MINISTRY OF ROAD TRANSPORT AND HIGHWAYS
THE REPUBLIC OF INDIA

Data Collection Survey on Bridge Sector

FINAL REPORT

APRIL 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.
EAST NIPPON EXPRESSWAY CO., LTD.

南ア
JR
14-033

MINISTRY OF ROAD TRANSPORT AND HIGHWAYS
THE REPUBLIC OF INDIA

Data Collection Survey on Bridge Sector

FINAL REPORT

APRIL 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.
EAST NIPPON EXPRESSWAY CO., LTD.

The Republic of India

Data Collection Survey on Bridge Sector

FINAL REPORT

Table of Contents

Page

List of Figure

List of Table

List of Abbreviations

ADG	Additional Director General
Admin	Administration
ADT	Annual Daily Traffic
AEE	Assistant Executive Engineer
AS & FA	Additional Secretary and Financial Advisor
BIS	Bureau of Indian Standards
BOT	Build Operation Transfer
BRDB	Border Roads Development Board
BRO	Border Roads Organization
CBIC	Chennai-Bangarole Industrial Corridor
CCA	Chief Controller of Accounts
CE	Chief Engineer
CFRP	Carbon-Fiber Reinforced Plastic
CR	Customer Relationship
CRF	Central Road Fund
CRM	Concrete Masonry
CRRI	Central Road Research Institute
CRZ	Coastal Regulation Zone
DDO	Drawing and Disbursing Officer
DG (RD) & SS	Director General and Special Secretary
DMIC	Delhi-Mumbai Industrial Corridor
DPR	Detailed Project Report
EAC	Expert Appraisal Committee
EAP	Externally Aided Project
EC	Environmental Clearance
ECF	Epoxy Coated and Filled
EE	Executive Engineer
EIA	Environmental Impact Assessment
ELO	Engineer Liaison Office
Fin	Finance
GDP	Gross Domestic Product
GQ	Golden Quadrilateral
GS road	General Staff road
GSDP	Gross State Domestic Product
HDM	Highway Development and Management
IAHE	Indian Academy of Highway Engineers
IC	International Cooperation
IRC	Indian Road Congress (Code)
JICA	Japan International Cooperation Agency
JS	Joint Secretary
LA&P	Land Acquisition and Parliament
LWE	Left Wing Extremist affected area
MoEF	Ministry of Environment and Forests
MORTH	Ministry of Road Transport and Highways

MOTC	Ministry of Transport and Communications (Kyrgyzstan)
MRT	Ministry of Roads and Transport (Mongolia)
NDP	Net Domestic Product
NER	North East Region
NEXCO-East	East Nippon Expressway Company Limited
NH	National Highway
NHDP	National Highway Development Project
NHAI	National Highway Authority of India
NS-EW	North South-East West
NSDP	Net State Domestic Product
OECD	Organization for Economic Co-operation and Development
O&M	Operation and Maintenance
P&M	Planning& Monitoring
P&P	Policy and Planning
PAC	Public Accounts Committee
PC	Prestressed Concrete
PCI	Per Capita Income
PCU	Passenger Car Unit
PIC	Project Implementation Cell
PMU	Project Management Unit
PPP	Public-Private Partnership
PRIDe	Peninsular Regional Industrial Development
PSC	Pre-Stressed Concrete
PWD	Public Works Department
RC	Reinforced Concrete
RCT	Reinforced Concrete T-Girder
RO	Regional Office
ROB	Roads Over Bridges
RTI	Right to Information
RUB	Roads Under Bridges
SARDP-NE	Special Accelerate Road Development Programme- North East
SD office	Sub-Division office
SE	Superintending Engineer
SEAC	State or Union territory Expert Appraisal Committee
SEIAA	State or Union territory Environmental Impact Assessment Authority
SIA	Social Impact Assessment
SPCB	State Pollution Control Board
SR&T	Standard Research and Technology
TC	Toll and Coordination
ToR	Terms of Reference
TR	Transportation Research
UBC	Ulaanbaatar City (Mongolia)
UTPCC	Union Territory Pollution Control Committee

1. INTRODUCTION

1.1 Background

Roads are an essential element of transport infrastructure in domestic distribution in the Republic of India (hereinafter called India), as roads account for 85% of passenger transport and 63% of freight transport. While road traffic volume has increased by 9.1% per year after 1950 in tandem with growth of population and economic growth, road construction is lagging behind. As a result, the government of India is undertaking the development of 18,000 km of road for expressway networks under the National Highway Development Plan to link major economic centers such as "Delhi – Mumbai – Chennai – Calcutta", "North – South Axis and East – West Axis", "Access Road to Port" and "BOT system 4 Lane Road". In 40 years, the length of the road network in India increased eightfold to about 4.24 million km, which is 2nd largest road expansion in the world. However, roads with pavements only account for 50 per cent (2.1 million km) of the total length. To ensure an efficient physical distribution system, road and pavement maintenance by the government of India is required. Furthermore, the government of India has not implemented adequate action to protect pavements to address overloaded vehicles and increased traffic. Thus, many pavements are being damaged and are beginning to bottleneck the distribution system.

In the 12th Five-Year Plan (April 2012 to March 2017), the amount invested into road improvement projects (9.7 trillion Rupees) is 2.1 times that of the previous plan, and the amounts invested into railways, ports and communications have all also more than doubled those prior. The 12th Five-Year Plan was formulated to carry out planning for large infrastructure. According to the 12th Five-Year Plan, the Ministry of Road Transport and Highway (hereinafter called MORTH) is responsible for 1,290 bridges, of which 169 were constructed between 1947 and 1969 and 302 were constructed between 1969 and 1990. These aging bridges are also a major issue. However, of the total number of bridges, the state and number of aging bridges in need of maintenance in each state is not accurately detailed. Moreover, bridge rehabilitation and improvement, which MORTH is promoting, needs advanced techniques and extensive experience. As a result, the planning and execution of bridge rehabilitation and improvement has not seen significant progression.

In these circumstances, the long-term JICA bridge experts/advisors carried out bridge inspections for MORTH and National Highway Authority of India (hereinafter called NHAI) and a great deal of major damage was found. In their reports, they highlighted the need for bridge inspection,

rehabilitation and improvement. A short-term JICA bridge expert/advisor was also hired by MORTH/NHAI in March 2013 to carry out bridge inspections, and in his report to MORTH, he proposed methods for bridge maintenance, rehabilitation and improvement, as well as key inspection points. As a result, MORTH and NHAI came to the conclusion that bridge reinforcement and rehabilitation support must be carried out using advanced techniques developed in Japan.

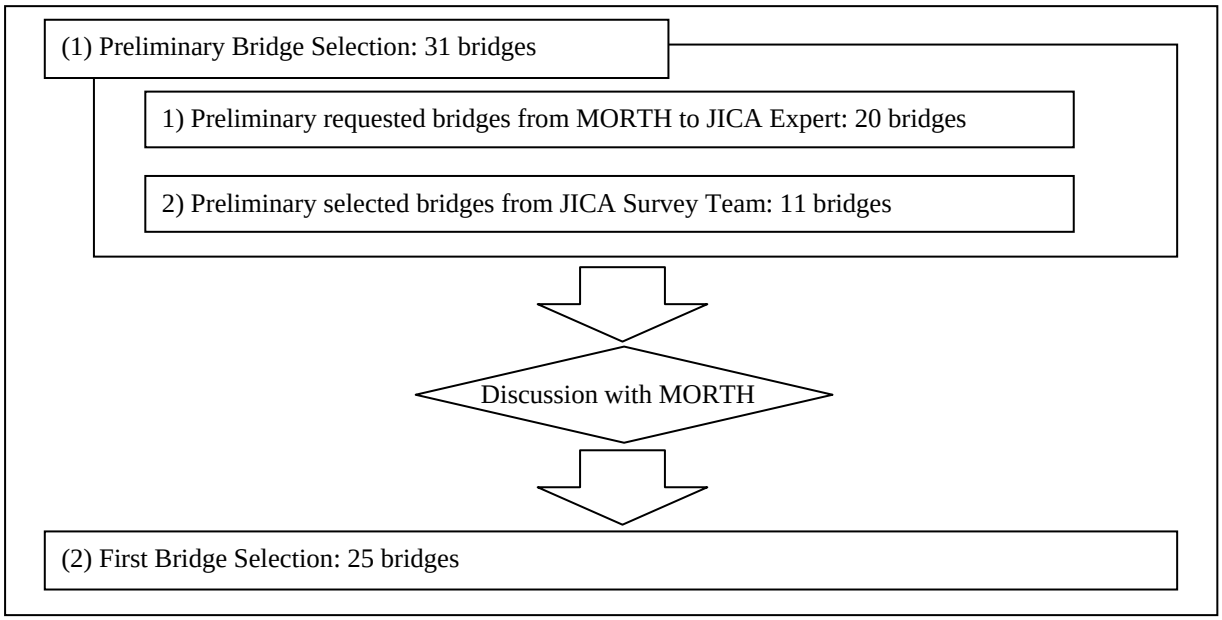
1.2 Objectives of the Survey

Project name:	Data Collection Survey on Bridge Sector
Objective of the survey:	Bridges are inspected with the view to make effective use of Japanese advanced technology in India
Survey area:	India-wide
Counterpart:	Ministry of Road Transport and Highways (MORTH)

2. FIRST BRIDGE SELECTION

2.1 First Bridge Selection

The first bridge selection was carried out using the following proccess:



Source: JICA Survey Team

Figure 2.1.1 Procedure of First Bridge Selection

(1) Preliminary Bridge Selection

1) Preliminary Requested Bridges from MORTH

The preliminary requested bridges from MORTH to JICA Expert are shown in Table 2.1.1.

Table 2.1.1 Requested Bridge Survey List by MORTH

LIST OF BRIDGES REQUIRING REHABILITATION							
Sl. No	State	NH No.	Location and Yerar of Construction	Name of River	Span Arrangement (m)	Type of Superstructure	Damage Observed
1	BIHAR	19	Mahatma Ghandhi Setu (Ist 2 lane 1972-1892 Addl two lane 1982-1987)	Ganga	44x121.06+2x(60+57)+2x7.1	Single cell Box Girder	Loss of Pre-stress, Damage of central Hinge bearing, damage of wearing coat and expansion joint
2	GOA	17B	Ponda side KM 9/00 to KM 9/411 (1986)	Zuari	Ponda side 69.8+121 b alanced cantilever+69.8 Margao side +4x37.5 viaduct spans	PSC Box Girder . Main span balanced cantilever with ecentral hinge	Crack in superstructure, exxcessive deflection and loss of prestress
3	Kerala	17	Poduponnani (1986)	Kanhiramuck river	2x16.4+7x24.40	RCC	Damage to piles, pier caps, deck slabs, wearing coat and expansion joints
4		17	Kottapuram (1982 to 1986)	Periyar	9x30.25+11x30.75	Pre-stressed girder with RCC	Wearing coat damaged. Near to costal area , salinity attacks damaged exposed surfaces
5	ODISHA	200	401/210 (1964)	Brahmani River	1x20.50+27x44.25+1x32.50		Distressed . Parapet and Footpath slab damaged
6	MEGHALAYA	44	173/000	Baleswar	Total Length = 160 m		
7	ASSAM	52	166/000	Jaibharali	15x 41.60		
8	MIZORAM	54	506/720	R.Chhimtuipui	68+128+70+19		
9	JHARKHAND	75	174/194	Amanat	Total Length = 291.80m		

Source: MORTH

When the JICA experts carried out the bridge survey, the addition and replacement of several bridges to the list was requested by Goa, Kerala and Assam state. Taking these additional requests into account, JICA and MORTH modified the list of requested bridges, as shown below:

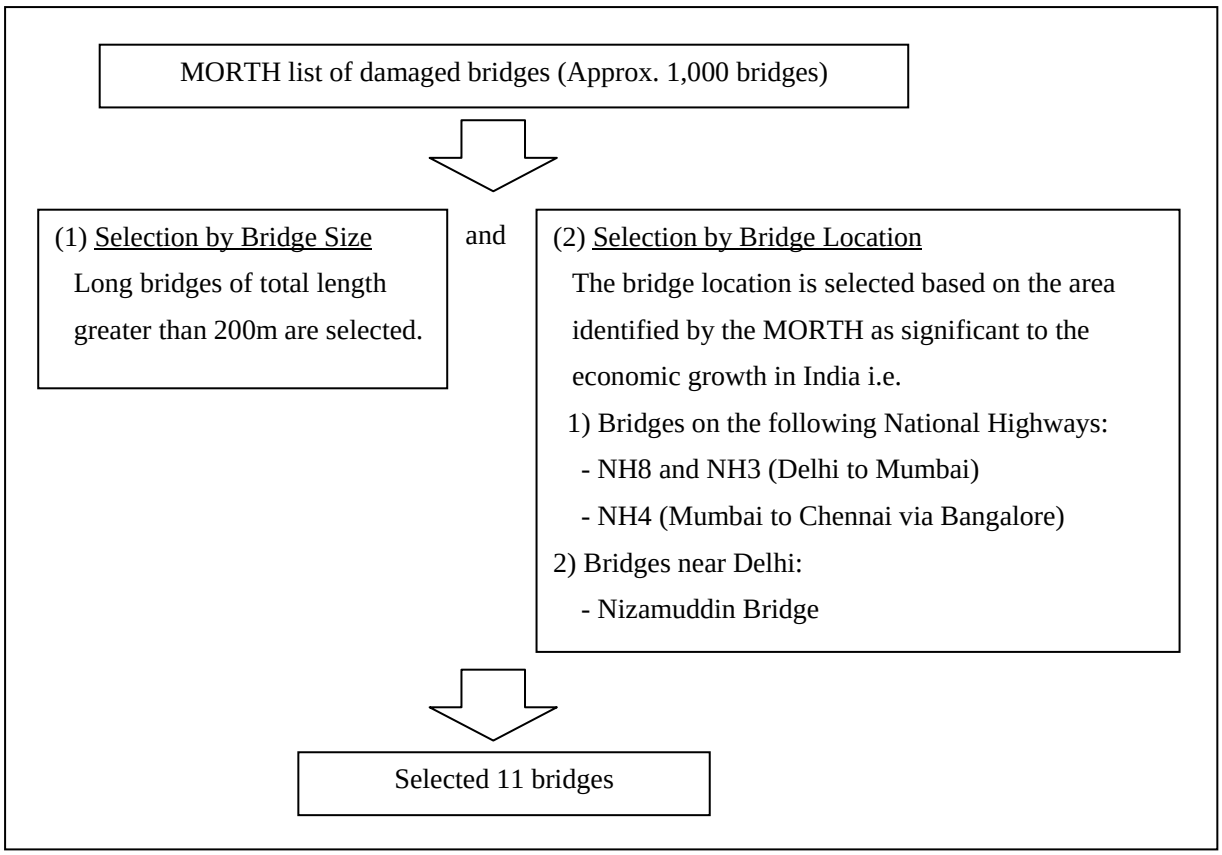
Table 2.1.2 Preliminarily Bridges Requested by MORTH (20 bridges)

State	NH No.	Bridge Name	State	NH No.	Bridge Name
Bihar	-	4 bridges (to be selected)	Odisha	-	4 bridges (to be selected)
Goa	NH17	Zuari Bridge	Assam	NH52	Jia-Bharali Bridge
		Borim Bridge		NH37A	Kaliabhomora Bridge
		Mandvi Bridge (old, new)		NH53	Sadarghat Bridge
		Khanderpar Bridge		NH44	Badarpurghat Bridge
Kerala	NH17	Mahe Bridge			
		Valapattanam Bridge			
		Perumba Bridge			
		Kariyangodu Bridge			

Source: JICA Survey Team

2) Preliminarily Bridges Selected by JICA Survey Team

From the list of approximately 1,000 damaged bridges, supplied by MORTH, the bridges were selected using the following procedure.



Source: JICA Survey Team

Figure 2.1.2 Preliminary Bridge Selection Procedure by JICA Survey Team

The list of preliminary selected bridges by JICA Survey Team is shown in Table 2.1.3.

Table 2.1.3 Preliminary Selected Bridges by JICA Survey Team

No.	Bridge Name	Bridge Basic Data
1	Purna Major Bridge (Gujarat, NH-8)	Bridge Type: PC-I girder Construction Year: 1959 Bridge Span: 2×34.79m+2×35.3m+2×35.375m+2×35.4m Bridge Length: 281.71m
2	Par River Bridge (Gujarat, NH-8)	Bridge Type: CRM Arches Construction Year: 1953 Bridge Span: 2×25.76m+3×27.13m+4×27.74m Bridge Length: 243.87m
3	Bridge name is unknown (Gujarat, NH-8E, Dhatarwadi River)	Bridge Type: Unknown Construction Year: Unknown Bridge Span: 10×19.8m+4×13.4m Bridge Length: 254m
4	Bridge name is unknown (Gujarat, NH-8E, Shetrunji River)	Bridge Type: Unknown Construction Year: Unknown Bridge Span: 10×24m Bridge Length: 242m
5	Bridge name is unknown (Gujarat, NH-8E, Medhacreek River)	Bridge Type: Unknown Construction Year: Unknown Bridge Span: 21×39.62m Bridge Length: 832.02m
6	Bridge name is unknown (Rajasthan, NH-8, Khari River)	Bridge Type: Unknown Construction Year: Unknown Bridge Span: 18×12m Bridge Length: 223m
7	Bridge name is unknown (Rajasthan, NH-8, Banas River)	Bridge Type: Unknown Construction Year: Unknown Bridge Span: 12×18m Bridge Length: 270m
8	Vaitama Bridge (Maharashtra, NH-8)	Bridge Type: RC-Box girder with center hinge Construction Year: 1966 Bridge Span: 2×12.2m+6×22.86m+3×27.43m Bridge Length: 243.85m
9	Bridge name is unknown (Maharashtra, NH-3, Tapi River)	Bridge Type: PC girder Construction Year: 1995 Bridge Span: 13×46m Bridge Length: 598m
10	Bridge name is unknown (Maharashtra, NH-3, Girna River)	Bridge Type: RC-T girder Construction Year: 2007 Bridge Span: 17×26.75m Bridge Length: 454.75m
11	Nizamuddin Bridge (near Delhi)	Bridge Type: PC-I girder Construction Year: Unknown Bridge Span: Unknown Bridge Length: Unknown

Source: JICA Survey Team

3) Result of Preliminary Bridge Selection Process

As a result, 31 bridges were chosen (consisting of (1) those requested by MORTH and (2) those identified by the JICA survey team) for the preliminary selection stage, as shown in Table 2.1.4.

Table 2.1.4 Preliminary Bridge Selection

No.	State	N.H. No.	Bridge Name
1 to 4	Bihar	-	To be discussed 4 bridges
5	Goa	NH17	Zuari Bridge
6			Mandvi Bridge (old, new)
7		NH17B	Borim Bridge
8		NH4A	Khanderpar Bridge
9	Kerala	NH17	Mahe Bridge
10			Valapattanam Bridge
11			Perumba Bridge
12			Kariyangodu Bridge
13 to 16	Odisha	-	To be discussed 4 bridges
17	Assam	NH52	Jia-Bharali Bridge
18		NH37A	Kaliabhomora Bridge
19		NH53	Sadarghat Bridge
20		NH44	Badarpurghat Bridge
21	Gujarat	NH8	Purna Major Bridge
22			Par River Bridge
23		NH8E	Dhatarwadi River (Bridge)
24			Shetrunji River Bridge
25			Medhacreek Bridge
26	Rajasthan	NH8	Khari River (Bridge)
27			Banas River (Bridge)
28	Maharashtra	NH8	Vaitama Bridge
29		NH3	Tapi River (Bridge)
30			Girna River (Bridge)
31	New Delhi	NH24	Nizamuddin Bridge

Source: JICA Survey Team

(2) First Bridge Selection

1) Meeting with MORTH

As a result of the meeting about these preliminary selected bridges with MORTH, 9 bridges in the states of Uttar Pradesh and the Himachal Pradesh were added, and several bridges, including those in the NHDP (National Highway Development Program), were deemed unnecessary and removed .

Table 2.1.5 Result of Meeting with MORTH

No.	State	N.H. No.	Bridge Name	Selected or Cancelled
1 to 4	Bihar	-	4 bridges (to be discussed)	Cancelled by MORTH
5	Goa	NH17	Zuari Bridge	
6			Mandvi Bridge (old, new)	
7		NH17B	Borim Bridge	
8		NH4A	Khanderpar Bridge	
9	Kerala	NH17	Mahe Bridge	
10			Valapattanam Bridge	
11			Perumba Bridge	
12			Kariyangodu Bridge	
13 to 16	Odisha	-	4 bridges (to be discussed)	Cancelled by MORTH
17	Assam	NH52	Jia-Bharali Bridge	
18		NH37A	Kaliabhomora Bridge	
19		NH53	Sadarghat Bridge	
20		NH44	Badarpurghat Bridge	
21	Gujarat	NH8	Purna Major Bridge	Cancelled due to NHDP
22			Par River Bridge	
23		NH8E	Dhatarwadi River (Bridge)	Cancelled by MORTH
24			Shetrunji River Bridge	
25			Medhacreek Bridge	
26	Rajasthan	NH8	Khari River (Bridge)	Cancelled due to NHDP
27			Banas River (Bridge)	
28	Maharashtra	NH8	Vaitama Bridge	Cancelled due to NHDP
29		NH3	Tapi River (Bridge)	Cancelled by MORTH
30			Girna River (Bridge)	
31	New Delhi	NH24	Nizamuddin Bridge	
Added 9 bridge				
1	Uttar Pradesh	NH730	Sharada Bridge	Added by MORTH
2			Ghaghra Bridge	
3	Himachal Pradesh	NH20A	Dehra Bridge (Beas River)	
4		NH88	Kandrour Bridge (Satluj River)	
5			Nadaun Bridge (Beas River)	
6		NH70	Man Khad Bridge	
7			Kheran Khad Bridge	
8			Swan River Bridge	
9			Shivbari Khad No. II Bridge	

Source: JICA Survey Team

2) Result of First Bridge Selection

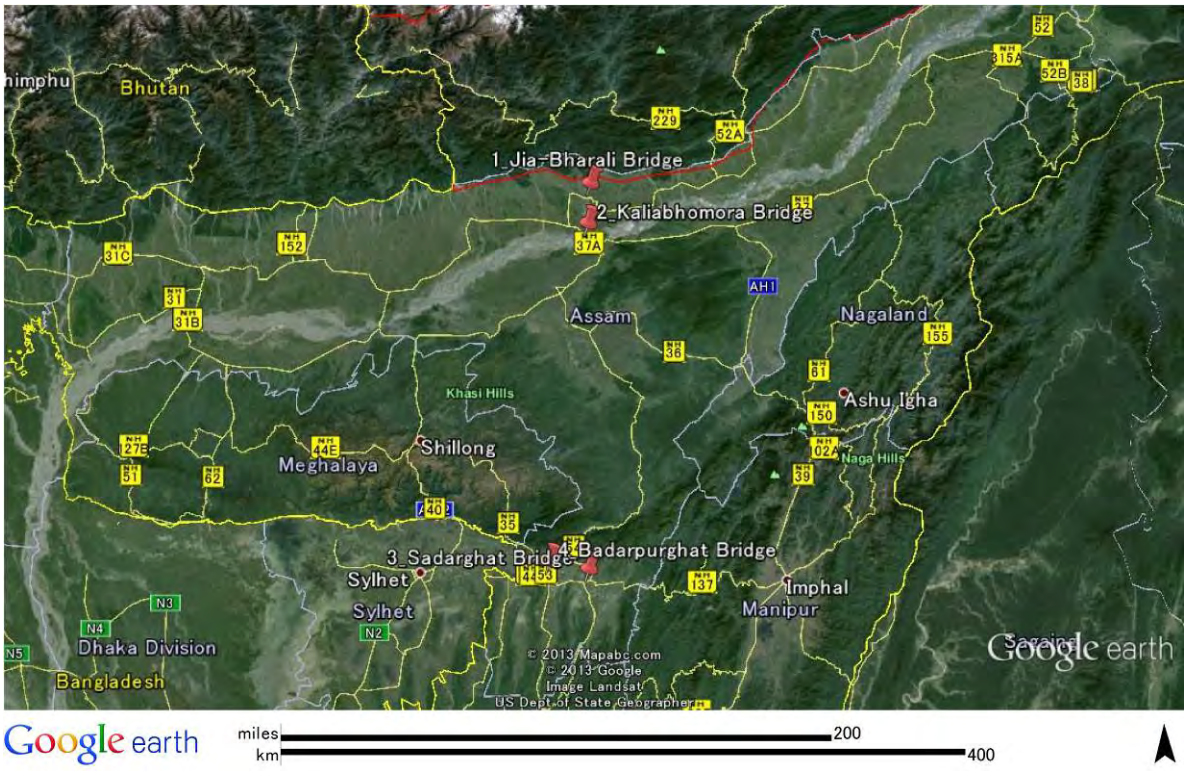
Taking this into account, the bridges in the first selection stage were finalized as the list shown in Table 2.1.6. These were the 25 bridges that proceeded to be inspected in the second field survey.

Table 2.1.6 Result of First Bridge Selection

No.	State	NH. No.	Bridge Name
1	Assam	NH52	Jia-Bharali Bridge
2		NH37A	Kaliabhomora Bridge
3		NH53	Sadarghat Bridge
4		NH44	Badarpurghat Bridge
5	Goa	NH17	Zuari Bridge
6			Mandvi Bridge (old)
7			Mandvi Bridge (new)
8		NH17B	Borim Bridge
9		NH4A	Khanderpar Bridge
10	Kerala	NH17	Mahe Bridge
11			Valapattanam Bridge
12			Perumba Bridge
13			Kariyangodu Bridge
14	Gujarat	NH8E	Shetrunji Bridge
15			Medhacreek Bridge
16	Delhi	NH24	Nizamuddin Bridge
17	Uttar Pradesh	NH730	Sharada Bridge
18			Ghaghra Bridge
19	Himachal Pradesh	NH20A	Dehra Bridge (Beas River)
20		NH88	Kandrour Bridge (Satluj River)
21			Nadaun Bridge (Beas River)
22		NH70	Man Khad Bridge
23			Kheran Khad Bridge
24			Swan River Bridge
25			Shivbari Khad No. II Bridge

Source: JICA Survey Team

The bridges' locations are shown from Figure 2.1.3 to Figure 2.1.9.

