector	MOPT, Direction of Bridges	Working Group 3 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 3 (MP-3)	Monitoring Report of Working Group 3 (WG-3)
Aggregation	Aggregator	MOPT, Direction of Bridges	Working Group 1 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 3 (MP-3)	Monitoring Report of Working Group 3 (WG-3)

Table 6.4.5. Monitoring Plan for Modular Project 4

Monitoring Activities		Project Purpose	Output
Objectively Verifiable Indicators		By the end of the financial year 2012, 100 percent of guidelines, regulations, standards and manuals related to bridge maintenance practices, procurement procedures and traffic safety, together with their applications and operations, will be improved up to the international level.	By the end of the financial year 2012, the following documents will be prepared In accordance with the plan of operations. 1. Bridge Inspection Manual, 2.BMS Operation Manual, 3. Guidelines for Bridge Maintenance, 4. Bridge Design Standards, 5. Regulations for Bridge Maintenance, 6. Guidelines for Procurement Procedures by MOPT, CONAVI and CNC, 7. Regulations on Traffic Safety on Bridges
Means of Verifications		List of Guidelines, Regulations, Standards and Manuals related to Bridge Maintenance Practices, Procurement Procedures and Traffic Safety on Bridges	Work Records and Progress Reports of the Working Group 4 (WG-4)
Data Collection	Collector	MOPT, Direction of Bridges	Working Group 4 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 4 (MP-4)	Monitoring Report of Working Group 4 (WG-4)
Aggregation	Aggregator	MOPT, Direction of Bridges	Working Group 1 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 4 (MP-4)	Monitoring Report of Working Group 4 (WG-4)

Table 6.4.6. Monitoring Plan for Modular Project 5

Monitoring Activities		Project Purpose	Output
Objectively Verifiable Indicators		1. By the end of the financial year 2012, 80 percent of financial and planning officials of relevant ministries as well as MOPT/CONAVI will understand the importance of asset management. 2. By the end of the financial year 2012, 80 percent of bridge users as well as taxpayers will understand the importance of bridge maintenance.	1. By the end of the financial year 2012, 10 officials of the Ministry of Finance and the Ministry of National Planning will annually participate in a series of seminars on asset management. 2. By the end of the financial year 2012, a considerable number of bridge users and taxpayers will continuously be advocated through a wide range of public relation activities in the field of bridge maintenance.
Means of Verifications		1. Survey on Understanding by Financial and Planning Officials, 2. Survey on Understanding by Bridge Users and Taxpayers	1. Attendance List of Seminars, 2. Number and Target List of Public Relation Activities
Data Collection	Collector	MOPT, Direction of Bridges	Working Group 5 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 5 (MP-5)	Monitoring Report of Working Group 5 (WG-5)
Aggregation	Aggregator	MOPT, Direction of Bridges	Working Group 1 of BMCG
	Timing	5 Times (January 2009, January 2010, January 2011, January 2012, January 2013)	5 Times (February 2009, February 2010, February 2011, February 2012, February 2013)
	Method	Monitoring Report of Modular Project 5 (MP-5)	Monitoring Report of Working Group 5 (WG-5)

Capacity development is a transformational change through an accumulated incremental process. Since impacts and changes by the capacity development affect a wide range of individuals and organizations in terms of both incremental and transformational changes, the evaluation during the implementation stage of the integrated modular projects will cover the following full-scale evaluation dimensions based on the above monitoring system.

a) Relevance: The degree to which modular projects can be justified in terms of national development priorities.
b) Effectiveness: The extent to which the purposes of modular projects have been achieved.
c) Efficiency: How economically inputs of modular projects converted into outputs
d) Impact: The degree of positive and negative changes to which outputs of modular projects are delivered to beneficiaries.
e) Sustainability: The extent to which the positive effects of the modular projects will still continue even after the study is completed.

6.5 Public Relations for Capacity Development

6.5.1 Domestic Public Relations

In an attempt to domestically extend the outcomes of the capacity development to a wide range of stakeholders in the society, various domestic public relations activities in the field of bridge maintenance have been carried out and planned to be implemented by using available channels of public relations. Taxpayers as well as bridge users are the main target group for the public relations, while the government officials concerned are also included. Due to the limited financial resources of MOPT and CONAVI, a series of large-scale campaigns through

various medias such as TV-program campaigns to appeal the importance of the bridge maintenance are not realistic. Table 6.5.1. shows the list of public relation activities to be conducted during the study and to be planned after the study.

Table 6.5.1. Varieties of Domestic Public Relations Activities

Activity	Main Target	Frequency	Timing	Channel
Workshop on Capacity Development	Administrative Officials and Engineers	4 times	During the Study	Workshop
Technical Seminar on Bridge Maintenance Technologies	Engineers	4 times	During the Study	Technical Seminar
Creation of Web Site Attached to MOPT Web Site	Taxpayers	Once	During the Study	Web Site
Press Release Kit for PPP Seminar	Taxpayers	Depends on Budget	During the Study	News Paper
Leaflet for Taxpayers on Understanding of Bridge Maintenance	Taxpayers	Depends on Budget	After the Study (Included in MP-5)	Documents
Leaflet for Bridge Users on Understanding of Bridge Maintenance	Bridge Users	Depends on Budget	After the Study (Included in MP-5)	Documents
Press Tour for News Paper Campaign of Bridge Maintenance	Tax Payers and Bridge Users	Once	After the Study (Included in MP-5)	News Paper
Provision of Materials for Public Relation Videos for TV Program	Tax Payers and Bridge Users	Depends on Budget	After the Study (Included in MP-5)	TV Program
Implementation of Bridge Photo Contests	Students	2 Times	After the Study (Included in MP-5)	Photo Contest

6.5.2 Extension to PPP Member Countries

Costa Rica is one of PPP member countries, and is currently responsible for the technical commission of PPP on the highway network. In an attempt to extend the results of the capacity development activities in the field of the bridge maintenance, the PPP regional seminar on the capacity development will be held in December 2006 at the timing of submitting the draft final report. As one of crucial components of the modular project 3 (MP-3), the opportunity for the PPP regional seminar is regarded as the international commitment by MOPT and CONAVI, and the program of the seminar is divided into two parts of capacity development and bridge maintenance technology.

6.6 Exit Strategy after the Termination of the Study

Since the field survey of this study will be terminated in December 2006, an ***"exit strategy"*** is required to keep the sustainability of the capacity development even after the study is completed. An exit strategy is defined as a withdrawal plan covering actions to be taken by counterparts and donors towards the end of a project cycle, when supports from donors are gradually terminated. While it is narrowly understood that the strategy allows donors to exit in due time without jeopardizing the sustainability of the capacity development, in the broader sense, it is a strategy for planning, implementing, and ending external supports in a manner consistent with the objective of the capacity development.

In general, phasing out is usually a delicate process which requires special individual and organizational skills for the exit strategy. It should be also noted that crucial steps towards exit and sustainability are usually those taken at the beginning of the process. The following factors should be especially taken into account when the exit strategy is formulated.

a) Feedback mechanisms which encourage continuous learning, both internal and external to the members of BMCG, should be included in the exit strategy so as to ensure that the feedback loop is linked to a continuous review of the implementation of 5 integrated modular projects.

b) Further donors' supports which may undermine capacities by simply providing direct supports or filling gaps not aiming at the capacity development should be avoided.

c) The unlimited injection of donors' supports after the termination of the study without ownership which lead to difficulties in bringing about far-reaching institutional reforms should not be provided.

CHAPTER 7 HUMAN RESOURCE DEVELOPMENT

7.1 Basic Concept

It is generally known that the Human Resource Development is to comprehend an enhancement of the individual competence, which comprises three fundamental capabilities i.e. Knowledge, Skill and Attitude. With a feedback from experienced technical assistances and/or technical transfer in past, however, it has certainly been recognized that to enhance the individual competence would hardly be a necessary & sufficient condition but a merely part of requirements for a capacity building of the personnel of the recipient country.

As described in the previous chapter, under a concept of the Capacity Development, the Human Resource Development plays a part of roles of the Capacity Development Program (herein after described "the CD program") upon the individual level. The CD program, named the Total Improvement Program for Bridge Maintenance and Management, conducts the individual competence to be focused on its technical strengthening for the bridge rehabilitation and maintenance, tightly and widely binding with the organizational and the institutional competence, which are to be requirements as pivotal roles to complement effectiveness, influence and own efforts on developing the capacity of both recipient and neighboring countries.

On this study, a component of the Human Resource Development initiates with technical training activities prior to the establishment of the CD program. It is an intention that the Program implicates those prior activities into so-called module projects and comes into force in the process of the study, so as to roll-play thoroughly a human resource development under the Program-Project-Management for the rest of the study as well as for future scene.

7.2 Implementation Plan for Human Resource Development

7.2.1 Basic Plan

Consequently that the technical training is to be synthetically assembled and launched as a part of the CD program with module projects based on the study workflow, a training program are preliminarily designed and conducted for the earliest stage of the study. Accordingly, technical training activities have been introduced and initiated essentially aiming upon the counter-parts technical staff at the beginning of the study, whereas the module projects and its log-frames are examined to open to implementation amongst wide-ranged target levels as a part of the CD program.

Outputs and/or Outcome of the training are to be regional-widely disseminated to 7 neighbouring countries, which join in Puebla-Panama Plan, throughout a seminar at the end of the study.

1) Methodology

The training activities are thoroughly practiced, with intention of multiplying the learning effect, in manner of both On-the-Job (OJT) and Technical Seminar basis to aim an enhancement of Knowledge, Skill & Attitude.

In addition, it is remarked that an Overseas Study Tour has been applied for the study, which is aimed to obtain supplementary effects and amplify effectiveness on both the technical training and dissemination.

The following summarizes key methods to be employed on the training:

i) On-the-Job Training (OJT): is to involve working closely with Costa Rican Staff actually responsible for producing and disseminating results and to provide them with Hands-on experiences with major technical pillars such as inspection, planning & design and management.

ii) Technical Seminar: is to be contemplated in consequence with the OJT exercise, respectively. Seminars are to help reviewing & learning over both experienced knowledge and skill by OJT. It is noted that each seminar duly summarizes the feedback with the technical explanation from OJT into a manner of hands-out. This will function both as a place to exhibit those experiences & exercises in a participatory manner with the trainee, and as an opportunity for the trainee to review outputs fed from OJT in manner of technical lecture.

   An International Seminar is phased-in at the end of the study for a regional-wide dissemination. The Seminar shall also render further effects that enable the trainee to disseminate outputs and/or outcome of the training to 7 neighbouring countries in North-Central America, which join in the Puebla-Panama Plan.

iii) Overseas Study-Tour: is to be contemplated in a part of the program, which is expected to fertilize expertise and embody the objectives & goals for the study in the bridge maintenance.

   - Visit to Chile (a study report is detailed lately on the following section) to observe on Similar Existing Bridge Maintenance Management System has been implemented during this phase.
   - JICA Counter Part training program in Japan (a study report is detailed lately on the following section) to obtain and to experience the technical knowledge regarding practices of the bridge maintenance in Japan.

2) Technical Training Program

Extending over whole period of the study, the technical training is focused on improving a competence of the individual level. In a harmonization with above-mentioned methodology, training activities are to be phased-in to achieve two essential outputs such as; the bridge rehabilitation-reinforcement-improvement planning and design as well as the bridge management system.

Technical Training program comprises 4 major technical pillars of the bridge rehabilitation and maintenance. The following states program details per each pillar and a series of components to be scheduled in practices of the study.

Table 7.2.1. Technical Training Program

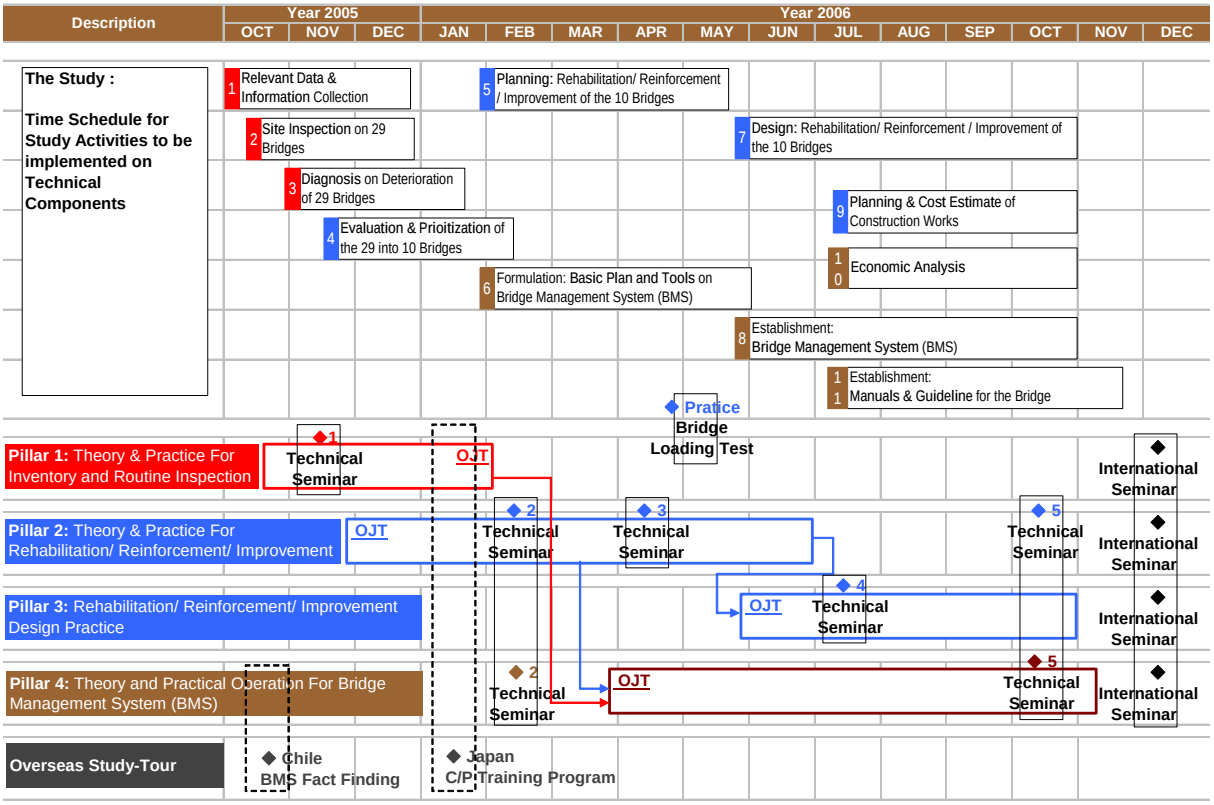
Technical Pillars		Program Details		
		Goal / Target	Components	Method
1	Training on: ***Theory & Practice For Inventory and Routine Inspection*** Targeted on: ***29 bridges***	Aimed to: - experience basic methods. - obtain basic knowledge & skills. - obtain understandings, motivation on importance of maintenance. Targeted trainee: - C/P responsible for the bridge maintenance. Local Civil engineer.	i) Concept comprehension Theory & Importance of the bridge inspection. ii) Implementation **the preliminary and/or periodical inspection**. iii) Preparation of Inspection sheet and Survey logs. iv) Examination inspection results. v) **Diagnosis** the bridge deficiency/deteriorations. vi) Provision of **Manual & Technical explanation** for its practical use.	- OJT basis - Seminar basis - Overseas Study *1: C/P training program in Japan
2	Training on: ***Theory & Practice For Rehabilitation/ Reinforcement/ Improvement Planning*** Targeted on: ***Selected 10 bridges***	Aimed to: - experience advanced methods. - obtain advanced knowledge & skills Targeted trainee: - C/P responsible for the bridge maintenance. - Local Civil engineer.	i) **Evaluation the bridge deficiency/deteriorations** based on 29 bridges with the Analytic Hierarchy Process (AHP). ii) **Prioritization** for the bridge Rehabilitation/ Reinforcement/ Improvement based on the Evaluation of deteriorations. iii) Implementation the **Detailed Inspection.** iv) **Structural Modeling** and Analysis v) **Loading test** vi) **Identification of deterioration mechanisms** vii) Selection and **Planning of Rehabilitation/ Reinforcement/ Improvement methods** per structural elements i.e. Slab/Girder/Substructure. viii) Cost estimation ix) Economic Analysis x) Provision of **Guideline & Technical explanation** for its practical use.	- OJT basis - Seminar basis - Overseas Study *1: C/P training program in Japan
3	Training on: ***Rehabilitation/ Reinforcement/ Improvement Design practice*** Targeted on: ***Selected 10 bridges***	Aimed to: - experience basic skills. - obtain basic knowledge. Targeted trainee: - C/P responsible for the bridge maintenance. - Local Civil engineer.	i) **Preliminary Design** for the bridge Rehabilitation/ Reinforcement/ Improvement based on the planning. ii) **Construction Planning** iii) Provision of **Guideline & Technical explanation** for its practical use.	- OJT basis - Seminar basis

Technical Pillars		Program Details		
		Goal / Target	Components	Method
4	Training on: ***Theory & Practical Operation For Bridge Management System (BMS)*** Targeted on: ***29 bridges***	Aimed to: - experience advanced methods. - obtain advanced knowledge & skills. Targeted trainee: - C/P responsible for the bridge maintenance. - Local Civil engineer.	i) **Examination the existing Chilean BMS**. ii) Obtain information of Chilean organizational structure related to the bridge maintenance. iii) Networking with Chilean Personnel iv) **Data Piling & Up-dating** on the bridge inventory & conditions by inspections. v) **Examination of methodology for evaluation & prioritization.** vi) **Establishment of the Bridge Management System.** vii) **Operation & Maintenance** of the established BMS. viii) Provision of **Manual & Technical explanation** for its practical use.	- Overseas Study *1: C/P training program in Japan *2: BMS fact-finding study in Chile - OJT basis - Seminar basis

3) Program Schedule

4 technical pillars of the training program are to be phased-in the implementation schedule of the Study as follows.

Table 7.2.2. Schedule for Technical Training Program



7.2.2 Modular Projects for individual competence improvement

As stated earlier, throughout the full-scale gap assessment and problems/ objectives tree-analysis during the first phase of the study, there have been extracted thirteen module projects to be roll-played for future scene inclusively the second phase.

The following four modular projects of 13 are stated for improving and/or securing qualified human resources on individual level:

- Modular Project 1-a: to improve competences on the Bridge Inspection and Diagnosis
- Modular Project 1-b: to improve competences on the Bridge Management System
- Modular Project 1-c: to improve competences on the Bridge Rehabilitation/ Reinforcement/ Improvement Planning & Design
- Modular Project 1-d: to secure recruitment and training opportunities on the field of Bridge Engineering and Maintenance.

As a part of the Program-Project-Management, these four modules on individual level are to be incorporated into integrated projects, named Project 1 and Project 3 for a roll-play by Working Groups formulated under directions of the Bridge Management Core Group. It reaches totally to 5 integrated projects which entirely count over 13 modules as above mentioned.

Further details for plans of implementation of the integrated projects are fully indicated on previous chapters. Linkage and coherence between technical pillars of the training program and the 5 integrated projects of the Capacity Development program are briefly summarized in the following table.