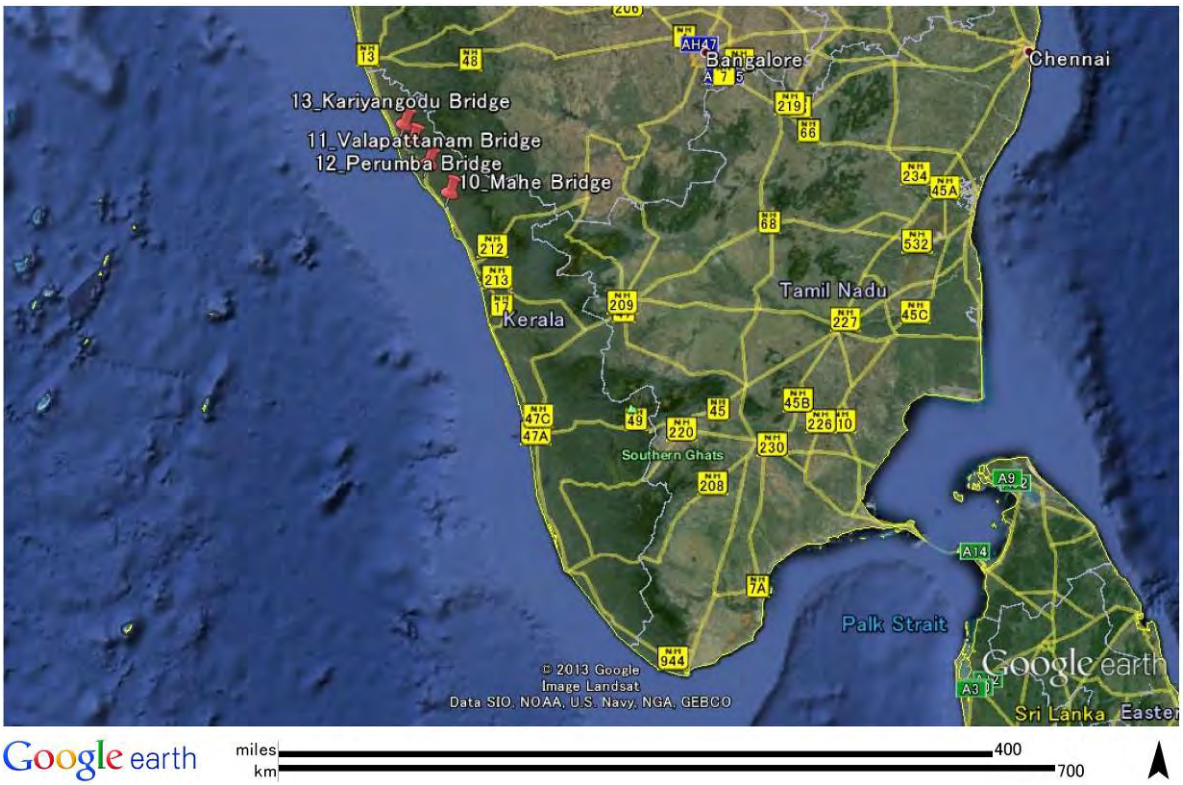


Source: JICA Survey Team/Google Earth

Figure 2.1.3 Bridge Location in Assam

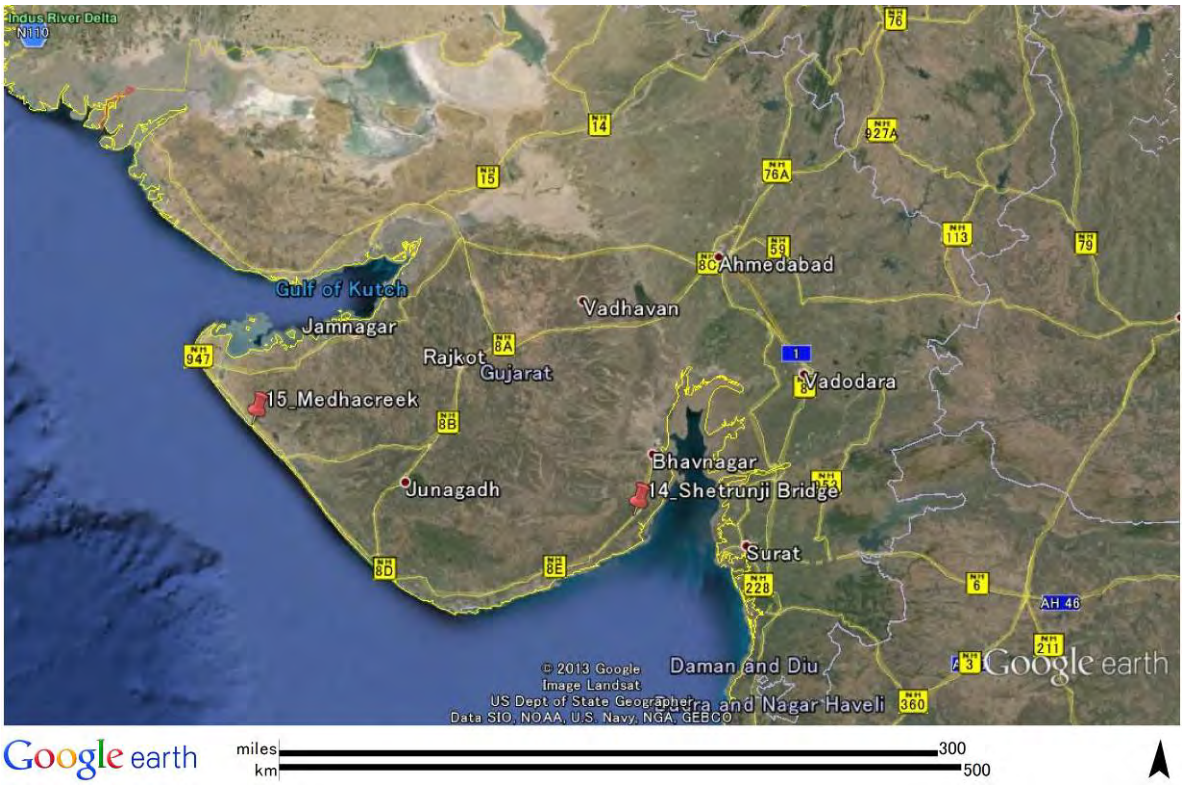
Source: JICA Survey Team/Google Earth

Figure 2.1.4 Bridge Location in Goa



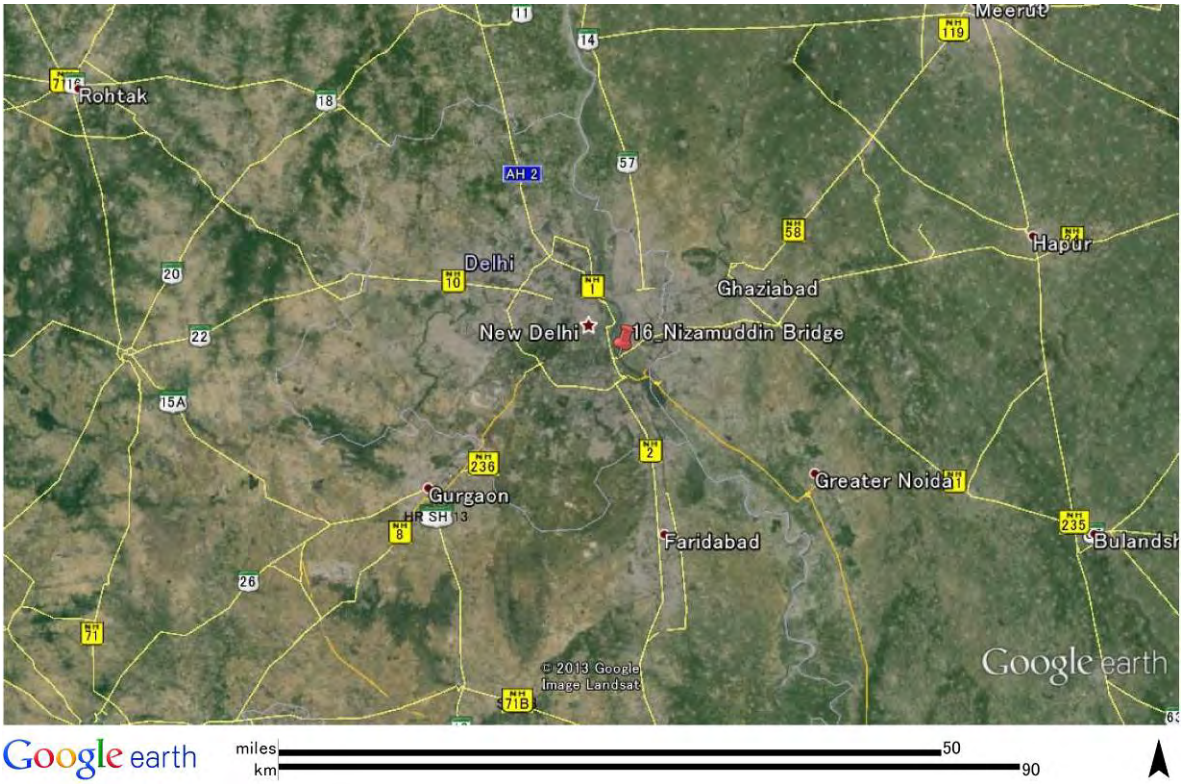
Source: JICA Survey Team/Google Earth

Figure 2.1.5 Bridge Location in Kerala



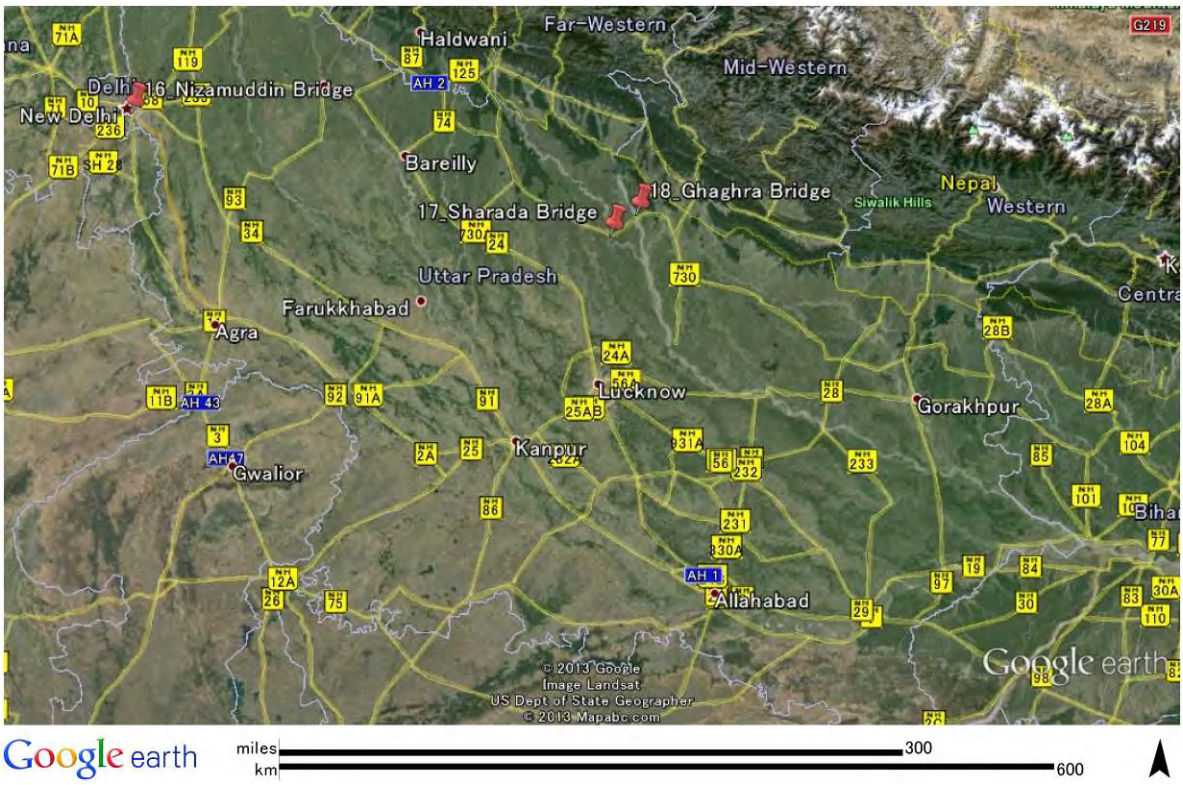
Source: JICA Survey Team/Google Earth

Figure 2.1.6 Bridge Location in Gujarat



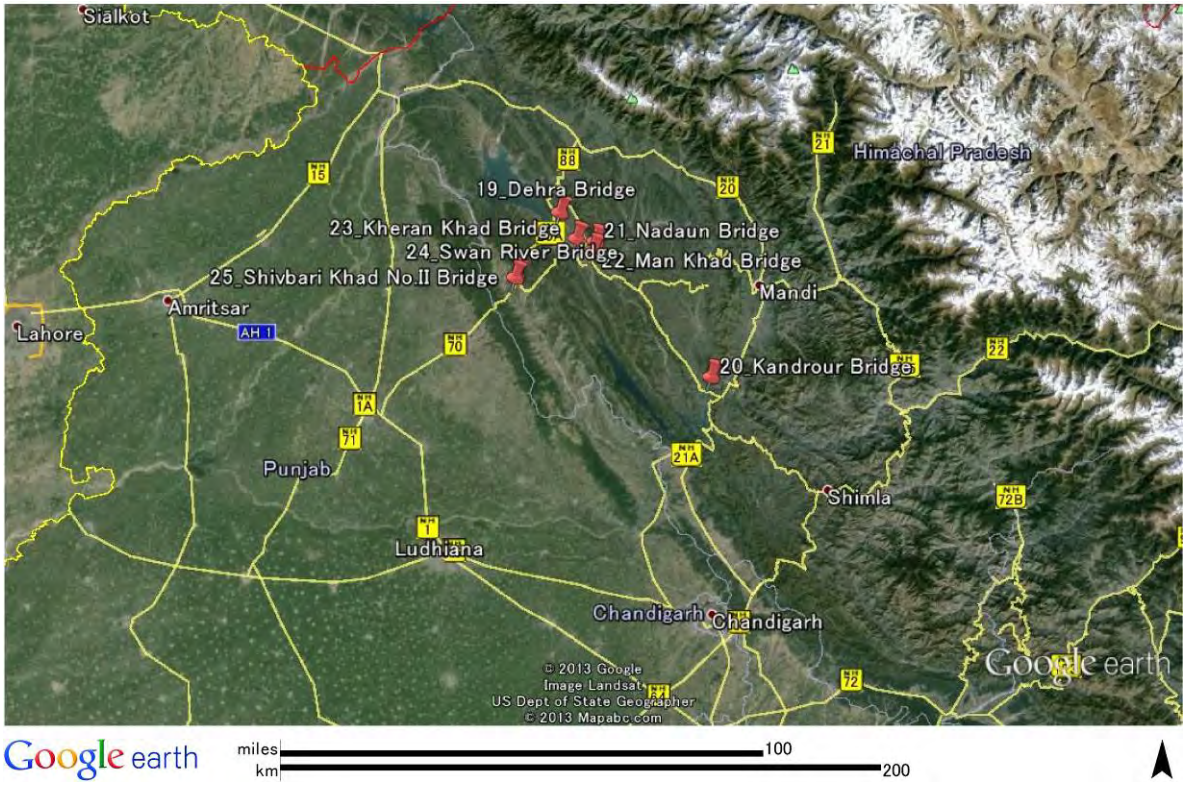
Source: JICA Survey Team/Google Earth

Figure 2.1.7 Bridge Location in New Delhi



Source: JICA Survey Team/Google Earth

Figure 2.1.8 Bridge Location in Uttar Pradesh



Source: JICA Survey Team/Google Earth

Figure 2.1.9 Bridge Location in Himachal Pradesh

3. FIRST FIELD SURVEY

3.1 Result of First Field Survey

3.1.1 Field Survey Schedule

The first field survey was conducted from the 15th of November, 2013 to the 30th of November, 2013.

Table 3.1.1 Field Survey Schedule

Date	Team-1	Team-2
15 (F)	Delhi - Nizamuddin Bridge	
16 (S)	Preparation for site survey	
17 (S)	Gujarat - Shetrunji Bridge - Medhacreek Bridge	Kerala - Mahe Bridge - Valapattanam Bridge - Perumba Bridge - Kariyangodu Bridge
18 (M)		
19 (T)		
20 (W)		
21 (T)	Move to Goa	
22 (F)	Goa - Khanderpar Bridge - Borim Bridge - Zuari Bridge - Mandvi Bridge (old) - Mandvi Bridge (new)	Uttar Pradesh - Sharada Bridge - Ghaghra Bridge
23 (S)		
24 (S)	Data arrangement	
25 (M)		Data arrangement
26 (T)		Assam - Jia-Bharali Bridge - Kaliabhomora Bridge - Sadarghat Bridge - Badarpurghat Bridge
27 (W)	Himachal Pradesh - Kandrour Bridge (Satluj River) - Nadaun Bridge (Beas River) - Man Khad Bridge - Kheran Khad Bridge - Dehra Bridge (Beas River) - Swan River Bridge - Shivbari Khad No. II Bridge	
28 (T)		
29 (F)		
30 (S)	Data arrangement	Move to Delhi

Source: JICA Survey Team

3.1.2 Result of First Field Survey

The results of first field survey are shown from Table 3.1.2 to Table 3.1.7.

Table 3.1.2 Summary of First Survey Result (1/6)

State	Bridge No.	NH No.	Bridge Name & Photo	Basic Data	Major Damages (by visual inspection)	Remarks
Assam	1	NH52	Jia-Bharali Bridge 	1. Superstructure: RC-T (Gerber girder) 2. Substructure: RC 3. Bridge Length: 625.4m 4. Span Length: 16.6 - 49.0m 5. Width: 7.8m (2-lane) 6. Year of Completion: 1962	- Some cracks on well cap.	- There is no alternative bridge that can be used to cross this river. - The bridge is of high importance to the surrounding society and economy..
	2	NH37A	Kaliabhomora Bridge 	1. Superstructure: PC Box (Gerber girder) +RC T 2. Substructure: RC 3. Bridge Length: 3,105m 4. Span Length: 67.5 - 120.0m 5. Width: 10.5m (2-lane) 6. Year of Completion: 1987	- Unequal level in deck slab of Gerber Girder in some spans	- Urgent rehabilitation work is necessary. - There is no alternative bridge that can be used to cross this river. - The bridge is of high importance to the surrounding society and economy.
	3	NH53	Sadarghat Bridge 	1. Superstructure: PC Box (Centre Hinge) 2. Substructure: RC 3. Bridge Length: 472m 4. Span Length: 15.86 - 121.0m 5. Width: 8.75m (2-lane) 6. Year of Completion: 1967	- End point of girders damaged at several locations. - Abnormal vibration at center hinge, and 10m span timber bridge are provided over the center hinge.	- Urgent rehabilitation work is necessary. - There is no alternative bridge that can be used to cross this river. - The bridge is of high importance to the surrounding society and economy. - Construction of a new bridge has been sanctioned by PWD.
	4	NH44	Badarpurghat Bridge 	1. Superstructure: PC Box (Centre Hinge) 2. Substructure: RC 3. Bridge Length: 359.44m 4. Span Length: 30.04 - 108.50m 5. Width: 10.5m (2-lane) 6. Year of Completion: 1972	- End point of girders damaged. - Abnormal vibration and 10m span steel bridge are provided over the center hinge.	- Urgent rehabilitation work is necessary. - There is no alternative bridge that can be used to cross this river. - The bridge is of high importance to the surrounding society and economy.

Source: JICA Survey Team

Table 3.1.3 Summary of First Survey Result (2/6)

State	Bridge No.	NH No.	Bridge Name & Photo	Basic Data	Major Damages (by visual inspection)	Remarks
Goa	5	NH17	Zuari Bridge 	1. Superstructure: PC Box (Centre Hinge) 2. Substructure: RC 3. Bridge Length: 809m 4. Span Length: 36-121m 5. Width: 7.5m (2-lane) 6. Year of Completion: 1982	- Re-bar corroded at EXP joint at center hinge. - Some peeling and re-bar exposed on girder. - Some broken EXP joints	- Repairs are needed at center hinge. - There is no alternative bridge that can be used to cross this river - Very high importance of the Bridge for surrounding society and economy.
	6	NH17	Mandvi Bridge (old) 	1. Superstructure: PC Box 2. Substructure: RC 3. Bridge Length: 741m 4. Span Length: 40m 5. Width: 7.5m (2-lane) 6. Year of Completion: 1993	- No major damages	- Very high importance of the Bridge for surrounding society and economy.
	7	NH17	Mandvi Bridge (new) 	1. Superstructure: PC Box 2. Substructure: RC 3. Bridge Length: 891m 4. Span Length: 40m 5. Width: 7.5m (2-lane) 6. Year of Completion: 1997	- No major damages	- Very high importance of the Bridge for surrounding society and economy.
	8	NH17B	Borim Bridge 	1. Superstructure: PC Box (Centre Hinge) 2. Substructure: RC 3. Bridge Length: 411 m 4. Span Length: 20-122m 5. Width: 7.5m (2-lane) 6. Year of Completion: 1983	- Level difference at center hinge. - Re-bar corroded at EXP joint at center hinge.	- Need repairing at center hinge. - There is no alternative bridge that can be used to cross this river. - The bridge is of high importance to the surrounding society and economy.
	9	NH4A	Khanderpar Bridge 	1. Superstructure: RC T 2. Substructure: RC 3. Bridge Length: 110m 4. Span Length: 12m 5. Width: 5.45m (2-lane) 6. Year of Completion: 1961	- Some cracks on lower flange and concrete pavement.	- There is an improvement plan with 4 lane beside existing bridge under NHDP.

Source: JICA Survey Team

Table 3.1.4 Summary of First Survey Result (3/6)

State	Bridge No.	NH No.	Bridge Name & Photo	Basic Data	Major Damage (by visual inspection)	Remarks
Kerala	10	NH17	Mahe Bridge 	1. Superstructure: RC T 2. Substructure: Stone Masonry 3. Bridge Length: 117m 4. Span Length: 23.4m 5. Width: 8.50m (2-lane) 6. Year of Completion: 1930 (1972)	- Some cracks on the lower flange, web and the bottom of the slab. - Some bearing shoes are broken. - Kerb height is not available.	- Urgent rehabilitation work is necessary. - Although there are plans for a 4-lane bypass 1km upstream under NHDP, this bridge is located between Mahe town and Puducherry, and is of high importance to the surrounding society and economy.
	11	NH17	Valapattanam Bridge 	1. Superstructure: RC Box 2. Substructure: RC 3. Bridge Length: 420.77m 4. Span Length: 8.3 - 31.09m 5. Width: 10.2m (2-lane) 6. Year of Completion: 1980	- Some cracking and honeycombing on the bottom of the slab. - Some cracks and CC peeling on surface of piers.	- Urgent repairing work for piers is necessary. - The bridge is of high importance to the surrounding society and economy.
	12	NH17	Perumba Bridge 	1. Superstructure: RC T 2. Substructure: Stone Masonry 3. Bridge Length: 146.8m 4. Span Length: 8 - 23.1m 5. Width: 6.7 m (2-lane) 6. Year of Completion: 1952	- Some cracks and efflorescence on web and bottom slab. - Some voids in bearing block of P6 - EXP joints are covered by asphalt and not functioning properly, and have some cracks.	- The bridge is of high importance to the surrounding society and economy. - Although there are plans for a 4-lane bypass 1km upstream under NHDP, this bridge needs very urgent superstructure rehabilitation.
	13	NH17	Kariyangodu Bridge 	1. Superstructure: RC T 2. Substructure: RC 3. Bridge Length: 186.75m 4. Span Length: 12.45m 5. Width: 6.7m (2-lane) 6. Year of Completion: 1963	- Some cracks on lower flange. - Bearing shoes has some cracks, peeling and no functioning properly.	- There are plans for a 4-lane bypass bridge 60m upstream under NHDP.

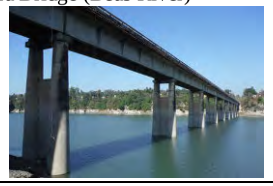
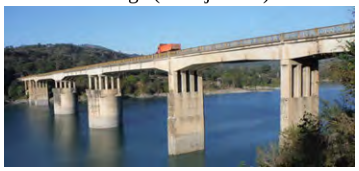
Source: JICA Survey Team

Table 3.1.5 Summary of First Survey Result (4/6)

State	Bridge No.	NH No.	Bridge Name & Photo	Basic Data	Major Damages (by visual inspection)	Remarks
Gujarat	14	NH8E	Shetrunji Bridge 	1. Superstructure: RC T 2. Substructure: RC 3. Bridge Length: 240m 4. Span Length: 10m 5. Width: 7.5m (2-lane) 6. Year of Completion: 1985	- A large degree of spalling on girder and wing wall of A1 abutment.	- Urgent rehabilitation work is necessary. - The bridge is of high importance to the surrounding society and economy.
	15	NH8E	Medhacreek Bridge 	1. Superstructure: RC Box 2. Substructure: RC 3. Bridge Length: 831m 4. Span Length: 39m 5. Width: 8.0m (2- lane) 6. Year of Completion: 1978	- A large degree of spalling on girder.	- Improvement (4-lane bridge) plan on 400m upstream - Existing bridge is to be turned into a pedestrian bridge and repair work is ongoing.
Delhi	16	NH24	Nizamuddin Bridge 	1. Superstructure: PC T 2. Substructure: RC 3. Bridge Length: 520m 4. Span Length: 40m 5. Width: 19.0m (4-lane) 6. Year of repair: 1982	- Some out-cable are broken and slacking (P1-P2, P2-P3). - Concrete spalling at P2 and P3. - Uneven gap in some EXP joints. - A large degree of peeling on pavement.	- Repairing of out-cables is possible by conventional repairing methods.
Uttar Pradesh	17	NH730	Sharada Bridge 	1. Superstructure: RC T 2. Substructure: RC 3. Bridge Length: 581m 4. Span Length: 52 - 53m 5. Width: 7.5m (2 lane) 6. Year of Completion: 1967	- Several cracks on girder web. - Numerous cracks on concrete pavement. - EXP joints are mostly broken, and uneven gaps are observed. - Footpath slab c.c. completely broken in 1.5m x 1.5m (approx.) size.	- There is no alternative bridge that can be used to cross this river. - Most cracks on girder were already repaired in 1981. - Urgent rehabilitation work is necessary.
	18	NH730	Ghaghra Bridge 	1. Superstructure: RC T 2. Substructure: RC 3. Bridge Length: 837m 4. Span Length: 51.82 - 52.46m 5. Width: 7.5m (2-lane) 6. Year of Completion: 1968	- Several cracks on girder web. - Numerous cracks on concrete pavement. - EXP joints are mostly broken, and uneven gap are observed.	- There is no alternative bridge that can be used to cross this river. - Most cracks on girder were already repaired in 1986. - Urgent rehabilitation work is necessary.

Source: JICA Survey Team

Table 3.1.6 Summary of First Survey Result (5/6)

State	Bridge No.	NH No.	Bridge Name & Photo	Basic Data	Major Damages	Remarks
Himachal Pradesh	19	NH20A	Dehra Bridge (Beas River) 	1. Superstructure: RCT & Box Girder 2. Substructure: RC Pier 3. Bridge Length: 357m 4. Span Length: 35m 5. Width: 7.5m (2 lane) 6. Year of Completion: 1962	- A crack and leaking water on P2. - Many cracks on concrete pavement.	- Rehabilitation work is necessary.
	20	NH88	Kandrour Bridge (Satluj River) 	1. Superstructure: PC T 2. Substructure: RC 3. Bridge Length: 280m 4. Span Length: 45m 5. Width: 11.7m (2 lane) 6. Year of Completion: 1962	- Some small cracks on girder web.	- Rehabilitation work is necessary. - According to PWD, fatal accidents occur frequently. Road safety measures required to be taken.
	21	NH88	Nadaun Bridge (Beas River) 	1. Superstructure: PC T 2. Substructure: RC 3. Bridge Length: 324m 4. Span Length: 45m 5. Width: 7.5m (2 lane) 6. Year of Completion: 1974	- Some honeycombing, efflorescence and unusual vibration were observed on girder. - Level difference at EXP joint of P6.	- Rehabilitation work is necessary. - There is no alternative bridge that can be used to cross this river nearby.
	22	NH70	Man Khad Bridge 	1. Superstructure: RC T 2. Substructure: Stone Masonry 3. Bridge Length: 181m 4. Span Length: 22m 5. Width: 4.25m (2 lane) 6. Year of Completion: 1968	- Much rebar exposure and corrosion on girders.	- There is no alternative bridge that can be used to cross this river nearby, but there is a planned new 2-lane bridge beside the existing bridge on the upstream side.

Source: JICA Survey Team

Table 3.1.7 Summary of First Survey Result (6/6)

State	Bridge No.	NH No.	Bridge Name & Photo	Basic Data	Major Damages	Remarks
Himachal Pradesh	23	NH70	Kheran Khad Bridge 	1. Superstructure: RC T 2. Substructure: RC 3. Bridge Length: 53m 4. Span Length: 13m 5. Width: 4.25m (2 lane) 6. Year of Completion: 1975	- Some spalling and re-bar exposed on girder. - All EXP joints are covered by pavement and not functioning properly.	- Rehabilitation work is necessary.
	24	NH70	Swan River Bridge 	1. Superstructure: RC T 2. Substructure: Stone Masonry 3. Bridge Length: 175m 4. Span Length: 13m 5. Width: 7.0m (2 lane) 6. Year of Completion: 1968	- Some spalling on girder concrete. - Slight scouring at P2.	- Rehabilitation work is necessary.
	25	NH70	Shivbari Khad No. II Bridge 	1. Superstructure: RC T 2. Structure: Stone Masonry 3. Bridge Length: 41m 4. Span Length: 13m 5. Width: 7.0m (2 lane) 6. Year of Completion: 1968	- Slight scouring at some piers.	- Rehabilitation work is necessary.

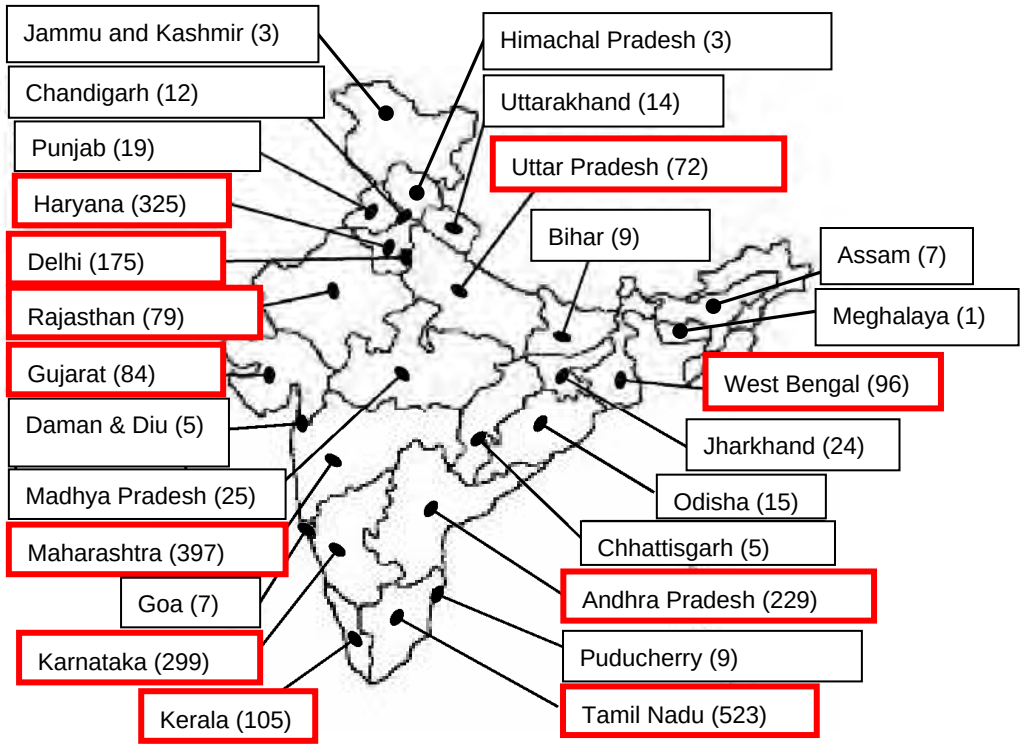
Source: JICA Survey Team

3.2 Extraction of the Issues with the Introduction of Japanese Repair Technology

3.2.1 Interview of Japanese Companies in India

(1) Advance of Japanese Companies into India

A total of 1,072 Japanese companies have markets in India and these companies have total of 2,542 footholds which consist of (i) overseas offices, (ii) subsidiaries and (iii) factories as shown in Figure 3.2.1.



Source: List of Japanese Companies in India [JETRO (Jan. 2014)]

Figure 3.2.1 Number of Footholds of Japanese Companies in India (by State)

Among the Japanese companies in India, the major companies associated with the construction and business sectors are listed in Table 3.2.1.

Table 3.2.1 Major Japanese Construction and Business Companies in India

Main Business	Company Name	Location of Offices / Subsidiaries in India (State Name [City Name])										
		Delhi [Delhi]	Haryana [Gurgaon]	Gujarat [Ahmedabad, Vadodara]	Maharashtra [Mumbai, Pune]	Goa [Goa]	Karnataka [Bengaluru]	Kerala [Cochin]	Tamil Nadu [Chennai]	Andhra Pradesh [Hyderabad]	Jharkhand [Jamshedpur]	West Bengal [Kolkata]
Construction	Kajima Corporation	X	X	X								
	Taisei Corporation		X									X
	Shimizu Corporation	X			X		X		X			
	Sumitomo Mitsui Construction Co., Ltd.	X		X	X		X		X			
	Maeda Corporation	X							X			
	Penta-Ocean Construction Co., Ltd.		X									
	Nishimatsu Construction Co., Ltd.									X		
	Fujita Corporation								X			
Manufacturing	JFE Engineering Corporation				X							
Steel Mill	JFE Steel Corporation		X		X							
	Nippon Steel & Sumitomo Metal Corporation	X									X	X
Industry	Hitachi Zosen Corporation		X	X	X					X		
	IHI Corporation	X						X				
Business	Marubeni Corporation	X			X	X			X			X
	Mitsui & Co., Ltd.	X			X				X			X
	Mitsubishi Corporation	X			X		X		X			X
	Sumitomo Corporation	X			X				X			
	Sojitz Corporation	X	X		X				X			X

Source: List of Japanese Companies in India [JETRO (Jan. 2014)]

(2) Interview of Japanese Companies in India / Japan

Some major Japanese companies associated with the construction and business sectors were interviewed in relation with the following matters;

(i) Beneficial Areas for Japanese Companies in India
(ii) Japanese Advanced Technologies for bridge repair to be applied in India
(iii) Issues with the introduction of Japanese Advanced Technology for bridge repair in India
(iv) Interest in entering the Indian bridge market

In addition, some Japanese construction companies were interviewed regarding to the above (iv). The interviewees are listed in Table 3.2.2.

Table 3.2.2 Results of Interviews

No.	Main Business	Company Name	Location of Interview	Remarks
A1	Construction	Shimizu Corporation	India	
A2		Obayashi Corporation	India	Only registration in India
A3		Kajima Corporation	India	
A4		Sumitomo Mitsui Construction Co., Ltd.	India	
A5		Penta-Ocean Construction Co., Ltd.	India	
A6		Maeda Corporation	Japan	
A7		Fujita Corporation	Japan	
A8		Nishimatsu Construction Co., Ltd.	Japan	
A9		The Zenitaka Corporation	Japan	No foothold in India
A10		Hazama Ando Corporation	Japan	No foothold in India
A11		Dai Nippon Construction	Japan	No foothold in India
A12		Daiho Corporation	Japan	No foothold in India
B1	Manufacturing	JFE Engineering Corporation	India	
B2		IHI Infrastructure Systems co., Ltd.	Japan	No foothold in India
C1	Steel Mill	JFE Steel Corporation	Japan	
C2		Nippon Steel & Sumitomo Metal Corporation	Japan	
D1	Industry Business	IHI Corporation	India	
E1		Sumitomo Corporation	India	
F1	Public	Japan External Trade Organization (JETRO)	India	

Source: JICA Survey Team

(3) Beneficial Areas for Japanese Companies in India

Based on the interviews conducted with the Japanese companies in Table 3.2.2, the beneficial areas for Japanese companies in India are located along the two major industrial corridors; e.g. (i) Delhi – Mumbai Industrial Corridor (DMIC) and (ii) Peninsular Region Industrial Development (PRIDe) Corridor. The Chennai - Bangarole Industrial Corridor, which is part of PRIDe Corridor, is particularly expected to promote investment and business. This is because JICA signed a Japanese ODA loan agreement with the Government of India in New Delhi to provide up to 13 billion yen for the Tamil Nadu Investment Promotion Program on November 12, 2013.

2,111 footholds of Japanese companies, which accounts for 83 %, of the total, are located in 8 states along the aforementioned 2 corridors as shown in Figure 3.2.2.

Corridors	State Name	Main City Name	No. of Japanese Footholds
DMIC	Delhi	Delhi	175
	Haryana	Gurgaon	325
	Rajasthan	Jaipur	79
	Gujarat	Vadodara, Dahej	84
	Maharashtra	Mumbai, Pune	397
PRIDe	Karnataka	Bengaluru	299
	Tamil Nadu	Chennai	523
	Andhra Pradesh	Hyderabad	229
Total			2,111

Source: JICA Survey Team

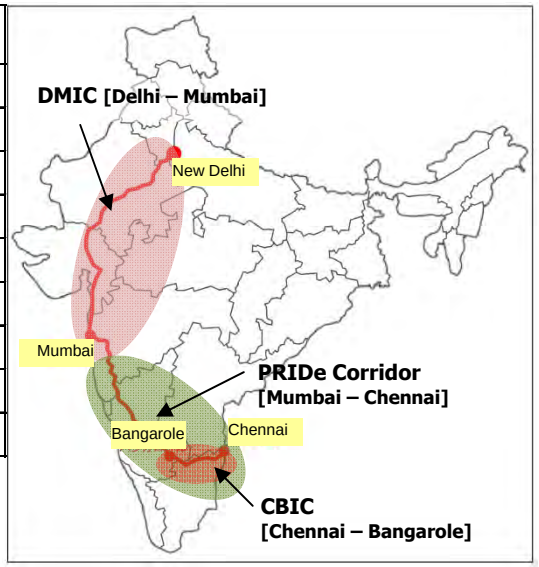


Figure 3.2.2 Higher Beneficial Area for Japanese Companies in India

3.2.2 Japanese Advanced Technologies for Bridge Repair

Based on the interviews with the Japanese companies, the Japanese advanced technologies which can be applied for bridge repair in India, including partial replacement and additional reinforcement, are listed in Table 3.2.3 and explained in more detail in Figure 3.2.3.

Table 3.2.3 Japanese Advanced Technology to be applied in India

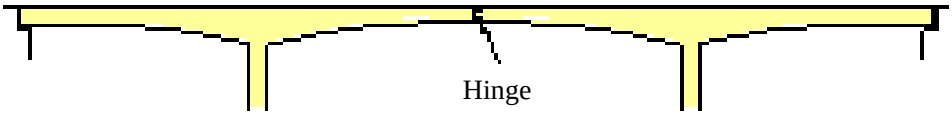
Japanese Technology Name	Features	Main Application
Centre Hinge Connection Method	This is an effective reinforcement method for bridges with center hinges.	Centre hinges of concrete box girder (Detour roads or temporary bridges are required.)
Reinforcement using High Modulus Carbon Fiber	This technology is effective in bridges which have been damaged from salt and overloaded vehicles. This technology minimizes influence on the substructure because it does not increase the weight of superstructures. Also, it is effective in bridge foundations requiring reinforcement against earthquakes.	Slabs, girders and piers of concrete bridges in coastal and/or earthquake-prone areas
Out Plate Method	This technology is effective in bridges which have been damaged by overloaded vehicles. Carbon-Fiber Reinforced Plastic (CFRP) Plating is utilized.	Girders of concrete bridges with serious damage requiring prestressing
Epoxy Coated Reinforcing Bar	This technology is effective in bridges which have been damaged by salt attack. It has a high durability for corrosion. And it is suitable to replace the corroded rebar with damage such as cracking and exfoliation of concrete in coastal areas.	Slabs, girders and piers of concrete bridges with corroded rebar in coastal areas
Epoxy Coated and Filled Strand Cable (ECF Strand)	This technology is effective in bridges which have been damaged by salt attack and require external prestressing.	Girders of concrete bridges requiring external prestressing in coastal areas
Bearing using Plasma Thermal Spraying	This technology is effective for the replacement of the existing bearings which have been damaged by salt attack. It has a high durability for corrosion.	Bearings in coastal areas
Reinforcement of Bridge Foundation (Steel Pipe Sheet Piles / Additional Piles)	This technology is effective in bridge foundations that have undergone severe scouring and/or require reinforcement against earthquake.	Bridge foundations undergoing scouring and/or having insufficient seismic resistance
Weathering steel of the superstructures	This technology is effective for the replacement of the existing superstructures. The weathering steel features are lightweight and need minimum maintenance. However, it cannot be applied in coastal areas.	Superstructures of concrete bridges excluding coastal areas

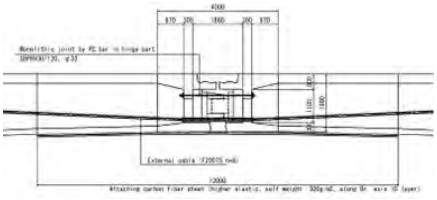
Source: JICA Survey Team

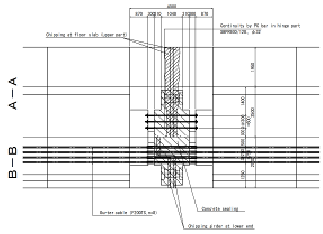
Centre Hinge Connection Method

In this method, part of the center hinge is removed and replaced with both box girders using the concrete and PC wires. Removing the center hinges makes maintenance free in center hinges, and extensive maintenance technology and traffic restriction will not be necessary. This reduces maintenance costs.

However, in the case of long-span bridges, connecting all spans with this method is sometimes impossible due to excessive restraint forces due to temperature change. In this case, the Maurer Expansion Joints can be applied.



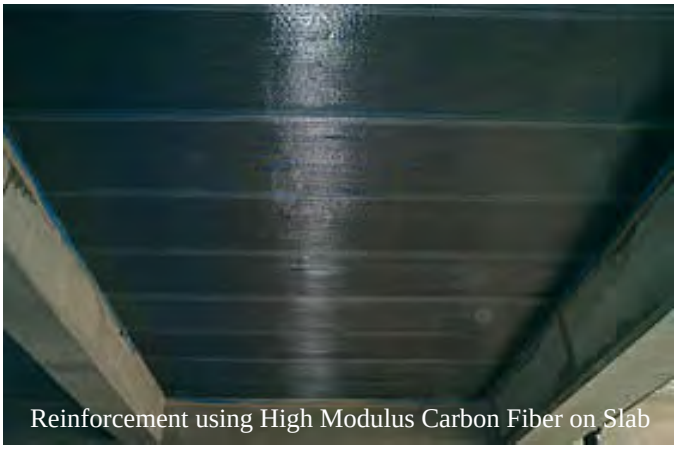





Maurer Expansion Joint

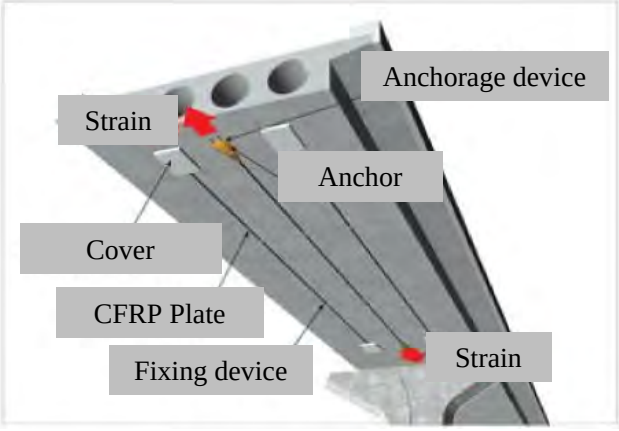
Reinforcement using High-Modulus Carbon Fiber

Bridges damaged by salt can be reinforced using high-modulus carbon fiber.


Reinforcement using High Modulus Carbon Fiber on Slab

Out Plate Method

This method reinforces the existing concrete through pre-stressing using the carbon-fiber reinforced plastic (CFRP) plating. This method can give pre-stress in the existing concrete girder, and the existing concrete can get high reinforcing effects.



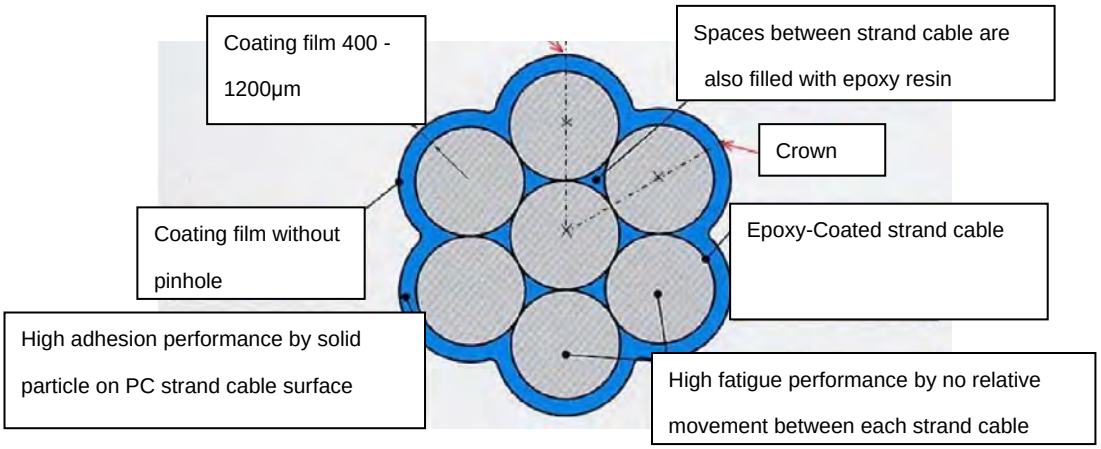
Epoxy Coated Reinforcing Bar

This method uses the epoxy coated reinforcement bar. This reinforcement has high anti corrosion property and is adopted to replace the reinforcement in areas affected by salt.


Epoxy Coated Reinforcing Bar

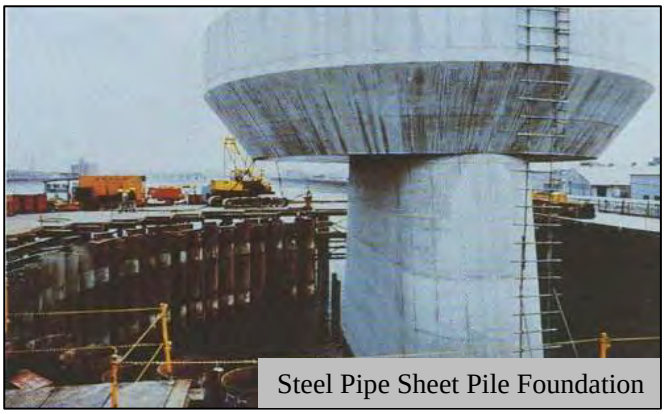
Epoxy Coated and Filled Strand Cable

The Epoxy Coated and Filled Strand Cable (ECF Strand) is PC strand cable with coating by epoxy resin. The spaces between each ECF Strand are filled by epoxy material. The ECF Strand has high anti corrosion property and is adopted in areas affected by salt.



Reinforcement of Bridge Foundation
(Steel Pipe Sheet Piles / Additional Piles)

This method is adopted for protection against scouring and seismic reinforcement for foundations of existing bridges using Steel Pipe Sheet Piles and additional piles. Mainly, the Steel Pipe Sheet Pile foundations are used in the river and the additional piles are used on land.



Steel Pipe Sheet Pile Foundation

Plasma Thermal Spraying on Bearings

The aluminium (95%) and magnesium (5%) plasma thermal spraying is applied to bearings susceptible to corrosion.

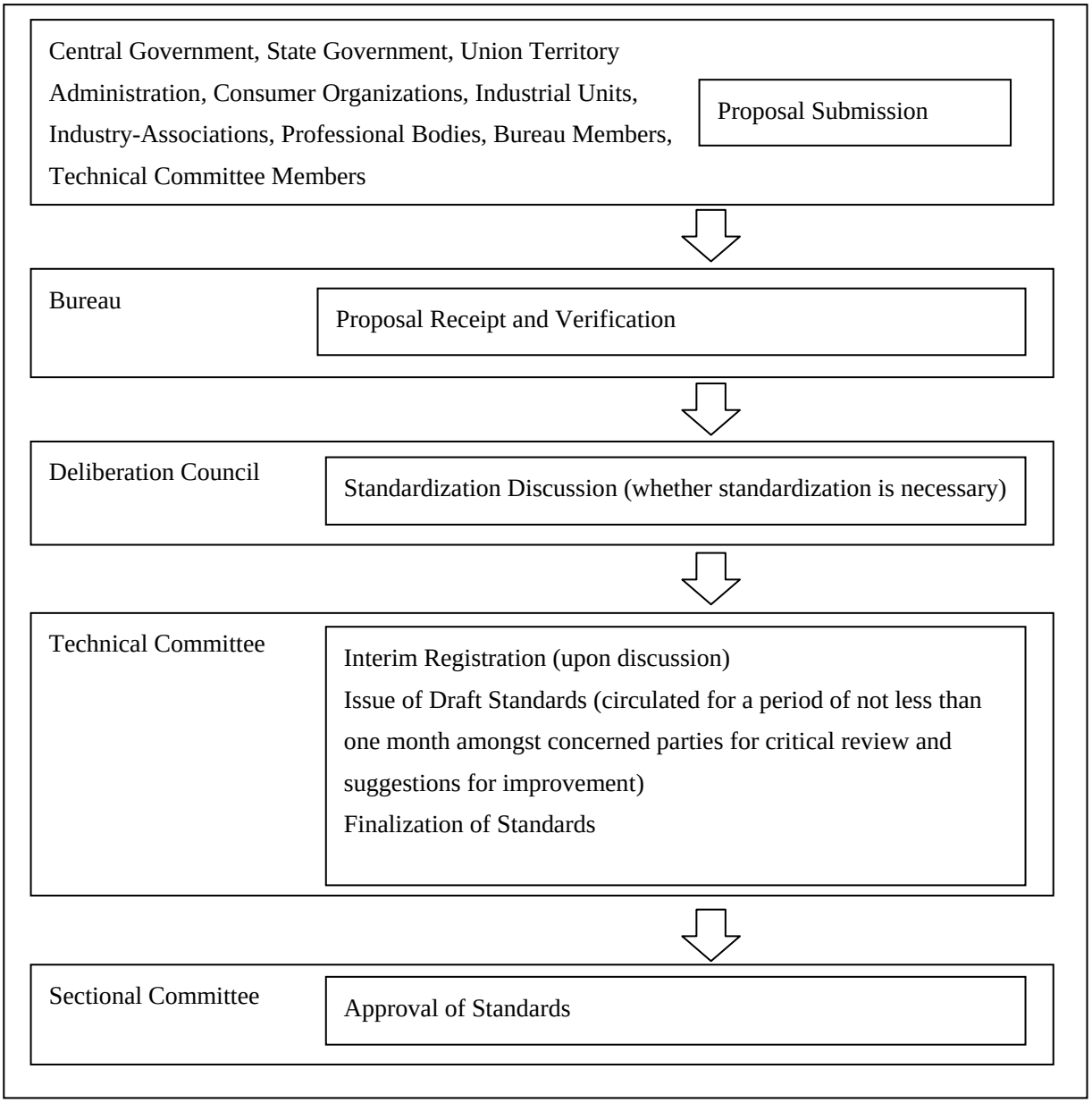
Figure 3.2.3 Japanese Advanced Technology

3.2.3 Issues with the Introduction of Japanese Advanced Technology for Bridge Repair in India

Based on the interviews with the Japanese companies, the following issues appear to apply to the Japanese advanced technologies in India.

(1) Standardization in Indian

In India, it is required that all technologies be certified by the Indian Standards, developed by the Bureau of Indian Standards (BIS). However, the Japanese technology to be utilized in this project has not yet been certified. The certification by the BIS usually takes approximately 6 to 10 years, but this can be shortened to period of 2 to 3 years if the technology is approved for special certification. The general process of acquiring certification is shown in the figure below.



Source: JICA Survey Team / http://www.bis.org.in/sf/pros_setting_std.asp

Figure 3.2.4 Process of BIS Certification

It generally takes a great deal of time from the submission of a proposal until the commencement of deliberation by the Technical Committee. If the BIS and each ministry come to a mutual agreement, the processing time can be shortened.

However, Japanese technology can be applied in JICA loan projects even without the certification of BIS, so long as the corresponding authorities who control and manage the project certify its application. In the case of the MORTH, deliberation is carried out by the CRRI (Central Road Research Institute) or the IRC (Indian Roads Congress) using almost the same procedure as BIS, and then the certification by the MORTH takes several years.

(2) Defect Liabilities and Design Responsibilities

As the results of first and second field survey, it is difficult to obtain the as-built and/or the detailed design drawings because almost of the bridges selected in the first and second stages were constructed more than 40 – 50 years ago. Therefore, the design for bridge repair will be conducted based on the structural calculation with many assumptions or empirical methods considering the damage conditions. Also, the contractors will hold their own inspections before commencement of the works and may propose changes to the design and methods. If some wrong matters or lower effects which were expected in design are observed after completion of the rehabilitation works, it is possibility for the design consultants and/or the contractors to be called the design responsibilities and/or defect liabilities. Therefore, it is necessary to clearly allocate the responsibility for these issues before the commencement of the works.

3.2.4 Interest about the Entry into Indian Market of Bridge Sector

The Japanese construction companies essentially don't have any interest in the entry into the Indian bridge market including STEP projects.

Some Japanese manufacturing/steel mill companies were showed interest in entry into the Indian market. However, they have to find construction companies to set up joint-ventures.

3.3 Environmental and Social Impacts

In this chapter, possible environmental and social impacts based on the preliminary environmental examination on the first site survey are summarized.

3.3.1 Natural and Social Features

Based on the existing information, environmental and social conditions around the respective project sites are reviewed in the following sections.

(1) Social Aspect

The populations of each state containing one or more of the project sites are given in the Table 3.3.1.

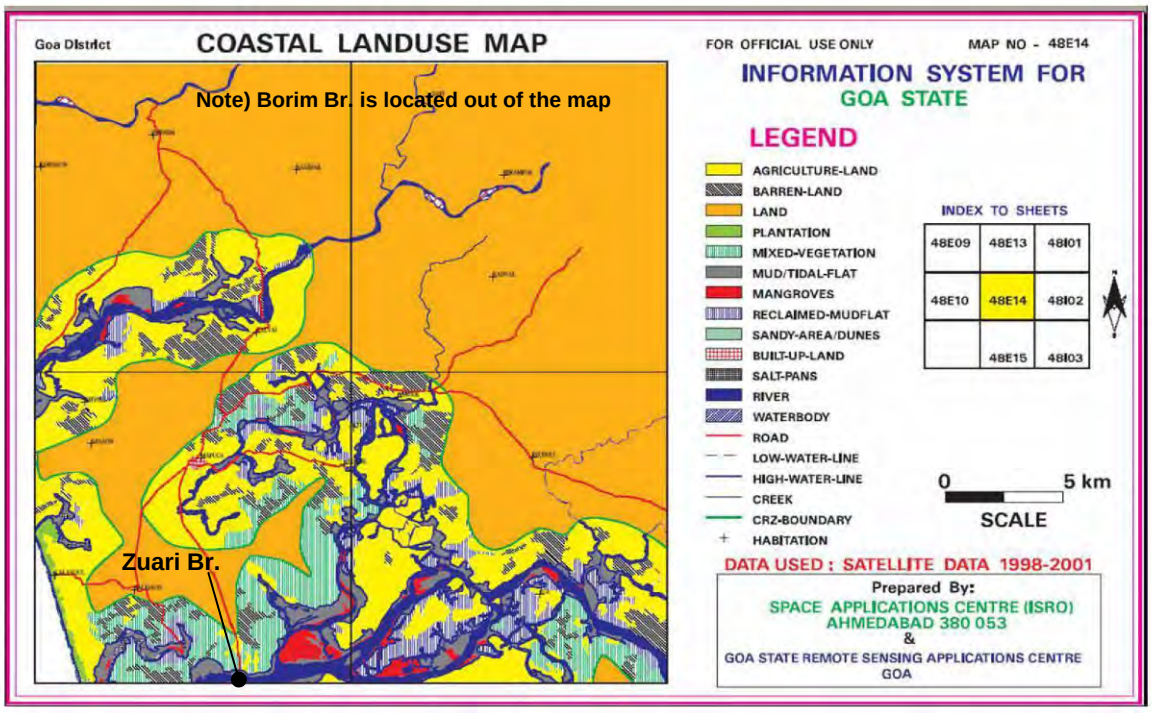
Table 3.3.1 Capital City and Population of the States that Candidate Bridges Located

Location (State)	Capital city	Population (2011)
Assam	Dispur	31,205,576
Goa	Panaji	1,458,545
Kerala	Thiruvananthapuram	33,406,061
Gujarat	Gandhinagar	60,439,692
Maharashtra	Mumbai	112,374,333

Source: 2011 Census Data, Government of India, Ministry of Home Affairs

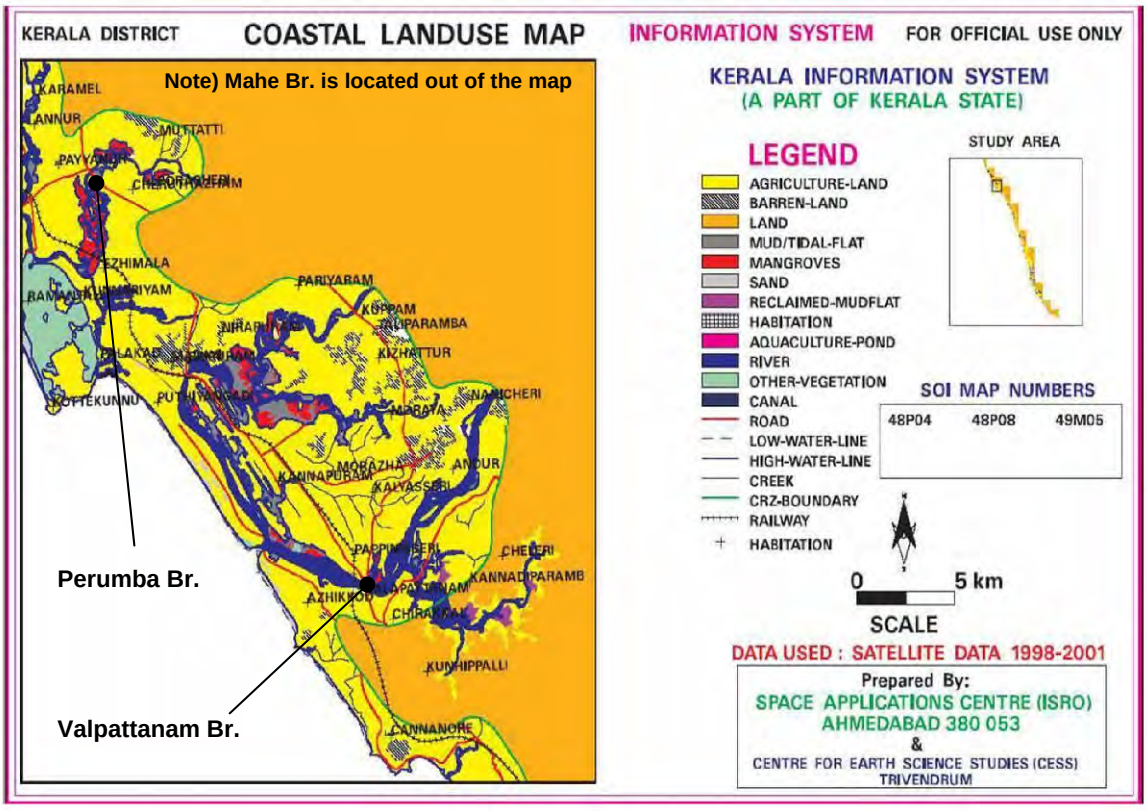
(2) Natural Aspect

All target bridges, other than those in Assam State, are located near coastal areas. Mangrove vegetation and swampy grass areas are observed around these bridges. Thus, these bridges are distributed in the Coastal Regulation Zone (hereinafter referred to as “CRZ”. Land use maps and CRZ maps are shown on the following pages.



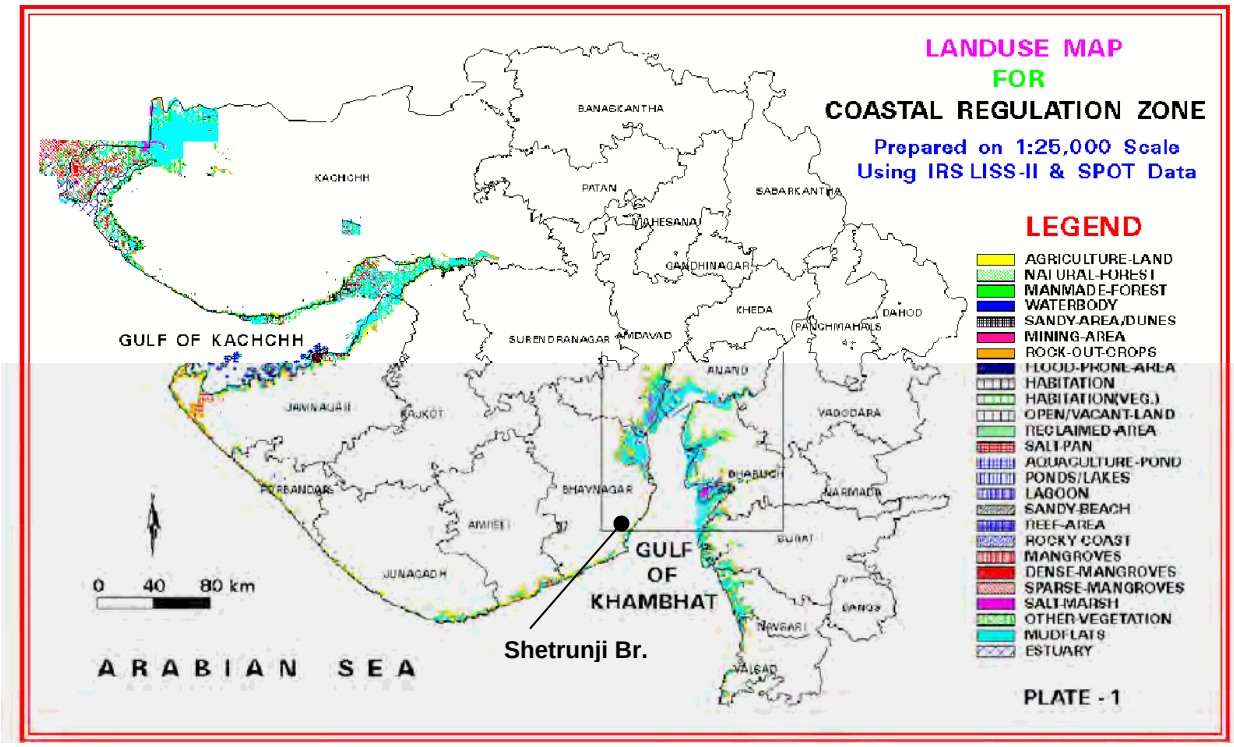
Source: Coastal Zones of India Published by Space Applications Centre

Figure 3.3.1 Land Use Map and the Location of the Project Site of Goa



Source: Coastal Zones of India Published by Space Applications Centre

Figure 3.3.2 Land Use Map and the Location of the Project Site of Kerala



Source: Coastal Zones of India Published by Space Applications Centre

Figure 3.3.3 Land Use Map and the Location of the Project Site of Gujarat

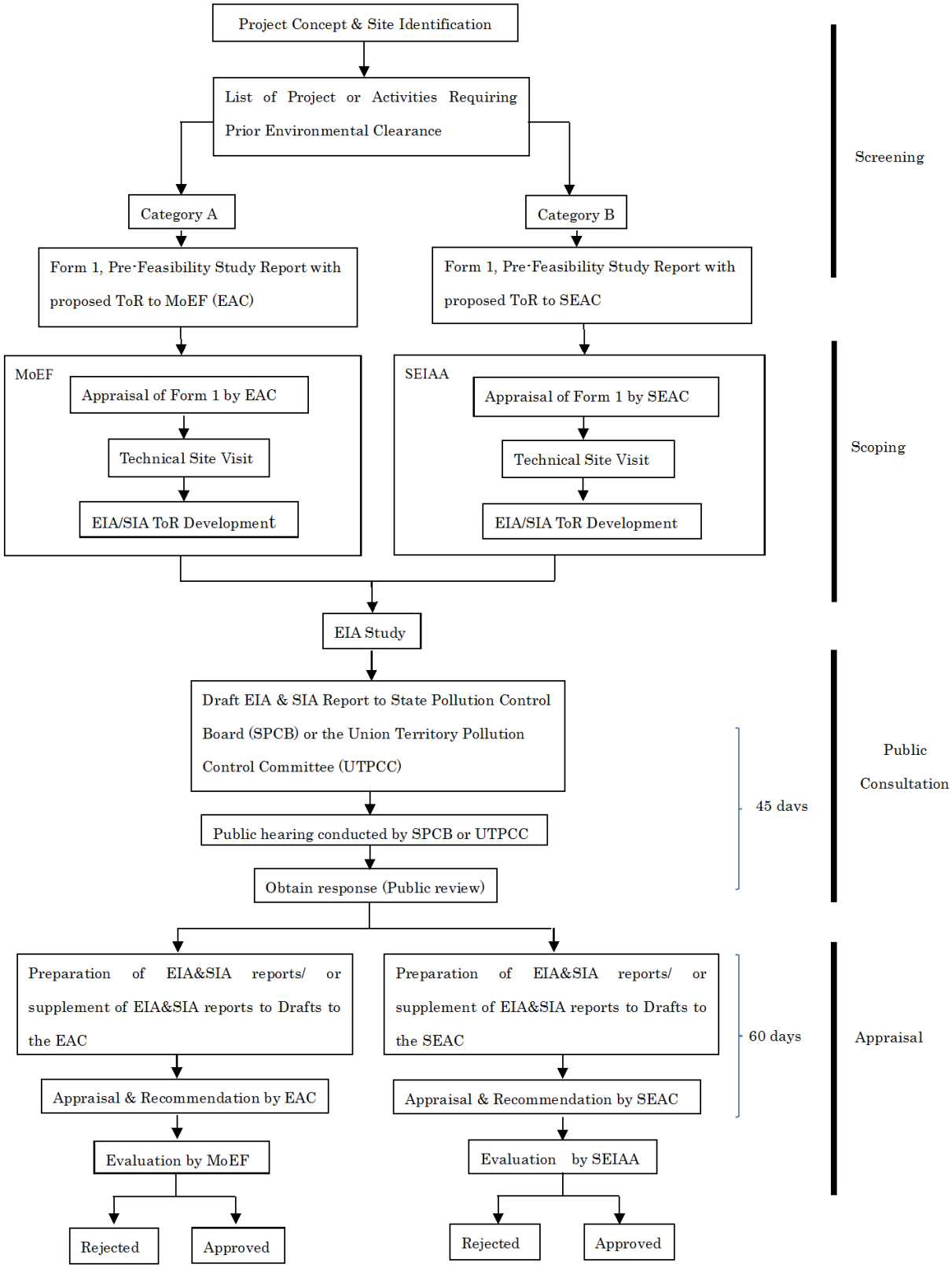
3.3.2 Related Environmental Legislation

(1) EIA Law (Environmental Impact Assessment Notification (2006, 2009 and 2012))

In India, EIAs are stipulated in The Environment (Protection) Act, 1986, and related processes are described in Environmental Impact Assessment Notification (2006, 2009 and 2012). According to the EIA Notification (2006), projects listed in the SCHEDULE require prior Environmental Clearance (EC). All projects and activities are broadly categorized into two categories - Category A and Category B, based on the type and size of the projects.

Projects included as Category A will require prior environmental clearance from the Central Government in the Ministry of Environment and Forests (MoEF) on the recommendations of an Expert Appraisal Committee (EAC). Projects included as Category 'B' in the schedule will require prior environmental clearance from the State/Union territory Environment Impact Assessment Authority (SEIAA). The SEIAA shall base its decision on the recommendations of State or Union territory level Expert Appraisal Committees (SEAC).

The process of obtaining EC is shown in Figure 3.3.4.



Source: JICA Study Team (based on Environmental Impact Assessment Notification (2006, 2009 and 2012))

Figure 3.3.4 Flowchart of EIA

Bridge projects are not included in the mandatory list of the projects that require environmental impact assessment with environmental clearance (EC). According to a survey with environmental agencies in

each state, the actual screening is conducted by Ministry of Environment and Forest (MoEF). In general, EC is not required when rehabilitation activities are limited, such as replacement of superstructures. However EC is required in case of new bridge construction, even when the new bridge is constructed adjacent to the existing bridge.

(2) Coastal Regulation Zone (Coastal Regulation Zone Notification (2011))

Coastal Regulation Zone Notification (2011) restricts setting up and expansion of industries, operations and processes in the Coastal Regulation Zone (hereinafter referred to as "CRZ") in order to ensure the livelihood and security of the community living in coastal zones, as well as to protect coastal environment. CRZ is strictly classified and activities subjected to the CRZ are categorized into the permissible activities and prohibited activities. For those permissible activities, acquisition of the clearance is required and the process of seeking clearance is described in the notification. Regarding the projects, some bridges in coastal states such as Gujarat, Goa and Kerala are subjected to the designated CRZ. The necessity of the clearance for CRZ is determined depending on the type of activities and location.

(3) Land Acquisition (Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act (2013))

Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act (2013) received the consent of the President of India on September 2013 and it came into effect from the 1st of January 2014. This new law stipulates not only appropriate compensation for landowners, but also rights for people with livelihood on the affected land. The fundamental principle of the new law is shown below;

- Clarification of purpose for land acquisition
- Amendment of compensation policy (fair evaluation methodology for compensation and disclosure, compensation for landowners and people with livelihood on the affected land)
- Obligation of social impact assessment
- Restriction of unintended use after land acquisition
- Monitoring of land acquisition process by state government and central government

With regards to this project, land acquisition as well as resettlement based on this act may be required when existing bridges with approach roads need to be replaced with new bridges. If this takes place, Social Impact Assessment will need to be conducted.

(4) Other relevant laws

Other related Environmental Policies and Regulations in India are shown in Table 3.3.2

Table 3.3.2 Related Environmental Legislation

No.	Name	Year
1	Environmental（Protection）Act	1986
2	Environment Impact Assessment Notification	2006, 2009, 2012
3	Forest Conservation Act	1927, 1980
4	National Forest Policy	1952, 1988
5	Coastal Regulation Zone Notification	2011
6	Wildlife（Protection）Act	1972
7	Land Acquisition Act	1894, 1989
8	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act	2013
9	Air（Prevention and Control of Pollution）Act）	1981
10	Hazardous Waste(Management and Handling) Rules）	1989, 2003
11	Municipal Solid Waste（Management and Handling）Rules）	2000
12	Noise Pollution Regulation and Control Rule）	2000
13	Water(Prevention and Control of Pollution) Act）	1974

Source: JICA Study Team

3.3.3 Key Items to be Evaluated

Several key items are selected as indicators for final 8 candidate bridges based on the natural and social environment features at the each bridge through preliminary environmental survey. Although most candidate bridges are located outside of residential areas, some dwellings and commercial shops are distributed along the approach roads. With regard to natural environment, mangrove communities are observed along the rivers due to adjacent sea in Goa, Kerala and Gujarat state.

Selected key items, reasons and proposed criteria are shown below;

Table 3.3.3 Selected Key Items and Reasons on Environmental Evaluation

Area	Key item	Reasons	Detailed Item	Proposed Rating Criteria		
				A	B	C
I. Pollution	1. Noise and air pollution	Reconstruction of bridge with the new approach road may give negative impact to residential area	Distance from the nearest residential area	D≦50m	50<D<100m	100m≦D
	2. Turbid water	Foundation repair works may generate turbid water in the river	Necessity of foundation repair works	No. of repaired foundation 3 or more	No. of repaired foundation 1 or 2	No. of repaired foundation 0
II Social	1. Involuntary Resettlement	Construction activities may give impact to dwellings and sacred places. Reconstruction bridge on new alignment may cause resettlement and land acquisition.	Number of affected dwellings	50≦No.	10<No.<50	No. ≦10
	2. Culture (sacred place)		Number of affected religious facility	1&more (not moveable)	1&more (moveable)	No.=0
III Natural	1. Biota	Mangrove area may be cut by setting up of construction yard and reconstruction bridge on new alignment.	Affected Mangrove area	10,000m2 ≦A	100 <A< 10,000m2	A≦100m2

Source: JICA Survey Team

3.3.4 Summary of Environmental Evaluation

A summary of environmental evaluation for candidate bridges is shown below. As shown in Chapter 4.2, it is proposed that three (3) bridges should be reconstructed with the new approach road and, five (5) bridges should be repaired respectively. In case of only repair level works, it is expected that any permissions such as the Coastal Regulation Zone (CRZ) and the Environmental Certificate (EC) is not required. However, in case of reconstruction of bridge with the new alignment in CRZ, clearance shall be obtained from the Ministry of Environment and Forest (MOEF) in accordance with interview survey with environmental section of each state.

The summary of environmental evaluation is shown below. Survey check sheets and screening & scoping matrix are attached in Appendix.

3.3.5 Screening Result on JICA Guidelines

Screening result is shown in the next table. The bridges to be reconstructed may acquire land for new approach road, thus land acquisition and resettlement may be caused. However it is expected that the number of resettlers does not exceed 200. Hence reconstruction bridges are categorized as “Category B” and other bridges to be conducted repair works are classified as “Category C” basically in accordance with JICA Guidelines for Environmental and Social Considerations (2010).