Table 7.2.3. Links with Modules and Integrated Projects

Capacitty Development Targeted Levels	Integrated Project				
	Project 1	Project 2	Project 3	**Project 4**	Project 5
Individual Level	●		**Module 1-d**		
Organizational Level		●	●		
Social & Institutional Level			●	●	●
Pillar 1: Inventory and Routine Inspection Theroy / Practice	**Module 1-a** as **Prior-Trial activity** Training results into "Input"of Project			**Bridge Inspection Manual**	
Pillar 2: Rehabilitation/ Reinforcement/ Improvement Planning	**Module 1-c** as **Prior-Trial activity** Training results into "Input"of Project			**Bridge Maintenance Guideline**	
Pillar 3: Rehabilitation/ Reinforcement/ Improvement Design Practice	**Module 1-c** s **Prior-Trial activity** Training results into "Input"of Project			**Bridge Maintenance Guideline**	
Pillar 4: Theory and Practical Operation For Bridge Management	**Module 1-b** as **Prior-Trial activity** Training results into "Input"of Project			**BMS Operation Manual**	

Each modular projects identify its detailed activities, necessary inputs & outputs and verifiable indicators on logical frameworks. Logical frameworks will theoretically render two effects.

Firstly, it enables to continuously develop the above-mentioned technical training program by integrating those 4 pillars into the modular projects.

And secondly, to enhance an human resource development wide-rangedly in terms of disseminate of the technical competence (e.g. amplification of the target personnel, formulation of the informative and/or communicative platforms) by combining with further modular projects, which compose the Capacity Development Program for improving on both the organizational and the institutional levels simultaneously and transversally to individual level.

7.3 Implemented Activities for Human Resource Development

Based on the implementation plan, technical training program with 4 pillars has been duly carried out throughout the Study period. Details of the implemented training activities and their attainments are stated as follows.

7.3.1 Technical Pillar-1

1) Implemented Schedule and Outline of Key Activities

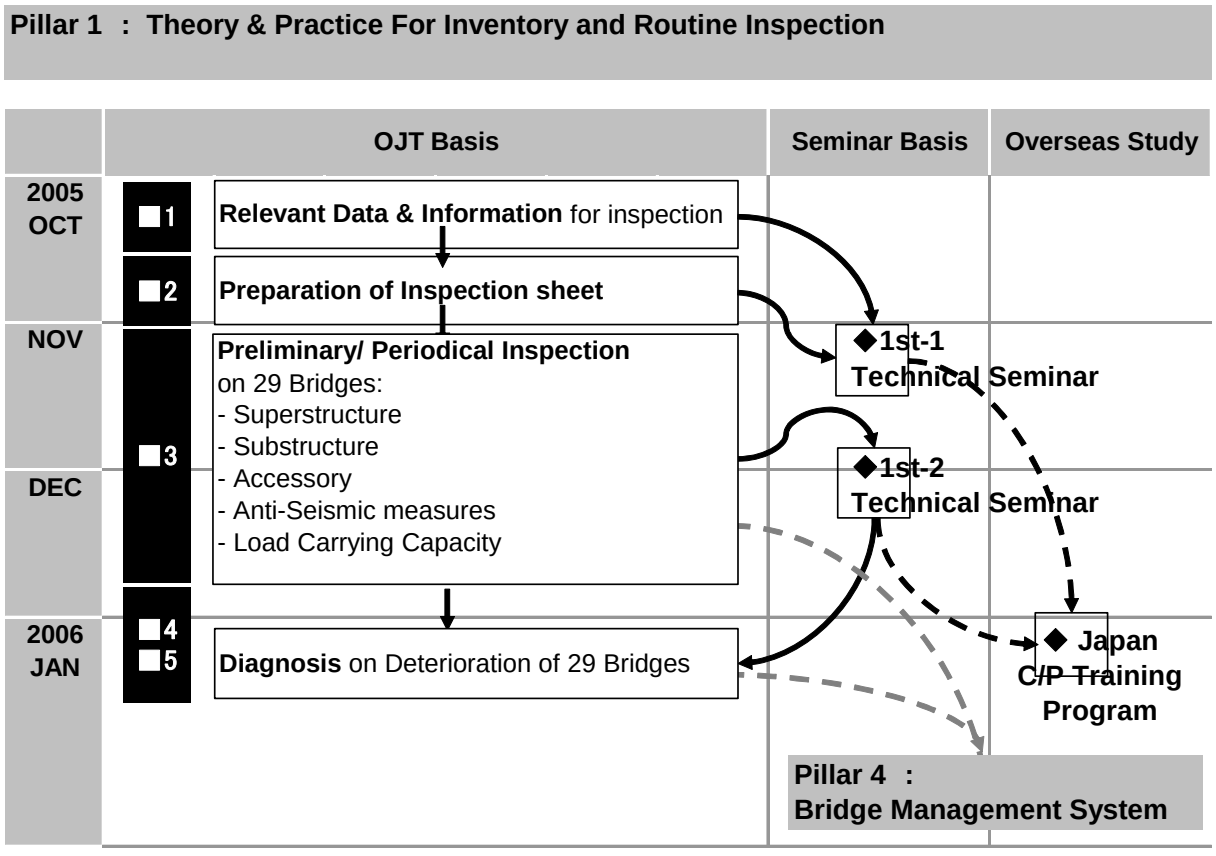


Figure 7.3.1. Outline of Key Activities : Pillar-1

2) Training Components

On the Job Training (OJT) Basis,

the technical training extended over the following knowledge and skills:

■ **1** Necessary data collection and analysis prior to the preliminary and/or periodical site inspection of 29 bridges, i.e. drawings, bridge inventory, historical repairing records, traffic volume, topographical map, river conditions at site.

■ **2** Preparation of the check list for the visual inspection and inspection sheet/survey logs

■ **3** Preliminary and/or Periodical Inspection method on 29 bridges with inspection tools such as Crack Scale, Convex, Caliper, Hummer for:
- Superstructure
- Substructure
- Accessory
- Anti-Seismic measures
- Load Carrying Capacity

■ **4** Diagnosis methodology on 29 bridges of the deterioration:
- Superstructure
- Substructure
- Accessory

■ **5** Examination method with inspection results
- Live load and condition of Deck slab (Load Carrying Capacity)
- Overlap length and Condition of bridge seat (Anti-Seismic measures)

On the Technical Seminar Basis,

the technical training extended over the following knowledge and skill:

◆ **1st -1** Technical Seminar on November 3rd, 2005 (attendance: 33 counterpart engineers): was to render a conceptual comprehension: Importance of the asset management and the bridge maintenance, and to illustrate the methodology for site inspection, diagnosis and the bridge rehabilitation/ reinforcement.

Table 7.3.1. Participation: Seminar1-1

Organization	Quantity of Personnel Participated	Remarks
MOPT	28	Bridges/Planning Direction
CONAVI	5	
Other Public Institution	0	
Academic Sector	0	National laboratory, University
Private Sector	0	Consultants, Contractors
Total	**33**	

Theme:

- Outline of Bridge Maintenance
- Outline of Asset Management and Bridge Management System
- Outline of Methodology for Site Inspection, Diagnosis
- Outline of Methodology for Bridge Rehabilitation/Reinforcement

◆**1st -2** Technical Seminar on November 30th, 2005 (attendance: 71 counterpart and local engineers): was to focus on Inspection, Diagnosis method and evaluation of the bridge deficiency. There were technical presentations by two counterpart engineers as to results of the site inspection, i.e. classification, severity of observed deteriorations.

Table 7.3.2. Participation: Seminar1-2

Organization	Quantity of Personnel Participated	Remarks
MOPT	23	Bridges/Planning Direction
CONAVI	8	
Other Public Institution	17	
Academic Sector	2	National laboratory, University
Private Sector & NGO	21	Consultants, Contractors, NGO
Total	**71**	

Theme:

- Outline of Bridge Maintenance
- Outline of Asset Management and Bridge Management System
- Outline of Methodology for Site Inspection, Diagnosis
- Outline of Methodology for Bridge Rehabilitation/Reinforcement

3) Provision of Manuals & Technical explanations

Inspection Manual has been edited by the Study team in order for the counterparts to utilize it on the practice of Bridge maintenance for future scene, which is to be fed into the CD program. The Manual aims at being a practical and an educational work references for bridge inspectors not limited to bridges engineers. The following states brief contents of the Manual. Details and coverage are thoroughly described in Chapter 15.

- Technical terms and Basic concepts of the Bridge
- Inspection Methodology
- Inspection sheet
- Evaluation Criteria on deteriorations of bridges

7.3.2 Technical Pillar-2

1) Implemented Schedule and Outline of Key Activities

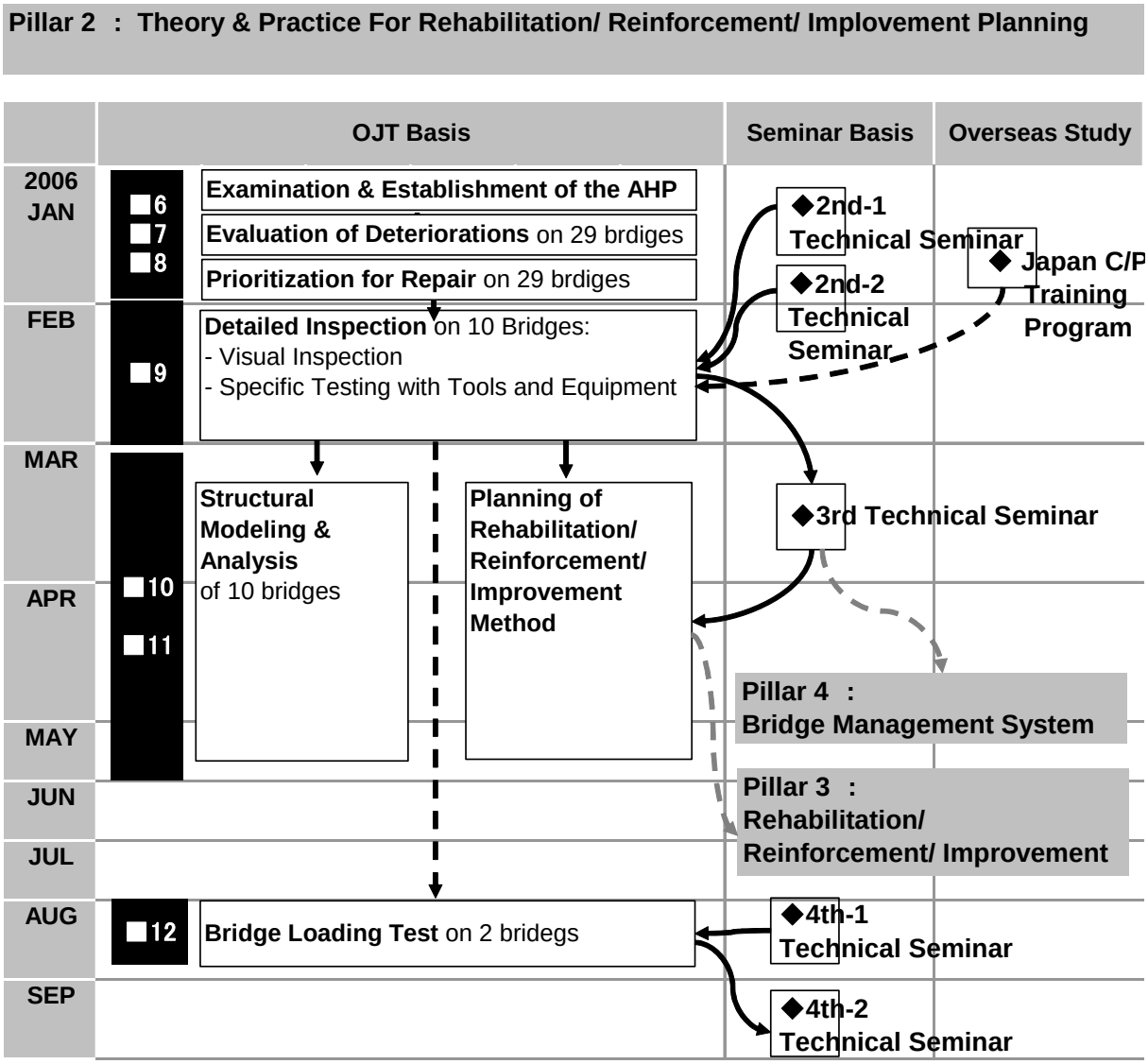


Figure 7.3.2. Outline of Key Activities : Pillar-2

2) Training Components

On the Job Training (OJT) Basis,

the technical training extended over the following knowledge and skills:

■ **6** Examination and Establishment of the Analytic Hierarchy Process (AHP) by weighting damages and/or deteriorations per bridge parts to assess.

■ **7** Evaluation method and Establishment of the deficiency rate throughout 29 bridges with AHP.

■ **8** Screening method into 10 Prioritized bridges for the Rehabilitation/ Reinforcement/ Improvement based on evaluation of deteriorations.

■ **9** Practice of the Detailed Inspection Method on 10 bridges with inspection tools / equipments for:

- Carbonation
- Insufficient strength
  - Carbonation with Phenolphthalein Method
  - Concrete strength with the Schumidt Hummer Method,
  - Concrete-Core Testing

■**10** Practice of the Structural Modeling and Analysis of 10 bridges

■**11** Examination, Selection and Planning of Rehabilitation/ Reinforcement/ Improvement method for:

- Deck Slab
- Main Girder
- Substructure
- Pier and foundation

■**12** Theory & Practice of the Bridge Loading Test for Rio Chrripo on Rout 32 and Rio Chirripo on Route 4 on August 29th to 31st 3 days.

- Static Load Testing on both bridges
  - Deflection and Stress Measurement
- Dynamic Load Testing on Rio Chrripo Rout 32
  - Stress Frequency Measurement with actual traffic volume
  - Stress Measurement with moving test load
- Analysis, Evaluation of results
- Applications for the Bridge maintenance planning
- Traffic control and Safety measures

On the Technical Seminar Basis,

the technical training extended over the following knowledge and skill:

◆**2nd -1** Technical Seminar on January 6th, 2006 (attendance: 10 counterpart engineers) was to focus on the methodology of the detailed inspection. A general procedure of the inspection, detailed methodology for both the concrete structure and the steel structure are lectured with visualized illustration:

Table 7.3.3. Participation: Seminar2-1

Organization	Quantity of Personnel Participated	Remarks
MOPT	10	Bridges/Planning Direction
CONAVI	0	
Other Public Institution	0	
Academic Sector	0	National laboratory, University
Private Sector	0	Consultants, Contractors
Total	**10**	

Theme:

- General procedure of Inspection
- Methodology in detail for both the Concrete Structure and the Steel

Structure
- Deterioration Mechanisms
  - Carbonation
  - Salt Corrosion
  - Alkali Aggregate Reaction
  - Insufficient Concrete Strength

◆**2nd -2** Technical Seminar on January 12th, 2006 (attendance: 10 counterpart engineers) was to focus on the methodology of the detailed inspection same as the previous seminar but particularly on the practical use of the inspection tools and equipment this time including an analysis/evaluation method with inspection results. The following inspection methods were to be introduced and practiced with instruments as hands-on:

Table 7.3.4. Participation: Seminar2-2

Organization	Quantity of Personnel Participated	Remarks
MOPT	10	Bridges/Planning Direction
CONAVI	0	
Other Public Institution	0	
Academic Sector	0	National laboratory, University
Private Sector	0	Consultants, Contractors
Total	**10**	

Theme:
- Visual Inspection
- Carbonation with Phenolphthalein Method
- Concrete strength with the Schumidt Hummer Method, Concrete-Core Test
- Exploration of Re-bars with the "Profometer" to determine concrete strength

◆**3rd** Technical Seminar on March 7th (attendance: 48 counterpart and local engineers) was to be themed on major issues on the Costa Rican bridge maintenance from the technical point of view of JICA study team and the strategic bridge maintenance to be aimed for future.

Table 7.3.5. Participation: Seminar3

Organization	Quantity of Personnel Participated	Remarks
MOPT	19	Bridges/Planning Direction
CONAVI	3	
Other Public Institution	9	
Academic Sector	1	National laboratory, University
Private Sector	16	Consultants, Contractors
Total	**48**	

Theme:
- Fact finding: Actual Condition of Bridges in Costa Rica

- Important Notices and Tasks upon actual status of bridges
- Major Issues for Bridge Maintenance

◆**4th -1** Technical Seminar twice in August (attendance: 10 counterpart engineers x 2 times) was to focus on the Bridge Loading Test. General explanation of the test, methodology and procedures are lectured with visualized illustration.

Table 7.3.6. Participation: Seminar4-1

Organization	Quantity of Personnel Participated	Remarks
MOPT	7	Bridges/Planning Direction
CONAVI	0	
Other Public Institution	0	
Academic Sector	0	National laboratory, University
Private Sector	3	Consultants (Holcim)
Total	**10**	

Theme:

- Introduction of the Bridge Loading Test
- General Explanation of the Test
  - Methodology of the Test
  - Procedure of the Test
- Use of Materials, Equipment and Devices for measurement

◆**4th -2** Technical Seminar on September 29th, 2006 (attendance: 52 counterpart and local engineers) was to focus on the Bridge Loading Test same as the previous seminar but inclusively Results of the test, Evaluation and Conclusions, which are taken into account for Rehabilitation/Reinforcement Planning. Practical use of tools and equipment, as well as analysis/evaluation method were to be introduced.

Table 7.3.7. Participation: Seminar4-2

Organization	Quantity of Personnel Participated	Remarks
MOPT	12	Bridges/Planning Direction
CONAVI	1	
Other Public Institution	19	
Academic Sector	0	National laboratory, University
Private Sector	21	Consultants, Contractors
Total	**52**	

Theme:

- Introduction of the Bridge Loading Test
- Technical Concept and Criteria to be applied
  - Load Carrying Capacity
  - Durability for Fatigue

- Technical Description of Materials, Equipment and Devices for measurement
- Methodology of the Test
  - Static Load Testing on both bridges
    - Deflection and Stress Measurement
  - Dynamic Load Testing on Rio Chrripo Rout 32
    - Stress Frequency Measurement with actual traffic volume
    - Stress Measurement with moving test load
- Procedure of the Test
- Analysis and Evaluation of test results
- Results and Conclusion

3) Provision of Guideline & Technical explanations

"Bridge Maintenance Guideline" has been edited by the Study team based on the ASSHOT with an essence of technical criteria experienced in Japanese Bridge Maintenance in order for the counterparts to utilize it on the practice of Bridge maintenance for future scene, which is to be fed into the CD program.

The Guideline aims at being a practical and an educational work references for bridge engineers as well as those students who will keenly be a bridge engineer. The following states contents of the Guideline. Details and coverage are thoroughly described in Chapter 15.

- Introduction
  - Objectives
  - Scope
- Outline of the Guideline
- Bridge Management System
- Identification of Deteriorations
  - Classification
  - Cause and Mechanisms
- Detailed Inspection
  - Method and Classification of detailed inspection
- Investigation of Load Carrying Capacity
  - Analytical Method
  - Loading Test
- Repair Work Design and Construction Method
- Safety Measures

7.3.3 Technical Pillar-3

1) Implemented Schedule and Outline of Key Activities

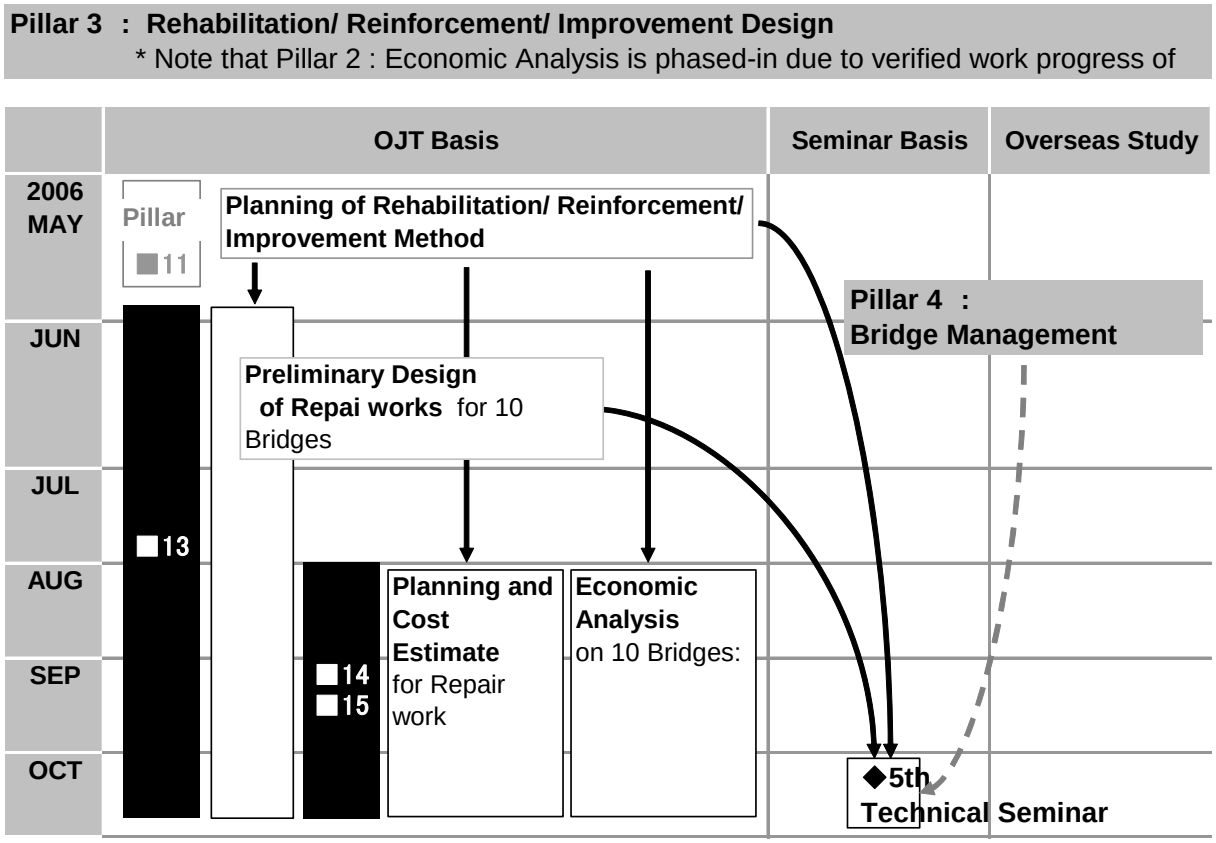


Figure 7.3.3. Outline of Key Activities : Pillar-3

2) Training Components

On the Job Training (OJT) Basis,

the technical training extended over the following knowledge and skills:

■**13** Preliminary Design of 10 bridges

■**14** Planning and Cost Estimation for Repair Work of 10 bridges

- # 2 Rio Aranjuez
- # 3 Rio Abangares
- # 7 Rio Azufrado
- #12 Rio Puerto Nuevp
- #16 Rio Nuevo
- #17 Rio Chirripo
- #18 Rio Sarapiqui
- #20 Rio Sucio
- #26 Rio Chirripo
- #29 Rio Torres

■**15** Economic Analysis

- Traffic Volume Estimation
- Vehicle Operation Cost (VOC) and Travel Time Cost (TTC)
- Calculation for the Social Cost of 10 bridges
- Scenario of Deterioration and Deficiency for 10 Bridge without the case of proper maintenance and/or repair works

On the Technical Seminar Basis,

the technical training extended over the following knowledge and skill:

◆**5th** Technical Seminar on October 18th, 2006 (attendance: 33 counterpart and local engineers) was to focus on the Planning and the Design for Bridge Rehabilitation/ Reinforcement/ Improvement as well as the Bridge Management System. The Guideline & Manuals were to be briefly introduced. Overall structures and sequences of the bridge maintenance activities are systematically lectured with visualized illustration:

Table 7.3.8. Participation: Seminar5

Organization	Quantity of Personnel Participated	Remarks
MOPT	5	Bridges/Planning Direction
CONAVI	4	
Other Public Institution	9	
Academic Sector	0	National laboratory, University
Private Sector	15	Consultants, Contractors
Total	**33**	

Theme:

- Planning: Bridge Rehabilitation/ Reinforcement/ Improvement
  - Basic Principles for Bridge Maintenance
  - Deteriorating Mechanism
  - Detailed Inspection
  - Remedial Measures
    - Type of Remedial Measures
    - Methods for Repair
    - Methods for Reinforcement
    - Examples
- Design: Bridge Rehabilitation/ Reinforcement/ Improvement
  - Design and Calculation Examples
    - Deck Slab
    - Main Girder
    - Substructure
    - Pier and foundation
  - Repair/Reinforcement Works
    - Deck Slab
    - Main Girder

- Bridge Maintenance Guideline for Engineers
  - Outline of the Guideline
  - Components of the Guideline
- Inspection Manual for Inspectors
- Bridge Management System

3) Provision of Guideline & Technical explanations

The Guideline stated earlier has contemplated "Design and Construction Methods for Rehabilitation/ Reinforcement/ Improvement Work" in addition to "Planning "components.

Details and coverage are thoroughly described in Chapter 15.

7.3.4 Technical Pillar-4

1) Implemented Schedule and Outline of Key Activities

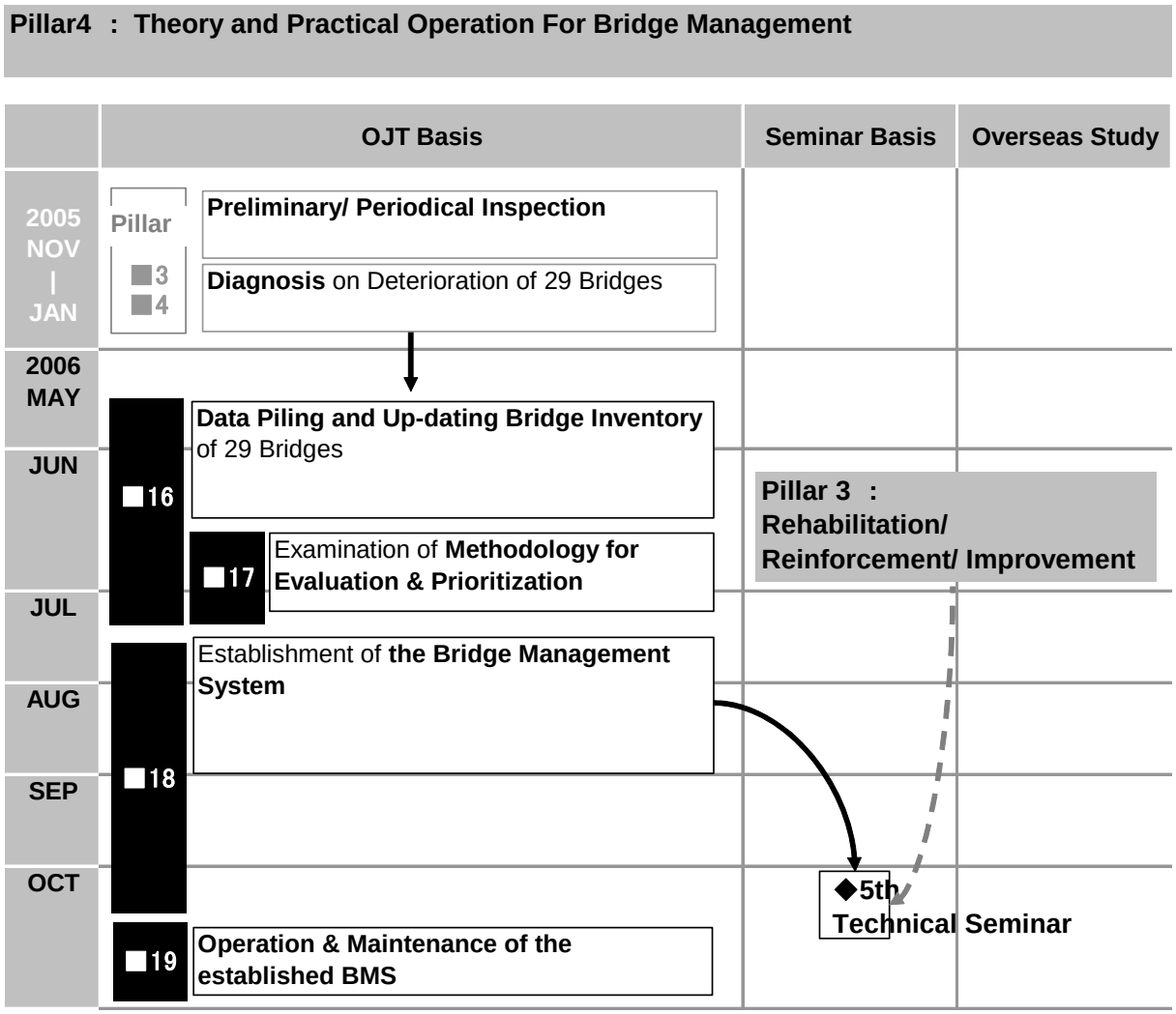


Figure 7.3.4. Outline of Key Activities : Pillar-4

2) Training Components

On the Job Training (OJT) Basis,

the technical training extended over the following knowledge and skills:

■**16** Data Piling and Up-dating Bridge Inventory of 29 bridges

■**17** Examination of Methodology for Evaluation & Prioritization.

■**18** Establishment of the Bridge Management System.

- Structure of BMS Data Base
- Establishment the System Environment
- Establishment the Operation & Maintenance Group/Personnel
- Development Deficiency Rating, Prioritization and Cost Estimate System

■**19** Operation & Maintenance of the established BMS.

On the Technical Seminar Basis,

the technical training extended over the following knowledge and skill:

◆**5th** Technical Seminar on October 18th, 2006 as stated earlier in this Chapter.

Theme:

- Planning: Bridge Rehabilitation/ Reinforcement/ Improvement (Pillar-3)
- Design: Bridge Rehabilitation/ Reinforcement/ Improvement (Pillar-3)
- Bridge Maintenance Guideline for Engineers (Pillar-3)
- Inspection Manual for Inspectors
  - Technical terms and Basic concept of the Bridge
  - Inspection Methodology
  - Inspection sheet
  - Evaluation Criteria on deteriorations of bridges
- Bridge Management System
  - System Design Concept
  - Overall Scheme of the System and the
  - Data Bases
  - Diagram of the Data processing
  - System Demonstration
    - Search function
    - Bridge Inventory and Inventory sheet
    - Photo Archive
    - Drawing Archive
    - Inspection sheet
    - Bridge Deficiency Rating List
    - Repair Priority Rating List
    - Repair Cost Estimate System

3) Provision of Manual & Technical explanations

System Manual has been edited by the Study team in order for the counterparts to utilize it on the practice of Bridge maintenance for future scene, which is to be fed into the CD program.

The Manual aims at being a practical and an educational work references for bridge engineers and system administrators and operators. The following states contents of the Manual. Details and coverage are thoroughly described in Chapter 15.

- Introduction
  - Objective
  - Concept
  - System Components
  - Tools for the System Development
  - System Operation Environment
  - System Operation
  - Data Registration Process
- Operation for the System
  - Display
  - System Operation Flow
  - Instruction for Operation
- Administration of the System Data
  - Structure of Data
  - Data Registration and Up-dating, Renewal
  - Data Administration

7.3.5 Overseas Study Tour: Fact-finding Study of Bridge Management System in Chile

A study similar to this one was implemented with Japanese aid from 1991 to 1993 in Chile. In order to take full advantage of the results of this previous study and to promote a common understanding for the direction and result of this Study, four study team members including the interpreter, five staff members including three bridge engineers in from MOPT and CONAVI from the Costa Rican side, and also the Executive Director a.i. of CONAVI with his own budget, had visited Chile to examine the present status of this study, its implementation framework, and how some issues have been dealt with etc.

(1) Participants and Study Schedule

The study schedule and the participants of the study were as shown in Table 7.3.9 and 7.3.10 and Table 7.3.11 shows the counterpart from Chile side.

Table 7.3.9. Schedule of Study in Chile

Date		Activities
10/16	Sun	Movement from Costa Rica to Chile
10/17	Mon	Meeting with Bridge Department, Ministry of Public Works, Transport and Telecommunications (MOPTT), Chile
		Explanation of the Contents of the JICA Study in Costa Rica and the purpose of the visit to Chile Outline of bridge maintenance and management in Costa Rica Outline of bridge maintenance and management in Chile Explanation of Bridge Management System in Chile Questions and answers, Change of opinions
10/18	Tue	Bridge Investigation (National Road Route 5, Northern side, Approx. 300km)
10/19	Wed	Bridge Investigation (National Road Route 5, Southern side, Approx. 210km)
10/20	Thu	Meeting with Bridge Department, MOPTT, Chile Concession of Road Project and Maintenance and Management of Bridge Bridge Investigation (Local Road in Mountain Area)
10/21	Fri	Visit to Bridge Management System in Head Office. Operative situation of BMS in Chile. Questions and Answers and Exchange of Opinions. Meeting with JICA Chile Representative Office Explanation of the Results about the Study in Chile
10/22	Sat	Movement from Chile to Costa Rica (Costa Rica members came back on 23rd.)

Table 7.3.10. Participants from Costa Rica for BMS Study in Chile

Participants	Position
Eng. Alejandro Molina Solís	Executive Director a.i , CONAVI
Eng. Maria Ramirez Gonzalez	Chief, Department of Bridge Design, MOPT
Eng. Mario Loría Galagarza	Engineer, Department of Bridge Design, MOPT
Eng. Gabriela Muñoz Peralta	Engineer, Department of Bridge Design, MOPT
Eng. Andrea Soto Rojas	Director, Planning and Control, CONAVI
MBA. Rafael Hernán Vásquez Astorga	Chief, Sector Planning, MOPT

Table 7.3.11. Counterpart from Chile for BMS Study

Participants	Position
Eng. Walter Wilson	Chief of Bridge Department, MOPTT
Eng. Manuel Carracedo	Accountant, Chief of Bridge Administration System
Eng. Karime Darwiche	Department of Bridges, MOPTT
Eng. Zeus Aguilera	Department of Bridges, MOPTT

(2) Present Conditions of Bridges in Chile

1) General Condition of Roads in Chile

Chile is located southwest in South America, between 18° and 56° latitude, it's territory land

is a thin strip with a variable of 80-150 km and it stretches 4,270 km. from north to south it's consist by twelve regions. The population is 15 million in a total area of 750,000 km^2. Region I, II and III at the north part of the country are located in a dessert area with rich mining resources as the main support of the national economy. Region IV and VII have temperate weather with moderate precipitations located at the central zones of the country. Industry and population are concentrated in this region and the metropolitan city of Santiago with six million habitants is in region V. Region VIII to X have much rain and the are the major source of agricultural products. Region XI and XII are glacial area with rich forest and lakes.

Legend

	Substructure	Superstructure	Deck Slab
CCC	Concrete	Concrete	Concrete
CSW	Concrete	Steel	Wood
CWW	Concrete	Wood	Wood
SSW	Steel	Steel	Wood
WWW	Wood	Wood	Wood

Figure 7.3.5. Condition of Road Network in Chile

2) General Condition of Bridges in Chile

It is estimated that the total number of bridge is around 10,000 in Chile and 8,000 bridges are recorded in the Bridge Management System, with the total length of bridges add up to 180,000 lineal meters. Data of the structures, which were constructed through the Contract of Concession of Public Works during the last decade, are barely registered in the system, because the exact data was not presented from the contractors.

The bridges are classified by type of material of its main components, for example: **CSW** implies that the Substructure is made of **C**oncrete, the Beams are made of **S**teel and the Floor is made of **W**ood, respectively, the percentages of distribution by type are the following:

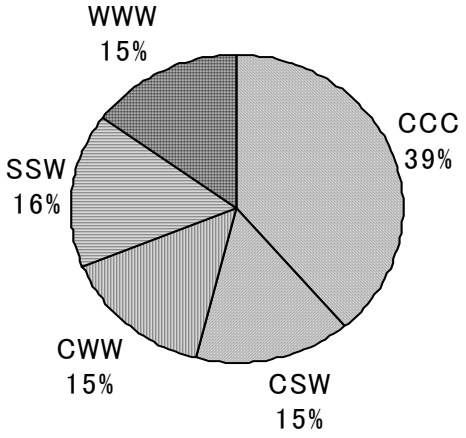


Figure 7.3.6. Bridge Classification by Material in Chile

3) Major Issues of Existing Bridges in Chile

Major issues of existing bridges in service in Chile are as follows;

- ✓ Deficiency of bearing capacity of the bridges
  Many bridges were constructed in different decades of the last century. Design live load of those bridges were HS 15 of AASHTO. Design live load HS 20-44 of AASHTO standard was introduced since 1970.

- ✓ Deficiency of anti- seismic design
  The anti-seismic design method was introduced to bridge design due to the high earthquake frequency with return periods of 20 years. The largest earthquake of the world with 9.2 degrees in the Richter Scale was recorded at Vadivia in 1960.

- ✓ Scoring of the foundation due to the rapid rivers
  Inclinations of most rivers are sharp, because the relief of land is 5,000 m above sea level and the length of the rivers is within 120 km with much rainfall plus water by thaw at springtime.

(3) Bridge Management System in Chile

"The Project of Rehabilitation and Conservation of Bridges in the Republic of Chile" was implemented by the Study Team from Japan International Cooperation Agency (JICA) with the cooperation of the Bridge Conservation Department of MOPTT in Chile from 1991 to 1993. The purpose of this project was to establish methodologies for maintenance management, bridge inspection method and modernization of bridge inventory of 250 bridges on Route No5.

- ✓ Inspection of all the bridges on Route No.5 (Pan-American Highway) between Serena City and Mont Harbour, approximate length of 1,500 km and specially selected 10 bridges. Detail site survey includes determination of the strength of concrete, quality of structural steel, detection of reinforcement steel, carbonation of concrete, deformation of structure which are implemented to evaluate 10 bridges as model projects.
- ✓ Prepare an Inspection Manual for Bridge Maintenance.
- ✓ Establish a Bridge Maintenance System with MS-DOS Ver. 5.0, MS-C Ver 7.0 and Date Base III PLUS Ver. 1.1. The system is not used now because of the development of Microsoft Windows operation system and more versatile languages as Visual Basic.

Under these circumstances, the Bridge conservation Sub department in charge of Eng. Manuel Carracedo Contador, with Chilean resources has developed its own managenent System in Basic Language denominated "De Pontibus" for the Department of Bridges and Structures. The system keeps the format of the Data Base elaborated by JICA study team in 1993 but improved through new system technologies such as slot in photograph, videos, as built drawings, reparation files and the information of the previous bridge when the bridge has been substituted.