Table 3.3.4 Definition of Category on JICA Guideline

Category	Definition
Category A	Proposed projects are classified as Category A if they are likely to have significant adverse impacts on the environment and society. Projects with complicated or unprecedented impacts that are difficult to assess, or projects with a wide range of impacts or irreversible impacts, are also classified as Category A. These impacts may affect an area broader than the sites or facilities subject to physical construction. Category A, in principle, includes projects in sensitive sectors, projects that have characteristics that are liable to cause adverse environmental impacts, and projects located in or near sensitive areas.
Category B	Proposed projects are classified as Category B if their potential adverse impacts on the environment and society are less adverse than those of Category A projects. Generally, they are site-specific; few if any are irreversible; and in most cases, normal mitigation measures can be designed more readily.
Category C	Proposed projects are classified as Category C if they are likely to have minimal or little adverse impact on the environment and society.

Source: JICA Guidelines for Environmental and Social Considerations (2010)

Table 3.3.5 Preliminary Environmental Evaluation and Screening based on JICA Guideline (as of 3rd 2013)

Location (state)	Br. No	Bridge Name	Repair /Reconstruction	Pollution: Noise and Air pollution During and After Const. Rating	Pollution: Noise and Air pollution During and After Const. Description	Pollution: Water Quality (Turbid Water) During Const. Rating	Pollution: Water Quality (Turbid Water) During Const. Description	Social Environment: Involuntary Resettlement Rating	Social Environment: Involuntary Resettlement Description	Social Environment: Culture (Sacred place and Facility) Rating	Social Environment: Culture (Sacred place and Facility) Description	Natural Environment: Mangrove Trees Rating	Natural Environment: Mangrove Trees Description	JICA Category: Result of **Screening** based on JICA Guideline for Environmental and Social Considerations (2010)		Expected clearances to be acquired*1: EC	Expected clearances to be acquired*1: Clearance for CRZ
	1	Kaliabhomora	Replacement by steel girder for Gerber Girder	C	Some dwellings are observed but impact is not expected	C	No activities in the river	C	No dwelling will be affected	C	Temple is located in the north-bank but not directly affected.	C	No mangrove observed	**C**	Repair part is limited on the bridge	-	-
	2	Badarpurghat	New Bridge Construction	B	Residential area is observed but impact is limited	A	Construction activities in the river	C	Few dwelling will be affected.	C	Crematory will be nearby the bridge but will not be affected directly	C	No mangrove observed	**B**	Resettlement is limited but land acquisition is required	✓	-
Goa	3	Zuari	New Bridge Construction and Connection of Centre Hinge	B	Residential area is observed but impact is limited	A	Construction activities in the river	B	Residential area and commercial area is observed and might be affected.	B	A grave and Temple is located on the north bank	B	Cutting mangrove is expected on the north bank	**B**	Resettlement is limited but land acquisition is required	✓	✓
	4	Borim	New Bridge Construction and Connection of Centre Hinge	B	Residential area is observed but impact is limited	A	Construction activities in the river	B	Residential area and commercial area is observed and might be affected.	C	A church is located on the north bank, but it is app. 200 m away from the river bank	A	Cutting mangrove is expected on the both bank	**B**	Resettlement is limited but land acquisition is required	✓	✓
Kerala	5	Mahe	Replacement by steel girder for Superstructure (Temporary Bridge construction)	B	Mainly commercial area is observed	A	Construction activities in the river (for temporary bridge)	B	Some dwellings and commercial area are observed and might be affected.	C	Mosque is observed but not directly affected.	C	No mangrove observed	**B**	Resettlement is limited but land acquisition is required	✓	✓
	6	Valapattanam	Replacement by steel girder for Superstructure	B	Residential area and commercial area are	A	Construction activities in the river (for	B	Residential area and commercial area is	C	No sacred facility is observed	B	Cutting mangrove is expected	**B**	Resettlement is limited but land acquisition is	✓	✓

Location (state)	Br. No	Bridge Name	Repair /Reconstruction	Pollution: Noise and Air pollution During and After Const. Rating	Pollution: Noise and Air pollution During and After Const. Description	Pollution: Water Quality (Turbid Water) During Const. Rating	Pollution: Water Quality (Turbid Water) During Const. Description	Social Environment: Involuntary Resettlement Rating	Social Environment: Involuntary Resettlement Description	Social Environment: Culture (Sacred place and Facility) Rating	Social Environment: Culture (Sacred place and Facility) Description	Natural Environment: Mangrove Trees Rating	Natural Environment: Mangrove Trees Description	JICA Category: Result of **Screening** based on JICA Guideline for Environmental and Social Considerations (2010)		Expected clearances to be acquired*1: EC	Expected clearances to be acquired*1: Clearance for CRZ
			Reinforcement by carbon fiber for piers (Temporary Bridge construction)		observed but impact is limited		temporary bridge)		observed and might be affected.						required		
	7	Perumba	Replacement by steel girder for Superstructure (Temporary Bridge Construction)	B	Mainly commercial area is observed	A	Construction activities in the river (for temporary bridge)	C	Mainly commercial area is observed and impact is limited.	C	Temple is observed but not affected directly	B	Cutting mangrove is expected	**B**	Resettlement is limited however land acquisition is expected	✓	✓
Gujarat	8	Shetrunji	Replacement by steel girder for Superstructure	C	Diversion is constructed, but no residential area nearby the bridge	C	No activities in the river.	C	Temporary land acquisition for detour may be required on the open land, not farming and residential area.	B	A community temple may be in the construction yard.	C	No mangrove is observed due to no water in the dry season (March—July)	**C**	Few impacts are expected. However appropriate consultation with local stakeholders of community temple.	✓	✓

Impact Rating: (A): Serious impact is expected. (B): Some impact is expected. (C): Few impacts are expected. (D): Impact is unknown (serious impacts are not expected, but detailed survey is required on preparatory survey stage)
Screening definition: (A) serious (B) A degree of impact, but not serious (C) Few impacts are expected (refer to Table 3.5.3 Definition of Category on JICA Guideline)
*1: These are based on the interview as of 4th Dec 2013

Source: JICA Survey Team

3.3.6 Recommended Environmental Mitigation Measures

Recommended major mitigation measures are shown below;

Table 3.3.6 Environmental Management Plan (Expected Mitigation Measures)

Category	№	Item JICA Guidelines	Recommended Mitigation Measures	
			Pre and During Construction phase	Operation phase
Pollution	1	Air pollution	-Dust Water sprinkling near residential area	-
	2	Water pollution	- Turbid water Sheet pile method is adopted to minimize turbid water during foundation repair works	-
	3	Waste	- Construction waste (waste concrete) Construction waste such as waste concrete is disposed at designated disposal site	-
	4	Soil contamination	-	-
	5	Noise and vibration	-Construction noise near residential area Installing noise barrier and selecting low-noise equipment. Avoiding works of heavy equipment during night time. Informing the construction schedule to surrounding communities to obtain their consensus.	-
	6	Sediment quality	-	-
Natural environment	9	Protected Area	CRZ permission shall be taken from environmental authorized agency (Ministry of Environment and Forest), if the reconstruction bridge with new approach road is in CRZ	-
	11	Hydrology	Designing of bridges with sufficient capacity	-
	12	Topography and geology	-	-
Social environment	13	Involuntary resettlement	Appropriate compensation shall be implemented in accordance with JICA Guidelines	-
	14	The poor		-
	15	Indigenous and ethnic people		-
	16	Local economy such as employment and livelihood		-
	17	Land use and utilization of local resources		
	18	Water usage	Installation of alternative water distribution system when unexpected situation such as reduction of water level of wells, if any	
	19	Existing social infrastructures and services	Appropriate compensation and displacement shall be implemented in accordance with JICA Guidelines	-
	22	Local conflict of interests	Local workforce is prioritized for construction of the bridge.	-
	23	Cultural heritage	If the project affects the community temple, sacred places and monument, appropriate consultation and agreement shall be concluded with local stakeholders	-
	27	Infectious diseases such as HIV/AIDS	In order to prevent spread of infectious diseases such as HIV/AIDS, awareness of the labors is promoted.	-
Others	29	Accidents	-Installing gate structure at the entrance of the construction site to set up restricted area -Deploying flagman at the gate and crossing points of the construction vehicles -Installing fence around the construction site to keep out local people such as children -Restricting mobilization speed in the construction site -Safety training for the workers -Safety patrol at the construction site by supervisors -Monthly safety meeting	Traffic safety control and management should be done on the bridges without sidewalk
	30	Cross boundary impacts and climate change	-	-

(-): Not required mitigation measures since negative impacts are negligible
Source: JICA Survey Team

3.4 Second Bridge Selection

3.4.1 Evaluation Criteria of Second Bridge Selection

In the second selection, 5 to 10 bridges shall be selected from the 25 bridges of the first selection stage. Evaluation criteria in the second selection stage are shown in Table 3.4.1. The second bridge selection shall be conducted by comprehensive evaluation according these criteria.

Table 3.4.1 Evaluation Criteria of Second Bridge Selection

No.	Evaluation index	Contents
1	Traffic Demand	Current traffic volume based on observation. - Very High, - High, - Moderate
2	Distance of Detour Route	Distance (km) of detour route based on interview and measurement by satellite imagery.
3	Project Effects for Japanese Companies	State-wise number of Japanese companies. (Figure 3.2.1) - Very High (more than 100) - High (more than 50) - Moderate (more than 5) - Low (less than 5)
4	Damage Level of the Bridges	Bridge damage level inspected by first field survey. (refer to data sheets of first field survey)
5	Application of Japanese technology	Adoption of Japanese advanced technologies on existing bridges is verified according to Table 4.1.2.
6	Duplication with Other Projects by Donors or Local	Projects from other donors except JICA and ministry of India are verified from MORTH and major donors.
7	Importance of the bridge on Surrounding Society and Economy	Importance of the bridge on economic activities (farming, industry, manufacture, tourist business etc.) and public facilities (schools and hospitals etc.).
8	Impact on the Environment	The environmental impacts are estimated from nature levels (land use and protected zones), ease of land acquisition and concentration of population. (refer to environmental survey sheets)

Source: JICA Survey Team

Table 3.4.2 Applicable Japanese Advanced Technology

Japanese Technology Name	Application	Candidate Bridges
Connected Centre Hinge Method	This technology is effective in bridges with center hinges.	PC Box girder having damaged center hinges, for example in Assam and Goa states.
Strength using High Modulus Carbon Fiber	This technology is effective in bridges experiencing damage from salt and overloaded vehicles. This technology does not increase weight therefore has a minimal effect on the substructure.	Superstructures to be strengthened for live loading Substructures to be strengthened for seismic loading Bridges in coastal areas such as Gujarat, Goa and Kerala states
Out Plate Method	This technology is effective in the bridges experiencing damage from overloaded vehicles.	Superstructures to be strengthened for live loading
Epoxy Coated Reinforcing Bar	This technology is effective in replacing the reinforcement with damages such as corrosion because of cracks and spalling concrete.	Bridges in coastal areas such as Gujarat, Goa and Kerala states
Epoxy Coated and Filled Strand Cable (ECF Strand)	This technology is effective for bridges damaged by salt.	Bridges in coastal areas such as Gujarat, Goa and Kerala states
Reinforcement of Bridge Foundation	This technology is effective for the bridge foundations that require reinforcement and seismic retrofitting	Foundations to be strengthened due to river scouring
Bearing using Al-(5%) Mg Plasma Thermal Spraying	This technology is effective where the existing bearings are to be replaced. Durability of bearings is increased	Bearings with damage
Steel Girder Bridge	This technology is effective for replacing superstructures consisting of PC or RC girders with severe damage. Steel girders can reduce the weight of superstructures and minimize the construction period. Weathering steel can be applied in all areas other than coastal areas to minimize maintenance costs.	Superstructure with severe damage

Source: JICA Survey Team

3.4.2 Result of Second Bridge Selection

The Table 3.4.3 shows the result of the second bridge selection stage. 8 bridges are nominated as targets of the second field survey.

Table 3.4.3 Result of Second Bridge Selection

State	Br No.	NH No.	Bridge Name (River Name)	Year of Construction	Traffic Demand	Distance of Detour Route	Project Effects for Japanese Companies	Damage Level of the Bridges	Application of Japanese Technology	Duplication with Other Projects by Donor's or Local	Importance of the Bridge on Surrounding Society and Economy	Impacts on the Environment	Comprehensive Evaluation
					1	2	3	4	5	6	7	8	
Assam	1	NH52	Jia-Bharali Bridge	1962	Moderate	423 km	Low	Minor damages	Local Technology	None	High	-	Not target
	2	NH37A	Kaliabhomora Bridge	1987	Moderate	327 km	Low	Need repairing for removing of level difference at Gerber girder	Applicable (replacement by Steel girder for Gerber portions)	None	Very High	Minimal	Target for replacement of Gerber girder
	3	NH53	Sadarghat Bridge	1967	Very High	67 km	Low	Very serious damages at centre hinge	Applicable (centre hinge connection)	New 2 lane bridge plan beside existing bridge has been sanctioned by PWD.	Very High	Moderate	Not target
	4	NH44	Badarpurghat Bridge	1972	High	64 km	Low	Very serious damages at centre hinge	Applicable (centre hinge connection)	None (a rehabilitation estimate has been sanctioned for Rs2.65 Cr. But the work has not yet tendered)	Very High	Minimal	Target for center hinge connection
Goa	5	NH17	Zuari Bridge	1982	Very high	54 km	Moderate	Need repairing at centre hinge	Applicable (centre hinge connection)	None	Very High	Minimal	Target for center hinge connection
	6		Mandvi Bridge (old)	1993	Very high	63 km	Moderate	Very minor damages	Local Technology	None	Very High	-	Not target
	7		Mandvi Bridge (new)	1997	Very high	63 km	Moderate	Very minor damages	Local Technology	None	Very High	-	Not target
	8	NH17B	Borim Bridge	1983	High	48 km	Moderate	Need repairing at centre hinge	Applicable (centre hinge connection)	None	Very High	Minimal	Target for center hinge connection
	9	NH4A	Khanderpar Bridge	1961	Moderate	28 km	Moderate	Minor damages	Local Technology	Improvement (4 lane bridge, 40m upstream) plan beside existing bridge under NHDP	Moderate	-	Not target
Kerala	10	NH17	Mahe Bridge	1930	Very High	16 km	High	Need repairing on superstructure	Applicable (replacement by Steel girder)	Bypass (new 4 lane bridge plan on 1km upstream under NHDP)	Very High	Moderate	Target for replacement of superstructure
	11		Valapattanam Bridge	1980	High	26 km	High	Need repairing on some portions	Applicable (Carbon fibre for piers and bottom of slabs)	Improvement (additional 2 lane bridge plan beside existing bridge under NHDP)	High	Minimal	Target for repairing substructure by carbon fiber
	12		Perumba Bridge	1952	High	23 km	High	Need repairing on superstructure	Applicable (replacement by Steel girder)	Bypass (new 4 lane bridge plan on 1km upstream under NHDP)	High	Moderate	Target for replacement of superstructure
	13		Kariyangodu Bridge	1963	High	27 km	High	Need repairing in some portions	Local Technology	Improvement (new 4 lane bridge plan on 60m upstream under NHDP)	Moderate	-	Not target
Gujarat	14	NH8E	Shetrunji Bridge	1985	High	7 km	High	Very serious damages on superstructure	Applicable (replacement by Steel girder)	None	High	Minimal	Target for replacement of superstructure
	15		Medhacreek Bridge	1978	High	184 km	High	Very serious damages on superstructure	Applicable (replacement by Steel girder)	Improvement (4 lane bridge plan on 400m upstream) Existing Br. will be pedestrian Br.	Very High	-	Not target
Delhi	16	-	Nizamuddin Bridge	1982	Very High	11 km	Very High	Need repairing in some portions	Local Technology	None	Very High	-	Not target
Uttar Pradesh	17	NH730	Sharada Bridge	1967	Moderate	156 km	Low	Need repairing in some portions	Applicable (Carbon fibre for the end of RC girder)	None	Moderate	-	Not target
	18		Ghaghra Bridge	1968	Moderate	171 km	Low	Need repairing in some portions	Applicable (Carbon fibre for the end of RC girder and piers)	None	Moderate	-	Not target
Himachal Pradesh	19	NH20A	Dehra Bridge (Beas River)	1962	Moderate	90 km	Low	Minor damages	Local Technology	None	Moderate	-	Not target
	20	NH88	Kandrour Bridge (Satluj River)	1962	Moderate	200 km	Low	Minor damages	Local Technology	None	Moderate	-	Not target
	21		Nadaun Bridge (Beas River)	1974	Moderate	90 km	Low	Minor damages	Local Technology	None	Moderate	-	Not target
	22	NH70	Man Khad Bridge	1968	Moderate	150 km	Low	Need repairing on superstructure	Applicable (Carbon fibre for the superstructure)	New 2 lane bridge plan beside existing bridge on upstream side.	Moderate	-	Not target
	23		Kheran Khad Bridge	1975	Moderate	150 km	Low	Minor damages	Local Technology	None	Moderate	-	Not target
	24		Swan River Bridge	1968	Moderate	100 km	Low	Minor damages	Local Technology	None	Moderate	-	Not target
	25		Shivbari Khad No.II Bridge	1968	Moderate	100 km	Low	Minor damages	Local Technology	None	Moderate	-	Not target

Source: JICA Survey Team

4. SECOND FIELD SURVEY

4.1 Result of Second Field Survey (Non-Destructive Inspection)

4.1.1 Schedule of Second Field Survey

The second field survey was carried out from January 12th (Sun) to January 28th (Tues).

Table 4.1.1 Schedule of Second Field Survey

Date	Bridges surveyed
12(S)	Gujarat - Shetrunji Bridge
13(M)	
14(T)	Goa - Zuari Bridge - Borim Bridge
15(W)	
16(T)	Kerala - Perumba Bridge - Mahe Bridge - Valapattanam Bridge
17(F)	
18(S)	
19(S)	Mumbai - Trans Harbour Link
20(M)	
21(T)	Data arrangement
22(W)	Assam - Kaliabhomora Bridge - Dhuburi-Phulbari Bridge - Badarpurghat Bridge
23(T)	
24(F)	
25(S)	
26(S)	
27(M)	
28(T)	

Source: JICA Survey Team

4.1.2 Outline of Second Field Survey

The second field survey was carried out to investigate maintenance and reinforcement methods for the 8 bridges selected in the first field survey.

(1) Hammering Test

The degree of spalling of concrete surfaces was inspected using the hammering test.

The hammering test involves striking the surface of concrete members with a test hammer, and measuring the location and amount of spalling by comparing the sound difference in shock using the human ear. As it is a simple test, it can be used as a test for deterioration on the structure's outer surface, and the soundness of an extensive range of concrete surfaces can be rapidly measured.

Source: JICA Survey Team

Figure 4.1.1 Testing Hammer (Left), Hammering Test (Right)

<Measurement fundamentals>

If the material and the composition of two concrete surfaces are the same, then the two concrete members should produce the same elastic wave and sound when struck. On the other hand, if the surface contains cavities or spalling, the propagation of the elastic wave will be hindered due to these defects, and a different sound will be produced. The surface quality of the concrete (spalling and cavities) is evaluated using the difference in sound.

(2) Schmidt Hammer Test

Concrete compressive strength is estimated using the Schmidt Hammer Test.

The Schmidt Hammer test uses the shock energy produced by the hammer and spring within the test apparatus, treats the rebound energy when the concrete surface is hit as the "degree of rebound", and then estimates the concrete compressive strength from an empirical relationship between compressive strength and degree of rebound. It is also called the rebound hammer method.

Source: JICA Survey Team

Figure 4.1.2 Rebound Hammer (Left), Schmidt Hammer Test (Right)

＜Measurement fundamentals＞ By pressing the device against the target concrete, the built-in hammer is jacked up. Then once the hammer reaches a fixed height, the stopper comes off, and the end of the steel stick called a pusher is struck by the spring at a certain force. The rebound length of the hammer at this point is recorded as the “degree of rebound”. Concrete compressive strength has a strong correlation with this degree of rebound, and several types of empirical equations to calculate the compressive strength from the degree of rebound have been proposed. In this survey, equation presented by the “Society of Materials Science, Japan” is employed.

F_c＝-18.0＋1.27R (MPa), where F_c is the compressive strength and R is the degree of rebound

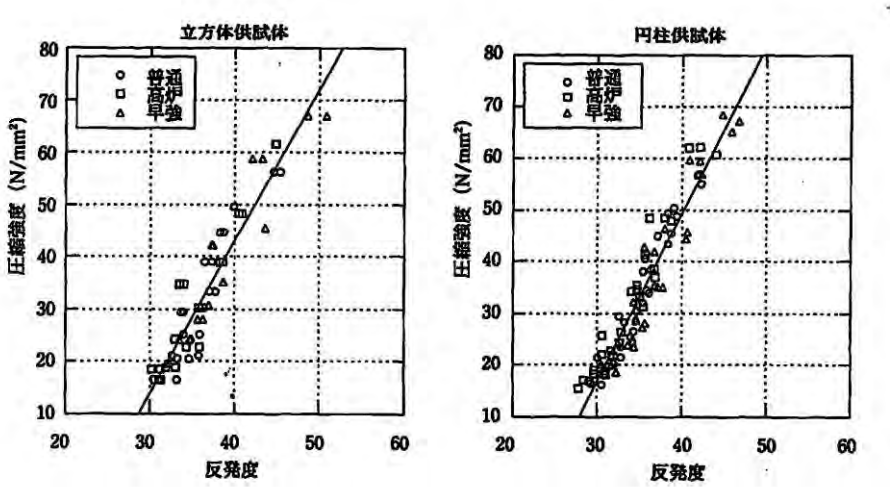


Figure 4.1.3 Example of the Correlation between Degree of Rebound and Compressive Strength

(3) Rebar survey

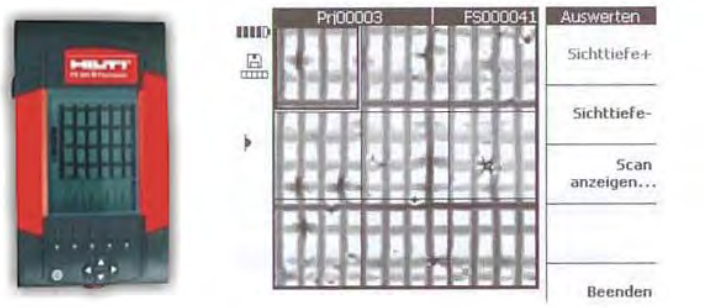
1) Electromagnetic Inspection

Rebar’s location and diameter, and the corresponding concrete cover are probed using the electromagnetic inspection.

The electromagnetic inspection uses the phenomena of electromagnetism to gather information such as the location, depth and diameter of rebar within concrete.

Source: JICA Survey Team

Figure 4.1.4 Electromagnetic Inspection Equipment (Left), Electromagnetic Inspection (Right)



Source: JICA Survey Team

Figure 4.1.5 Example of Results of Electromagnetic Inspection

<Measurement fundamentals>

An alternating current of approximately 1 – 100 kHz is run through the excitation coil arranged inside the probe, and a first-order magnetic field is generated. If rebar (a magnetic substance) is present inside this field, eddy currents will flow through the surface of the rebar, and a second-order magnetic field will be generated, and the overall magnetic field will be altered. The change in the magnetic field is influenced by the distance between the rebar (magnetic body) and the probe (excitation coil) and the size of the magnetic body. The rebar's location, depth and diameter are calculated in accordance with the change in magnetic field measured by the detection coil within the probe.

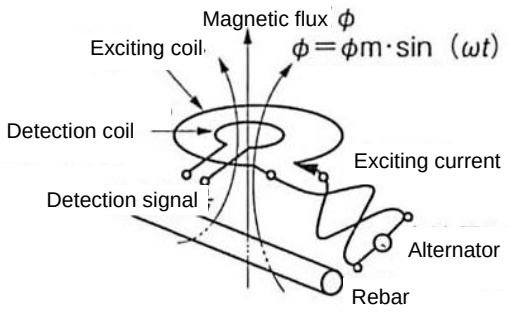


Figure 4.1.6 The Principles of Measurement using the Electromagnetic Inspection

If the thickness of concrete cover is relatively low, the electromagnetic inspection can measure the rebar location and cover thickness with high accuracy when compared to the RC Rader inspection. However, the attenuation of the magnetic field generated by the excitation coil is great, so the signal sharply drops off with increasing cover thickness, and in turn, the accuracy of measurement also decreases. The maximum applicable concrete cover depth is said to be in the range of 150mm, but to ensure accuracy, it is only used for depths up to 100mm in practice. Taking this into account, it was decided that the electromagnetic induction method and the RC Rader inspection would be used in conjunction.

2) RC Rader Inspection

The RC Rader inspection is a non-destructive test procedure for inspecting the inside of concrete using the same radar technology that is utilized in aviation, naval and climate applications.

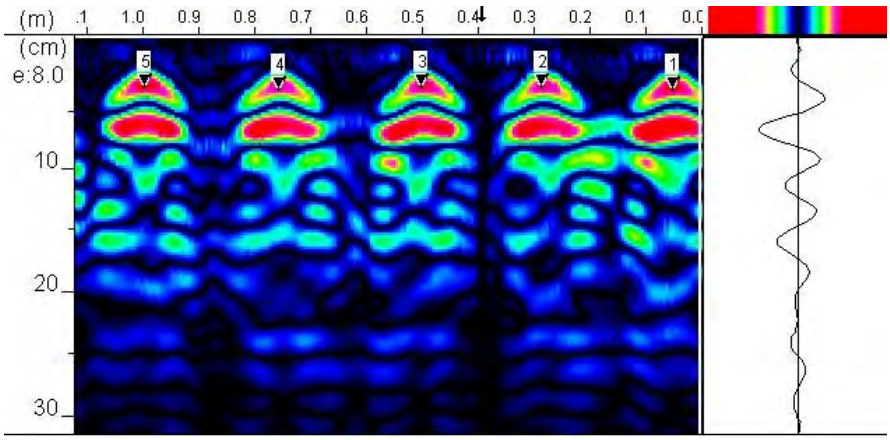
The RC Rader inspection can be used to acquire information about the location of rebar, the concrete cover, internal porosity, the presence and location of foreign substances, and cavities in the rear of the concrete. In this method, a measuring apparatus equipped with transmitting devices (transmitter, transmitting antenna) and receiving devices (receiving antenna, receiver) is utilized to manually scan the surfaces of concrete structures. To comply with the degree of wave propagation within concrete, the device measuring device used for concrete was equipped with radar capable of sending/receiving RC Rader in the range of 200Mz to 2GHz.

Source: JICA Survey Team

Figure 4.1.7 RC Radar Equipment (Left), RC Rader Inspection (Right)

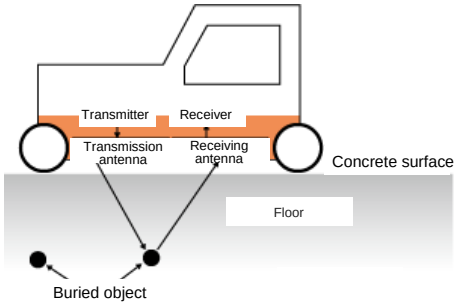
<Measurement fundamentals>

If the medium is a gas or a non-conductive liquid or solid, RC Rader will penetrate the medium and pass through it at a fixed speed. In this process, when the waves meet a different substance (the object for measurement), the waves will either be reflected or pass through, depending on the object's electric properties (relative permittivity, etc.). If the object for measurement is a metal with a relative permittivity of infinity, the electromagnetic waves will all be reflected from the metallic surface, and not pass through the metal. Conversely, if the relative permittivity is low (4 to 20 in concrete), the majority of RC Rader will pass through the metal. In the RC Rader inspection, the travel time, phase and intensity of the reflected waves are used to calculate the location of the rebar, the cover depth, the internal porosity, and the presence and location of foreign objects within the concrete.



Source: JICA Survey Team

Figure 4.1.8 Example of Results attained using the RC Rader Equipment



Source: JICA Survey Team

Figure 4.1.9 The Principles of Measurement using the RC Rader Inspection

4.1.3 Results of the Second Field Survey

The results of the second field survey are shown from Table 4.1.2 to Table 4.1.4.

Table 4.1.2 Result of Second Field Survey (1/3)

State	Br. No.	NH No.	Bridge Name & Photo	Bridge Basic Data	Result of Survey
Assam	1	NH37A	Kaliabhomora Bridge 	1. Superstructure: PC Box (Gerber girder) +RC T 2. Substructure: RC 3. Bridge Length: 3,105m 4. Span Length: 67.5 - 120.0m 5. Width: 10.5m (2 lane) 6. Year of Completion: 1987	The Schmidt hammer test confirmed that both the main girder concrete and pier concrete have sufficient strength. Rebar probing confirmed that rebar has the appropriate diameter and is arranged at the appropriate intervals. Visual inspection confirmed that differences in level have appeared in 8 of the 24 girder sites in the central portion of the span.
	2	NH44	Badarpurghat Bridge 	1. Superstructure: PC Box (Centre Hinge) 2. Substructure: RC 3. Bridge Length: 359.44m 4. Span Length: 30.04 - 108.50m 5. Width: 10.5m (2 lane) 6. Year of Completion: 1972	The Schmidt hammer test confirmed that both the main girder concrete and pier concrete have sufficient strength. Rebar probing confirmed that rebar has the appropriate diameter and is arranged at the appropriate intervals. Visual inspection confirmed that a difference in level has appeared on the gap slab. Data collection confirmed that rehabilitation of the bridge (the outer cable reinforcement, crack repair and replacement of gap slab) was carried out from 2002 to 2003. Additionally, subsidence of the piers (P1 pier 21.9cm, P2 piers 11.9cm, P3 pier 9.8cm) was also confirmed.
Goa	3	NH17	Zuari Bridge 	1. Superstructure: PC Box (Centre Hinge) 2. Substructure: RC 3. Bridge Length: 809m 4. Span Length: 36-121m 5. Width: 7.5m (2 lane) 6. Year of Completion: 1982	The Schmidt hammer test confirmed that both the main girder concrete and pier concrete have sufficient strength. Rebar probing confirmed that rebar has the appropriate diameter and is arranged at the appropriate intervals. Visual inspection confirmed that a difference in level of 1.5cm has appeared at the center hinge. Data collection confirmed that rehabilitation of the outer cable was carried out from 1996 to 1998.
	4	NH17B	Borim Bridge 	1. Superstructure: PC Box (Centre Hinge) 2. Substructure: RC 3. Bridge Length: 411 m 4. Span Length: 20-122m 5. Width: 7.5m (2 lane) 6. Year of Completion: 1983	The Schmidt hammer test confirmed that both the main girder concrete and pier concrete have sufficient strength. Rebar probing confirmed that rebar has the appropriate diameter and is arranged at the appropriate intervals. Visual inspection confirmed that a difference in level of 1.5cm has appeared at the center hinge.

Source: JICA Survey Team

Table 4.1.3 Results of Second Field Survey (2/3)

State	Br. No.	NH No.	Bridge Name & Photo	Bridge Basic Data	Result of Survey
Kerala	5	NH17	Mahe Bridge 	1. Superstructure: RC T 2. Substructure: Stone Masonry 3. Bridge Length: 117m 4. Span Length: 23.4m 5. Width: 8.50m(2 lane) 6. Year of Completion: 1930 (1972)	Implementation of Schmidt hammer test and rebar exploration test was not possible because main girder had been implemented reinforced concrete spraying and pier was stone masonry. Visual inspection confirmed that cracks have appeared on main girder and deck slabs, and that the bearings have sustained damage. The hammering test did not confirm the presence of any voids in the pier.
	6	NH17	Valapattanam Bridge 	1. Superstructure: RC Box 2. Substructure: RC 3. Bridge Length: 420.77m 4. Span Length: 8.3 - 31.09m 5. Width: 10.2m (2 lane) 6. Year of Completion: 1980	The Schmidt hammer test confirmed that both the main girder concrete and pier concrete have sufficient strength. Rebar probing confirmed that rebar has the appropriate diameter and is arranged at the appropriate intervals. Visual inspection confirmed that most of the spans are subject to large-scale concrete spalling at girder ends, rebar exposure, and rebar corrosion. Large-scale spalling was found at the ends of the girders of the super structure between piers P4 and P13. Additionally, large scale cracking was found in piers P4 and P5.
	7	NH17	Perumba Bridge 	1. Superstructure: RC T 2. Substructure: Stone Masonry 3. Bridge Length: 146.8m 4. Span Length: 8 - 23.1m 5. Width: 6.7 m (2 lane) 6. Year of Completion: 1952	Implementation of Schmidt hammer test and rebar exploration test were not possible because the main girder has been reinforced with concrete spraying and pier was constructed with stone masonry. Visual inspection confirmed cracking and free lime in the main girder and slabs. Additionally, voids were found in the shoe. The only test performed on the piers was the hammering test, and no voids were found.

Source: JICA Survey Team

Table 4.1.4 Results of Second Field Survey (3/3)

State	Br. No.	NH No.	Bridge Name & Photo	Bridge Basic Data	Result of Survey
Gujarat	8	NH8E	Shetrunji Bridge 	1. Superstructure: RC T 2. Substructure: RC 3. Bridge Length: 240m 4. Span Length: 10m 5. Width: 7.5m (2 lane) 6. Year of Completion: 1985	The Schmidt hammer test and the rebar exploration test were only performer on the piers. They could not be performed on the main girder due to it being reinforced with concrete spraying. The Schmidt hammer test confirmed that the pier concrete has sufficient strength. Rebar probing confirmed that rebar in the piers has the appropriate diameter and is arranged at the appropriate intervals. The hammering test did not confirm the presence of any voids within the piers. The third span in the superstructure has been reinforced with concrete spraying due to its collapse resulting from vehicular overloading in 2009, but low-quality concrete has been used, so it is difficult to say whether it has been properly reinforced.