The Bridge Management System "De Pontibus" saves bridge damage investigation data as

well as bridge information such as name of the structure, type, location (Route, kilometre, name of the river or gorge), Geometry (road, length, template, bridge's slope) technical description (number of stretches and their length, amount of beams, slab's thickness), average daily traffic, design live load, that intertwines all the existent information, such as videos, photographs, working drawings, repairs and others. Figure 7.3.7 shows a sample of outputs of bridge data.

Figure 7.3.7. Visual Output of BMS in Chile

(4) Lessons Learned from Chile Study

There are a lot of lessons learned from the Chile study, which could be effectively utilized for the improvement of the bridge maintenance and management in Costa Rica.

✓ Strong Political Commitment to Bridge Maintenance

Even in case of the Ministry of Public Works and Transport of Chile, the bridge maintenance totally depends on the individual capacity of a senior engineer, who was a counterpart official of the JICA development study. Stronger political commitment to the Bridge Management System will be absolutely necessary, and the top officials' understanding on the concepts of the total management of bridges such as "Asset Management" and "Life Cycle Cost" will be also required.

✓ Comprehensive Human Resources Development and Budget Allocation for Bridge Maintenance

Inspections for bridges in Chile are being implemented by the individual capacity of the senior engineer and his network on ad hoc basis, and more systematic and comprehensive human resources development such as training of inspectors as well as budgetary allocation for the bridge maintenance activities should be guaranteed.

✓ Sustainable Maintenance System of Bridge Management System

In Chile, the Bridge Management System has been modified from the original version to make the System more user-friendly and flexible in the longer term. However, it might be difficult to keep the System workable, if the senior engineer, who is individually capable of

maintaining the System, retired from his position. In this sense, it is critical to create a sustainable maintenance system Bridge Management System, which could be adapted to each country.

✓ **Maintenance for Concession-based Bridge**

Although the concession-based construction of roads and bridge have been nation-widely adopted in Chile, the bridge maintenance practices such as reporting of bridge inspections under those concessions are extremely unsatisfactory and might provoke serious problems in near future. Even in the case of the concession-based constructed bridges, the basic requirements for the maintenance of existing bridges remain the same as the conventionally constructed bridges.

✓ **Knowledge Management on Bridge Maintenance**

It is also required to share and exchange information and knowledge on the bridge maintenance, and promote a wide range of cooperation in the field of human resources development and training among the PPP countries as well as between Costa Rica and Chile. It has been offered by the Government of Chile that it is ready to extend the cooperation to Costa Rica in the field of the bridge maintenance as one of South-South cooperation activities.

✓ **Other Related Factors to Bridge Maintenance**

The proper maintenance of bridges will not be able to be performed solely by well-trained bridge engineers. For example, there are several cross-cutting issues which cannot be solved by the bridge-related department of the Ministry. Those issues include i) instability of the basis of bridges by lowering riverbeds, ii) possibility of collisions of vehicles to bridges due to lack of horizontal clearances, iii) impacts on bridges by repair works of rivers, iv) damages of bridges by overloaded vehicles. It is required to take a wide range of social and cross-border counter-measures.

✓ **Consideration of Costa Rica's Unique Natural Environment**

While almost of regions of Chile belong to arid and semi-arid zones, those of Costa Rica have much rainfall. Bridge maintenance activities are frequently affected by the natural environment condition of the region, and the unique natural environment of Costa Rica should be taken into account when the proper bridge maintenance is studied.

✓ **Total Management through BMS**

Both Costa Rica and Chile officials tend to misunderstand that the function of the BMS is merely output of data from computers. It is essential to understand that the BMS is a tool for the total management of the bridge maintenance data processed by computers.

7.3.6 Overseas Study Tour: JICA Counterpart Training Program in Japan

1) Background

It remarks that JICA Counterpart training program has been taken place as a part of the study,

which renders a practicable learning of the Japan's bridge maintenance. It is aimed to obtain supplementary effects and amplify effectiveness on both the technical training and dissemination of technical transference.

Two bridge engineers from the bridge department in the Ministry of Public Works and Transport (MOPT) were nominated to participate in the training program. JICA designed the technical contents of the course program "Bridge Rehabilitation Planning, Maintenance and Management", jointly to the Study team and scheduled it from past January 16th to February 3rd, 2006.

2) Training Program

The course program was to comprise the wide variety from a concept comprehension on the asset management, particularly the bridge maintenance, up to a specific case study of the bridge rehabilitation/ reinforcement work as well as learning of the practical use of inspection instruments undergoing site-visits. The programs were implemented throughout the training period in manner of both delivering lecture and "hands-on" practice basis. The engineers have duly been certified and finished up entire program with undergoing cumulative experiences.

The programs and their components undertaken are briefly introduced in the table below. And the lecturers are:

- Ministry of Land, Infrastructure and Transport.
- National Institute for Land and Infrastructure Management: NILIM.
- Public Works Research Institute: PWRI.
- Kanto Regional Development Bureau.
- Tokyo Metropolitan Gov. Construction Bureau Road Management Division, Maintenance Section.
- Metropolitan Expressway Company Limited.
- Hanshin Expressway Company Limited.
- Honshu-Shikoku Bridge Expressway Company Limited
- Oriental Consultants Co., Ltd.

Table 7.3.12. JICA Counterpart Training Program

Training Program	Program Components	Method
To learn: ***Japan's national-wide organizational structure for the bridge maintenance***	i) **Concept comprehension**: Asset management & Bridge maintenance ii) **Introduction of Relevant authorities** and its jurisdiction and roles for the maintenance of the National road, Regional road and Highway iii) **Organizational structure for the maintenance** of the National road, Regional road and Highway	- Seminar basis
To learn: ***Detailed activities and Practices for the bridge maintenance***	i) Introduction of **periodical / emergency inspection** ii) Introduction of t**he practical manuals, guidelines for inspection** etc. with illustrated bridge deteriorations iii) Introduction of **the Bridge Management System.**	- Seminar basis
To learn : ***Specific technologies for the bridge rehabilitation, reinforcement and maintenance***	i) Introduction of **basic and advanced technology for bridge inspection, diagnosis** ii) **Site visit:** iii) Observation & Hands-on: **bridge inspection practice** iv) Introduction of **seismic reinforcement** with illustrated bridge rehabilitations	- OJT Hands on basis - Seminar basis

7.3.7 Puebla-Panama Plan International Seminar

(1) Puebla-Panama Plan

Puebla - Panama Plan (PPP) is a series of industrial development mega-projects proposed through Mexico and Central America to provide the infrastructure groundwork required for the Central American Free Trade Agreement (CAFTA) and ultimately part of the bigger Free Trade of the Americas Agreement (FTAA) that would unite North, Central, and South America. The Plan-Puebla Panama has been launched since 2001, paving the way to integrate transportation and electrical infrastructure between Mexico, Belize, Guatemala, Honduras, El Salvador, Nicaragua and Panama and 8 initiatives that cover 8 different sectors are formed to embody and undertake the Plan. Costa Rica is a secretariat country on the Road Integration Initiative with chairing the Technical Committee of the Sector concerned.

The participating countries have adopted to the proposed road network, which named as INTERNATIONAL MESOAMERICAN ROAD NETWORK (RICAM), as part of the PPP Road Integration Initiative. The Implementation of the RICAM will be under the plan for the construction and development of roads of international importance, which will be undertaken within the framework of each country's programs

(2) Internatinal Seminar

1) Background

MOPT/CONAVI-JICA are aware of the importance of the Puebla-Panama Plan (PPP) for the development of strategies that allow the transformation and updating of the eight countries included in the Plan, throughout this initiatives that will contribute to the integration and sustainable development of the Mesoamerican Region, it has been considered appropriate to organize the International Seminary, which has as the main objective to disclose and search for a mechanism to calculate the results of the Study that contribute to the development of the capacities in the planning, rehabilitation, maintenance and management of bridges to the PPP countries that are considering it.

2) Outline of the Seminar Programs

Participants

8 countries of PPP are to participate in the Seminar. Each country despatches two personnel who are in charge of the Road Infrastructure Services inclusively the Maintenance and the Planning. An expertise on the bridge engineering not limited to the Bridge maintenance is requested for one as a technical personnel and an expertise on the Planning is for another as an administrative personnel.

In addition, representatives of the relevant organizations among an Academic sector, a Private and a Public sector, which are members of "the Bridge Maintenance Core Group (BMCG)" of the CD program, are to be jointly invited. Cooperation agencies and Donors in relation with the PPP and/or infrastructure improvement programs are expected their presence as well

Table 7.3.13. Participants in PPP seminar

Country	Participants	Position
Beliz: Ministry Public works	Ing. Graciano Medina	Chief Regional Engineer
	Ing. Esmond Segura	Executive Engineer
Colombia	Representative of Technical committee to be assigned	
El Salvador: Ministry of Public works	Ing. Carlos Ruiz	PPP representative
	Ing. Jose Angel Melendez	Chief of Design, Planning Unit
Guatemala: Ministry of Communications, Infrastructure and Housing	Ing. Miguel Alberto Lopez Estrada	Tech.Adviser Concession Unit
	Ing. Luis Humberto Leiva Prea	Special Adviser for Bridges
Honduras: Secretary of Public works, Transports and Housing	Ing. Jose Angel Diaz Rubio	Chief of Technical Support, Road Direction
	Ing. Oscar Amando Arriaga Rivera	Chief of Bridge Module
Mexico: Secretary of Communication and Transports	Ing. Hector Daniel Devesa Varas	Director Project Procurement
	Ing. Eduardo Verasco Santana	Sub-director of Structures
Nicaragua: Ministry of Transports	Ing. Jose Ernest Tellez Castellon	Director of Planning
	Ing. Manuel Antonio Guido Ayerdis	Chief of Bridge Office
Panama: Ministry Public works	Ing. Asdrubal Terreros	Chief of Bridge Department
	Ing. Lionel Moreno	Structure Engineer

Costa Rica	
MOPT:	Ministry of Public Works and Transport
CONAVI:	National Roads Council
CNC	National Concessions Council
MIDEPLAN	Ministry of National Planning
MH	Ministry of Finance
CIC	Organization of Civil Engineers
UCR	University of Costa Rica
LANAMME	National Laboratory of materials and Structure Models
International Entities	
IDB	Inter-American Development Bank
CABEI	Central American Bank for Economic Integration
CAF	Cooperacion Andina de Fomento

Seminar Programs

The Seminar is focused on two main themes which consist of the CD program the counterpart shall undertake in future scene, and technical aspects on the Bridge Maintenance. A session in the presentation basis is largely taken and a work shop is to be combined with the session. All sessions are initiatively conducted by the Counterpart's Engineers and Personnel so that the Study team performs a role of the technical advisors. The Seminar is scheduled on December 11th, 2006 in San Jose, Costa Rica. The following indicates an overall seminar program and details of sessions on technical issues to disseminate.

Table 7.3.14. PPP International Seminar Program

Time Table	Contents
8:00-8:30	Opening Remarks: MOPT
	Opening Remarks: Embassy of Japan / JICA
8:30-9:45	**Presentation : Capacity Development Program** Summary of the Improvement Plan for the Bridge Maintenace
	Question & Answer
9:45-10:00	Break
10:00-12:00	**Presentation : Technical Issue 1:**
	Question & Answer
12:00-13:30	Lunch break
13:30-16:15	**Presentation : Technical Issue 2:**
	Break
	Question & Answer, Exchange Views and Opinions
16:15-17:30	**Work shop : Capacity Development Program** Methodology of the Program Management for the improvement of Bridge Maintenance
	Question & Answer, Exchange Views and Opinions
17:30-17:45	Closing Address of Session: CONAVI

◆**Presentation** Technical Issue 1**:**

Theme: Bridge Management Experienced in the Study

- Introduction of the Session
- Overview of the Bridge Management System
- Experiences and Results of the Bridge Loading Test
- Introduction of Bridge Rehabilitation / Reinforcement Methods
- Report of Japan's Bridge Management based on the JICA Training Program

◆**Presentation** Technical Issue 2:

Theme: Case Study of the Repair Work on the "Rio Puerto Nuevo" Bridge

- Introduction of the Session
- Inventory Inspection and Assessment of the existing status
- Evaluation of Bridge Deteriorations, deficiency
- Detailed Inspection and Identification of Cause of Deteriorations
- Selection of Repair Method
- Design for Repair Work and Cost Estimate

CHAPTER 8 EXISTING CONDITIONS AND SITE INSPECTION OF THE STUDY BRIDGES

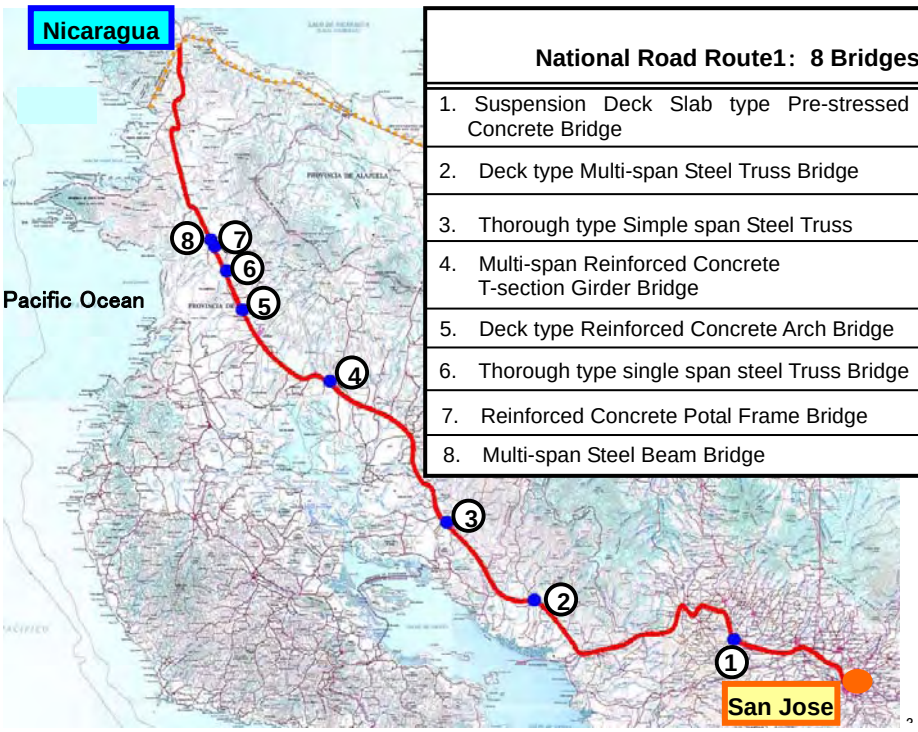
8.1 Existing Condition of Bridges

8.1.1 Condition of Study Route

29 Study bridges are located in Route 1, 2, 4, 32 and 218 as shown in Figure 8.1.1, 8.1.2, 8.1.3, 8.1.4 and Table 8.1.1. Although there are many bridges in the above routes, as shown Table 8.1.2, 29 Bridges have been selected by MOPT for this study.

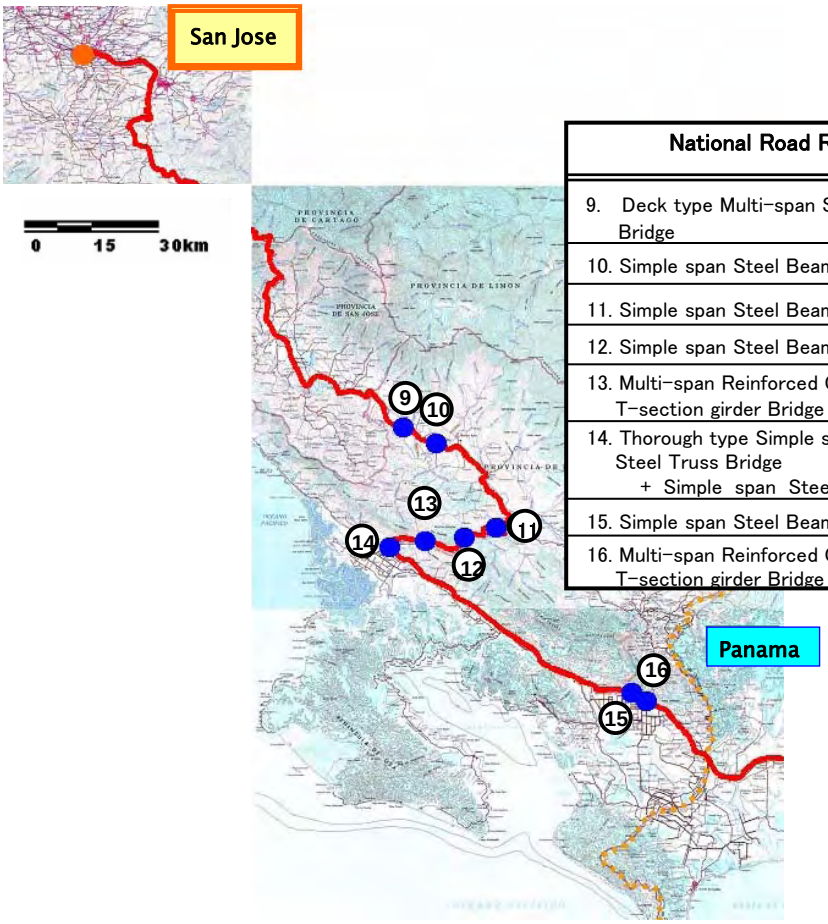
Table 8.1.1. Outline of Study Route

Route No.	Outline of Route
1	– This road is the Pan-American Highway and it was constructed in 1950's – A gently sloping hill continues to San Ramon from the San Jose downtown through the San Jose international airport. (Partway is six-lane road.) – The steep slope of two lanes and the road of a sharp curve continue to Barranca, which faces the Pacific Ocean from San Ramon. – A flat way continues from Barranca to the Nicaragua border. – It is a four lanes road and it is located in the north side of San Jose.
2	– The trunk road of four lanes continues from San Jose to Cartago. – Two-lane road in the mountain which consisted of a steep slope and a sharp curve that continues from Cartago to San Isidro. – A bridge hardly exists from San Jose up to San Isidro. Because the road is built along the mountain ridge exceeding the altitude of 2000 m. – The road passing through a comparatively flat hill from San Isidro to Buenos Aires. A lot of sugarcane and a pineapple fields are in this section. – From Buenos Aires to the Panama border the road is located on the flat ground.
4	– The bridge set as the object of investigation is among 30 km from Santa Clara located at the junction of Route 32 and Route 4. – This road is built on comparatively flat ground. – Agricultural products as sugarcane and pineapple in the Puerto Viejo area have been transported to San Jose through the route 4.
32	– This road is connected with Limon, the only port town in the Caribbean Sea side from San Jose. Moreover, this road is planned as a Pueblo Panama road in the Caribbean Sea side. – This road passes through the national park, which is in between Carrillo and the San Jose suburbs. This section of the road is in the mountain, it's in a steep slope with sharp curves that continue. – The road, which continues from Carrillo to Limon, is located on the flat ground.
218 & San Jose	– It was located in the suburbs of the capital San Jose, and the candidate bridge was built when turning a national highway Route 218 into four lanes. – Although there is heavy traffic in this route, the bridge pier of the candidate bridge is extremely thin, and its scouring is also intense. Therefore, the possibility of serious damage to it from now on is very high. – Traffic congestion is remarkable in the trunk road to which the central part is connected from a residential area.