Source: JICA Survey Team

4.2 Traffic Count Survey Results

4.2.1 General

As part of the work of the Data Collection Survey on Bridge Sector, the traffic count survey was carried out at 8 bridges on weekdays from 11 February 2014 to 19 February 2014. The data obtained from the traffic count survey will be utilized to carry out traffic demand forecasting and to evaluate benefits from bridge improvements.

4.2.2 Execution of Traffic Count Survey

The traffic count survey was carried out for each location as follows;

- Survey period: each one (1) day in the weekday for the duration of 24 hours (6:00 AM to 6:00 AM of the following day).
- Survey method: counting the number of vehicles by vehicle types by directions at Mid-Blocks on the bridge.
- The types of vehicles: the following 11 categories;

Type No.	Categories	Type No.	Categories
Type 1	Motor Bike	Type 7	Large Truck (3 axels and more)
Type 2	Three Wheeler	Type 8	Container Trailer
Type 3	Car, Jeep	Type9	Minibus (29 seats and below)
Type 4	Passenger Van	Type 10	Bus
Type 5	Pick-up (Single/ Double Cab)	Type 11	Others( )
Type 6	Medium Truck (2 axels)		

Source: JICA Survey Team

4.2.3 Results of Traffic Count Survey

(1) PCU Factors

The Passenger Car Unit (PCU) recommended by IRC-106 (the Indian Roads Congress Code) and IRC-64 as shown in Table 4.2.1. And, the adopted values have been used for analysis as shown in Table 4.2.2.

Table 4.2.1 PCU Factors by IRC-64

Type of Vehicle	PCU Factor	Type of Vehicle	PCU Factor
Two Wheeler	0.5	2-Axel Truck	3.0
Three Wheeler / Auto Rickshaw	0.75	3-Axel Truck	3.0
Car / Jeep / Van	1.0	Multi-Axle Truck	4.5
Mini Bus	1.5	Others( )	8.0
Bus	3.0		

Source: Guidelines for Capacity of Roads in Rural Areas (IRC-64:1990)

Table 4.2.2 Adopted PCU Factors

Type of Vehicle	PCU Factor	Type of Vehicle	PCU Factor
Motor Bike	0.5	Large Truck (3 axels and more)	4.5
Three Wheeler	0.75	Container Trailer	4.5
Car, Jeep	1.0	Minibus (29 seats and below)	1.5
Passenger Van	1.0	Bus	3.0
Pick-up (Single/ Double Cab)	1.0	Others( )	8.0
Medium Truck (2 axels)	3.0		

Source: JICA Survey Team

(2) Traffic Volume

The traffic volumes by vehicle types on both directions for each bridge are tabulated in Table 4.2.3.

Table 4.2.3 Counted Traffic Volume

S.No	Name of Bridge	Vehicular type / Traffic volume	Motor Bike	Three Wheeler	Car, Jeep	Passenger Van	Pick-up (Single/ Double Cab)	Medium Truck (2 axels)	Large Truck (3 axels and more)	Container Trailer	Minibus (29 seats and below)	Bus	Others	Total
1	Kaliabhomora	**ADT (In vehicles)**	710	227	2,036	440	524	817	850	131	349	372	120	**5,639**
		ADT (In PCU)	355	170	2,036	440	524	2,451	3,825	590	524	1,116	960	**12,465**
2	Badarpughat	**ADT (In vehicles)**	1,196	1,904	1,198	1,233	74	2,383	1,389	11	107	240	69	**6,704**
		ADT (In PCU)	598	1,428	1,198	1,233	74	7,149	6,251	50	161	720	552	**17,387**
3	Zuari	**ADT (In vehicles)**	13,131	168	13,927	170	4	2,111	0	0	404	1,374	9	**17,999**
		ADT (In PCU)	6,566	126	13,927	170	4	6,333	0	0	606	4,122	72	**25,234**
4	Borim	**ADT (In vehicles)**	8,388	200	7,155	524	210	4,220	683	399	695	198	22	**14,106**
		ADT (In PCU)	4,194	150	7,155	524	210	12,660	3,074	1,796	1,043	594	176	**27,231**
5	Mahe	**ADT (In vehicles)**	6,861	4,131	6,362	180	587	1,449	531	903	271	1,059	54	**11,396**
		ADT (In PCU)	3,431	3,098	6,362	180	587	4,347	2,390	4,064	407	3,177	432	**21,945**
6	Valapattnam	**ADT (In vehicles)**	11,142	5,565	9,848	1,507	1,931	1,651	834	516	1,829	2,099	7	**20,222**
		ADT (In PCU)	5,571	4,174	9,848	1,507	1,931	4,953	3,753	2,322	2,744	6,297	56	**33,411**
7	Perumba	**ADT (In vehicles)**	9,245	4,415	6,460	288	1,120	2,119	597	293	66	1,269	0	**12,212**
		ADT (In PCU)	4,623	3,311	6,460	288	1,120	6,357	2,687	1,319	99	3,807	0	**22,136**
8	Shetrunji	**ADT (In vehicles)**	6,531	1,207	1,876	794	0	364	1,404	135	130	360	169	**5,232**
		ADT (In PCU)	3,266	905	1,876	794	0	1,092	6,318	608	195	1,080	1,352	**13,315**

Source: JICA Survey Team

The details of the traffic count survey results are attached in Appendix 4.

(3) Hourly Traffic Flow

The hourly traffic flow for each bridge is shown in Figure 4.2.1and Figure 4.2.2. Peak hour rates vary from 4.41 % to 12.35 % in PCUs.

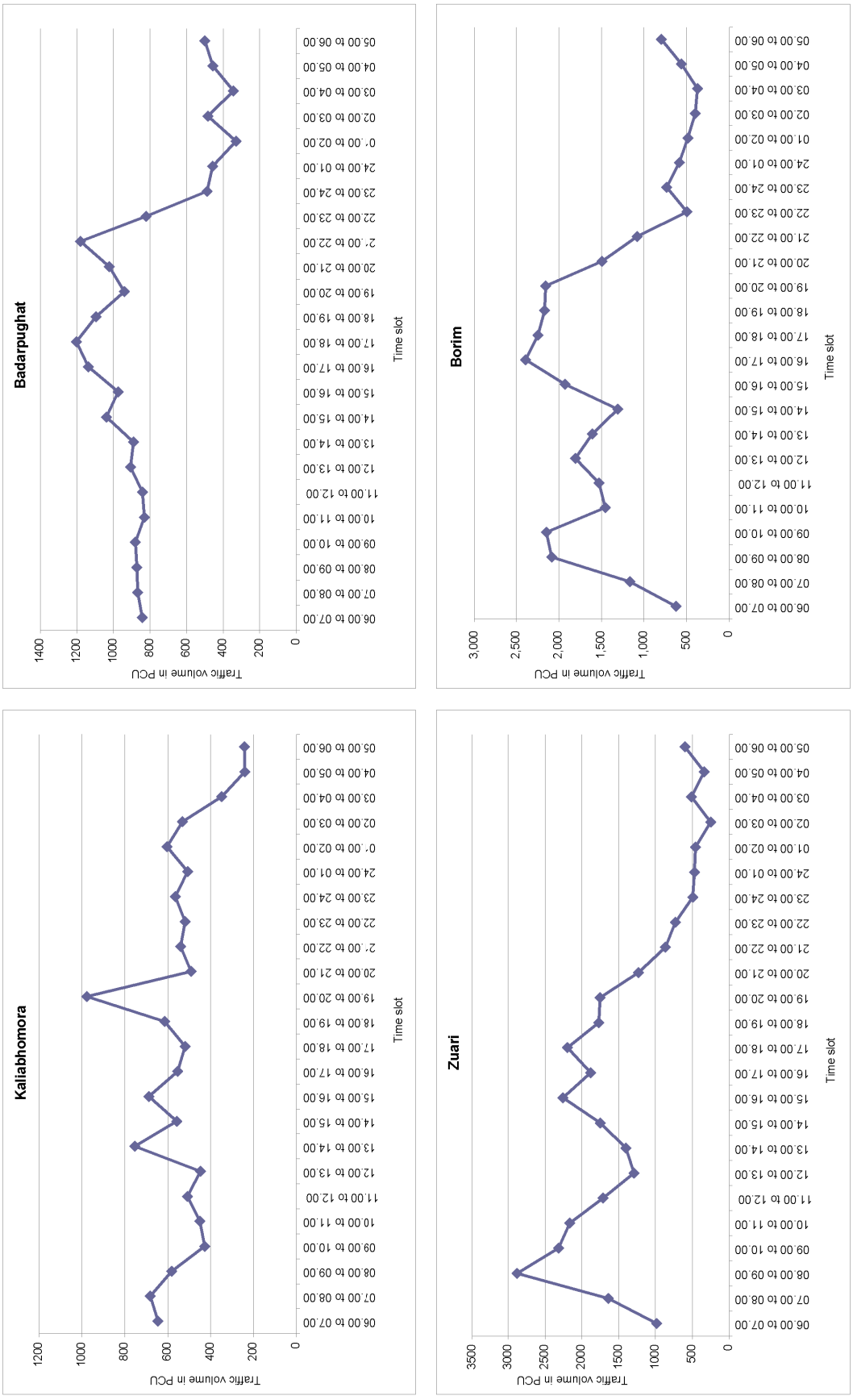


Figure 4.2.1 Hourly Traffic Flow (1/2)

Source: JICA Survey Team

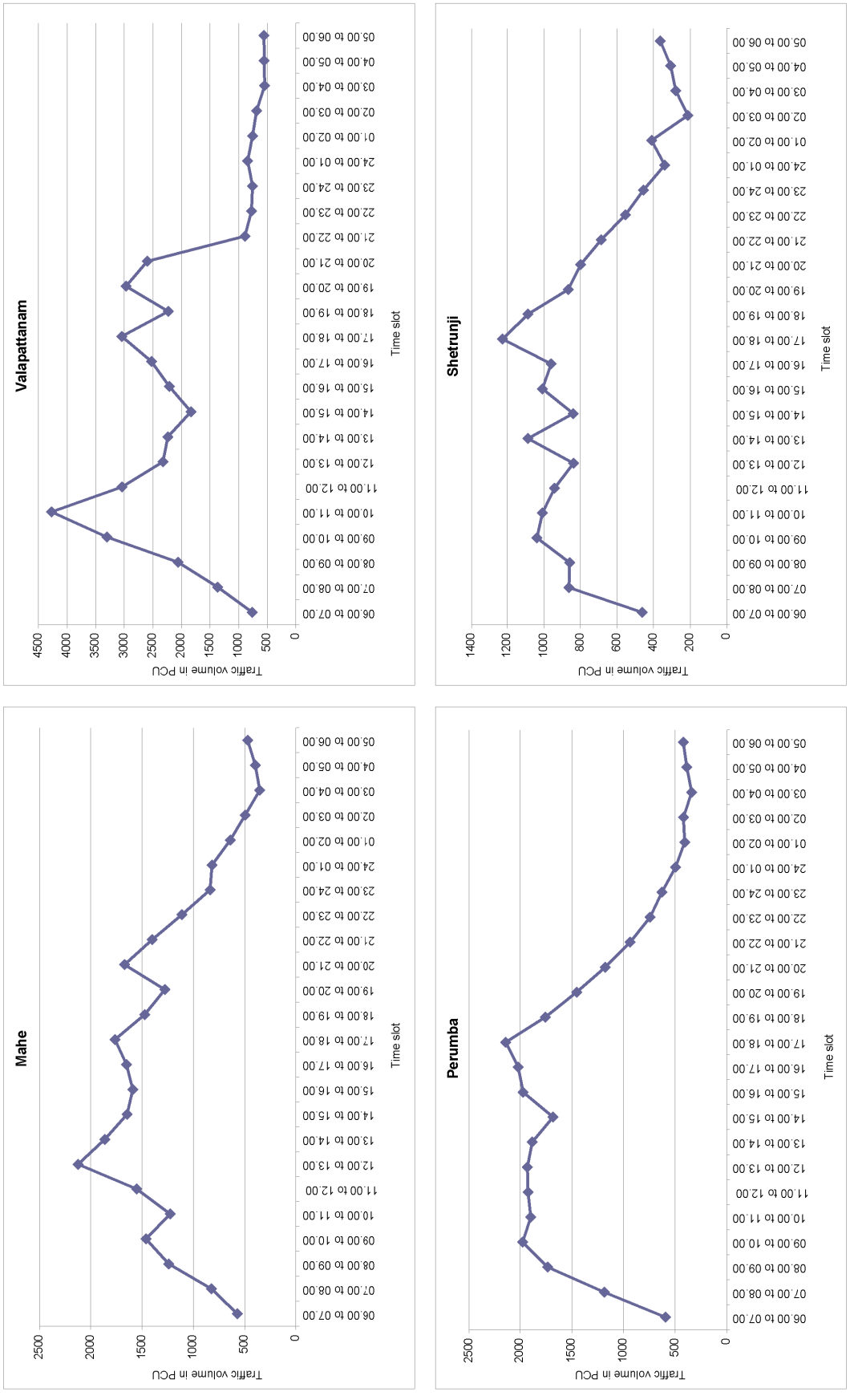
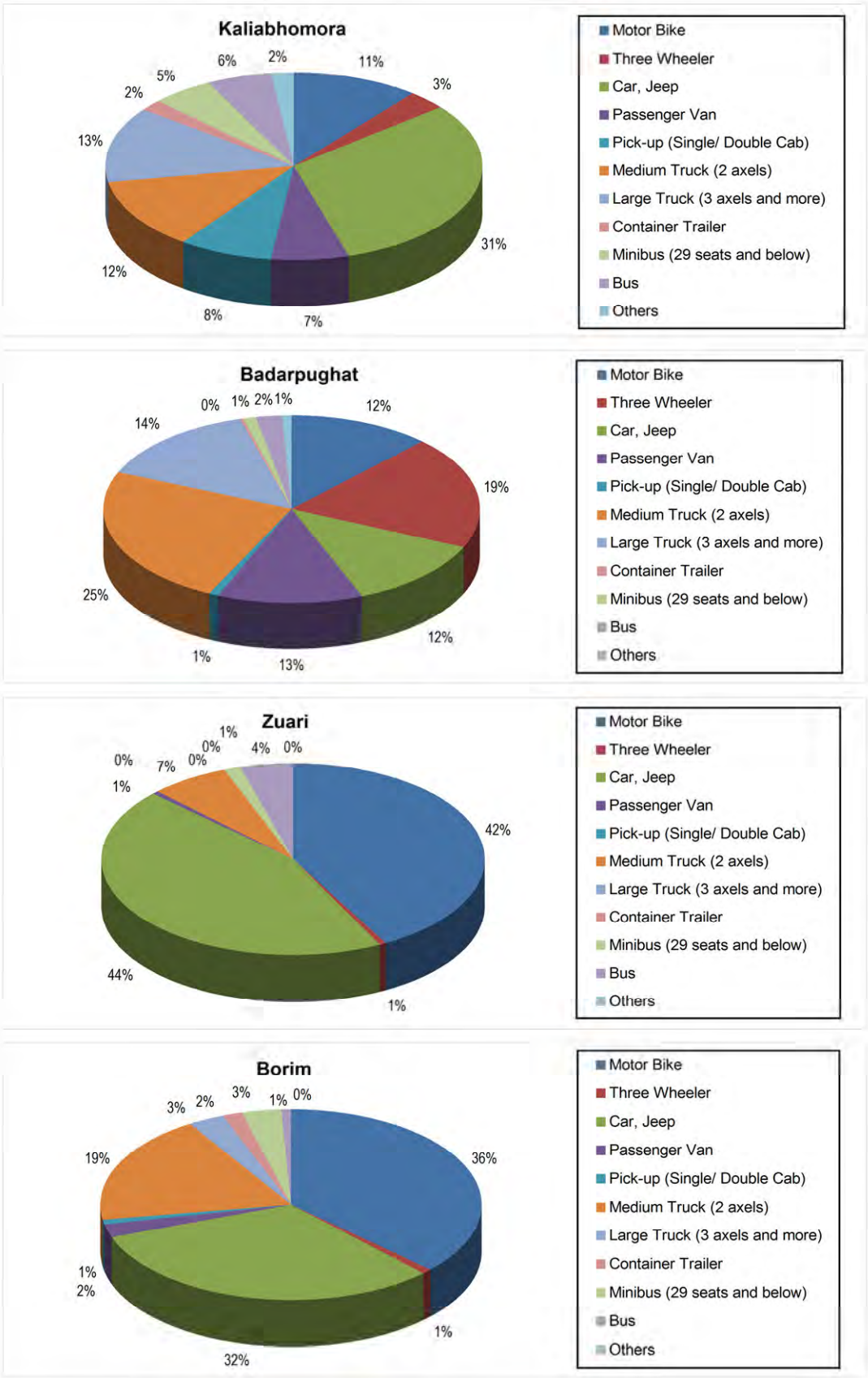


Figure 4.2.2 Hourly Traffic Flow (2/2)

Source: JICA Survey Team

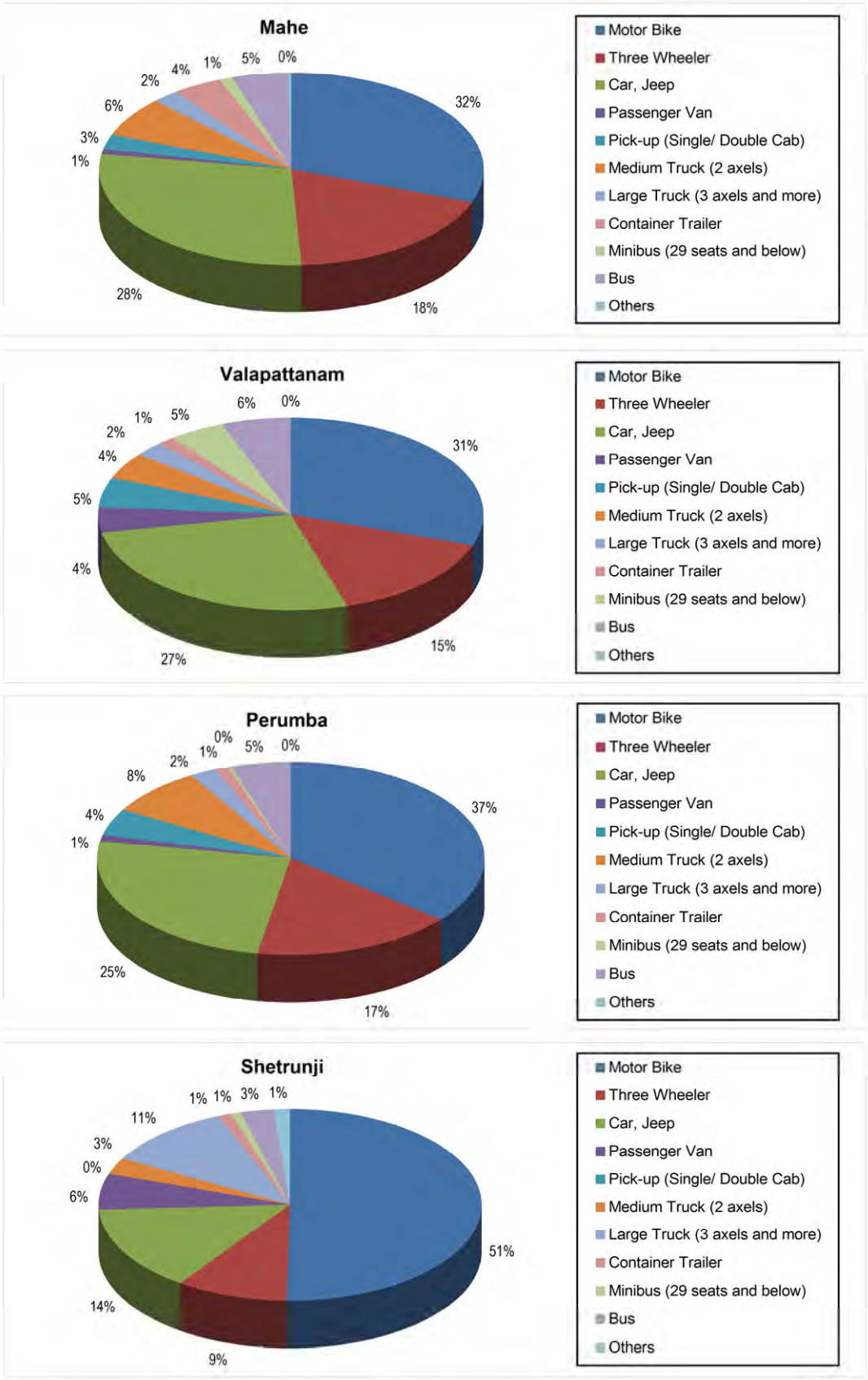
(4) Traffic Composition

The composition for each bridge is shown in Figure 4.2.3 and Figure 4.2.4. Motor bike rate are majority excluding Assam State and vary from 31 % to 51 % in PCUs. In Assam State, it varies from 11 % to 12 %.



Source: JICA Survey Team

Figure 4.2.3 Traffic Composition (1/2)



Source: JICA Survey Team

Figure 4.2.4 Traffic Composition (2/2)

4.3 Outline of the Proposal Project

4.3.1 Proposal of Methods for Bridge Rehabilitation

Rehabilitation methods for each bridge based on the second site survey are proposed. Proposals for reinforcement methods are shown in following table.

Table 4.3.1 Proposals for Bridge Repair Works (1/2)

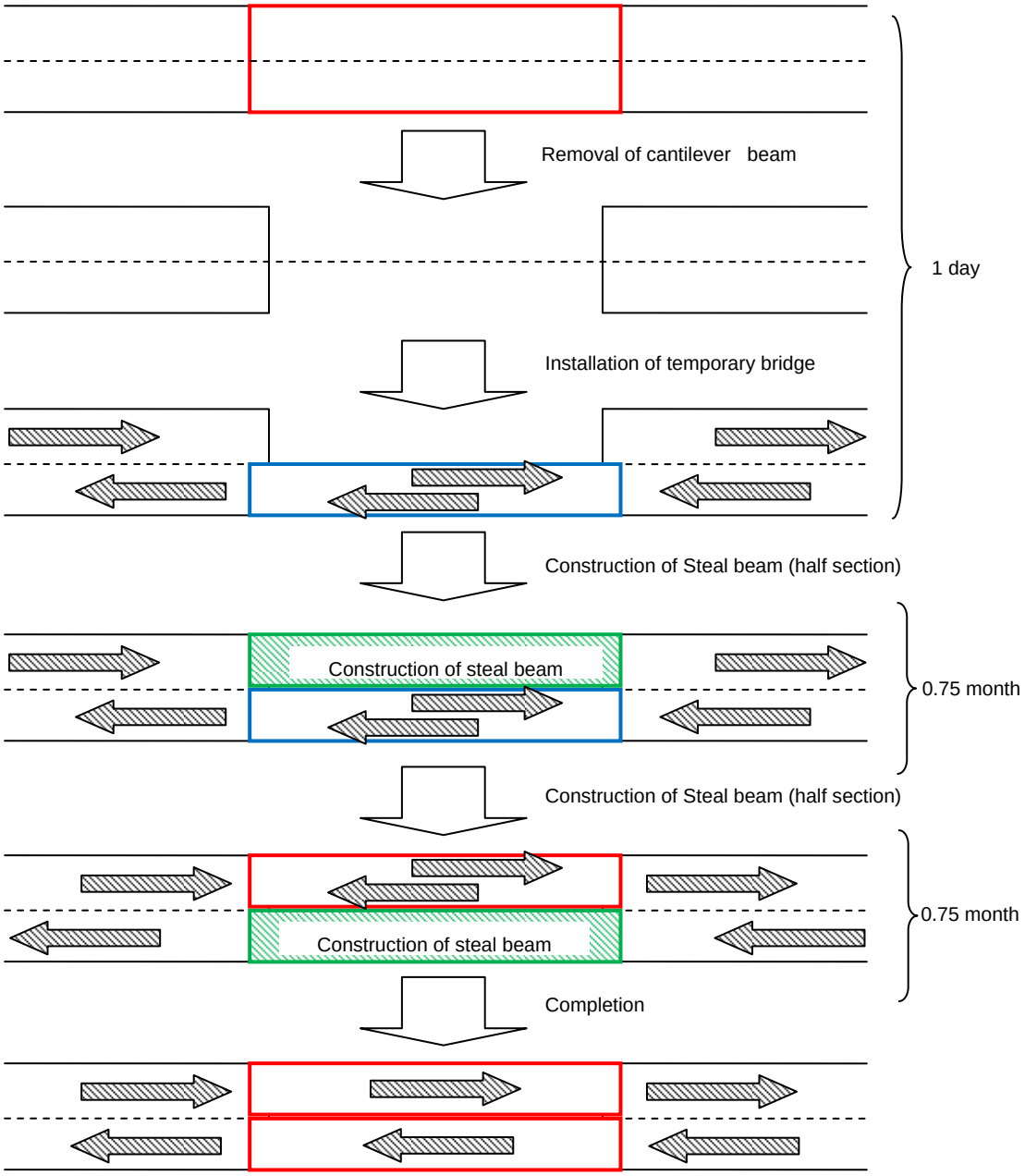
State	Bridge No.	National Highway No.	Name of Bridge	Sources of Bridge Damage and Repair Plans	Proposal for Repair Works	Notes
Assam	1	NH37A	Kaliabhomora Bridge	Due to the deflection of overhanging beams, differential deflection in girders has emerged. It is possible to reduce the weight of the superstructure and decrease the deflection of the overhanging beams by replacing the RC connecting slab with steel girder. Additionally, because the bridge is in a region far from the coast, atmospheric corrosion-resisting steel is to be used to make the structure maintenance-free. Construction step is shown in Figure 4.3.1.	Replacement by steel girder(weathering steel) for Gerber Girder	The new bridge is planned to be constructed using BOT.
	2	NH44	Badarpurghat Bridge	Due to subsidence of the substructure, differential displacement has appeared in the superstructure. Additionally, the superstructure has very severe damage, making reinforcement impossible.	Construction of a new bridge	
Goa	3	NH17	Zuari Bridge	This bridge had its superstructure reinforced in 2003, but has imposed loading restrictions on vehicular traffic. Additionally, partial differential displacement has been observed at the center hinge, and this differential displacement is very likely to increase in the future.	Construction of a new bridge Connection of the center hinge	
	4	NH17B	Borim Bridge	Because this bridge is used by large vehicles that are unable to cross Zuari bridge, the center hinge has suffered damage, and partial differential displacement has been observed at the center hinge. Additionally, the crossing of these large vehicles causes harsh vibrations, which is very likely to lead to an increase in differential displacement in the future. Because PWD is currently planning a new bridge, reinforcement of the existing bridge must be executed after the construction of the new bridge.	Construction of a new bridge Connection of the center hinge	

Source: JICA Survey Team

Table 4.3.2 Proposals for Bridge Repair Works (2/2)

State	Bridge No.	National Highway No.	Name of Bridge	Sources of Bridge Damage and Repair Plans	Proposal for Repair Works	Notes
Kerala	5	NH17	Mahe Bridge	80 years have passed since the construction of the substructure, but it was determined to still be sound in the inspection. The superstructure has suffered cracking, spalling, and severe damage, and hence repair work is proving difficult. The current substructure can continue to be used by replacing the superstructure's existing concrete girders with steel girders.	Replacement of superstructure with steel girders	
	6		Valapattanam Bridge	Large-scale cracking and spalling has taken place in the piers. By reinforcing the piers with carbon fiber, both the impediment ratio of river flow and the burden on the foundation can be reduced. The superstructure has suffered cracking, spalling, and severe damage, and hence repair work is proving difficult. By replacing the superstructure's existing concrete girders with steel girders, the effect on the substructure can be minimized.	Replacement of superstructure with steel girders Reinforcement of substructure with carbon fiber	
	7		Perumba Bridge	The substructure has been determined to be sound by the investigation. However, the superstructure has incurred severe damage, and hence repairs are proving difficult. By replacing the superstructure's existing concrete girders with steel girders, the effect on the substructure can be minimized.	Replacement of superstructure with steel girders	
Gujarat	8	NH8E	Shetrunji Bridge	The substructure has been determined to be sound by the investigation. However, the superstructure has incurred severe damage, and hence repairs are proving difficult. By replacing the superstructure's existing concrete girders with steel girders, the effect on the substructure can be minimized.	Replacement of superstructure with steel girders	

Source: JICA Survey Team



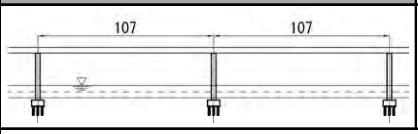
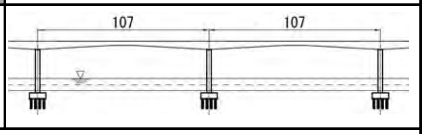
Source: JICA Survey Team

Figure 4.3.1 Construction Step of Kaliabhomora Bridge

4.3.2 Study of Bridge Type for New Bridge

The study of bridge type for new bridge is conducted because new bridges are required regarding Badarpurghat Bridge, Zuari Bridge and Borim Bridge. Comparison tables of bridge type are shown in Table 4.3.3, Table 4.3.4 and Table 4.3.5.

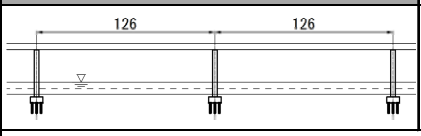
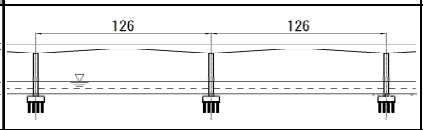
Table 4.3.3 Comparison Table (New Badarpurghat Bridge)

Bridge Type		Option 1 Steel Plate Deck Box Girder Bridge		Option 2 PC Box Girder Bridge	
Side elevation view					
Bridge specs	Length	360m			
	Maximum span	107m			
	Width	10m (2 lanes)			
Landscape		Excellent	A	Excellent	A
Impact to natural environment		Minimized impact to natural environment due to foundation that can be compacted because of light superstructure	A	Large impact to natural environment due to foundation that cannot be compacted because of heavy superstructure	C
Construction experience		Plentiful	A	Plentiful	A
Difficulty of construction		Erection by cantilever construction method	B	Erection by cantilever construction method	B
Construction period		24 months	A	32 months	C
Construction cost (million yen)		1,995 (1.11)	B	1,794 (1.00)	A
Evaluation		To be adopted (contruction period can be shortened by 8 months)			

Legend: A Excellent, B Good, C Poor

Source: JICA Survey Team

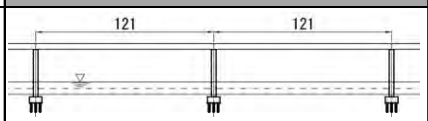
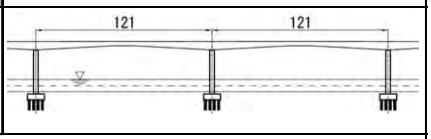
Table 4.3.4 Comparison Table (New Zuari Bridge)

Bridge Type		Option 1 Steel Plate Deck Box Girder Bridge		Option 2 PC Box Girder Bridge	
Side elevation view					
Bridge specs	Length	809m			
	Maximum span	126m			
	Width	10.5m (2 lanes)			
Landscape		Excellent	A	Excellent	A
Impact to natural environment		Minimized impact to natural environment due to foundation that can be compacted because of light superstructure	A	Large impact to natural environment due to foundation that cannot be compacted because of heavy superstructure	C
Construction experience		Plentiful	A	Plentiful	A
Difficulty of construction		Erection by cantilever construction method	B	Erection by cantilever construction method	B
Construction period		29 months	A	37 months	C
Construction cost (million yen)		4,253 (1.11)	B	3,823 (1.00)	A
Evaluation		To be adopted (contruction period can be shortened by 8 months)			

Legend: A Excellent, B Good, C Poor

Source: JICA Survey Team

Table 4.3.5 Comparison Table (New Borim Bridge)

Bridge Type		Option 1 Steel Plate Deck Box Girder Bridge		Option 2 PC Box Girder Bridge	
Side elevation view					
Bridge specs	Length	411m			
	Maximum span	212m			
	Width	10.5m (2 lanes)			
Landscape		Excellent	A	Excellent	A
Impact to natural environment		Minimized impact to natural environment due to foundation that can be compacted because of light superstructure	A	Large impact to natural environment due to foundation that cannot be compacted because of heavy superstructure	C
Construction experience		Plentiful	A	Plentiful	A
Difficulty of construction		Erection by cantilever construction method	B	Erection by cantilever construction method	B
Construction period		22 months	A	29 months	C
Construction cost (million yen)		2,205 (1.11)	B	1,982 (1.00)	A
Evaluation		To be adopted (contruction period can be shortened by 7 months)			

Legend: A Excellent, B Good, C Poor

Source: JICA Survey Team

4.3.3 Estimated Project Cost

(1) Exchange Rate

The exchange rates that have been used to estimate the project cost (current as of February 2014), are as follows.

- 1 USD = 102.08 yen
- 1 Indian rupee = 1.65 yen

(2) Estimated Project Cost

Estimated project costs in case of Japanese support are written in Table 4.3.6 and Table 4.3.7. The estimated total project cost (including construction costs, design costs and supervision costs) is approximately 14.2 billion yen.