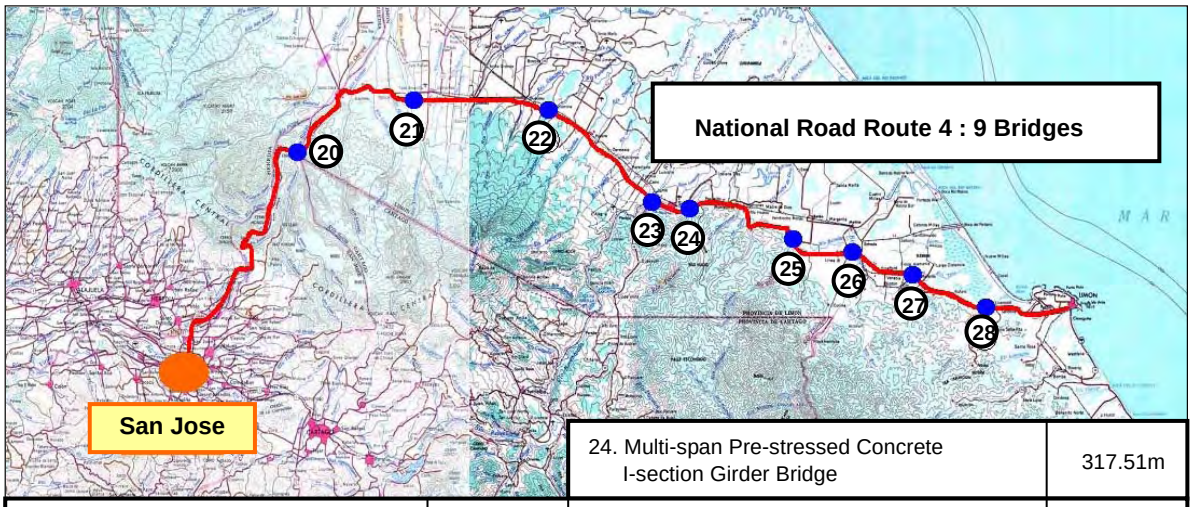
National Road Route1: 8 Bridges	
1. Suspension Deck Slab type Pre-stressed Concrete Bridge	204.00m
2. Deck type Multi-span Steel Truss Bridge	87.78m
3. Thorough type Simple span Steel Truss	100.00m
4. Multi-span Reinforced Concrete T-section Girder Bridge	55.47m
5. Deck type Reinforced Concrete Arch Bridge	52.00m
6. Thorough type single span steel Truss Bridge	91.50m
7. Reinforced Concrete Potal Frame Bridge	31.40m
8. Multi-span Steel Beam Bridge	71.22m

Figure 8.1.1. Location of Study Bridge (Route 1)



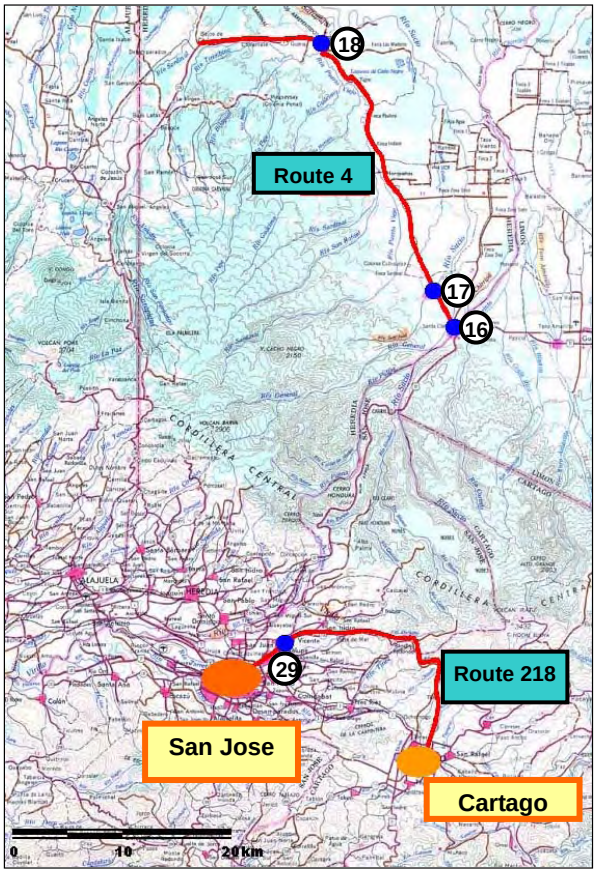
National Road Route 2 : 8 Bridges	
9. Deck type Multi-span Steel Truss Bridge	77.00m
10. Simple span Steel Beam Bridge	132.35m
11. Simple span Steel Beam Bridge	104.60m
12. Simple span Steel Beam Bridge	104.89m
13. Multi-span Reinforced Concrete T-section girder Bridge	55.47m
14. Thorough type Simple span Steel Truss Bridge + Simple span Steel Beam	341.00m
15. Simple span Steel Beam Bridge	71.32m
16. Multi-span Reinforced Concrete T-section girder Bridge	55.47m

Figure 8.1.2. Location of Study Bridge (Route 2)



20. Multi-span Pre-stressed Concrete Box Girder Bridge	187.25m	24. Multi-span Pre-stressed Concrete I-section Girder Bridge	317.51m
21. Multi-span Pre-stressed Concrete Box Girder Bridge	258.60m	25. Multi-span Pre-stressed Concrete I-section Girder Bridge	100.00m
22. Simple span Pre-stressed Concrete I-section Girder Bridge	106.00m	26. Multi-span Steel Beam Bridge	415.04m
23. Multi-span Pre-stressed Concrete Box Girder Bridge	341.40m	27. Simple span Pre-stressed Concrete I-section Girder Bridge	68.60m
		28. Simple span Pre-stressed Concrete I-section Girder Bridge	58.90m

Figure 8.1.3. Location of Study Bridge (Route 32)



National Road Route 4 : 3 Bridges	
17. Multi-span Pre-stressed Concrete Box Girder Bridge	175.80m
18. Simple span Pre-stressed Concrete I-section girder	40.50m
19. Multi-span Steel Beam Bridge	100.96m

National Road Route 218 : 1 Bridge	
29. Simple span Pre-stressed Concrete I-section girder	65.85m

Figure 8.1.4. Location of Study Bridge (Route 4,218)

8.1.2 Condition of Study Bridge

The 17 bridges of the 29 Study Bridges are the concrete girder type bridges and the 12 bridges are steel girder type bridges. Table 8.1.2 shows the bridge types of the 29 study bridges. However, since some of the 29 bridges are combined different type bridges, the total number of bridges for the bridge type becomes 38. There are 13 kinds of bridge type for the 29 Study Bridges as shown in Table 8.1.2..

The inventory for each Study Bridge is shown in Table 8.1.3..

Table 8.1.2. Bridge Type of Study Bridges

Type		Number
Concrete Bridge	1. Continuous Reinforced Concrete Deck Girder Bridge	3
	2. Single Span Reinforced Concrete Deck Girder Bridge	2
	3. Continuous PC Box Girder Bridge	4
	4. Single Span PC I Beam Bridge	5
	5. Connected PC I Beam Bridge	5
	6. Reinforced Concrete Arch Bridge	2
	7. Reinforced Concrete Rigid Frame Bridge	1
	8. Suspended Deck Slab Type Bridge	1
Steel Bridge	9. Single Span Steel Truss Bridge	4
	10. Continuous Steel Truss Bridge	1
	11. Simple Span I Beam Bridge	5
	12. Continuous I Beam Bridge	4
	13. Gerber Beam Bridge	1

Table 8.1.3. Inventory of 29 Study Bridges

N°	Bridge	Route	Km	Total Length (m)	Road Width (m)	# Span	Superestructure	Slab t (cm)	Slab Material	Design Date	End of Constructio
1	Colorado River	1	36.6	203.50	8.50	9	1 Span Supention Slab Bridge + 4 Spans CIP Concrete (15+25+108+25+15m)	15 (Centerl) 20 (for 15 & 25 m)	Concrete	July 1968	1970
2	Aranjuez River	1	112.3	87.78	7.30	3	3 Spans Continuous Steel Truss (24.38 + 39.01+ 24.38m)	18	Concrete	September 1944	1955
3	Abangares River	1	143.3	100.00	8.54	2	2 Spans Simple Steel Truss (40 + 60 m)	16.5	Concrete	February 1952	1953
4	Piedras River	1	189.8	55.47	7.31	3	3 Spans Continuous CIP Concrete Beam (17.07+31.33=17.07) (Variable Section)	18	Concrete	September 1952	1959
5	Colorado River	1	222.0	52.00	7.31	5	2 Spans Continuous CIP Concrete Beam + Simple Concrete Arch + 2 Spans Continuous CIP Concrete Beam (4.72 + 6.02+ 30.48+ 6.02 + 4.72m)	25	Concrete	Augoust 1955	1959
6	Ahogados River	1	232.5	91.50	7.31	3	Simple Steel Truss + 2 Spans Continuous Steel Girder (61m + 2x15.25m)	16.5 (Center)	Concrete	October 1951	1954
7	Azufrado River	1	239.8	31.40	7.31	3	3 Spans Continuous Rigid Frame RC Girder (5.79 + 19.81 +5.79m) (Variable Section)	16.5	Concrete	September 1953	1955
8	Tempisquito River	1	240.2	71.22	7.30	3	3 Spans Simple Steel I Girder (22.11 +27.0 + 22.11m)	18	Concrete	May 1905	N/D
9	Volcán River	2	181.8	77.00	7.31	3	Simple CIP RC Beam + Simple Steel Truss + Simple CIP RC Beam (18.29 + 45.72 + 12.19m)	18	Concrete	December 1957	1961
10	Ceibo River	2	189.6	132.35	7.31	5	5 Spans Simple Steel I Girder (24.54 + 3 x 30.80 +15.40 m)	18	Concrete	January 1958	1961
11	Curré River	2	229.4	104.60	7.31	4	4 Spans Simple Steel I Girder (21.50+ 30.80 + 30.80 + 21.50m)	17.75	Concrete	January 1958	1961
12	Puerto Nuevo River	2	234.4	104.89	7.31	5	5 Spans Simple Steel I Girder (21.41+ 2 x 21.65 + 24.73 + 15.43m)	17.75	Concrete	January 1958	1961
13	Zapote River	2	248.4	55.47	7.31	3	3 Spans Continuous CIP Concrete Beams (17.06 + 21.33 + 17.06m) Variable Section			-	1961
14	Terraba River	2	256.1	341.00	7.31	7	4 Spans Simple Steel I Girder + 3 Spans Simple Steel Truss (4 x 27.43 + 3 x 76.20 m)	20	Concrete	May 1956	1960
15	Caracol River	2	323.3	71.32	7.31	3	3 Spans Contimuous Steel I Girder (21.95 + 27.43 + 21.95m)	18	Concrete	December 1957	1961
16	Nuevo River	2	327.2	55.47	7.31	3	3 Spans Continuous CIP Concrete Beams (17.06 + 21.33 + 17.06m) Variable Section	18	Concrete	December 1957	1961
17	Chirripó River	4	0.5	175.80	10.90	3	3 Spans Continuous Prestressed Concrete Box Girder (45.50 + 82.50 + 45.5 m) Variable hight		Concrete	January 1974	1978
18	San José River	4	4.1	40.50	10.00	2	2 Spans Connected Prestressed Concrete I Beam (2 x 20.0 m)		Concrete	May 1905	1978
19	Sarapiquí River	4	30.8	97.90	7.30	3	3 Spans Gerber Type Steel I Girder (22.30 + 55.0 +22.30 m) Gerber span 37 m		Concrete	May 1905	1978
20	Sucio River	32	39.8	172.65	9.75	3	3 Spans Continuous Prestressed Concrete Box Girder (55.20 + 102.0 + 30.0 m) Variable hight	18	Concrete	N/D	N/D
21	Toro Amarillo River	32	59.7	260.00	10.10	4	4 Spans Continuous Prestressed Concrete Box Girder (46.5 + 2 x 82.8 +46.5 m) Variable hight		Concrete	N/D	N/D
22	Parismina River	32	78.7	106.00	10.10	3	3 Spans Simple Prestressed Concrete I Beam (3 x 35 m)	16	Concrete	November 1974	N/D
23	Reventazón River	32	95.1	341.40	10.10	5	5 Spans Continuous Prestressed Concrete Box Girder, (46.50 + 3 x 82.8 + 46.50 m) Variable hignt	20	Concrete	March 1975	N/D
24	Pacuare River	32	100.4	317.51	8.50	10	10 Spans Simple Prestressed Concrete I Beam (9 x 32.67 + 17.0 m)	19	Concrete	March 1969	N/D
25	Barbilla River	32	116.4	100.00	8.50	3	3 Spans Connnected Prestressed Concrete I Beam (32.89 + 32.70 +32.89m)	19	Concrete	September 1968	N/D
26	Chirripó River	32	126.2	431.86	8.50	8	Simple Steel I Girder + 6 Spans Continuous Steel I Girder + Simple Steel I Girder (15.88 + 59.39 + 67.0 + 2 x 73.2 + 67.0 + 59.39 + 15.88m) Variable hight	17	Concrete	July 1969	1974 - 1978
27	Cuba River	32	134.9	68.60	8.50	3	3 Spans Simple Prestressed Concrete I Beam (3 x 22.0m) Skewed Bridge	16	Concrete	July 1968	N/D
28	Blanco River	32	148.2	58.90	8.50	3	3 Spans Simple Prestressed Concrete I Beam (17 .0 + 22.0 + 17.0 m) Skewed Bridge	16	Concrete	September 1967	N/D
29	Torres River	218	1.2	66.46	7.00	3	3 Spans Simple Prestressed Concrete I Beam (30 .0 + 2 x 17.0 m) Corved Bridge	18	Concrete	November 1980	N/D

8.2 Method of Inspection

1) Study of the Documents before Site Inspection

Prior to the site inspection the related documents, e.g. Bridge Inventory in MOPT, Drawings, the history of repair, traffic volume, topography map, river information, were collected and reviewed to understand the condition of each bridge.

This study was important to make the plan for the inspection of 29 Study Bridges. The main points of the study of the documents before site inspection is shown below.

- Topographic and surrounding condition
- Design Specification (Live Load, Material)
- Structure type and Dimension
- River condition

2) Making a Plan for Site Inspection

a) Making the inspection sheet

Since items for inspection, parts of structure to inspect and evaluation of damage will not differ from each inspector, the inspection sheet that is shown in Table 8.2.1 was made by the study team and MOPT. Items and parts in this inspection sheet should correspond to the items and parts that are used to evaluate the damage of the bridge.

The characteristic of the bridge in Costa Rica should be taken into account in inspection sheet, so the study team and MOPT have discussed regarding items of inspection sheet and finalized.

b) Inspection sheet to measure the dimension

In case that enough bridge dimensions were not collected, the dimensions of the bridge should be measured by the inspector to the remake drawings, which will be kept in the database of BMS. In measuring the bridge inspector has to use the same inspection sheet which is shown in Figure 8.2.1 to avoid collecting different information.

In the case of the 29 Study Bridges, the main drawings have been kept in the MOPT. However if measuring parts of bridge will be required to make a plan for repair any dimension can be measured in the detail inspection.

c) Instruction of taking photography

Since photos of the bridge parts are useful information for evaluation or to make a plan of repair, these photos should be kept in the data saver in BMS. Moreover the angle or the part to take photos should be instructed to avoid a difference between each bridge data of BMS. The point of photography is described below and Figure 8.2.2 which shows the example of

photography.

- General view to understand the structure of the bridge
- Condition of the surface of the bridge
- Take a photo for every important member e.g. Girder, Slab, Deck Frame, Abutment, Pier etc.
- Damage part and condition

d) Make a Videotape record(VTR) of a Bridge

Since the VTR is a more effective measure to understand the general condition of or damage of the bridge than a photo the VTR of the bridge should be made and kept in the data server of BMS. The angle or the part of the VTR should be the same as the case of photography to be consisted with the photos of the bridge.

3) Execute Site Inspection of 29 Study Bridges

Site inspection of Study Bridges should be executed in every type of superstructure in a bridge. It is a visual inspection using the above inspection sheet.

The inspection result will be stored in the database of BMS.

4) Collect Inspection Result

In order to evaluate of damage and rank as the condition of damage in each bridge the result of the study document and the site inspection was arranged as follow:

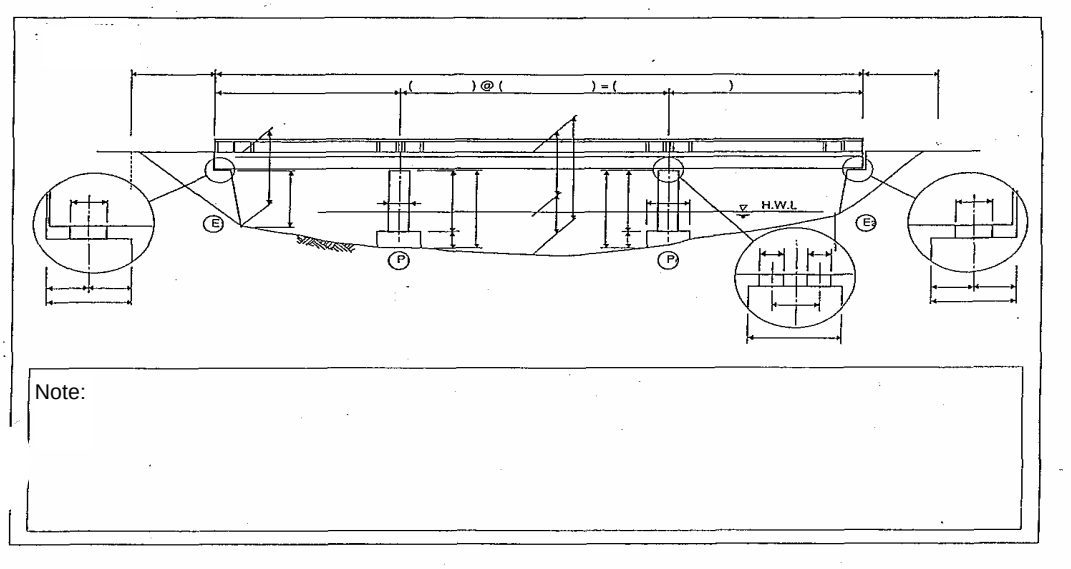
a) Making an inventory of 29 Study Bridges
b) Current condition of each bridge regarding structure, damage and maintenance
c) Making an examination of the cause of damage
d) An evaluation table for condition of damage