Construction of New Bridge

The estimated project cost of the construction of new bridges through loans (including construction costs, design costs and supervision costs) is approximately 9.6 billion yen.

Table 4.3.6 Estimated Project Cost (Construction of New Bridge)

		Total (Thousand)		
		JPY	USD	INR
Construction cost	New Badarpurghat Bridge	1,995,000	19,543	1,209,000
	New Zuari Bridge	4,252,500	41,659	2,577,000
	New Borim Bridge	2,205,000	21,601	1,336,000
	Subtotal	**8,452,500**	**82,803**	**5,122,000**
Design cost	New Badarpurghat Bridge	78,000	762	47,000
	New Zuari Bridge	166,000	1,625	101,000
	New Borim Bridge	86,000	842	52,000
	Subtotal	**330,000**	**3,229**	**200,000**
Supervision cost	New Badarpurghat Bridge	182,000	1,778	110,000
	New Zuari Bridge	387,000	3,791	235,000
	New Borim Bridge	201,000	1,966	122,000
	Subtotal	**770,000**	**7,535**	**467,000**
Total		**9,552,500**	**93,567**	**5,789,000**

Source: JICA Survey Team

Rehabilitation of Existing Bridges

The estimated project cost for the rehabilitation of existing bridges through loans (including construction costs, design costs and supervision costs) is approximately 4.6 billion yen.

Table 4.3.7 Estimated Project Cost (Rehabilitation of Existing Bridges)

		Total(Thousand)		
		JPY	USD	INR
Construction cost	Kaliabhomora Bridge	510,000	4,996	309,000
	Zuari Bridge	280,000	2,743	170,000
	Borim Bridge	70,000	686	42,000
	Mahe Bridge	427,400	4,188	258,000
	Valapattanam Bridge	1,532,400	15,013	928,000
	Perumba Bridge	517,400	5,069	313,000
	Shetrunji Bridge	755,400	7,401	458,000
	Sub-total	**4,092,600**	**40,096**	**2,478,000**
Design cost	Kaliabhomora Bridge	20,000	195	12,000
	Zuari Bridge	11,000	107	7,000
	Borim Bridge	3,000	27	2,000
	Mahe Bridge	17,000	163	10,000
	Valapattanam Bridge	60,000	586	36,000
	Perumba Bridge	20,000	198	12,000
	Shetrunji Bridge	29,000	289	18,000
	Sub-total	**160,000**	**1,565**	**97,000**
Supervision cost	Kaliabhomora Bridge	46,000	455	28,000
	Zuari Bridge	25,000	250	15,000
	Borim Bridge	6,000	62	4,000
	Mahe Bridge	39,000	381	23,000
	Valapattanam Bridge	139,000	1,366	84,000
	Perumba Bridge	47,000	461	28,000
	Shetrunji Bridge	69,000	673	42,000
	Sub-total	**371,000**	**3,648**	**224,000**
Total		**4,623,600**	**45,309**	**2,799,000**

Source: JICA Survey Team

4.3.4 Construction Schedule

(1) New Bridges

Construction schedule is shown in Table 4.3.8 to Table 4.3.10.

Table 4.3.8 Construction Schedule (New Badarpurghat Bridge)

Months				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Preparation works			2.0																													
Substructure	A1	Land division	2.0																													
	P1		3.0																													
	P2	River division	5.0																													
	P3		5.0																													
	P4		5.0																													
	A2	Land division	2.0																													
Superstructure	Main girder production		20.0																													
	A1-P1 (31m)	Main girder	0.5																													
		Slab	0.5																													
		Surfacing	0.5																													
	P1-P2 (57m)	Main girder	5.0																													
	P2-P3 (107m)		10.0																													
	P3-P4 (107m)		10.0																													
	P4-A2 (58m)		3.0																													
	P1-A2 (329m)	Surfacing	1.5																													
Rearrangement work			1.0																													

Source: JICA Survey Team

Table 4.3.9 Construction Schedule (New Zuari Bridge)

Months				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Preparation works			2.0																													
Substructure	A1	Land division	2.0																													
	P1	River division	5.0																													
	P2		5.0																													
	P3		5.0																													
	P4		5.0																													
	P5		5.0																													
	P6	Land division	3.0																													
	P7		3.0																													
	P8		3.0																													
	P9		3.0																													
	P10		3.0																													
	A2		2.0																													
Superstructure	Main girder production		22.0																													
	A1-P1 (71.4m)	Main girder	6.5																													
	P1-P2 (121.6m)		11.0																													
	P2-P3 (119.6m)		11.0																													
	P3-P4 (119.6m)		11.0																													
	P4-P5 (126m)		11.0																													
	P5-P6 (70.8m)		6.5																													
	A1-P6 (629m)	Surfacing	3.0																													
	P6-A2 (180m)	Main girder	3.0																													
		Slab	3.0																													
		Surfacing	1.0																													
Rearrangement work			1.0																													

Source: JICA Survey Team

Table 4.3.10 Construction Schedule (New Borim Bridge)

Months				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Preparation works			2.0																													
Substructure	A1	Land division	2.0																													
	P1	River division	5.0																													
	P2		5.0																													
	P3	Land division	3.0																													
	P4		3.0																													
	P5		3.0																													
	P6		3.0																													
	A2		2.0																													
Superstructure	Main girder production		18.0																													
	A1-P1 (69.8m)	Main girder	6.5																													
	P1-P2 (121m)		11.0																													
	P2-P3 (69.8m)		6.5																													
	A1-P3 (260.6m)	Surfacing	1.0																													
	P3-A2 (149.6m)	Main girder	2.5																													
		Slab	2.5																													
		Surfacing	1.0																													
Rearrangement work			1.0																													

Source: JICA Survey Team

(2) Existing Bridges

Construction schedule is shown in Table 4.3.11 to Table 4.3.17.

Table 4.3.11 Construction Schedule (Kaliabhomora Existing Bridge)

Months			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation works		2.0																								
Main girder production		8.0																								
P1-P2	Removal of existing main girder Temporary bridge installation	0.01																								
	Construction of main girder	0.25																								
	Slab, Surfacing	1.0																								
P2-P3	Removal of existing main girder Temporary bridge installation	0.01																								
	Construction of main girder	0.25																								
	Slab, Surfacing	1.0																								
P3-P4	Removal of existing main girder Temporary bridge installation	0.01																								
	Construction of main girder	0.25																								
	Slab, Surfacing	1.0																								
P4-P5	Removal of existing main girder Temporary bridge installation	0.01																								
	Construction of main girder	0.25																								
	Slab, Surfacing	1.0																								
P5-P6	Removal of existing main girder Temporary bridge installation	0.01																								
	Construction of main girder	0.25																								
	Slab, Surfacing	1.0																								
P6-P7	Removal of existing main girder Temporary bridge installation	0.01																								
	Construction of main girder	0.25																								
	Slab, Surfacing	1.0																								
P7-P8	Removal of existing main girder Temporary bridge installation	0.01																								
	Construction of main girder	0.25																								
	Slab, Surfacing	1.0																								
P24-P25	Removal of existing main girder Temporary bridge installation	0.01																								
	Construction of main girder	0.25																								
	Slab, Surfacing	1.0																								
Rearrangement work		1.0																								

Source: JICA Survey Team

Table 4.3.12 Construction Schedule (Zuari Existing Bridge)

Months			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation works		2.0																								
P1-P2	Connection of center hinge	1.0																								
P2-P3		1.0																								
P3-P4		1.0																								
P4-P5		1.0																								
Surfacing		0.5																								
Rearrangement work		1.0																								

Source: JICA Survey Team

Table 4.3.13 Construction Schedule (Borim Existing Bridge)

Months		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation works	2.0																								
Connection of center hinge	1.0																								
Surfacing	0.5																								
Rearrangement work	1.0																								

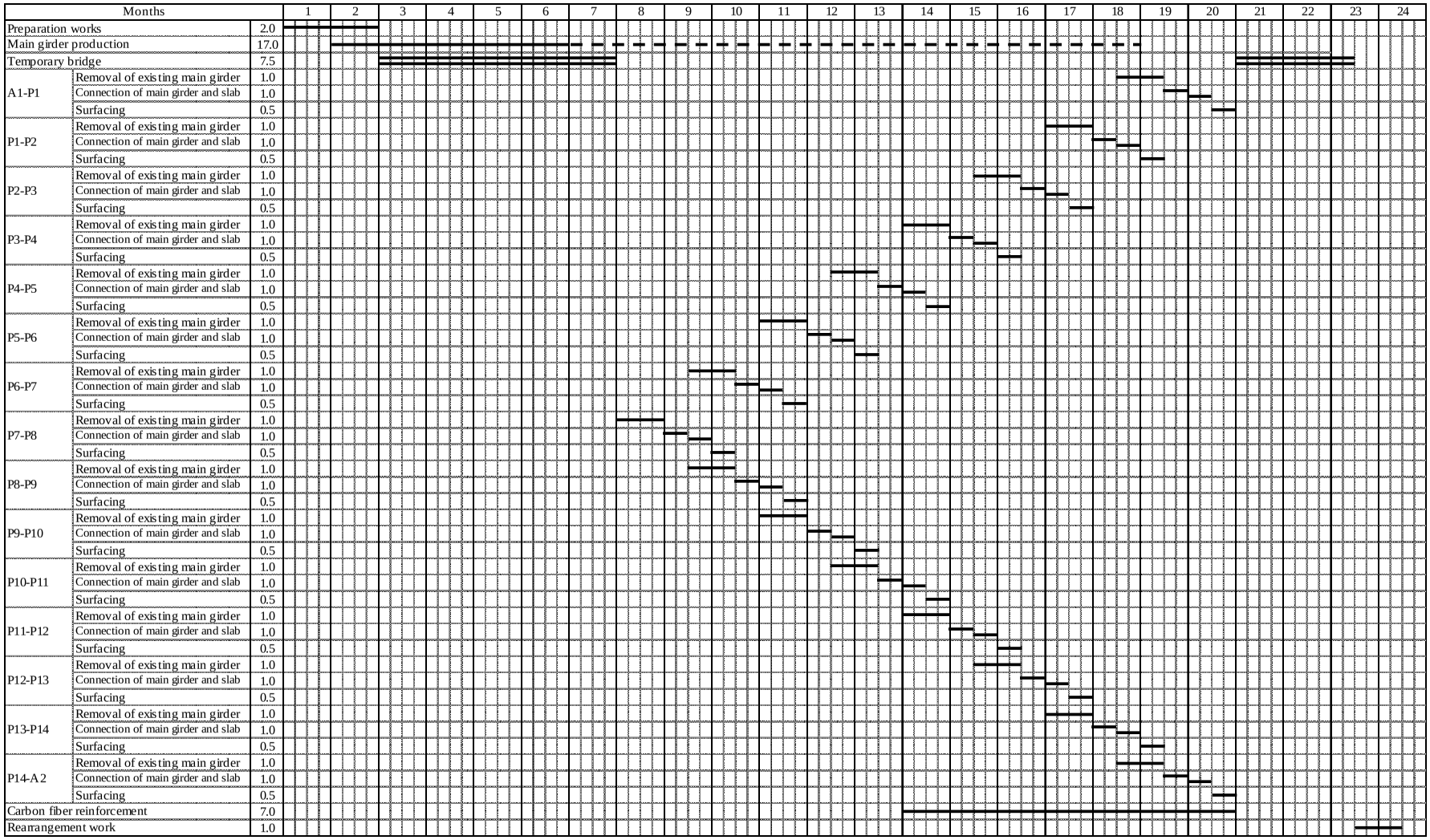
Source: JICA Survey Team

Table 4.3.14 Construction Schedule (Mahe Existing Bridge)

Months			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation works		2.0																								
Main girder production		11.0																								
Temporary bridge		4.0																								
A1-P1	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P1-P2	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P2-P3	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P3-P4	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P4-A2	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
Rearrangement work		1.0																								

Source: JICA Survey Team

Table 4.3.15 Construction Schedule (Valapattanam Existing Bridge)



Months			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation works		2.0																								
Main girder production		17.0																								
Temporary bridge		7.5																								
A1-P1	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P1-P2	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P2-P3	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P3-P4	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P4-P5	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P5-P6	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P6-P7	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P7-P8	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P8-P9	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P9-P10	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P10-P11	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P11-P12	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P12-P13	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P13-P14	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P14-A2	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
Carbon fiber reinforcement		7.0																								
Rearrangement work		1.0																								

Source: JICA Survey Team

Table 4.3.16 Construction Schedule (Perumba Existing Bridge)

Months			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation works		2.0																								
Main girder production		10.0																								
Temporary bridge		5.0																								
A1-P1	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P1-P2	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P2-P3	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P3-P4	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P4-P5	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P5-P6	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P6-A2	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
Rearrangement work		1.0																								

Source: JICA Survey Team

Table 4.3.17 Construction Schedule (Shetrunji Existing Bridge)

Months			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation works		2.0																								
Main girder production		8.0																								
Temporary bridge		1.5																								
A1-P1	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P1-P2	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P2-P3	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P3-P4	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P4-P5	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P5-P6	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P6-P7	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P7-P8	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P8-P9	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
P9-A2	Removal of existing main girder	1.0																								
	Connection of main girder and slab	1.0																								
	Surfacing	0.5																								
Rearrangement work		1.0																								

Dry season: 5 months

Source: JICA Survey Team

4.4 Economic Analysis

4.4.1 Traffic Demand Forecast

Based on the traffic count survey results, the traffic demand forecasting is developed for the economic internal ratio. Before forecast of the future traffic demand, the following information regarding to population, GDP/GSDP, PCI (NDP/NSDP), number of registered vehicles, Net Tonne-Kilometers and Passenger-Kilometers was reviewed (Refer to Appendix);

- Statistical Data
  - Economic Survey 2012-13; Government of India; 2013
  - Socio-Economic Review 2012-13, Gujarat State; Government of Gujarat; Feb-2013
  - Economic Survey 2012-13; Government of Goa; 2013
  - Economic Review 2013; Kerala State Planning Board; 2014
  - Economic Survey, Assam, 2012-13; Government of Assam; 2014
  - Road Transport Year Book (2011-12); Transport Research Wing, MORTH
  - Final Feasibility Report, Vol. 1 of 2, Text; Mumbai Metropolitan Region Development Authority; Dec 2012
- Projection Data
  - The Future Population of India; Population Foundation of India; Aug 2007
  - Twelfth Five Year Plan (2012-2017) Vol. II; Planning Commission, Government of India; 2013
  - Looking to 2060; OECD; Nov 2012
  - Global Economic Prospects; World Bank; Jan 2014

Also, the traffic data near the project site are available as shown in Table 4.4.1. However, some locations are far from the project site. Also, some data need the examination carefully.

Table 4.4.1 Traffic Data near the Project Site

No.	State Name	Survey Period	Name of NHs	Station	Nearest Town	Cars	LCV	Trucks	MAV	Buses	Motor Cycles	Cycles	Animal Drawn Vechicles	Agricultural Tractors	Others	Total in vehicle	Total in PCUs
1	**Assam**	**Kaliabhomora**	**NH37A**	**-**													
	Jan 2004 - Jun 2004		NH37	183	Sonapur	2,239	0	1,780	0	1,120	1,026	1,548	188	0	0	7,901	12,978
	Jan 2005 - Jun 2005		NH37	183	Sonapur	2,462	0	1,723	0	1,298	1,128	3,246	206	0	0	10,063	14,536
	Jan 2006 - Jun 2006		NH37	183	Sonapur	2,949	941	1,337	568	1,237	1,825	2,343	0	4	2	11,206	16,745
2	**Assam**	**Badarpurghat**	**NH44**	**201**													
	Jul 2004 - Dec 2004		NH53	16	Silchar	1,244	1,002	1,230	7	946	500	449	0	4	0	5,382	10,007
3	**Goa**	**Zuari**	**NH17**	**Panaji 14/800**													
	Jan 2004 - Jun 2004		NH17A	6	Panaji	5,268	0	1,212	0	715	5,214	130	0	0	0	12,539	13,721
4	**Goa**	**Borim**	**NH17B**	**Ponda 9/00**													
	Jan 2006 - Jun 2006		NH17B	5	Ponda	4,237	883	2,145	559	844	4,282	21	0	3	0	12,974	19,200
5	**Kerala**	**Mahe**	**NH17**	**184/600**													
	Jan 2006 - Jun 2006		NH17	187	Mahe	4,973	1,300	1,073	240	1,414	2,445	117	0	8	0	11,570	16,757
6	**Kerala**	**Valapattanam**	**NH17**	**147/250**													
	Jan 2006 - Jun 2006		NH17	155	Kannur	9,886	2,113	1,601	610	3,300	6,583	222	0	6	1	24,322	33,923
7	**Kerala**	**Perumba**	**NH17**	**115/400**													
	Jan 2006 - Jun 2006		NH17	120	Payyanur	3,968	1,303	1,076	223	1,252	2,517	151	0	7	2	10,499	15,271
8	**Gujarat**	**Shetrunji**	**NH8E**	**Budhel 10/0**													
	Jan 2006 - Jun 2006		NH8E	9/80	Bhavnagar	3,878	1,101	1,157	1,215	658	4,360	213	2	194	4	12,782	19,064

Source: MORTH

After review and analysis of the above data, the traffic demand forecast for the horizon years 2020 and 2030 are given in Table 4.4.2 and Table 4.4.3 for "With Cases". At present, heavy vehicles are prohibited to cross over the Zuari Bridge. And then, the traffic forecast in the "With Case" is considered the conversion traffic to Zuari Bridge from Borim Bridge and other bridges in Year 2020 when is planned to construct a new bridge beside the existing Zuari Bridge. On the other hand, the traffic demand forecast for "Without Cases" of 2 bridges is given in Table 4.4.4.

Table 4.4.2 Summary of Traffic Demand Forecast (With Case)

S.No	Year	State	Assam		Goa		Kerala		Kerala	Gujarat
		Name of Bridge	Kaliabhomora	Badarpughat	Zuari	Borim	Mahe	Valapattnam	Perumba	Shetrunji
0	Feb-2014	ADT (In Number of vehicles)	6,576	9,804	31,298	22,694	22,388	36,929	25,872	12,970
		ADT (In PCU)	12,990	19,413	31,926	31,575	28,473	43,155	30,070	17,485
1	2020	ADT (In Number of vehicles)	9,727	14,417	50,776	30,373	32,360	55,440	41,002	21,652
		ADT (In PCU)	19,990	29,916	58,841	40,688	42,596	66,445	49,249	30,824
2	2030	ADT (In Number of vehicles)	14,645	21,500	80,979	43,065	47,253	84,113	66,055	36,650
		ADT (In PCU)	31,358	46,664	96,917	59,677	64,571	103,756	82,134	55,408

Source: JICA Survey Team

Table 4.4.3Traffic Demand Forecast by Vehicle Types (With Case)

S.No	Year	State	Assam									
		Name of Bridge	Kaliabhomora					Badarpughat				
		Vehicular type / Traffic volume	Passenger Car	Truck	Bus	Motor Cycle	Total	Passenger Car	Truck	Bus	Motor Cycle	Total
0	Feb-2014	ADT (In Number of vehicles)	2,703	2,442	721	710	6,576	4,335	3,926	347	1,196	9,804
		ADT (In PCU)	2,646	8,350	1,640	355	12,990	3,859	14,075	881	598	19,413
1	2020	ADT (In Number of vehicles)	3,778	3,949	1,008	992	9,727	5,997	6,285	480	1,655	14,417
		ADT (In PCU)	3,699	13,504	2,292	496	19,990	5,339	22,532	1,218	828	29,916
2	2030	ADT (In Number of vehicles)	5,330	6,494	1,422	1,399	14,645	8,378	10,139	671	2,312	21,500
		ADT (In PCU)	5,218	22,206	3,234	700	31,358	7,458	36,348	1,703	1,156	46,664
S.No	Year	State	Goa									
		Name of Bridge	Zuari					Borim				
		Vehicular type / Traffic volume	Passenger Car	Truck	Bus	Motor Cycle	Total	Passenger Car	Truck	Bus	Motor Cycle	Total
0	Feb-2014	ADT (In Number of vehicles)	14,265	2,124	1,778	13,131	31,298	7,879	5,534	893	8,388	22,694
		ADT (In PCU)	14,223	6,409	4,728	6,566	31,926	7,829	17,915	1,637	4,194	31,575
1	2020	ADT (In Number of vehicles)	22,041	5,700	2,747	20,288	50,776	10,851	6,739	1,230	11,553	30,373
		ADT (In PCU)	21,976	19,416	7,305	10,144	58,841	10,782	21,874	2,255	5,777	40,688
2	2030	ADT (In Number of vehicles)	34,558	10,305	4,307	31,809	80,979	15,013	10,366	1,702	15,984	43,065
		ADT (In PCU)	34,456	35,102	11,454	15,905	96,917	14,918	33,647	3,120	7,992	59,677
S.No	Year	State	Kerala									
		Name of Bridge	Mahe					Valapattnam				
		Vehicular type / Traffic volume	Passenger Car	Truck	Bus	Motor Cycle	Total	Passenger Car	Truck	Bus	Motor Cycle	Total
0	Feb-2014	ADT (In Number of vehicles)	10,673	3,524	1,330	6,861	22,388	16,920	4,939	3,928	11,142	36,929
		ADT (In PCU)	9,640	11,819	3,584	3,431	28,473	15,529	13,015	9,041	5,571	43,155
1	2020	ADT (In Number of vehicles)	15,097	5,677	1,881	9,705	32,360	24,883	8,394	5,777	16,386	55,440
		ADT (In PCU)	13,636	19,039	5,069	4,853	42,596	22,837	22,119	13,296	8,193	66,445
2	2030	ADT (In Number of vehicles)	21,502	9,248	2,680	13,823	47,253	36,832	14,474	8,552	24,255	84,113
		ADT (In PCU)	19,422	31,017	7,221	6,912	64,571	33,804	38,142	19,683	12,128	103,756
S.No	Year	State	Kerala					Gujarat				
		Name of Bridge	Perumba					Shetrunji				
		Vehicular type / Traffic volume	Passenger Car	Truck	Bus	Motor Cycle	Total	Passenger Car	Truck	Bus	Motor Cycle	Total
0	Feb-2014	ADT (In Number of vehicles)	11,163	4,129	1,335	9,245	25,872	3,877	2,072	490	6,531	12,970
		ADT (In PCU)	10,059	11,482	3,906	4,623	30,070	3,575	9,370	1,275	3,266	17,485
1	2020	ADT (In Number of vehicles)	17,266	7,371	2,065	14,300	41,002	6,318	3,892	799	10,643	21,652
		ADT (In PCU)	15,559	20,499	6,042	7,150	49,249	5,826	17,598	2,079	5,322	30,824
2	2030	ADT (In Number of vehicles)	27,071	13,325	3,238	22,421	66,055	10,390	7,444	1,314	17,502	36,650
		ADT (In PCU)	24,394	37,055	9,474	11,211	82,134	9,581	33,657	3,419	8,751	55,408

Source: JICA Survey Team

Table 4.4.4 Traffic Demand Forecast by Vehicle Types (Without Case)

S.No	Year	State	Goa									
		Name of Bridge	Zuari					Borim				
		Vehicular type / Traffic volume	Passenger Car	Truck	Bus	Motor Cycle	Total	Passenger Car	Truck	Bus	Motor Cycle	Total
0	Feb-2014	ADT (In Number of vehicles)	14,265	2,124	1,778	13,131	31,298	7,879	5,534	893	8,388	22,694
		ADT (In PCU)	14,223	6,409	4,728	6,566	31,926	7,829	17,915	1,637	4,194	31,575
1	2020	ADT (In Number of vehicles)	22,041	3,787	2,747	20,288	48,863	10,851	8,399	1,230	11,553	32,033
		ADT (In PCU)	21,976	11,427	7,305	10,144	50,852	10,782	27,189	2,255	5,777	46,002
2	2030	ADT (In Number of vehicles)	34,558	6,847	4,307	31,809	77,521	15,013	12,919	1,702	15,984	45,618
		ADT (In PCU)	34,456	20,660	11,454	15,905	82,475	14,918	41,821	3,120	7,992	67,851

Source: JICA Survey Team

4.4.2 Economic Analysis

(1) General

1) General

The main purpose of the economic analysis is to show the effects of the implementation of highway bridge rehabilitation project on the selected eight highway bridges, from the point of view of the nation's economic well-being and to estimate a return on the resources invested.

For the purposes of economic evaluation, the economic internal rate of return (EIRR) is demonstrated.

Economic analysis follows a conventional cost benefit analysis of discounted cash flow methodology. The cost benefit analysis is made by comparison between economic benefits and costs.

2) Basic assumption

The following basic assumptions are made:

(a) Cost benefit analysis

Cost benefit analysis is made in comparison between the incremental costs and the incremental benefits, in which "incremental" means the difference between "With Project" condition (implementation of existing bridge rehabilitation including new bridge construction) and "Without Project" condition.

In the case of "Without Project", in near future the bridge collapse or the vehicle traffic block will be predicted. In such a case, as a result, the rehabilitation work including new bridge construction

will be carried out later after occurrence of the bridge collapse or the vehicle traffic block as countermeasure. During the period of the bridge collapse or the vehicle traffic block, the detour route will be used in order to keep vehicle traffic.

(b) Precondition of "With Project" and "Without Project" for each bridge

The preconditions of "With Project" and "Without Project" for each bridge are mentioned later.

(c) Calculation period

In this economic analysis, the total calculation period is assumed to be from year 2014 to year 2030, taking the followings into consideration:

- Implementation schedule of bridge rehabilitation including new bridge construction either in the case of "With Project" or in the case of "Without Project"
- Timing of benefit generation

(d) Scope of economic analysis

In this Study, regarding implementation scheme (financing, project costs and implementation schedule) for bridge rehabilitation including new bridge construction, there are following two schemes as mentioned in another section:

- Implementation by loan:

  Implementation by loan either for new bridge construction or for rehabilitation work

- Implementation by loan/grant:

  Implementation by loan for new bridge construction and by grant for rehabilitation work

In this economic analysis, the project cost and implementation schedule in the case of implementation by loan is treated.

(2) Precondition of With Project and Without Project for Each Bridge

The preconditions of With Project and Without Project for each bridge are shown in the following Table 4.4.5.

Table 4.4.5 Precondition of With Project and Without Project for Each Bridge

Bridge	Precondition
Kaliabhomora (Distance: 3.1 km)	(With Project) Year 2018: Rehabilitation work Year 2019: Start of operation of rehabilitated bridge
	(Without Project) Year 2024: Vehicle traffic blocked due to level difference in the position of Gerber (During period before year 2024, vehicle running speed decreased) Year 2024: Rehabilitation work Year 2025: Start of operation of rehabilitated bridge (During rehabilitation work after vehicle traffic blocked (year 2024), detour route (distance: 327 km) of vehicle traffic)
(2) Badarpurghat (Distance: 0.4 km)	(With Project) Year 2018: New bridge construction (to year 2019) Year 2020: Start of operation of new bridge
	(Without Project) Year 2024: Possibility of bridge collapse (During period before year 2024, vehicle running speed decreased) Year 2024: Detailed design Year 2025: New bridge construction (to year 2026) Year 2027: Start of operation of new bridge (During new bridge construction after bridge collapse (year 2024 to 2026), detour route (distance: 64 km) of vehicle traffic)
(3) Zuari (Distance: 0.8 km)	(With Project) Year 2018: New bridge construction (to year 2019) Year 2020: Start of operation of new bridge Year 2020: Rehabilitation work of existing bridge. Year 2021: Start of operation of rehabilitated bridge (At present, vehicle traffic control for heavy truck. After new bridge construction, vehicle traffic control for heavy truck released)
	(Without Project) Year 2024: Vehicle traffic blocked due to level difference in the position of Gerber Year 2024: Rehabilitation work. Year 2025: Start of operation of rehabilitated bridge (After rehabilitation work , vehicle traffic control for heavy truck released) (During rehabilitation work after vehicle traffic blocked (year 2024), detour route (distance: 54 km) of vehicle traffic)
(4) Borim (Distance: 0.4 km)	(With Project) Year 2018: New bridge construction (to year 2019) Year 2020: Start of operation of new bridge Year 2020: Rehabilitation work of existing bridge. Year 2020: Start of operation of rehabilitated bridge
	(Without Project) Year 2024: Vehicle traffic blocked due to level difference in the position of Gerber Year 2024: Rehabilitation work of existing bridge. Year 2025: Start of operation of rehabilitated bridge (During rehabilitation work after vehicle traffic blocked (year 2024), detour route (distance: 48 km) of vehicle traffic)
(5) Mahe (Distance: 0.2 km)	(With Project) Year 2018: Rehabilitation work Year 2019: Start of operation of rehabilitated bridge
	(Without Project) Year 2024: Possibility of bridge collapse (During period before year 2024, vehicle running speed decreased) Year 2024: Detailed design

	Year 2025: Rehabilitation work Year 2026: Start of operation of rehabilitated bridge (During rehabilitation work after bridge collapse (year 2024 to 2025), detour route (distance: 16 km) of vehicle traffic)
(6) Valapattanam (Distance: 0.5 km)	(With Project) Year 2018: Rehabilitation work (to year 2019) Year 2020: Start of operation of rehabilitated bridge
	(Without Project) Year 2024: Possibility of bridge collapse (During period before year 2024, vehicle running speed decreased) Year 2024: Detailed design Year 2025: Rehabilitation work (to year 2026) Year 2027: Start of operation of rehabilitated bridge (During rehabilitation work after bridge collapse (year 2024 to 2026), detour route (distance: 26 km) of vehicle traffic)
(7) Perumba (Distance: 0.2 km)	(With Project) Year 2018: Rehabilitation work Year 2019: Start of operation of rehabilitated bridge
	(Without Project) Year 2024: Possibility of bridge collapse (During period before year 2024 vehicle running speed decreased) Year 2024: Detailed design Year 2025: Rehabilitation work Year 2026: Start of operation of rehabilitated bridge (During rehabilitation work after bridge collapse (year 2024 to year 2025), detour route (distance: 23 km) of vehicle traffic)
(8) Shetrunji (Distance: 0.3 km)	(With Project) Year 2019: Rehabilitation work Year 2020: Start of operation of rehabilitated bridge
	(Without Project) Year 2024: Possibility of bridge collapse (During period before year 2024 vehicle running speed decreased) Year 2024: Detailed design Year 2025: Rehabilitation work Year 2026: Start of operation of rehabilitated bridge (During rehabilitation work after bridge collapse (year 2024 to 2025), detour route (distance: 7 km) of vehicle traffic)

Source: Assumed by JICA Survey Team
Note: Distance of bridge: rounded number

(3) Project Cost

The project cost in terms of financial prices is shown in Table 4.4.6. Then using conversion factor of 0.9 (which is assumed referring to another study report of infrastructure project in India), the above cost is converted into the cost in terms of economic prices. (Refer to Table 4.4.7)

Table 4.4.6 Project Cost (Financial Prices)

(Million Rs)

Bridge	With Project							
	New Bridge				Rehabilitation			
	D/D	Const	S/V	(Total)	D/D	Const	S/V	(Total)
(1)Kaliabhomora				0.0	12.0	309.0	28.0	349.0
(2) Badarpurghat	47.0	1,209.0	110.0	1,366.0				0.0
(3) Zuari	101.0	2,577.0	235.0	2,913.0	7.0	170.0	15.0	192.0
(4) Borim	52.0	1,336.0	122.0	1,510.0	2.0	42.0	4.0	48.0
(5) Mahe					10.0	258.0	23.0	291.0
(6) Valapattanam				0.0	36.0	928.0	84.0	1,048.0
(7) Perumba				0.0	12.0	313.0	28.0	353.0
(8) Shetrunji				0.0	18.0	458.0	42.0	518.0

Bridge	Without Project			
	D/D	Const	S/V	(Total)
(1)Kaliabhomora	12.0	309.0	28.0	349.0
(2) Badarpurghat	47.0	1,209.0	110.0	1,366.0
(3) Zuari	7.0	170.0	15.0	192.0
(4) Borim	2.0	42.0	4.0	48.0
(5) Mahe	10.0	258.0	23.0	291.0
(6) Valapattanam	36.0	928.0	84.0	1,048.0
(7) Perumba	12.0	313.0	28.0	353.0
(8) Shetrunji	18.0	458.0	42.0	518.0

Source: JICA Survey Team
Note: D/D: Detailed Design, Const: Construction, S/V: Supervision

Table 4.4.7 Project Cost (Economic Prices)

(Million Rs)

Bridge	With Project							
	New Bridge				Rehabilitation			
	D/D	Const	S/V	(Total)	D/D	Const	S/V	(Total)
(1)Kaliabhomora					10.8	278.1	25.2	314.1
(2) Badarpurghat	42.3	1,088.1	99.0	1,229.4	0.0	0.0	0.0	0.0
(3) Zuari	90.9	2,319.3	211.5	2,621.7	6.3	153.0	13.5	172.8
(4) Borim	46.8	1,202.4	109.8	1,359.0	1.8	37.8	3.6	43.2
(5) Mahe					9.0	232.2	20.7	261.9
(6) Valapattanam					32.4	835.2	75.6	943.2
(7) Perumba					10.8	281.7	25.2	317.7
(8) Shetrunji					16.2	412.2	37.8	466.2

Bridge	Without Project			
	D/D	Const	S/V	(Total)
(1)Kaliabhomora	10.8	278.1	25.2	314.1
(2) Badarpurghat	42.3	1,088.1	99.0	1,229.4
(3) Zuari	6.3	153.0	13.5	172.8
(4) Borim	1.8	37.8	3.6	43.2
(5) Mahe	9.0	232.2	20.7	261.9
(6) Valapattanam	9.0	232.2	20.7	261.9
(7) Perumba	10.8	281.7	25.2	317.7
(8) Shetrunji	16.2	412.2	37.8	466.2

Source: JICA Survey Team
Note: D/D: Detail Design, Const: Construction, S/V: Supervision

(4) Economic Benefits

1) Estimated benefits

In this economic analysis, the following benefits are treated.

- Benefit of saving in vehicle operating cost
- Benefit of saving in time cost

(a) Benefit of saving in vehicle operating cost

The vehicle operating costs (VOC) are estimated by multiplying the estimated unit VOC per vehicle-km by the vehicle-km.

The vehicle-km is obtained by multiplying the number of vehicle by the distance km. For the period of rehabilitation work after bridge collapse or vehicle traffic block, the distance of detour route is applied for the case of “Without Project”.

These calculations are made by vehicle type. The difference of vehicle operating costs between “Without Project” and “With Project” are treated as benefit of saving in vehicle operating cost.

The unit vehicle operating cost (VOC) by vehicle type is mentioned in the next sub-section.

(b) Benefit of saving in time cost

The benefit of saving in vehicle time cost can be obtained from the difference of the vehicle time cost between “With Project” and “Without Project”. The vehicle time cost is calculated by multiplying the estimated vehicle unit time value by the vehicle-hour. The vehicle-hour is obtained by dividing the vehicle-km by the assumed running speed of vehicle.

The unit vehicle time cost value by vehicle type is mentioned in the next sub-section.

2) Unit vehicle operation cost (VOC) and unit vehicle time value

In this economic analysis, the unit vehicle operating cost and the unit time value are estimated based on the “Manual on Economic Evaluation of Highway Projects in India (Second Revision), Indian Road Congress, 2009”, representing the information in the level of whole India as of year 2009.

(a) Unit vehicle operating cost (VOC)

The year 2009 unit VOC of car, motorcycle, bus and truck are obtained.

Then, the above unit VOC is adjusted at year 2014 prices level by applying the growth rate of 1.3 which is assumed based on the recent trend of wholesale price index (WPI) in India.

The wholesale price index during 2009-10 to 2011-12 is shown in Table 4.4.8. The growth rate from 2009-10 to 2011-12 is estimated to be 19.4%. The annual growth rate of 2011-12 to 2012-13 and 2012-13 to 2013-14 is assumed to be 5% and 5%, respectively, referring to the information of Ministry of Commerce & Industry, India (inflation rate of 4.84% for 2012–2013 and 5.35% for 2013-2014 in the financial year basis). As a result, the growth rate during 2009-10 to 2013-14 is assumed to be 31.6%, (roughly rounded as 30%).

The estimated unit VOC is shown in Table 4.4.9.

Table 4.4.8 Wholesale Price Index (WPI) in India

Year	WPI Index	Growth Rate
2004-05	100.00	
2005-06	104.5	4.5%
2006-07	111.4	6.6%
2007-08	116.6	4.7%
2008-09	126.0	8.1%
2009-10	130.8	3.8%
2010-11	143.3	9.6%
2011-12	156.1	8.9%
Estimated Growth Rate from 2009-10 to 2011-12		19.4%
Assumed Growth Rate of 2011-12 to 2012-13		5.0%
Assumed Growth Rate of 2012-13 to 2013-14		5.0%
Assumed Growth Rate from 2009-10 to 2013-14		31.6%

Source: Compiled by Study Team based on India Economic Survey 2012-13 and information acquired from the Ministry of Commerce and Industry, India.

Table 4.4.9 Estimated Unit Vehicle Operating Cost (VOC)

(Unit: Rs. / vehicle-km)

	Car	Motorcycle	Bus	Truck
Year 2009 Unit VOC	2.71	1.09	7.30	9.84
Assumed Growth Rate (= 1.3)				
Estimated Year 2014 Unit VOC	3.52	1.42	9.49	12.75

Source: Compiled by Study Team based on Manual on Economic Evaluation of Highway Projects in India (Second Revision), Indian Road Congress, 2009
Note: For the setting-up of unit VOC, the following conditions are assumed taking the road condition nearby the bridge site into consideration: (roughness: 4000, and RF (rise and fall): 10.)

(b) Unit time value

The year 2009 unit time value (per passenger per hour) is obtained.

The unit time value of passenger is considered to be reflected the level of per capita income. Then, the above unit time value are adjusted at year 2014 prices level, by applying the growth rate of 1.2 which is assumed based on the recent trend of per capita net national income in India.

The per capita net national income from 2009-10 to 2011-12 is shown in Table 4.4.10, with the estimated average annual growth rate of 5.9%. The growth rate from 2009-10 to 2011-12 is estimated to be 12.2%. Taking the above figures into account, the growth rate from 2011-12 to 2012-13 and from 2012-13 to 2013-14 is assumed to be 5.0% and 5.0% respectively. As a result, the growth rate from 2009-10 to 2013-14 is calculated to be 23.7% (roughly rounded as 20%). The estimated results are shown in Table 4.4.11.

While the original data of unit time value is for whole India, the study area of the Project ranges over the states of Assam, Gujarat, Goa and Kerala. The unit time value of passenger is considered to be influenced by the level of per capita income in the objective area. Then, the adjustment factor is examined taking the differences of the level of per capita income in the study area into consideration.

The recent trend of per capita net state domestic products of the above states including Maharashtra and Karnataka as neighboring state of Goa is shown in Table 4.4.12.

While the calculated ratio of Gujarat and Kerala to whole India is the level of 1.4, the ratio of Goa is about 3.0. On the other hand, the calculated ratio of Maharashtra and Karnataka (neighboring states of Goa) to whole India are the level of 1.6 and 1.1, respectively.

Taking the vehicle traffic flow related to Maharashtra and Karnataka into consideration, the adjustment factor of Goa is to be reconsidered. The changing factor of Goa is assumed to be the same level of Gujarat and Kerala. As a result, while the adjustment factor for Assam is assumed to be 0.6, the factor for Gujarat, Goa and Kerala is assumed to be 1.4.

As a result, the assumed unit time value of passenger by state at 2014 prices is shown in Table 4.4.13.

Assuming the number of passenger per vehicle, the unit time value per vehicle-hour is estimated as shown in Table 4.4.14.

Table 4.4.10 Per Capita Net National Income in India (2004-05 Prices, Rs.)

Year	Per Capita Net National Income	Growth Rate
2008-2009	31,754	
2009-2010	33,901	6.8%
2010-2011	36,342	7.2%
2011-2012	38,037	4.7%
Estimated Average Annual Growth Rate of 2009-10 to 2011-12		5.9%
Estimated Growth Rate from 2009-10 to 2011-12		12.2%
Assumed Growth Rate of 2011-12 to 2012-13		5.0%
Assumed Growth Rate of 2012-13 to 2013-14		5.0%
Assumed Growth Rate from 2009-10 to 2013-14		23.7%

Source: Compiled by Study Team based on India Economic Survey 2012-13

Table 4.4.11 Assumed Unit Time Value of Passenger in Whole India

(Unit: Rs per Passenger/ Hour)

	Car	Motorcycle	Bus
Year 2009 Unit Time Value	62.5	32.0	39.5
Assumed Growth Rate (= 1.2)			
Estimated Year 2014 Unit Time Value	75.0	38.4	47.4

Source: Compiled by Study Team based on Manual on Economic Evaluation of Highway Projects in India (Second Revision), Indian Road Congress, 2009

Table 4.4.12 Per Capita Net State Domestic Products at Current Prices

(Unit: Rs)

State	Per Capita Net State Domestic Products at Current Prices			Estimated Ratio to Whole India (Changing Factor)		
	2009-10	2010-11	2011-12	2009-10	2010-11	2011-12
Assam	27,464	30,569	33,633	0.60	0.57	0.55
Gujarat	63,549	75,115	89,668	1.38	1.41	1.48
Goa	149,164	159,244	190,652	3.23	2.99	3.15
Kerala	60,264	71,434	83,725	1.31	1.34	1.38
Whole India	46,117	53,331	60,603	1.00	1.00	1.00
Maharashtra	71,300	87,686	101,314	1.55	1.64	1.67
Karnataka	51,386	59,975	68,374	1.11	1.12	1.13

Source: Compiled by Study Team based on India Economic Survey 2012-13 and Gujarat Socio-Economic Review 2012-13 (data for 2011-12)

Table 4.4.13 Unit Time Value of Passenger by Sate at 2014 Prices

(Unit: Rs per Passenger/ Hour)

Vehicle Type	Whole India	State of Assam	State of Gujarat, Goa, and Kerala
(Adjustment Factor)	1.0	0.6	1.4
Car	75.0	45.0	105.0
Motorcycle	38.4	23.0	53.8
Bus	47.4	28.4	66.4

Source: Compiled by Study Team based on Manual on Economic Evaluation of Highway Projects in India (Second Revision), Indian Road Congress, 2009

Table 4.4.14 Estimated Unit Time Value per Vehicle

(Unit: Rs per Vehicle/Hour)

	Unit Time Value per Passenger (Rs. / hour)	Assumed Average Number of Passengers Per Vehicle	Assumed Unit Time Value per Vehicle (Rs. / hour)
Assam Sate			
Car	45.0	3.0	135.0
Motorcycle	23.0	1.5	34.5
Bus	28.4	30.0	852.0
Gujarat, Goa, Kerala State			
Car	105.0	3.0	315.0
Motorcycle	53.8	1.5	80.7
Bus	66.4	30.0	1,992.0

Source: Estimated by JICA Survey Team

(5) Estimated Economic Internal Rate of Return (EIRR)

Based on the project cost ("With Project" and "Without Project") and the estimated economic benefits, the cost benefit analysis is made. The calculation results of economic internal rate of return for each bridge are shown in Table 4.4.15.

The EIRR calculation tables are shown in Appendix Table.

Table 4.4.15 Estimated EIRR

Bridge	EIRR (%)
(1) Kaliabhomora	49.1%
(2) Badarpurghat	39.0%
(3) Zuari	38.1%
(4) Borim	31.3%
(5) Mahe	31.6%
(6) Valapattanam	45.1%
(7) Perumba	38.7%
(8) Shetrunji	21.7%

Source: Estimated by JICA Survey Team

4.5 Results of Dhuburi-Phulbari Bridge

Materials have been gathered relating to Dhuburi-Phulbari bridge.

(1) Dhuburi-Phulbari Bridge Outline

Dhuburi-Phulbari Bridge is a section of the planned 434km road that will run from NH31C in Assam state to Nongston in Meghalaya state (Assam state: 74km, Meghalaya state: 360km). Dhuburi-Phulbari Bridge is located in Assam state, crosses Bramhaputra River, connects Dhuburi and Phulbari, and has a total length of 15 km. The location of Dhuburi-Phulbari Bridge is shown in the figure below.

Source: Google earth/ JICA Survey Team

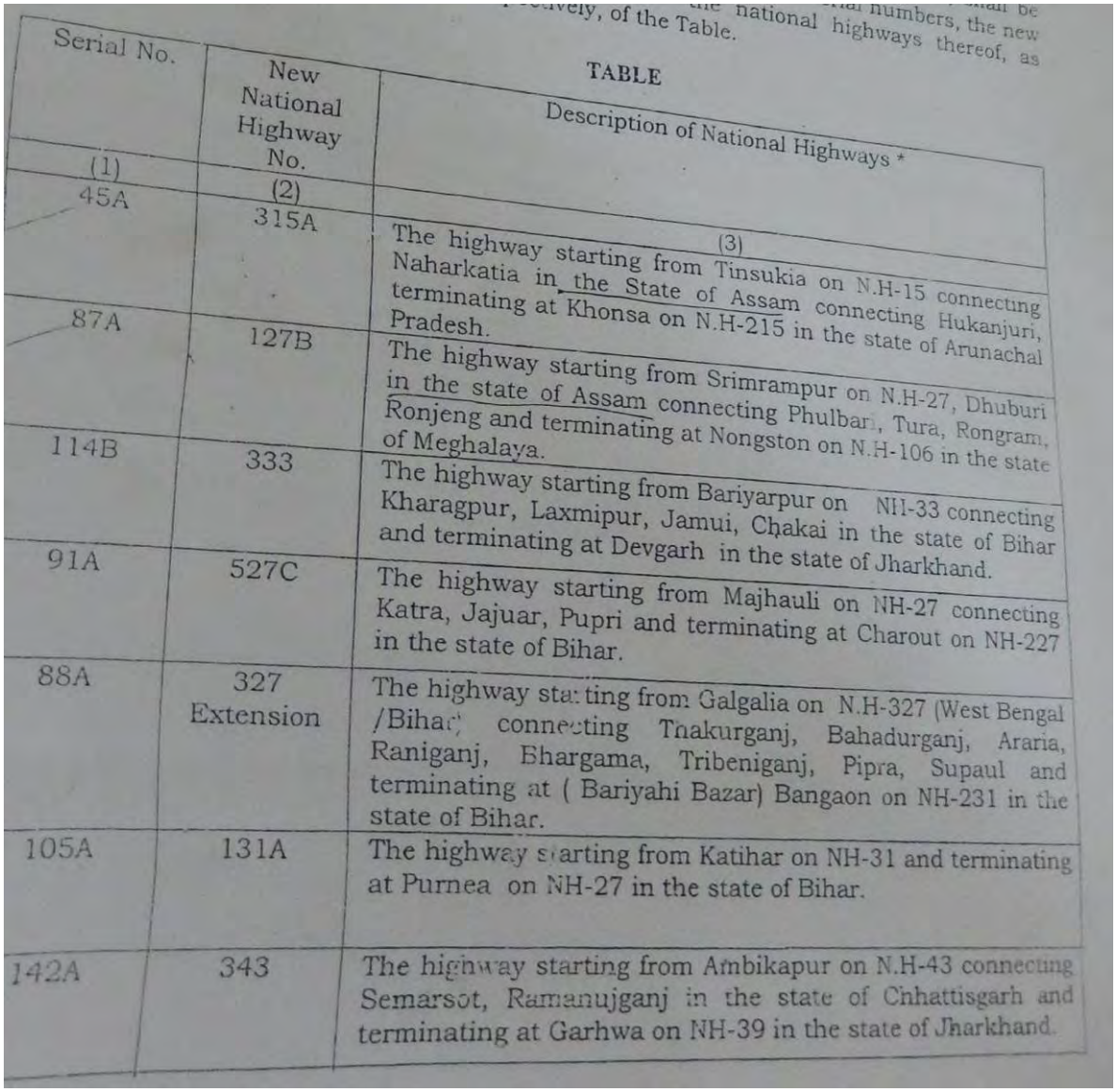
Figure 4.5.1 Dhuburi-Phulbari Bridge Location Map

(2) Current Condition of Dhuburi-Phulbari Bridge

Currently, the people of Meghalaya state are using a ferry to access Assam state. Situation of ferry between Dhuburi-Phulbari is shown in Figure 4.5.2.

Figure 4.5.2 Ferry between Dhuburi-Phulbari

In April 2012, an accident took place where the ferry capsized, and many lives were lost. Additionally, vehicles are using the Naranarayan Bridge 70 km upstream. Planning document of Dhuburi-Phulbari Bridge received by PWD of Assam state and the plan view of the Dhuburi-Phulbari Bridge is shown in the figure below.



...tively, of the Table.

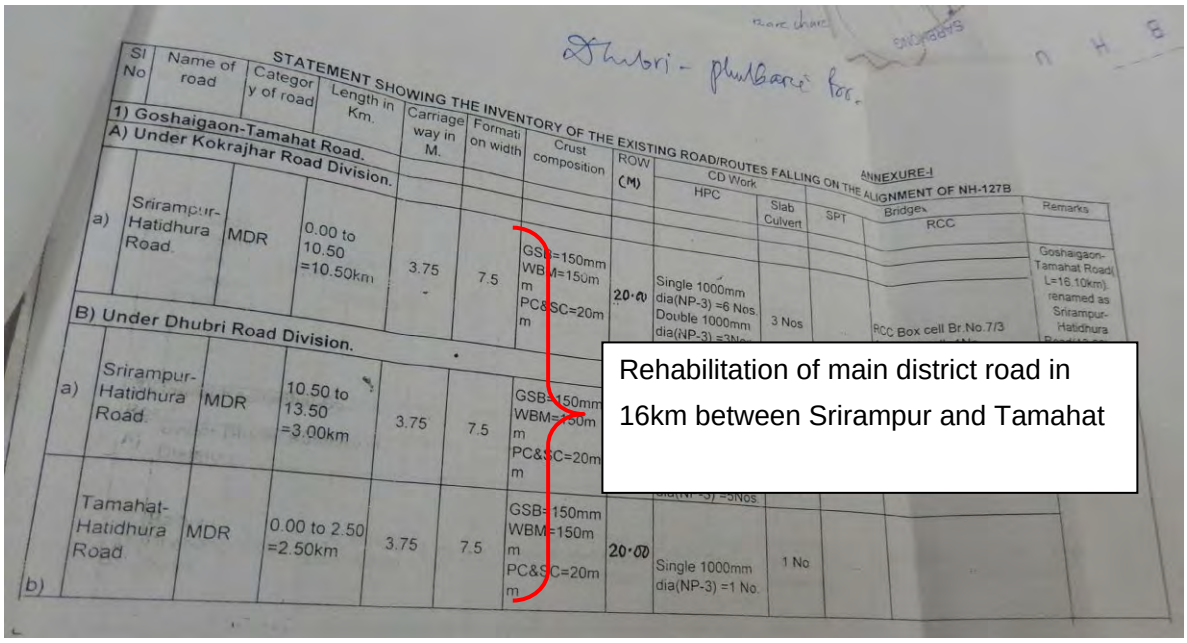
...national highways thereof, as

TABLE

Serial No.	New National Highway No.	Description of National Highways *
(1)	(2)	(3)
45A	315A	The highway starting from Tinsukia on N.H-15 connecting Naharkatia in the State of Assam connecting Hukanjuri, terminating at Khonsa on N.H-215 in the state of Arunachal Pradesh.
87A	127B	The highway starting from Srimrampur on N.H-27, Dhuburi in the state of Assam connecting Phulbari, Tura, Rongram, Ronjeng and terminating at Nongston on N.H-106 in the state of Meghalaya.
114B	333	The highway starting from Bariyarpur on NH-33 connecting Kharagpur, Laxmipur, Jamui, Chakai in the state of Bihar and terminating at Devgarh in the state of Jharkhand.
91A	527C	The highway starting from Majhauli on NH-27 connecting Katra, Jajuar, Pupri and terminating at Charout on NH-227 in the state of Bihar.
88A	327 Extension	The highway starting from Galgalia on N.H-327 (West Bengal /Bihar) connecting Thakurganj, Bahadurganj, Araria, Raniganj, Bhargama, Tribeniganj, Pipra, Supaul and terminating at (Bariyahi Bazar) Bangaon on NH-231 in the state of Bihar.
105A	131A	The highway starting from Katihar on NH-31 and terminating at Purnea on NH-27 in the state of Bihar.
142A	343	The highway starting from Ambikapur on N.H-43 connecting Semarsot, Ramanujganj in the state of Chhattisgarh and terminating at Garhwa on NH-39 in the state of Jharkhand.

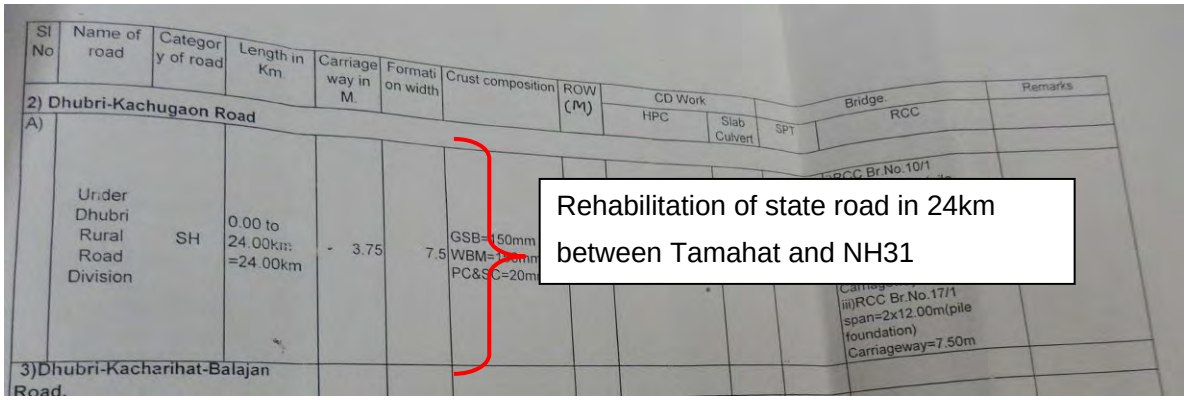
Source: PWD in Assam

Figure 4.5.3 Plan of Route of Dhuburi-Phulbari Bridge



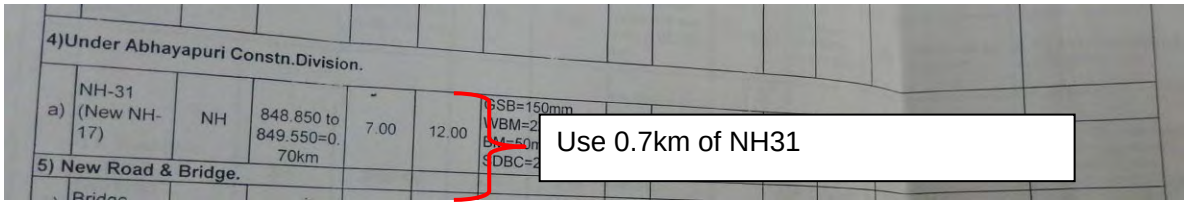
Source: PWD in Assam

Figure 4.5.4 Plan of Dhuburi-Phulbari Bridge (1/4)



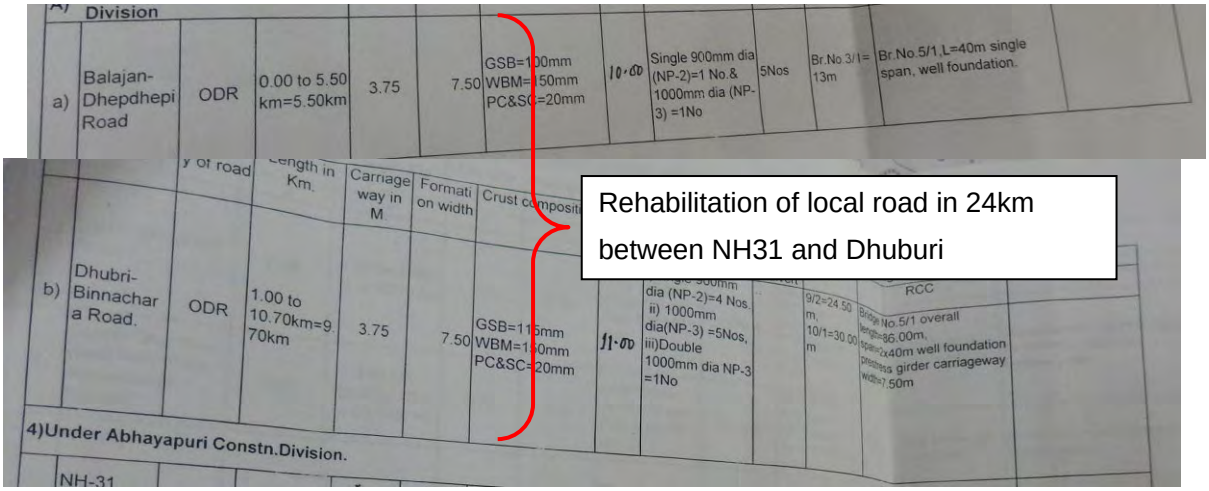
Source: PWD in Assam

Figure 4.5.5 Plan of Dhuburi-Phulbari Bridge (2/4)



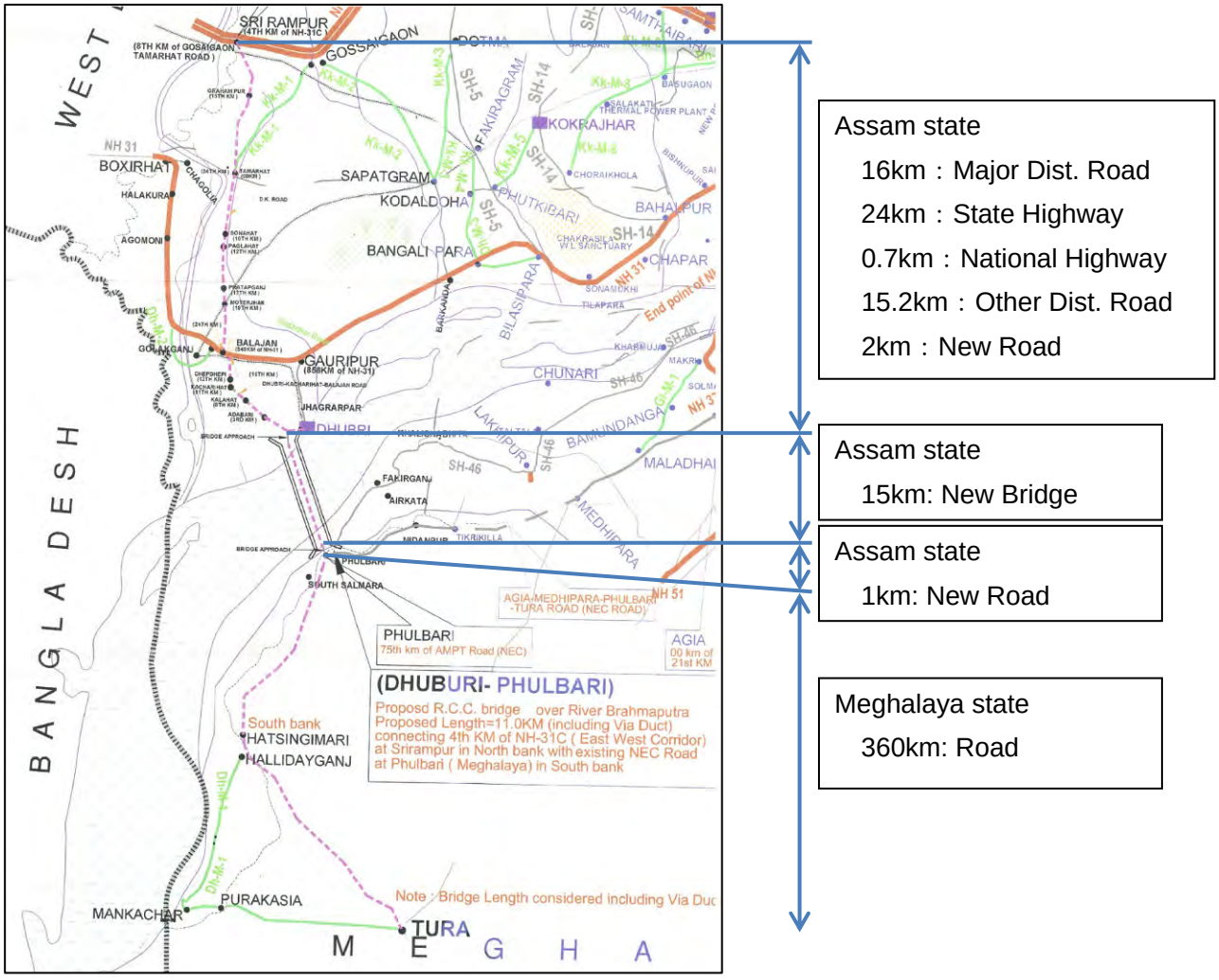
Source: PWD in Assam

Figure 4.5.6 Plan of Dhuburi-Phulbari Bridge (3/4)



Source: PWD in Assam

Figure 4.5.7 Plan of Dhuburi-Phulbari Bridge (4/4)



Source: PWD in Assam/ JICA Survey Team

Figure 4.5.8 Dhuburi-Phulbari Bridge Plan View

All planned roads are all 2-lane roads, and were recognized as national roads in February 2012.

Additionally, approximate construction costs for the Dhuburi-Phulbari Bridge were submitted in May 2013, and these costs totaled 17 billion Indian rupees. Since then, the submission has been under discussion by MORTH.

In Assam state, there is a 55.9km-section of road from NH31C (16km: Main Road, 24km: State Road, 0.7km: National Road, 15.2km: Local Road) that is being prepared for land acquisition, and hence the planned route cannot be revised. However, the following 2km-section of new road (which leads to the new bridge) can be revised, so the bridge plans can also be revised.

Pictures of Dhuburi-Phulbari Bridge are shown in Figure 4.5.9.

State Road between Tamarhat and NH31

NH31

Local Road between NH31 and Dhuburi

New Road planed site away 2km from Dhuburi-Phulbari Bridge planed site

Dhuburi-Phulbari Bridge Candidate site (Assam side)

Brahmaputra River

Source: JICA Survey Team

Figure 4.5.9 Picture of Dhuburi-Phulbari Bridge

(3) Japanese Advanced Technology for Dhuburi-Phulbari Bridge

The technology that can be applied in Dhuburi-Phulbari Bridge is shown in the table below.

Table 4.5.1 Japanese Technology for Dhuburi-Phulbari Bridge

Technology Name	Features
Steel Pipe Sheet Pile Foundation	This is an effective method applied to bridge foundations that receive damage from scouring or earthquakes.
Weathering Steel in Superstructures	This technology provides a shorter construction period than PC bridges, and is effective in bridges designed for early-service. As the superstructure is light-weight compared to PC bridges, piers and foundations can be small. Moreover, the weathering steel minimizes the required maintenance.

Source: JICA Survey Team

5. OPERATION AND MAINTENANCE OF BRIDGES ON NATIONAL HIGHWAYS

In this Survey, several interviews with organizations mentioned below had been conducted to confirm current situation of bridge operation and maintenance on National Highways (NHs).

- Standard Research and Technology (Bridges) (SR&T (B)) Section of MORTH
- Regional Offices of four figure(4) target cities (ROs (Guwahati, Gandhinagar, Thiruvananthapuram and Mumbai) (hereinafter referred to as "4ROs")
- Public Works Department (PWD) of four (4) target states (Assam, Goa, Gujarat and Kerala) (hereinafter referred to as "4PWDs")

5.1 Organizations

5.1.1 Relevant Organizations

The relevant organizations for operation and maintenance of bridges on NHs in India are:

- Ministry of Road Transport and Highways (MORTH)
- National Highways Authority of India (NHAI)
- Public Works Department of state government (PWD) and
- Border Roads Organization (BRO)

An outline of each organization is given in below.

(1) Ministry of Road Transport and Highways (MORTH)

1) Outline of Organization

MORTH was formed in 2009 by bifurcating the erstwhile "Ministry of Shipping, Road Transport and Highways" into two independent ministries. MORTH encompasses within its fold road transport and highways which includes construction and maintenance of NHs, administration of the "Motor Vehicles Act, 1988" and the "Central Motor Vehicle Rules, 1989", formulation of broad policies

relating to road transport, environmental issues, automotive norms, and fixation of the user fee rate for use of NHs etc. besides making arrangements for movements of vehicular traffic with neighboring countries.

MORTH under the central government is entrusted with the task of formulating and administering in consultation with other central ministries / departments, state governments / union territory administrations, organizations and individuals, policies for road transport, NHs and transport research with a view to increasing the mobility and efficiency of the road transport system in India.

(2) National Highways Authority of India (NHAI)

1) Outline of Organization

NHAI was constituted by an act of parliament, namely "the National Highways Authority of India Act, 1988" under the administrative control of MORTH. NHAI has been set up as a central authority to develop, maintain and manage NHs entrusted by the central government. NHAI became operational in February, 1995, and is responsible for highway network development through the "National Highways Development Project (NHDP)" which is undertaken under "Build Operate and Transfer (BOT) basis". NHAI has procured all consultants and contractors of NHDP, and has also implemented pre-construction activities such as a feasibility study of each project etc. in liaison with MORTH and state government for successful implementation of projects.

2) Outline of National Highway Development Project (NHDP)

NHDP is the largest highway project in India and has seven (7) phases. An outline and map of NHDP are given in Table 5.1.1 and Figure 5.1.1.

A national highway network of about seventy-six thousand and eight hundred eighteen (79,116) km (December, 2012) is the main road network in India. Expressways and NHs constitute only about one point seven (1.7) % of length of overall roads in India, although about forty (40) % of road traffic has passes along them.

In addition, number of vehicles has been increasing by an average ten point sixteen (10.16) % yearly during the past five (5) years (FY2008 to FY2012). The rapid growth of passengers and freight vehicles makes it urgent task to improve the road network in India. Therefore, the Government of India launched upgrade and strengthening of NHs in October, 1998.