Table 8.2.1. Bridge Inspection Sheet

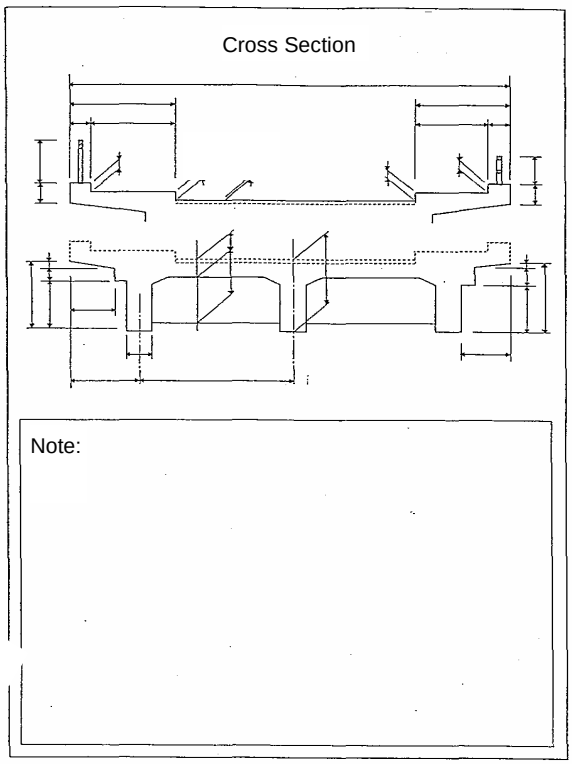
BRIDGE INSPECTION SHEET

BRIDGE NAME			BRIDGE CODE	ROUTE NUMBER	Km	DATE of INSPECTION	
Name of Inspector:						Page No. 1 of 1	
	TYPE OF DAMAGE & EVALUATION OF DAMAGE DEGREE						
1. PAVEMENT	ITEM	1. WAVING	2. RUTTING	3. CRACK	4. HOLES		
	EVALUATION						
2. BARRIER (STEEL)	ITEM	1. DEFORMATION	2. RUSTING	3. CORROSION	4. MISSING		
	EVALUATION						
3. BARRIER (CONCREATE)	ITEM	1. CRACK	2. EXPOSURE OF REINFORCEMENT	3. MISSING			
	EVALUATION						
4. EXPANSION JOINT	ITEM	1. ABNORMAL NOISE	2. WATER LEAKING	3. MISSING OR DEFORMATION	4. VERTICAL MOVEMENT	5. OBSTRUCTION JOINTS	6. EXPOSURE OF RC BAR
	EVALUATION						
5. DECK SLAB	ITEM	1. ONE DIRECTIONAL CRACK	2. TWO DIRECTIONAL CRACK	3. CONCRETE FISSILITY	4. EXPOSURE OF REINFORCEMENT	5. HONEYCOMB , CAVITY	6. FREE LIME
	EVALUATION						
	ITEM	7. ASPHALT OVERLAY	8. HOLES				
	EVALUATION						
6. STEEL DECK FRAME	ITEM	1. RUSTING	2. CORROSION	3. DEFORMATION	4. BREAKAGE OF CONNECTION	5. BREAKAGE OF ELEMENT	
	EVALUATION						
7. STEEL MAIN GIRDER	ITEM	1. RUSTING	2. CORROSION	3. DEFORMATION	4. DEFICIT OF BOLTS	5. CRACK OF WELDING OR PLATE	
	EVALUATION						
8. CONCRETE CROSS BEAM	ITEM	1. ONE DIRECTIONAL CRACK	2. TWO DIRECTIONAL CRACK	3. CONCRETE FISSILITY	4. EXPOSURE OF REINFORCEMENT	5. HONEYCOMB, CAVITY	6. FREE LIME
	EVALUATION						
9. CONCRETE MAIN GIRDER	ITEM	1. ONE DIRECTIONAL CRACK	2. TWO DIRECTIONAL CRACK	3. CONCRETE FISSILITY	4. EXPOSURE OF REINFORCEMENT	5. HONEYCOMB, CAVITY	6. FREE LIME
	EVALUATION						
10. BEARING	ITEM	1. BREAKAGE OF SUPPORT	2. ABNORMAL DEFORMATION	3. CLEANING REQUIRE			
	EVALUATION						
11. PAREPET AND WINGWALL (ABUTMENT)	ITEM	1. ONE DIRECTIONAL CRACK	2. TWO DIRECTIONAL CRACK	3. CONCRETE FISSILITY	4. EXPOSURE OF REINFORCEMENT	5. HONEYCOMB, CAVITY	6. FREE LIME
	EVALUATION						
12. BODY (ABUTMENT)	ITEM	1. ONE DIRECTIONAL CRACK	2. TWO DIRECTIONAL CRACK	3. CONCRETE FISSILITY	4. EXPOSURE OF REINFORCEMENT	5. HONEYCOMB, CAVITY	6. FREE LIME
	EVALUATION						
	ITEM	7. EMBANKMENT SLOPE	8. INCLINATION	9. SCOURING			
	EVALUATION						
13. BEAM (PIER)	ITEM	1. ONE DIRECTIONAL CRACK	2. TWO DIRECTIONAL CRACK	3. CONCRETE FISSILITY	4. EXPOSURE OF REINFORCEMENT	5. HONEYCOMB, CAVITY	6. FREE LIME
	EVALUATION						
14. BODY (PIER)	ITEM	1. ONE DIRECTIONAL CRACK	2. TWO DIRECTIONAL CRACK	3. CONCRETE FISSILITY	4. EXPOSURE OF REINFORCEMENT	5. HONEYCOMB, CAVITY	6. FREE LIME
	EVALUATION						
	ITEM	7. INCLINATION	8. SCOURING				
	EVALUATION						
15. PAINTING	ITEM	1. DISCOLORATION	2. RUSTING	3. RISING	4. PEELING		
	EVALUATION						

EVALUATION	DEGREE OF DAMAGE	SCOURING
1	No damage can be seen	No scouring
2	A few parts	Tendency of scouring
3	Many parts	Not dangerous scouring
4	Less than half of whole part	Dangerous scouring
5	Almost whole part	Emergency condition



Side View



Cross Section

Figure 8.2.1. Example of Measurement Sheet for Dimensions of Bridge

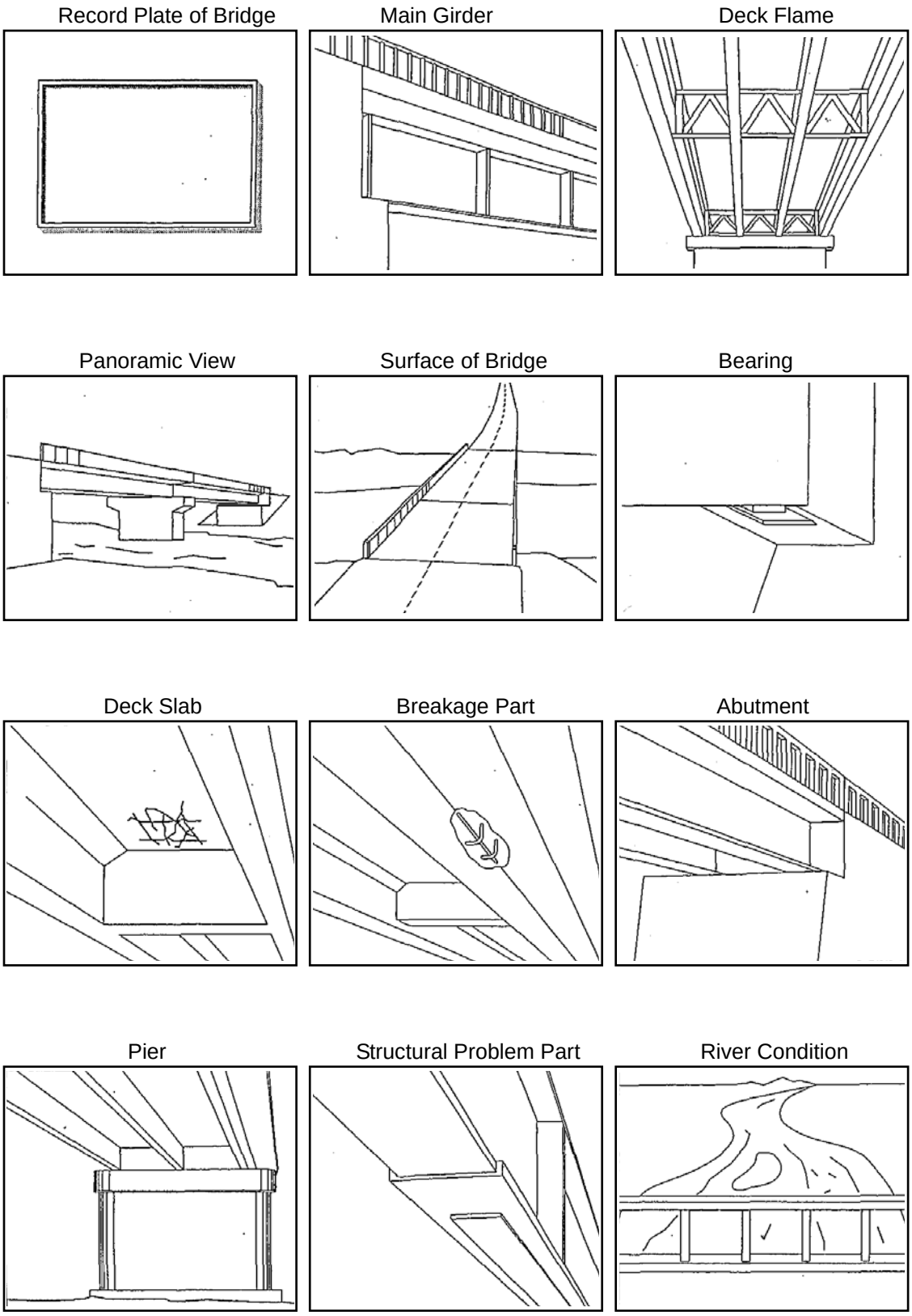


Figure 8.2.2. Standard of Viewpoint

8.3 Results of Inspections

8.3.1 Bridge Damage

A field survey to examine the current condition of the 29 Study bridges in order to rank the level of damage condition of each bridge were carried out by the Study Team and the counterparts from MOPT and CONAVI. And then the results of the survey were finalized in regards to the following items:

1) Establishment of a bridge inventory.
2) Evaluation of a bridge's current condition from both structural and maintenance.
3) Examination and evaluation of the cause of damage.
4) Evaluation ranks of the level of damage.

During site inspection the study team instructed the counterparts in Bridge Inspection Technique as shown below

- Purpose of inspection
- The points of evaluation of damage
- To record data in an inspection sheet

29 Study Bridges were constructed during the period from 1955 to 1980 and 23 bridges of them are over 50 years old. Therefore the damage which was guessed to be caused by superannuation, lack of maintenance, increase traffic volume, heavier live load and natural disaster (earthquake or flood) was observed in almost bridges. Site inspection results are shown in Table 8.3.1.

From the inspection result the tendency of the damage in 29 bridges are shown in Table 8.3.2. Table 8.3.3 describes the tendency of the damage with route and Table 8.3.4 the one with type of bridge.

Table 8.3.1. Inspection Result of 29 Bridges

No.	Bridge	Type of Damage																											
		Pavement		Barrier	Expansion	Deck					Steel				Concrete					Bearing	Parapet (Abutment)		Body (Abutment)		Cantilever (Pier)		Body (Pier)		Painting
											Deck		Main Girder		Cross Beam		Main Girder												
		a.	b.	c.	d.	b.	e.	f.	l.	m.	g.	k.	a.	k.	e.	f.	d.	e.	f.	g.	e.	f.	h.	i.	e.	f.	h.	i.	j.
1	Colorado River	△	△				△	△																					
2	Aranjuez River	X	X					△	△	△																		△	△
3	Abangares River	△	△			△	△	X	X	X	△																		△
4	Piedras River	△						△											△					△					
5	Colorado River	△	△					△																					
6- 1	Ahogados River	△	△					△	△			△		△															△
6- 2	Ahogados River	△	△					△	△	△		△		△															△
7	Azufrado River	△	△	△				△	△							△			△										
8	Tempisquito River	△	△					△	△															△					△
9- 1	Volcán River	△					△																	△					
9- 2	Volcán River	△			△						△																		△
10	Ceibo River							△	△																				△
11	Curré River																							△					
12- 2	Puerto Nuevo River	△																						△					
12- 1	Puerto Nuevo River	△																						X					
13	Zapote River																							△					
14- 2	Terraba River	△					△					△		△															△
14- 1	Terraba River	△																											
15	Caracol River		△											△										△				X	△
16	Nuevo River																							X				X	
17	Chirripó River		△		X												X							X					
18	San José River																							X					
19	Sarapiquí River			△				△	△			△		△										△				△	△
20	Sucio River		△		△												X	△						△					
21	Toro Amarillo River			△	△				△							△	X		△					△					
22	Parismina River																			△				△					
23	Reventazón River	△	△	△	△												X							△					
24	Pacuare River	△		△																				△				△	
25	Barbilla River	△		△																									
26- 1	Chirripó River	△					△	△	△	△										X									
26- 2	Chirripó River	△					△	△	△	△				△						△									△
27	Cuba River	△			X															X			X						
28	Blanco River	△			X				△											X			X	△				△	
29	Torres River	△		△																								△	

△: Damage Rank 2 or 3
X : Damage Rank 4 or 5

a. Crack
b. Holes
c. Missing
d. Deformation
e. Exposure of Reinforcement.
f. Free Lime
g. Breakage
h. Inclination
i. Scouring
j. Rusting
k. Corrosion
l. One Direction Crack
m. Two Direction Crack

Table 8.3.2. Evaluation of Inspection Result of Each Inspection Item

Part	Condition of damage	Bridge No.
Pavement	−Damage on pavement was mostly observed in almost all the bridges	
	−As Overlay of pavement was executed without cutting, pavement load of many bridges is increasing −As the pavement hangs over expansion, a hole opens and it has been an obstacle for passing vehicles.	3,4,5,6,7,8 13,15,16 17,19 20,21,26
Railing	−A part of a handrail of the bridge has been lost by human acts, such as a collision of vehicles, and a theft. Especially it is concentrating on Route32	19,23,24,25,26
Expansion Joint	−Water Leaking was observed in all bridges except Bridge No7 by lost of Water stop of Expansion in the bridge of short span, and by the damage of Expansion in the bridge of long span.	Almost all Bridges
	−The expansion of Route 32 had broken completely, so parts of many bridges are lost, almost in all the PC BOX beam bridges. −It seems that the earthquake in 1991 was a cause of the damage on bridge No.27 and No.28.	17,20,21,23, 27,28
Deck Slab	−Route1 planned and built in the 1950s has much damage of the deck. −In the steel bridge of Route 1, one direction crack or two directions crack accompanied by free lime was observed. But in the concrete bridge of Route1, was only Free Lime by bad construction joint was found. −The damage of the deck on the steel truss bridge in the steel bridge is especially intense, and there are some in which the deck falls out (No.3).	One Direction Crack: 7,8 Two Direction Crack: 2,3,6 Construction Joint: 1,4,5
	−Damage on the deck was observed in the steel bridge of Route 4 and Route 32 −It seems that the cause of the damage on the PC BOX beam bridge in Route32 is bad construction.	19,21,26
Steel Bridge Deck Flame	−The damage on the Deck Frame was looked at in Route1 No.3. The joint of stringer had a crack and loss of the rivet	3
	−The rusting by lack of regular maintenance, for example lack of repainting was observed.	2,3,6,8,9,10, 14,15,19,26
	−There are 4 bridges were partial corrosion is advancing. −It seems that the cause of corrosion is not only decrepitude but also lack of drainage or mud on the flange. −Moreover, they tend to concentrate them on Route 1 and Route 2.	6,14,19
	−The damage by the collision of vehicles in some truss bridges was checked by the style of a gate	3,9
Steel Main Girder	−There are many bridges where there is rusting by lack of regular maintenance, for example lack of repainting was observed.	2,3,6,8,9,10, 14,15,19,26
	−The 1 or 2 bridges, where corrosion is advancing, was observed in each route. −It is thought that the cause of this corrosion is based on the bad drainage of the near bearing base, the mud and rainwater from a ditch.	6,14,15,19,26
Concrete Cross beam	−Free Lime had been observed in only 2 bridges (No.7 and No21) −Free lime in Bridge No.7 is observed in small cracks, which might be caused fatigue by heavy traffic in fixed support of the Rigid Frame Type Bridge. −Free Lime in bridge No.21 is at the end of the cross beam and it might be caused by shrinkage of concrete at the time of construction	7,21
Concrete main girder	−Girder deformation was observed in all PC box girder bridges. −The reason of deformation might be the creep of concrete main girder.	17,20,21,23
	−In bridge No27 and No. 28 R I beam movement was observed −This movement was caused earthquake at 1991	27,28

	−One direction crack, free Lime, Honeycomb and fissility were observed in some bridges on Route No.1 and Route 32. −In the case of Route No.1 and Bridge No25 fatigue might be caused by heavy traffic volume −Deformation of bridge No 21 might be caused by the same reason. −In Bridge No.25 and 28, which might had been damaged by the earthquake in1991, one direction crack and fissility of girder surface was observed.	4,7,21,25,28
Bearing	−The bearing base of all bridges required cleaning and installing a drain system to keep dry condition the bearing base. −Some bearing. −On route 32 the bearing of same bridges was damaged by earthquake on 1991.	
Abutment	−The big damage at substructure is the outflow of back earth and sand of abutments etc. −Almost all abutments of a bridge are Pier-abutment types, and the guard fence of front slope is damaged for decrepitude, and back earth and sand are flowing out in many cases. −These are concentrated on roads other than Route 1	4,8,9,11,12, 13,15,16,17, 18,19,20,21, 22,23,24,28
	−Abutment of bridge No.28 and 27 on Route 32 were damaged by the earthquake in 1991	27,28
Pier	−Big modification etc. was not observed in the bridge pier. But one direction crack, Stripping, and exposure of steel bar were checked.	1,4,5,6,9,17, 20,26,27
	−The pier of the mountains for damage by collision of stone flow has exposure of steel bar.	17,20
	−Scouring of the bridge foundation was checked on some bridges. Especially No.15 and No.16 bridges have already a foundation pile projected.	2,15,16,19,24, 28,29

Table 8.3.3. Evaluation of Inspection Result in Each Route

Route No	Damage
1	−There is much damage on the pavement and the deck slab, and the floor system. Free Lime was observed on almost all bridges. −The cause of the Free Lime was water leakage from a joint by crack and bad construction. −The details of Free Lime are as follows: One Directional Crack: Bridge No. 7, 8 Two Directional Crack: Bridge No. 2, 3, 6 Construction Joint：Bridge No. 1, 4, 5 −The bridge No3 has intense damage on a hole of the deck slab and on the stringer joint of floor system −Cracks and a hole in the pavement were observed on all bridges −There is comparatively little damage of scouring of abutments and pier, and the small scouring is as follows: By abutment: No.8, 4 Scouring of pier footing: No.2
2	−The damage on pavement and the deck slab is not more severe than in Route 1. −The damages on the deck slab and the floor system was observed on No. 9, 10 and 14. −The scouring of the near abutments and collapse of a slope are produced on bridges other than No. 14. −The bridge pier foundations of No.15 and 16 near the PANAMA border are scoured greatly.
4,32,218	−The deformation of abutments, movement of a beam, damage of shoes, and the crack of a bridge pier was checked in No. 27 and 28 by the influence of the earthquake in 1991. −The abnormal deformation of a center span part was observed in the PC Box Bridge of all bridges. −There is much damage on pavement, handrail, expansion, etc. −There is damage on the deck slab and floor system In a steel bridge (No.19, 24). −The pillar of a bridge pier is thin. −Route 32 has much damage on bearing compared with other routes. −Especially three bridges of No.26 and 27 or 28 have been broken by the earthquake. −The scouring bridge pier of No29 has is progressing considerably.

Table 8.3.4. Evaluation of Inspection Result on Type of Bridge

Type of Bridge		Damage	Bridge No.
Concrete Bridge	1.Continuous Reinforced Concrete Deck Girder Bridge	Only Free Lime is observed at superstructure in No.4 Bridge.	4,13,16
	2.Single Span Reinforced Concrete Deck Girder Bridge	No damage can be seen at super structure	9,12
	3.Continuous PC Box Girder Bridge	Deformation of Main girder	17,20,21,23
	4.Single Span PC I Beam Bridge	Only in Bridge No.28, one direction crack was observed.	18,22,24,27 ,28
	5.Connected PC I Beam Bridge	No damage can be seen at super structure	24,25
	6.Reinforced Concrete Arch Bridge	Only Free Lime was observed at Deck	5
	7.Reinforced Concrete Rigid Frame Bridge	Free Lime and one direction crack were observed at deck	7
	8.Suspention Slab Bridge	Free lime and small damage were observed at Deck	1
Steel Bridge	9. Single Span Steel Truss Bridge	Many damages were observed in the Deck. Corrosion was observed at Deck Frame and Main girder	3,6,9,14,
	10.Continuous Steel Truss Bridge	Many damages were observed in the Deck and Deck Frame	2
	11.Simple Span I Beam Bridge	Some damage was observed of Deck Condition of damage is better than Continuous Bridge. In the case of No 26 bridge Girder had fallen down by the earthquake in 1991	10,11,12,14, 26
	12.Continuous I Beam Bridge	Many damages were observed in Deck. Corrosion was observed at Deck Frame and Main girder	6,8,15,26
	13.Gerber Beam Bridge	Many damages were observed in Deck and Deck Frame	19

Note: Bridges with line under their numbers have different type superstructures in the same bridge.

From above study, state of damage and the cause of damage are examined as below and Table 8.3.5 shows the relation between state of damage and the cause of damage

1) Superstructure

Damage of slab was observed in 14 bridges, it is about a half of the 29 Study Bridges. Especially, all bridges on Route 1 have been damaged on their deck slabs. Although the bridges on Route 2 were constructed around 1960, when were almost the same age of construction as the bridges on Route 1, any damages on their slabs are not observed. So, it seems that heavy traffic volume is one of the reasons, which cause the damage of the deck slab for bridges on Route 1.

The damage of deck slab of the steel girder bridges are more serious than that of the concrete girder bridges and especially the damages of deck slab of the steel truss type bridges are most seriously in the 29 Study Bridges. Moreover, the damage of connection parts between stringer and crossbeam are observed in the truss type bridges. It seems that the lack of rigidity of the deck frame is also one of the reasons, which cause the damage of the deck slab.

In the case of Bridge No.26, 27 and 28 in Route 32, which are located near Limon, the main girders have been moved and their supports have been broken by the earthquake in 1991.

The deformations of main girders are observed for the PC Box girder bridges on Route 4 and 32. It is considered that these deformations were caused by creep of the concrete of main girder.

2) Substructure

In the case of substructure, slope collapses around abutment are observed in almost all the bridges and the scouring around foundation at piers or abutments are observed in some of the bridges. Especially in the case of Bridge No. 16 the scouring around piers was a very serious condition, and the pile foundation of the pier has appeared more than 2m below the bottom of footing.

In the case of Bridge No.27 and 28 on Route 32, which are located near Limon, the foundations of abutment were seriously damaged by the earthquake in 1991.

3) Accessory

The accessories such as support, expansion joint and railing are damaged by the lack of maintenance in all 29 Study Bridges.

Table 8.3.5. Cause of Damage and Condition of Damage

Cause of damage	State of damage	Bridge No.
1) Deterioration 2) Lack of Maintenance	Rusting of Steel member	6, 14, 15, 19, 26
	Damage of Bearing Obstruction of function	22,26,27,28
	Damage of Expansion Joint	9, 17, 20,21,23,27,28
3) Damage of Slab by traffic of the Heavy Vehicle	Crack in Deck Slab (One direction)	2, 3, 6, 7, 8, 10,19, 21, 26, 28
	Crack in Deck Slab (Tow direction)	2, 3, 6, 26
	Free Lime	1, 2, 3, 4, 5, 6, 7, 8, 10, 19, 26
	Exposure of reinforcement	1,3, 14, 26
	Fissility or holes	3
	Waving or Crack in Pavement	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 14, 23, 24, 25, 26, 27, 28
4) Crashed by Vehicle	Damage of Member of Portal Bracing in Truss Bridge	3, 9
	Damage of Railing	7, 19, 21, 23, 24, 25, 28
5) Scouring around foundation of Pier 6) Damage of Column of Pier by the stone brought by flood	Slope collapse around abutment	4,8, 9, 11, 12, 13, 15, 16, 17, 18,19, 20, 21, 22, 23, 24, 28
	Appear foundation Degradation of stability	2, 15, 16, 19, 24, 28, 29
	Damage of Column of Pier by the stone brought by flood	17, 20
7) Damage of Foundation or Bearing 8) Movement Main Girder	Movement of girder	26, 27, 29
	Inclination of Abutment Shear failure of Pile foundation	27, 28
9) Inferior construction	Honeycomb	2, 7, 18, 20, 21, 22, 24, 25, 27, 28
	Deformation of main girder	17, 20, 21, 23

8.3.2 River Condition in Bridge Site

1) Present Condition of River in 29 Bridge Sites

The present conditions of rivers of the 29 bridge sites are shown in Table 8.3.6. The river flow conditions of the bridges No. 10, 11, 12, 13,15, 16, 17, 18 and 29 have changed from their conditions when the bridges were constructed.

Table 8.3.6. Present Condition of River in 29 Bridge Sites

Bridge No / Name		Route No	River Profile (%)	Catchment Area (km^2)	Distance from the Sea (km)
1	Colorado	1	3.0	159.8	36.6
2	Aranjuez	1	1.0	158.6	112.3
3	Abangares	1	1.6	128.1	143.3
4	Piedras	1	0.5	158.2	189.8
5	Colorado	1	1.0	90.5	221.9
6	Ahogados	1	0.6	188.0	232.5
7	Azufrado	1	1.0	12.8	239.8
8	Tempisquito	1	0.5	184.4	240.2
9	Volcan	2	1.0	147.1	181.8
10	Ceibo	2	0.7	251.0	189.6
11	Curre	2	1.1	15.5	229.3
12	Puerto Nuevo	2	1.0	6.1	234.4
13	Zapote	2	0.5	4.4	248.4
14	Terraba	2	0.2	-	256.1
15	Caracol	2	0.3	22.2	323.3
16	Nuevo	2	1.2	11.9	327.2
17	Chirripo	4	1.5	392.2	45.0
18	San Jose	4	2.3	37.5	50.0
19	Sarapiqui	4	0.5	841.6	65.0
20	Sucio	32	2.4	194.9	39.7
21	Toro Amarillo	32	2.5	149.2	59.6
22	Parismina	32	1.8	39. 7	78.7
23	Reventazon	32	1.0	1,720.8	95.0
24	Pacuare	32	1.2	662.8	100.4
25	Barbilla	32	1.0	216.4	116.3
26	Chirripo	32	0.5	1,070.4	126.2
27	Cuba	32	0.2	22.0	134.8
28	Blanco	32	0.3	58.3	148.2
29	Torres	218	2.1	30.7	66.4

2) Study on Bridge Condition for the River Flow

The evaluations to judge the stability of river conditions and factors that influence upon the river flow are shown in Table 8.3.7.(1) to Table 8.3.7.(4).

The equations to calculate the maximum flow volume or flow velocity are shown in Table 8.3.8. The required minimum span length (Figure 8.3.1) for bridges and the clearance under the beam (Table 8.3.8) were examined based on the "River Maintenance Law" in Japan.

Table 8.3.7.(1) Evaluation of Stability of River Bed (Route 1)

Bridge No		1	2	3	4	5	6	7	8
River Name		Colorado River	Aranjuez River	Abangares River	Piedras River	Colorado River	Ahogados River	Azufrado River	Tempisquito River
H.W.L (El. in m)		-	95.1	69.2	64.6	94.2	82.3	92	89.6
Depth of H.W.L (m)		-	3.4	4.3	8.5	6.1	10.1	6.4	3.8
Average Wide(B) (m)		-	67.1	83.8	55.5	28	91.7	23.8	57.9
Flow Area(A) (m2)		-	170	234	272	113	436	58	251
Average Grade		-	1	1.6	0.5	1	0.6	1	0.5
Coefficient of roughness(n)		-	0.04	0.035	0.03	0.04	0.04	0.04	0.047
Free Space		-	5.8	3	0.5	1.2	2	3.7	6.6
Bridge Length (m)		-	87.8	101.3	55.5	52	91.8	31.4	71.3
Span Number		-	3	2	3	1	3	2	3
Span Length (m)	(MAX)	-	39	73.9	21.3	30.5	61	19.8	27.4
	(MIN)		24.4	46.7	17.1	-	15.2	5.8	21.9
Type of Pire		Ramen	Wall	wall	Ramen+Wal l	Arch Bridge	Wall 5.0x1.6	Wall	Ramen+Wal l
Skew Degree		-	-	15	-	20	10	10	0
R(A/B)		-	2.53	2.79	4.9	4.04	4.75	2.44	4.34
Flow Velocity(m/s)		-	4.64	7.16	6.8	6.34	5.47	4.53	4
Flow Volume (m3)		-	788.8	1675.44	1849.6	716.42	2384.92	262.74	1004
Required Span Length (m)		-	20	20	20	20	32	12.5	20
Required Free Space (m)		-	1.0	1.0	1.0	1.0	1.2	0.8	1.0
Evaluation of Span length	Main		OK	OK	OK	OK	OK	OK	OK
	Side		OK	OK	Not enough	OK	Not enough	Not enough	OK
Evaluation of Free Space			OK	OK	Not enough	OK	OK	OK	OK

Table 8.3.7.(2) Evaluation of Stability of River Bed (Route 2)

Bridge No		9	10	11	12	13	14	15	16
River Name		Volcán River	Ceibo River	Curré River	Puerto Nuevo River	Zapote River	Terraba River	Caracol River	Nuevo River
H.W.L (El. in m)		354.2	250.2	79.6	65.8	39	24.4	25.9	99.4
Depth of H.W.L(m)		11.5	4.9	9.8	10.2	16	8.5	1.9	2
Average Wide(B) (m)		54.9	109.7	83.4	85.3	61	310.9	71.3	20.7
Flow Area(A) (m2)		342	276	457	657	252	3299	95	29
Average Grade		1	0.7	1.1	1	0.5	0.2	0.3	1.2
Coefficient of roughness(n)		0.04	0.04	0.04	0.04	0.04	0.027	0.035	0.035
Free Space		6.3	7.8	5.4	3.8	4.6	1.5	3	4.1
Bridge Length (m)		76.2	131.1	103.6	103.6	55.5	341.2	71.3	55.5
Span Number		3	5	4	5	3	7	3	3
Span Length (m)	(MAX)	45.7	30.5	30.5	24.4	21.3	76.2	27.4	21.3
	(MIN)	12.2	15.2	21.3	15.2	17.1	27.4	21.9	17.1
Type of Pire		Wall 4.3x0.85	Column D=1.83m	Column D=1.98m	Column D=1.82m	Ramen+Wal l	Oval 584x244	Hollow circle Pier D=5.20m	Wall
Skew Degree		-	-	-	12	30	-	0	30
R(A/B)		6.23	2.52	5.48	7.7	4.13	10.61	1.33	1.4
Flow Velocity(m/s)		8.46	3.87	8.15	9.75	4.55	8	1.89	3.92
Flow Volume (m3)		2893.32	1068.12	3724.55	6405.75	1146.6	26392	179.55	113.68
Required Span Length		34	20	39	52	20	152	15	12.5
Required Free Space		1.2	1.0	1.2	1.2	1.0	1.2	0.6	0.6
Evaluation of Span length	Main	OK	OK	Not enough	Not enough	OK	Not enough	OK	OK
	Side	Not enough	Not enough	Not enough	Not enough	Not enough	Not enough	OK	OK
Evaluation of Free Space		OK	OK	OK	OK	OK	OK	OK	OK

Table 8.3.7.(3) Evaluation of Stability of River Bed (Route 4 & 218)

Bridge No		17	18	19	29
River Name		Chirripó River	San José River	Sarapiquí River	Torres River
H.W.L (El. in m)		238	184	98.9	1261.683
Depth of H.W.L (m)		11	5	20.3	4.15
Average Wide(B) (m)		150	29	88	21.5
Flow Area(A) (m2)		567	101	197	52
Average Grade		1.5	2.3	0.5	2.1
Coefficient of roughness(n)		0.027	0.027	0.03	0.04
Free Space		2.5	3	2.1	6
Bridge Length (m)		175.8	40.5	100.96	66.46
Span Number		3	2	3	3
Span Length (m)	(MAX)	82.8	20	55	30
	(MIN)	46.5	20	22.28	17
Type of Pire		Oval 520x200	Column D=2.13m	Oval 300x100	Column D=1.5m
Skew Degree		-	20	-	30
R(A/B)		3.78	3.48	2.24	2.42
Flow Velocity(m/s)		11.01	12.9	4.04	6.53
Flow Volume (m3)		6242.67	1302.9	795.88	339.56
Required Span Length (m)		51	20	20	12.5
Required Free Space (m)		1.2	1.0	1.0	0.8
Evaluation of Span length	Main	OK	OK	OK	OK
	Side	Not enough	OK	OK	OK
Evaluation of Free Space		OK	OK	OK	OK

Table 8.3.7.(4) Evaluation of Stability of River Bed (Route 32)

Bridge No		20	21	22	23	24	25	26	27	28
River Name		Sucio River	Toro Amarillo River	Parismina River	Reventazon River	Pacuare River	Barbilla River	Chirripo River	Cuba River	Blanco River
H.W.L (El. in m)		462	295	72	85.5	54	29.5	16.4	11.2	6
Depth of H.W.L (m)		8.1	7	5	8	6.5	3.5	9.5	4.5	6.7
Average Wide(B) (m)		100	225	93	330	285	80	405	59	47
Flow Area(A) (m2)		252	724	208	1688	785	337	1500	130	166
Average Grade		2.4	2.5	1.8	1	1.2	1	0.5	0.2	0.3
Coefficient of roughness(n)		0.05	0.05	0.04	0.04	0.033	0.035	0.027	0.027	0.027
Free Space		19	3	2.2	4	4	4	6	2	1.6
Bridge Length (m)		187.25	258.6	106	341.4	317.5	100	415.04	68.6	58.9
Span Number		2	4	3	5	10	3	7	3	3
Span Length (m)	(MAX)	102	82.8	35	82.8	32.67	32.78	73.2	22	22
	(MIN)	55.25	46.5	35	46.5	17	32.78	15.86	22	17
Type of Pire		Hollow circle	Oval	Hollow Pier	Oval	Wall	Wall	Oval	Ramen+Wal	Ramen+Wal
Skew Degree		-	40	0	10	(50)	(66)	-	(60)	(55)
R(A/B)		2.52	3.22	2.24	5.12	2.75	4.21	3.7	2.2	3.53
Flow Velocity(m/s)		5.74	6.9	5.74	7.43	6.52	7.45	6.27	2.8	4.7
Flow Volume (m3)		1446.48	4995.6	1193.92	12541.84	5118.2	2510.65	9405	364	780.2
Required Span Length		20	45	20	83	46	33	67	15	20
Required Free Space		1.0	1.2	1.0	1.2	1.2	1.2	1.2	0.8	1.0
Evaluation of Span length	Main	OK	OK	OK	Not enough	Not enough	Not enough	OK	OK	OK
	Side	OK	OK	OK	Not enough	Not enough	Not enough	Not enough	OK	Not enough
Evaluation of Free Space		OK	OK	OK	OK	OK	OK	OK	OK	OK

Table 8.3.8. Equations of Calculation of Maximum Flow Volume and Flow Velocity

$$Q = A \cdot V$$

Q =Maximum Flow

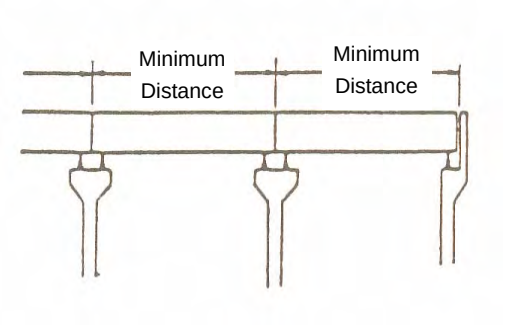
A =Cross-sectional hydraulic section to calculate on the basis of the level of H.W.L considered by the signs of last floods and obtained data of the inhabitants of the place

$$V = \left(1/n\right) \cdot R^{2/3} \cdot I^{1/2}$$

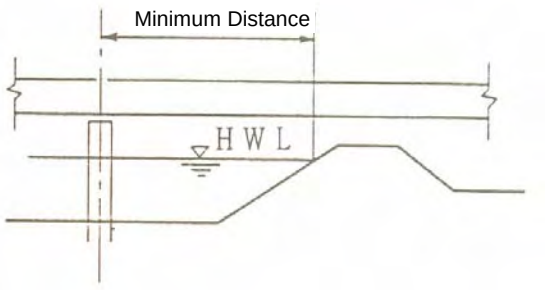
n =Coefficient of roughness, determined by means of visual inspection of photos Upstream and downstream, comparing with those of the book of professor Chon.

R =A/B (B =Width of the river)

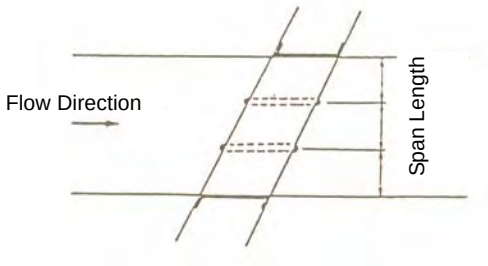
I =Slope average of the water surface during the flood ones



(a) Span length of bridge



(b) Span length in case when abutment is built on river bank or embankment



(c) Span length in case of skew bridge

Note: The span length is the distance between center of neighboring 2 piers and span length should be measured at right angle to the river flow.

Figure 8.3.1. Minimum Span Length

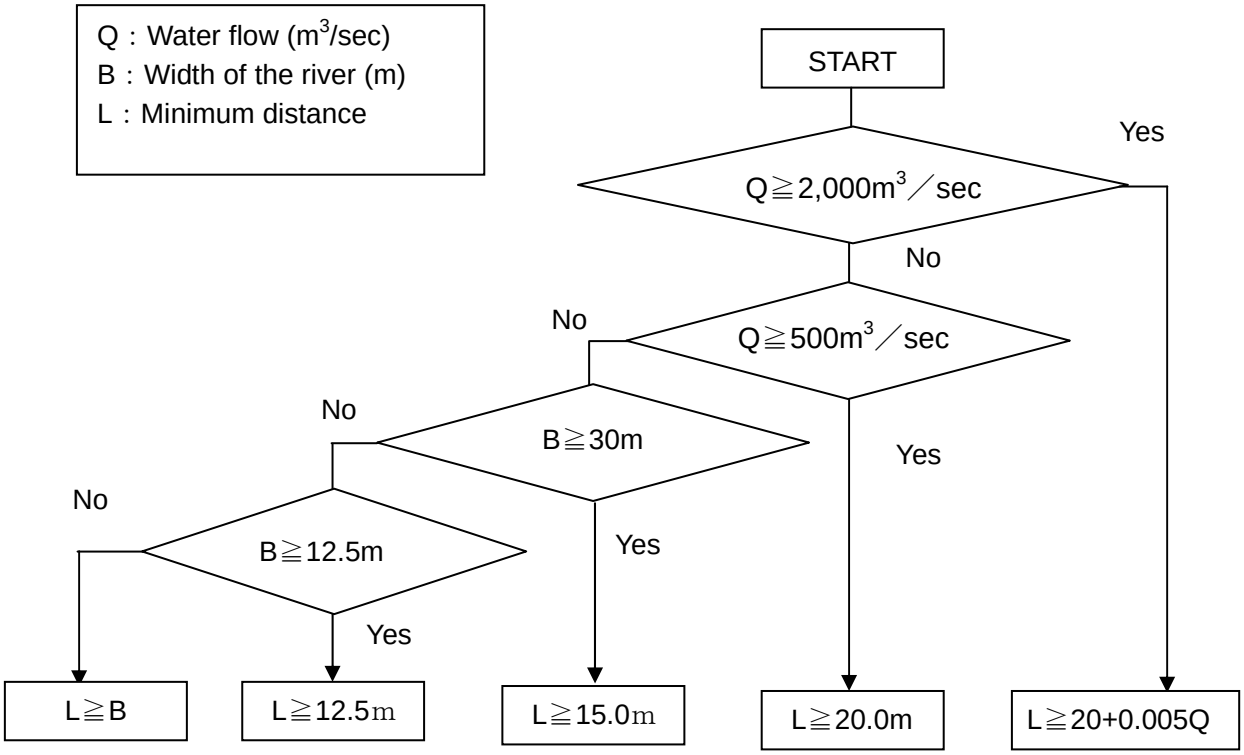
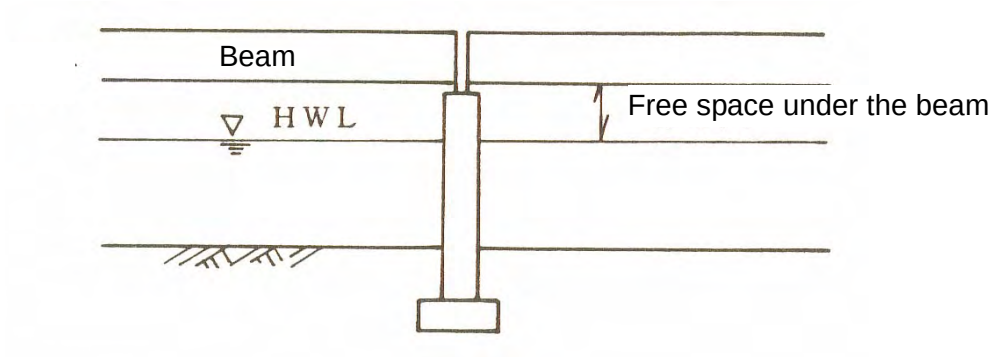


Figure 8.3.2. Required Minimum Span Length

Table 8.3.9. Required Free Space

Q （m^3／sec）	Q＜200	200≦Q＜500	500≦Q＜2000	2000≦Q＜5000
Free space under the beam (m)	0.6	0.8	1.0	1.2



8.3.3 Other relevant Condition with respedt to Bridge Maintenance

1) Live Load and Condition of Deck Slab

Table 8.3.10 shows the design specifications of live load and deck slab thickness for the 29 Study bridges. All bridges on Route 1 and 2 except the Bridge No.1 were designed with the H15-S12 live load, the bridges on other routes were designed with HS20-44 live load.

The thicknesses of the deck slab of these bridges are less than 20 cm and the minimum thickness is only 16.5 cm of the Bridge No.3. And these thicknesses correspond to the site inspection result.

The bridges on Route 1 and 2 were constructed during 1953 to 1961, the bridges on Route 32 were constructed in 1970's

Table 8.3.10. Design Specification of 29 Study Bridges

No.	Bridge	Route	Spans	Age	Simple or Continuous	Material	TYPE	Type of Superstructure	Live Load	Thickness of Slab
1- 1	**Colorado River**	1	5	1970	Simple	PC	8	Reversed Arch	H20-S16	15 or 20
2- 1	**Aranjuez River**	1	3	1955	Continuous	Steel	10	Truss	H15-S12	18
3- 1	**Abangares River**	1	2	1953	Simple	Steel	9	Truss	H15-S12	16.5
4- 1	**Piedras River**	1	3	1959	Continuous	RC	1	T-Girder	H15-S12	18
5- 1	**Colorado River**	1	3	1959	-	RC	6	Arch	H15-S12	25
6- 1	**Ahogados River**	1	1	1954	Simple	Steel	9	Truss	H15-S12	17.8
6- 2	**Ahogados River**	1	2	1954	Continuous	Steel	13	I-Girder	H15-S12	17.8
7- 1	**Azufrado River**	1	3	1955	Continuous	RC	7	Rigid	H15-S12	16.5
8- 1	**Tempisquito River**	1	3	n	Continuous	Steel	13	I-Girder	H15-S12	18
9- 1	**Volcán River**	2	2	1961	Simple	RC	2	T-Girder	H15-S12	18
9- 2	**Volcán River**	2	1	1961	Simple	Steel	9	Truss	H15-S12	18
10- 1	**Ceibo River**	2	5	1961	Simple	Steel	11	I-Girder	H15-S12	18
11- 1	**Curré River**	2	4	1961	Simple	Steel	11	I-Girder	H15-S12	17.75
12- 2	**Puerto Nuevo River**	2	1	1961	Simple	RC	2	T-Girder	H15-S12	17.75
12- 1	**Puerto Nuevo River**	2	4	1961	Simple	Steel	11	I-Girder	H15-S12	17.75
13- 1	**Zapote River**	2	3	1961	Continuous	RC	1	T-Girder	H15-S12	-
14- 2	**Terraba River**	2	3	1960	Simple	Steel	9	Truss	H15-S12	20
14- 1	**Terraba River**	2	4	1960	Simple	Steel	11	I-Girder	H15-S12	20
15- 1	**Caracol River**	2	3	1961	Continuous	Steel	13	I-Girder	H15-S12	18
16- 1	**Nuevo River**	2	3	1961	Continuous	RC	1	T-Girder	H15-S12	18
17- 1	**Chirripó River**	4	3	1978	Continuous	PC	3	Box-Girder	HS20-44	-
18- 1	**San José River**	4	2	1978	Simple	PC	4	T-Girder	HS20-44	-
19- 1	**Sarapiquí River**	4	3	1978	Simple	Steel	14	I-Girder	HS15-44	-
20- 1	**Sucio River**	32	2	n	Continuous	PC	3	Box-Girder	HS20-44	-
21- 1	**Toro Amarillo River**	32	4	n	Continuous	PC	3	Box-Girder	HS20-44	-
22- 1	**Parismina River**	32	3	n	Simple	PC	4	T-Girder	HS20-44	16
23- 1	**Reventazón River**	32	5	n	Continuous	PC	3	Box-Girder	HS20-44	20
24- 1	**Pacuare River**	32	10	n	Simple	PC	4	T-Girder	HS20-44	19
25- 1	**Barbilla River**	32	3	n	Simple	PC	5	T-Girder	HS20-44	19
26- 1	**Chirripó River**	32	1	1978	Simple	Steel	11	I-Girder	HS20-44	17
26- 2	**Chirripó River**	32	6	1978	Continuous	Steel	13	I-Girder	HS20-44	17
27- 1	**Cuba River**	32	3	n	Simple	PC	4	T-Girder	HS20-44	16
28- 1	**Blanco River**	32	3	n	Simple	PC	4	T-Girder	HS20-44	16
29- 1	**Torres River**	218	3	n	Simple	PC	4	T-Girder	HS20-44	18

2) Seat length of Bridge

The seat length is as shown in Figure 8.3.3. If the seat length is too short, the girders might fall down by earthquake.

The seat length in the 29 Study Bridges was investigated by the reviewing of drawings. The seat length in the case of both of concrete girder bridges and steel girder bridges are very small with 50 cm to 70 cm. According to Japanese Standard for Road Bridge, the seat length should be kept more than SE, which is given by the formula 8.3.3 below.

$$S_E = 0.7 + 0.005L \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (8.3.3)$$

S_E : Seat length (m)
L : Span length (m)

If the span length is 30 m the seat length will be required more than 0.85 m to prevent the possibility of bridge falling down due to earthquake. So there is a considerable danger that the girder will fall down by earthquake.

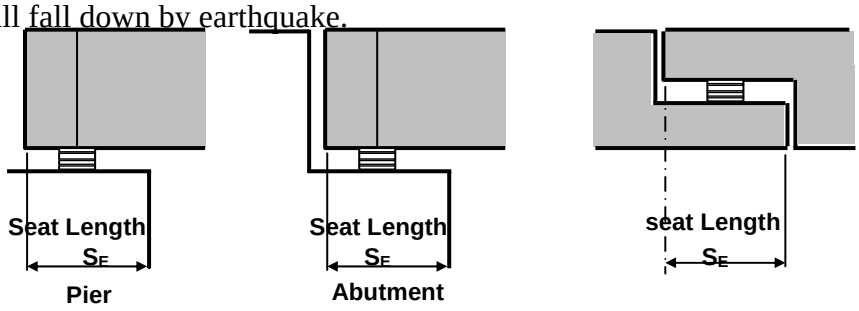


Figure 8.3.3. Seat Length

Moreover the distance between Anchor Bolt of bearing and substructure top edge, shown in Figure 8.3.4, will be kept more than S, which is given by the formula 8.3.4

$$S = 0.2 + 0.005L \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (8.3.4)$$

S : Distance between anchor bolt of bearing and substructure top edge(m)
L : Span length (m)

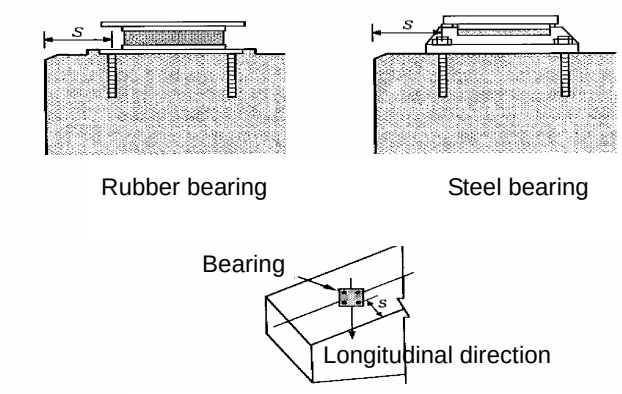


Figure 8.3.4. Distance between Anchor Bolt of Bearing and Substructure Top Edge

3) Substructure and Foundation

Table 8.3.11 shows the types of pier and foundation. The wall type pier is adopted for the old bridges such as the bridges on Route 1. T-shape piers with only 2 m diameter columns have been adopted in the bridges on Route 2.

Almost all bridge foundations have the spread type foundation. The pile foundations have been adopted for the bridges located in a flat area near Limon or the Panama border.

Table 8.3.11. Type of Pier and Foundation of 29 Study Bridges

Route 1									
Bridge No		1	2	3	4	5	6	7	8
River Name		Colorado River	Aranjuez River	Abangares River	Piedras River	Colorado River	Ahogados River	Azufrado River	Tempisquito River
Length (m)		204	87.8	101.3	55.5	52	91.8	31.4	71.3
Span No.		5	3	2	3	1	3	2	3
Span Length	(MAX)	124	39	73.9	21.3	30.5	61	19.8	27.4
	(MIN)	15	24.4	46.7	17.1	-	15.2	5.8	21.9
Skew Degree		0	-	15	-	20	10	10	0
Type of Pier		Rigid Frame	Wall	wall	Rigid Frame +Wall	Arch Bridge	Wall 5.0x1.6	Wall	Rigid Frame +Wall
Type of Foundation		Spread	Spread	Spread	Spread	Spread	Spread	Spread	Spread
Depth of Foundation		15	5.5	6.1	0	13	3	2.1	3.7
Bearing Layer		Tufa	Pasalt	Eruptiv	Solid Rock	Rock	Sand gravel	Solid Rock	Solid Volcaniv ash
Scoring		1	2	1	1	1	1	1	1
Comment		valley							

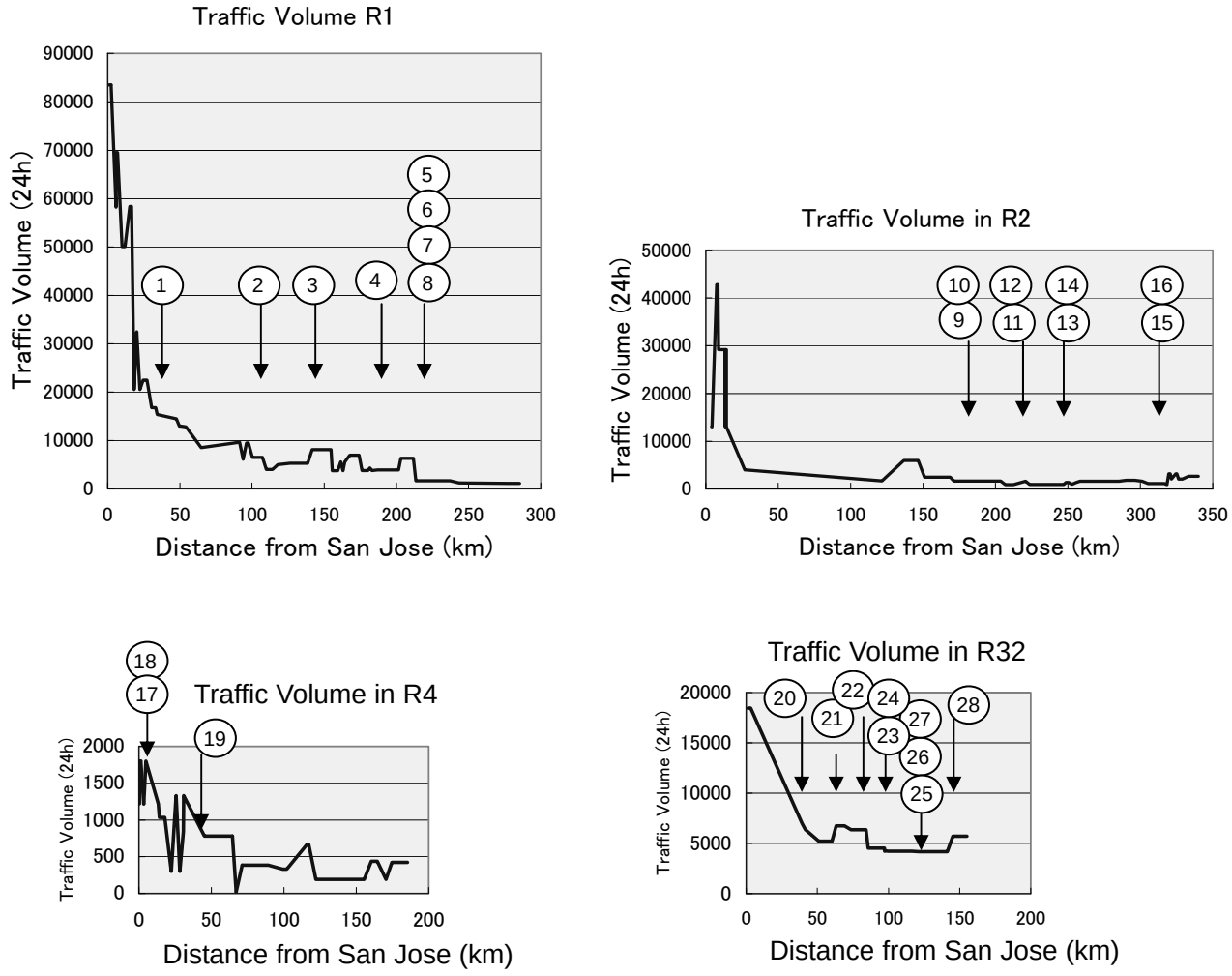
Route 2									
Bridge No		9	10	11	12	13	14	15	16
River Name		Volcán River	Ceibo River	Curré River	Puerto Nuevo River	Zapote River	Terraba River	Caracol River	Nuevo River
Length (m)		76.2	131.1	103.6	103.6	55.5	341.2	71.3	55.5
Span No.		3	5	4	5	3	7	3	3
Span Length	(MAX)	45.7	30.5	30.5	24.4	21.3	76.2	27.4	21.3
	(MIN)	12.2	15.2	21.3	15.2	17.1	27.4	21.9	17.1
Skew Degree		-	-	-	12	30	-	0	30
Type of Pier		Wall 4.3x0.85	Column D=1.83m	Column D=1.98m	Column D=1.82m	Ramen+Wall	Oval 584x244	Hollow circle Pier D=5.20m	Wall
Type of Foundation		Spread	Spread	Spread	Spread	Spread	Spread	Pile 0.36x0.36	Pile
Depth of Foundation		6	3.9	2.4	1	1	2.3	2.4	2.2
Bearing Layer		Clay Gravel	Conglomerate	Shale	basalt	Friable sofft shale	Boluder with sand	Sandy Clay	Silty Clay
Scoring		1	1	1	1	1	1	5	5
Comment									

Route 4 and 218						Route 32								
Bridge No		17	18	19	29	20	21	22	23	24	25	26	27	28
River Name		Chirripó River	San José River	Sarapiquí River	Torres River	Sucio River	Toro Amarillo River	Parismina River	Reventazon River	Pacuare River	Barbilla River	Chirripo River	Cuba River	Blanco River
Length (m)		175.8	40.5	100.96	66.46	187.25	258.6	106	341.4	317.5	100	415.04	68.6	58.9
Span No.		3	2	3	3	2	4	3	5	10	3	7	3	3
Span Length	(MAX)	82.8	20	55	30	102	82.8	35	82.8	32.67	32.78	73.2	22	22
	(MIN)	46.5	20	22.28	17	55.25	46.5	35	46.5	17	32.78	15.86	22	17
Skew Degree		-	20	-	30	-	40	0	10	(50)	(66)	-	(60)	(55)
Type of Pier		Oval 520x200	Column D=2.13m	Oval 300x100	Column D=1.5m	Hollow circle Pier D=5.20m	Oval 520x200	Hollow Pier D=2.0m	Oval 520x200	Wall	Wall	Oval 400x160	Rigid Frame +Wall	Rigid Frame +Wall
Type of Foundation		Spread	Spread	Pile 12BP53	Spread	Spread	Spread	Spread	Spread	Pile D=24"	Pile	Pile 17#8	Pile 0.36x0.36	Pile 0.36x0.36
Depth of Foundation		20	2.3	4.5	1.5	14.5	8	7	10	2	2	7.5	1	1.5
Bearing Layer		GB	GB	Sand	sand		GB	GB	GB	Sand Clay	Sand Boluder		Sand	Sand Silt
Scoring		1	1	2	2	1	1	1	1	2	1	1	1	3
Comment														

1) Traffic Volume and Others

Figure 8.3.5 shows the traffic volume of each study route and each bridge site. Although traffic volumes are more than 20,000 around San Jose. The traffic volume at the points, where located 30 km to 50 km from center of San Jose, which decreased less than 10,000 TPD (traffic per day).

Route 1 is heaviest traffic route in Costa Rica. However the traffic volumes at the location of 29 Study bridges are less than 10,000 TPD and the traffic volumes on Route 2 and 4 are less than 2,000 TPD.



Note; ⓘ indicates Bridge No. *i*

Figure 8.3.5. Traffic Volume at Location of 29 Study Bridges