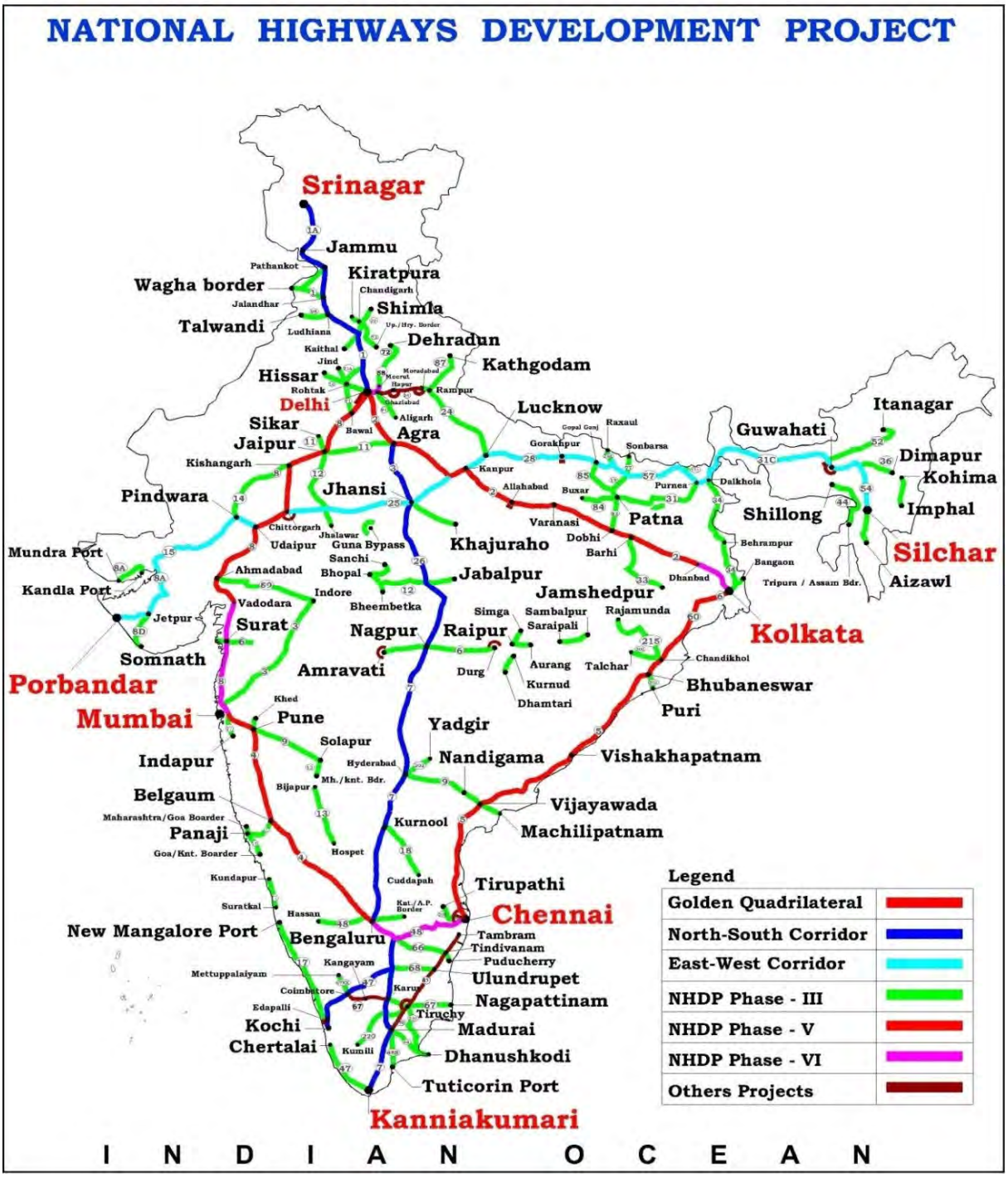
NHDP which has been developed under BOT basis, comprises the most important corridors including the "Golden Quadrilateral (GQ)" which connects four (4) major cities (Delhi, Mumbai, Kolkata and Chennai), and the "North South-East West (NS-EW) Corridors" which connect Srinagar in the north to Kanyakumari in the south, and Silchar in the east to Porbandar in the west and other economically important roads.

Table 5.1.1 Outline of Each Phase of NHDP

(31 October, 2013)

Phase	Total Length (km)
Phase Ⅰ GQ, NS-EW Corridors, port connectivity and others	7,522
Phase Ⅱ 4 / 6-laning, NS-EW Corridors and others	6,647
Phase Ⅲ Upgrading, 4/6-laning	12,109
Phase Ⅳ 2-laning with paved shoulders	20,000
Phase Ⅴ 6-laning of GQ and heavy traffic corridors	6,500
Phase Ⅵ Expressway	1,000
Phase Ⅶ Ring road, bypass and flyover etc.	700
Total	54,478

Source: NHAI HP (http://www.nhai.org/WHATITIS.asp)



Source: NHAI HP (http://www.nhai.org/nhdpmain_english.htm)

Figure 5.1.1 NHDP Map

(3) Public Works Department of State Government (PWD)

1) Outline of Organization

PWD has been set up in each state. PWD is a premier agency of the state government, and has been entrusted with the development and maintenance of NHs (by MORTH) and of state highways, major district roads and government buildings in each state (by the respective state governments). PWD has also acted as the technical advisor to the state government in all aspects of construction activities.

As an example, Assam PWD (established in 1980) has been responsible for development and maintenance of NHs, state highways, major district roads, rural roads, urban roads and government buildings. Assam PWD has been divided into two wings, namely, “Roads Wing” and “Building Wing”. The Roads Wing has been responsible for development and maintenance of roads, while the Building Wing has been responsible for development and maintenance of buildings. The Roads Wing also has been divided into thirteen (13) Sections. One (1) of the Sections, namely, the NH Section has been responsible for development and maintenance of NHs.

(4) Border Roads Organization (BRO)

1) Outline of Organization

BRO was set up in 1960 by the first prime minister of India, to develop road networks rapidly and maintain roads in border areas according to operational requirements from the Ministry of Defence. BRO is entrusted with the construction and maintenance of roads such as General Staff roads (GS roads), NHs, state highways etc. in the border areas. Development and maintenance of these roads are funded by the “Border Roads Development Board (BRDB)” through MORTH.

2) Outline of Border Roads Development Board (BRDB)

BRDB was set up in 1960, to coordinate the development of road communication in the border area of north and north-eastern regions, where insufficient road networks were seriously hampering defense preparedness and economic development. BRDB has financial and other powers of government department, and functions under over all control of the chairman of BRDB. All sanctions are processed by the secretariat of BRDB.

(5) Demarcation between MORTH, NHAI, PWD and BRO

MORTH has been primarily responsible for development and maintenance of NHs, and has owned all NHs in India. Development and maintenance works of all NHs have been executed by NHAI, BRO or PWDs.

Demarcation between NHAI, PWDs and BRO are as below,

- NHs developed and maintained by the concessionaires under BOT basis through the NHDP scheme are managed by NHAI.

- Development and maintenance works on NHs in border areas are executed by BRO under the coordination of BRDB.
- Development and maintenance works on other NHs are implemented by PWDs.

5.1.2 Details of Relevant Organizations for Operation and Maintenance of Bridges on NHs

(1) Ministry of Road Transport and Highways (MORTH)

1) MORTH

Organization Chart of MORTH is shown in Figure 5.1.2.

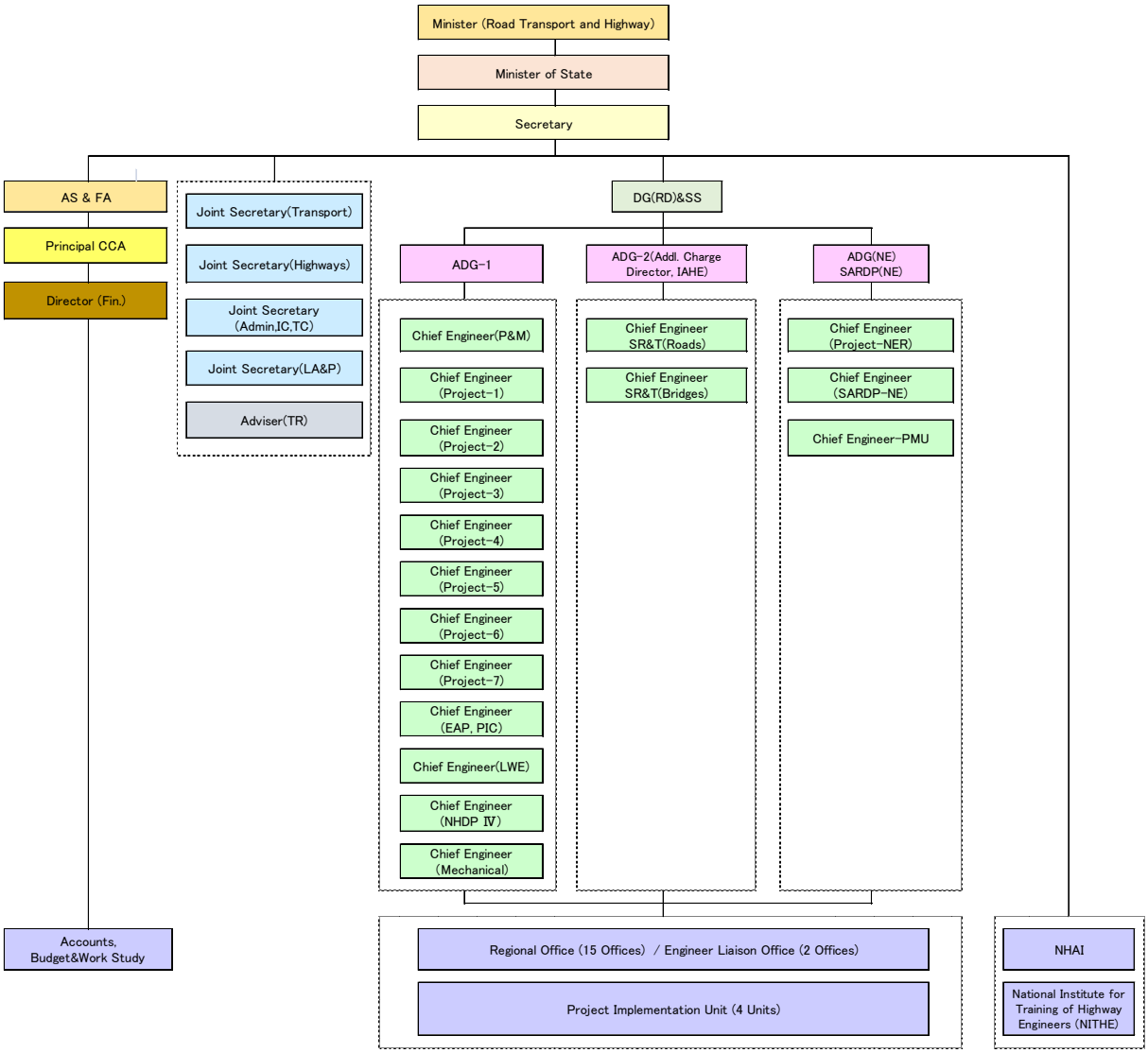
MORTH has been headed by the Minister (Road Transport and Highways) who has been assisted by "two (2) Ministers of State", "one (1) Secretary" and other senior engineers namely one (1) "Director General (Roads Development) & Special Secretary", four (4) "Joint Secretaries" and one (1) "Advisor".

The Secretary also has been assisted by one (1) "Additional Secretary & Financial Adviser" in formulating and processing all policies and other proposals having financial implications.

Under the Secretary, MORTH has five (5) main Wings (Transport, Highways, Toll & Coordination, Land Acquisition and Roads) and five (5) support Wings (Administration, International Cooperation, Parliament, Finance and Transport Research). Four (4) main Wings (Transport, Highways, Toll & Coordination and Land Acquisition) and Three (3) support Wings (Administration, International Cooperation and Parliament) have been headed by four (4) "Joint Secretaries", the Finance Wing has been headed by "Additional Secretary & Financial Advisor" and the Roads Wing has been headed by "Director General (Roads Development) & Special Secretary ". The roles and responsibilities of each Wing are shown in Table 5.1.2.

Nine (9) Wings except for the Roads Wing have been divided into some divisions and sections.

The Roads Wing has had seven (7) project Zones, four (4) special Zones and five (5) Sections. The project Zones (Project-1 to Project-7) have managed development and maintenance of NHs in each jurisdiction, and the special Zones (Special Accelerated Road Development Programme in the North-East Region (SARDP-NE), Externally-Aided Projects, Left Wing Extremism-affected Areas and NHDP Phase IV), and five (5) Sections. Each Zone and Section has been headed by one (1) Chief Engineer (CE).



Source: Annual Report 2012-2013 (2013, MORTH)

Figure 5.1.2 Organization Chart of MORTH

Table 5.1.2 Roles and Responsibilities of Each Section in MORTH

Wing	Division	Section / Zone	Roles and Responsibilities
Road Transport	Motor Vehicle Legislation	Motor Vehicle Legislation Section	・Amendment and clarification of Motor Vehicle Act 1988 ・Issues related to smart cards / driving licences
	Road Safety	Road Safety Section	・Formulation and amendment of NHs patrol scheme, NHs accident relief scheme ・Provision of information regarding road safety etc.
	Transport	Transport Section	・Coordination in the Wing ・Making budgets and annual plans, five (5) year plan in the Wing, training progrrames for state transport department
Highways	Highways & P&P	Highways & P&P Section	・Processing of draft notes in respect of projects implemented by NHAI for approval ・Review and monitoring of projects under NHDP managed by NHAI
	PPP	PPP Section	・Processing of proposals by NHAI for PPP appraisal committee etc. ・Approval and implementation of projects under NHDP
	IT	IT Section	・Operation and maintenance in respect of IT matters.
Administration	Establishment	E Ⅰ,E Ⅰ(B),E Ⅱ, E Ⅱ(B), Special Reservation Section	・Establishment matters such as appointments, transfer, payrolls, pension, training etc.
	General Administration	General,Welfare, Library, CR, Cash, RTI, O&M Section	・Handling general affairs such as payment for bills for hospitality, telephones and newspapers, etc. ・Organizing of various types of welfare ・Supervision and monitoring of library
	Vigilance	Vigilance Section	・Receipt and scrutiny of all complaints addressed to MORTH ・Proceedings in vigilance cases of staff of MORTH
International Cooperation	International Cooperation	International Cooperation Section	・Scrutinizing proposals and offers related to bilateral cooperation, Memorandum of Understanding with various countries, and all matters related to international authorities such as the World Bank and Asian Development Bank
Toll & Coordination	Toll	Toll Section	・Formulation and amendment of toll policy, rules, and toll notification matters related to NHs ・Installation activities for Electoronic Toll Collection system
	Coordination	Coordination Section	・Matters related to cabinet meetings, cabinet committee meetings, ・Making monthly summaries of important developments in MORTH ・Making annual reports for MORTH etc.
	Audit Paras	Audit Paras Section	・Monitoring and following up of inspection paras, reports, draft audit paras, PAC paras and COPU matters.
Land Acquisition	Land Acquisition	Land Acquisition Section	・Matters related to land acquisition, environmental clearances, NHs Act, etc.
Parliament	Parliament	Parliament Section	・Parliamentary work related to receipt and distribution of notices of parliament questions, and list of short notice questions etc. ・Preparation of answers to those questions etc.
Finance	Budget	Budget Section	・Budget work related matters of MORTH and Ministry of the Shipping. ・Collection and scrutiny of proposals budget estimates, and revised estimates from other divisions of both the Ministry.
	Finance	Finance Section	・Financial matters beyond delegated powers of each division ・Sanction of budget estimates and revised estimates under delegated powers of divisions related to roads and bridges on NHs. ・Release of funds to various sanctioned plan.

Wing	Division	Section / Zone	Roles and Responsibilities
Roads		Project-1 Zone	・Management of development and maintenance of NHs in Chandigarh state, Haryana state, Himachal Pradesh state and Jammu&Kashimir
		Project-2 Zone	・Management of development and maintenance of NHs in Delhi
		Project-3 Zone	・Management of development and maintenance of NHs in Andaman&Nicobar Island, Bihar state, Jharkhand state and West Bengal state.
		Project-4 Zone	・Management of development and maintenance of NHs in Daman&Diu, Gujarat state and Rajasthan state.
		Project-5 Zone	・Management of development and maintenance of NHs in Chattisgarh state, Madhya Pradesh state and Orissa state.
		Project-6 Zone	・Management of development and maintenance of NHs in Goa state, Karnataka state and Maharashtra state
		Project-7 Zone	・Management of development and maintenance of NHs in Andhra Pradesh, Kerala state, Lakshadweep Island, Puducherry and Tamil Nadu state
		Project (NER) Zone	・Management of development and maintenance of NHs in all eight (8) states of north eastern region including SARDP-NE
		Externally Aided Projects Zone	・Management of development for roads by externally aided projects
		Left Wing Extremism Affected Areas Zone	・Management of development for roads in left wing extremism affected areas
		NHDP Phase Ⅳ Zone	・Management of development and maintenance of NHs under NHDP Phase Ⅳ
		Planning&Monitoring Section	・Planning works (Five (5) year plan, annual plan, long-term plans) including allocation of funds. ・Making policy related to general issue of road development.
		SR&T(Roads) Section	・Reviewing of specifications ・Preparation of manuals ・Provision of advice to various ministries and agencies regarding road infrastructures.
		SR&T(Bridges) Section	・Standardization and research work related to bridges. ・Scrutiny of proposals from PWDs related to bridges, Road Over Bridges and Road Under Bridges.
		Mechanical Section	・Development and proposal of overall policies and short-term and long-term strategic plans for introduction of new technologies in the Highways sector. ・Monitoring of performance and utilization of new technological equipment supplied to PWDs.
		Works&Accounts Section	・Preparation and allocation to state governments in respect of development and maintenance, repair of NHs, and related matters.
Transport Research	Transport Research	Transport Research Section	・Collection, compilation and dissemination of statistics on roads and water in MORTH and Ministry of the Shipping.

Source: Induction material (March, 2013, MORTH) (http://morth.nic.in/showfile.asp?lid=995)

2) Relevant Section and Offices for Bridge Maintenance of NHs in MORTH

(a) Relevant Section

The Standard Research and Technology (Bridges) (SR&T (B)) Section has been responsible for maintenance of major bridges (over sixty (60) m length bridge) on NHs. In addition, minor bridge (under sixty (60) m length bridge) on NHs has been developed and maintained together with roads by Project-1 to Project-7, and Project-(NER) Zones.

The main roles and responsibilities of SR&T (B) Section are summarized in Table 5.1.3. Regarding maintenance of major bridges, the SR&T (B) Section has deliberated, judged and approved maintenance works which are reported by Regional Offices (ROs) and Engineer Liaison Offices (ELOs) of MORTH.

Table 5.1.3 Main Roles and Responsibilities of SR&T (B) Section

Section	Main Roles and Responsibilities
Standard Research & Technology (Bridges) (SR&T(B) Section)	・ Standardization related to bridges ・ Work related to specification and IRC Codes ・ Research schemes related to bridges ・ Empanelment of consultants/manufacturers of bearings and expansion joints ・ Scrutiny of proposals from PWDs related to construction repair and rehabilitation of bridges, Road Over Bridges (ROBs) and Road Under Bridges (RUBs) ・ Right to information, parliament questions ・ Issues related to movement of over dimensional and over weight consignments

Source: Induction material (March, 2013, MORTH) (http://morth.nic.in/showfile.asp?lid=995)

(b) Regional Office and Engineer Liaison Offices

MORTH has fifteen (15) ROs headed by Superintending Engineer (SE) and two (2) ELOs headed by Executive Engineer (EE). The name and jurisdiction of each RO and ELO are shown in Table 5.1.4 and Figure 5.1.3.

The main roles and responsibilities of RO and ELO are shown in Table 5.1.5. Essentially, RO and ELO have the same functions, but the scale of ELO is smaller than RO.

As a sample, an organization chart of Guwahati RO in Assam state is shown in Figure 5.1.4. Guwahati RO has been headed by SE, and SE has been assisted by two (2) EEs. They have monitored, supervised and arranged development and maintenance works on NHs which have been conducted by eight (8) PWDs in the north-east region.

Table 5.1.4 Name and Jurisdiction of each RO and ELO

No.	RO/ELO	Jurisdiction (Name of state)
Regional Office (RO)		
R1	Bangalore	Karnataka
R2	Bhopal	Madhya Pradesh, Chattisgarh
R3	Bubneshwar	Orissa
R4	Chandigarh	Haryana, Himachal Pradesh, Jammu & Kashimir, Punjab, Chandigarh(UT)
R5	Chennai	Tamilnadu, Panndichery
R6	Gandihinagar	Gujarat, Daman & Diu
R7	Guwahati	Assam, Meghalaya, Nagaland, Mizoram, Manipur, Sikkim, Tripura, Arunachal Pradesh
R8	Hyderabad	Andhra Pradesh
R9	Jaipur	Rajasthan
R10	Kolkata	West Bengal
R11	Lucknow	Uttar Pradesh
R12	Mumbai	Maharashtra, Goa
R13	Patna	Bihar
R14	Ranchi	Jhakhand
R15	Thiruvanthapuram	Kerala
Engineer Liaison Office (ELO)		
E1	Dehradun	Uttrakhand
E2	Raipur	Chattisgarh

Source: MORTH

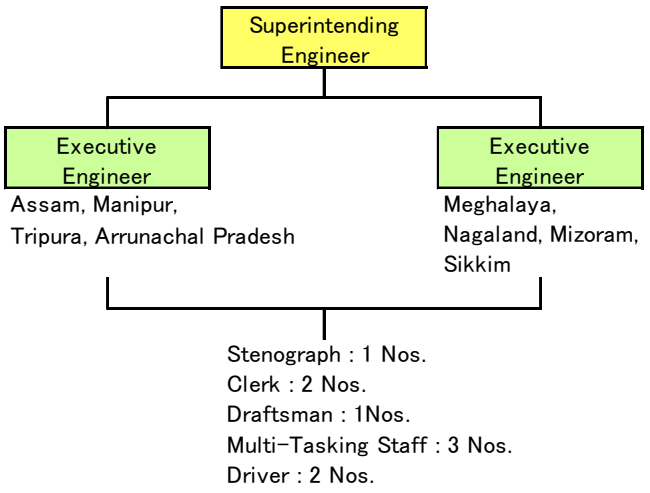
Source: JICA Survey Team based on the information from MORTH

Figure 5.1.3 Jurisdiction of each RO and ELO

Table 5.1.5 Main Roles and Responsibilities of RO and ELO

Section	Main Roles and Responsibilities
Regional Office (RO) / Engineer Liaison Office (ELO)	RO and ELO has been keeping close liaison with PWDs . RO and ELO handles ; ・Planning for annual plans, detailed investigations, technical advice in design, construction processes, preparation of DPRs of detailed investigations, rehabilitation works and construction works. ・Monitoring of all works on NHs. ・Frequent inspection, and monitoring the progress of all works on NHs including tendering and award of works ・Overseeing the quality control and timely completion of all works on NHs ・Assessment of flood damage and recommendations for the restoration of flood damage. ・Ensuring that all relevant data and registers are maintained and traffic census is carried out regularly. ・Promptly providing information in respect of parliament questions, consultative committees, court cases, PAC matters beside audit paras ・Undertaking duties as Drawing and Disbursing Officer (DDO) under direct payment procedure for all works, confirmation that certified bills for all works are submitted by PWDs. ・Reviewing the works funded by Central Road Fund (CRF) ・Monitoring of prequalification for tender followed instruction by MORTH ・Approval of contingency estimates for works as per MORTH's guidelines.

Source: Manual of Regional Offices Civil (2005, MORTH) (http://morth.nic.in/showfile.asp?lid=399)



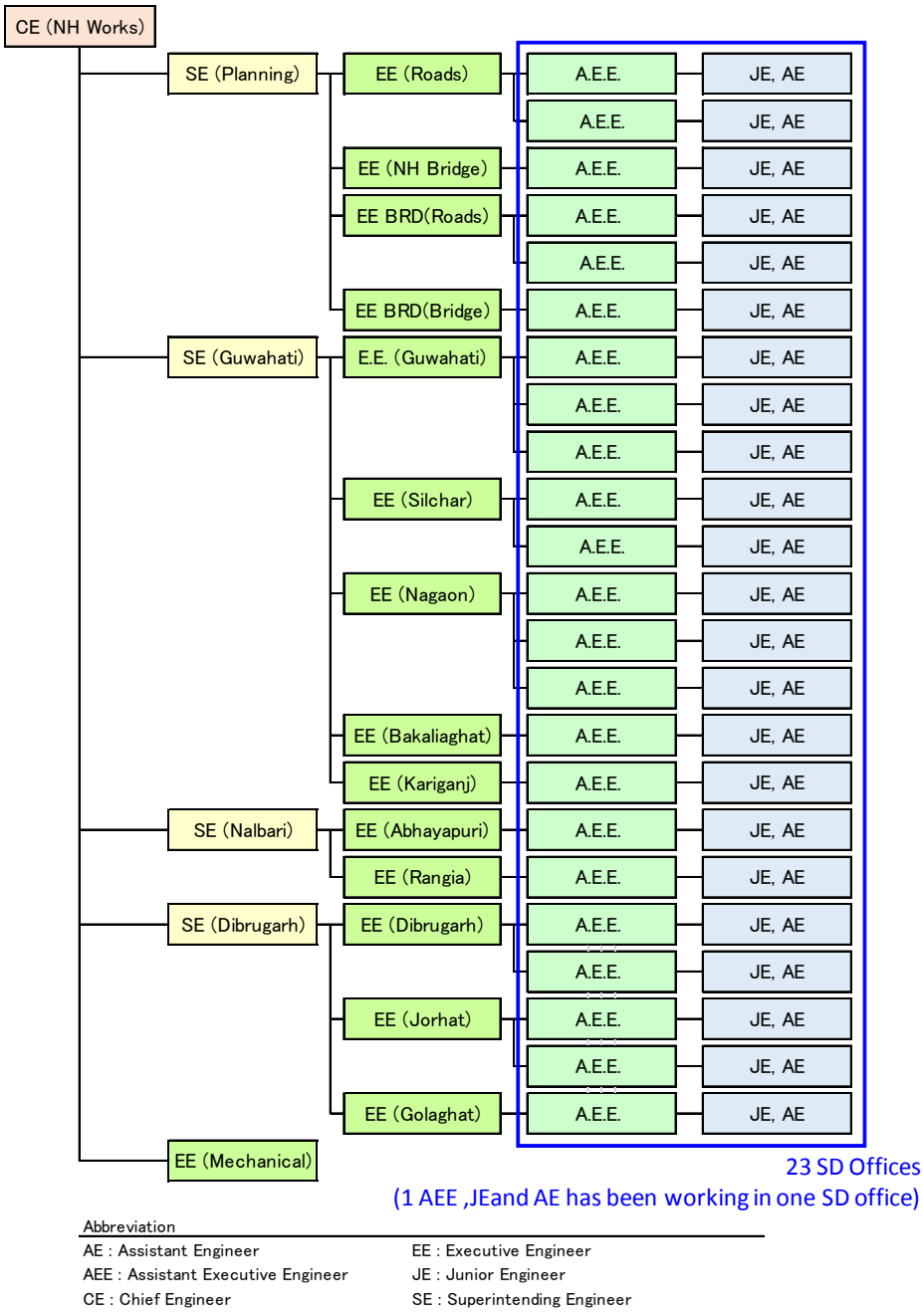
Source: JICA Survey Team

Figure 5.1.4 Organization Chart of Guwahati RO

(2) Public Works Department of State Government (PWD)

PWD in every state has set up an NH Section to develop and maintain NHs in their state. As an example, Assam PWD's organization chart of the NH Section is shown in Figure 5.1.5, and roles and responsibilities of the NH Section are shown in Table 5.1.6. The NH Section has been headed by one (1) CE, and the CE has been assisted by four (4) SEs and one (1) EE. One (1) SE is responsible for planning, three (3) SEs are responsible for supervising and monitoring of development and maintenance of NHs in a respective three (3) regions (Guwahati, Nalbari and Dibrugarh) and one (1) EE is responsible for mechanical matters such as maintenance and operation of mobile inspection unit and inspection equipment such as rebound hammer and RC-radar, and preparation of manuals for utilization of these equipment.

Two (2) to five (5) EEs have been arranged under one (1) SE, and also one (1) to three (3) Assistant Executive Engineers (AEE) have been arranged under one (1) EE. In addition, engineers (Junior Engineer and Assistant Engineer) have been arranged under one (1) AEE, and one (1) AEE and the engineers have been working in a Sub-Division office (SD office) adjacent to NHs managed by them.



Source: JICA Survey Team

Figure 5.1.5 Organization Chart of NH Section of Assam PWD

Table 5.1.6 Roles and Responsibilities of NH Section of Assam PWD

Name of Organization	Roles and Responsibilities
NH section, Assam PWD	・ Execution of construction project and major rehabilitation project on NHs ・ Implementation of routine inspection for roads and bridges on NHs ・ Implementation of routine maintenance works for roads and bridges on NHs ・ Arrangement and evaluation of inspection results and submission to MORTH ・ Preparation of DPR including project plan and cost estimation for construction and rehabilitation works on NHs and submission to MORTH. ・ Implementation of tender process for detailed investigation, rehabilitation and construction works.

Source: JICA Survey Team

5.2 Budget and Expenditure

5.2.1 Annual Budget for All Works on NHs

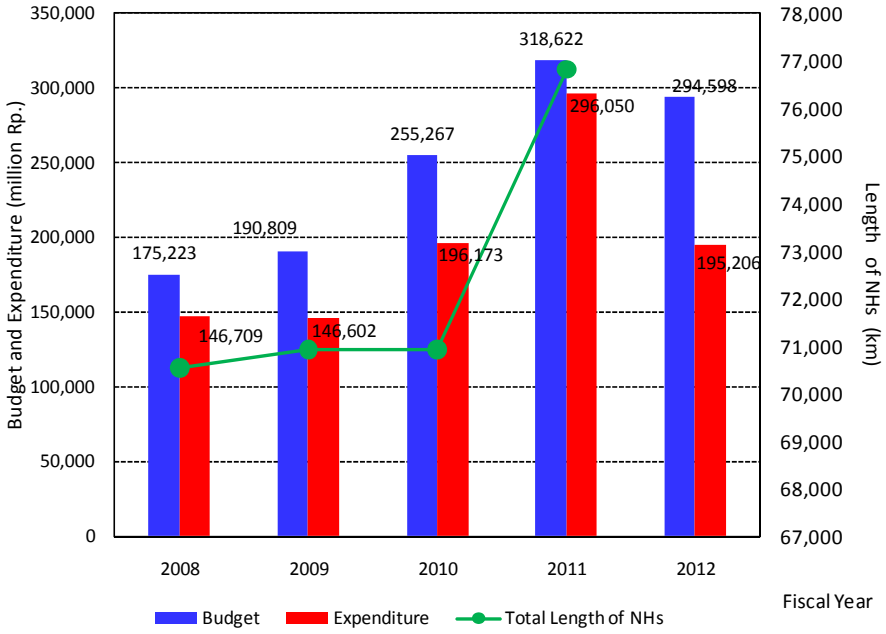
Annual budget for all works and the total length of NHs in FY2008 to FY2012 are shown in Table 5.2.1 and Figure 5.2.1. Annual budget tends to increase yearly with extension of the road network in recent years, although the budget in FY2012 has decreased slightly compared to FY2011.

Table 5.2.1 Annual Budget for All Works and the Total Length of NHs

(FY2008-FY2012)

Items	Fiscal Year				
	2008	2009	2010	2011	2012
Total Length of NHs (km)	70,548	70,934	70,934	76,818	----
Budget for all works on NHs (million Rp.)	175,223	190,809	255,267	318,622	294,598
Expenditure for all works on NHs (million Rp.)	146,709	146,602	196,173	296,050	195,206
Ratio of expenditure to budget (%)	83.7%	76.8%	76.9%	92.9%	66.3%

Source: MORTH



Source: MORTH

Figure 5.2.1 Annual Budget for All Works, and the Total Length of NHs (FY2008-FY2012)

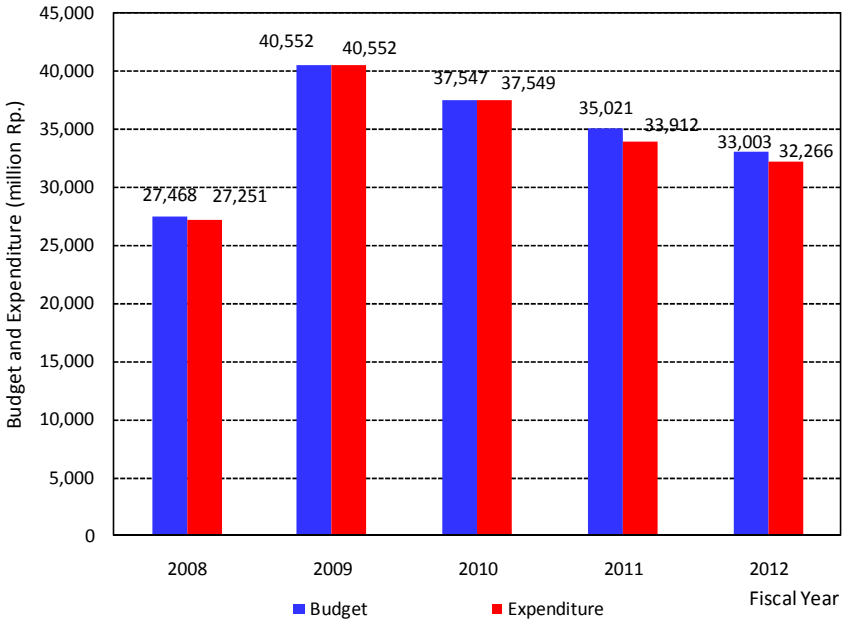
Annual budget for all works except NHDP in FY2008 to FY2012 is shown in Table 5.2.2 and Figure 5.2.2. Annual budget tends to decrease yearly.

Table 5.2.2 Annual Budget for All Works except NHDP

(FY2008-FY2012)

Items	Fiscal Year				
	2008	2009	2010	2011	2012
Budget for all works on NHs except NHDP (million Rp.)	27,468	40,552	37,547	35,021	33,003
Expenditure for all works on NHs except NHDP (million Rp.)	27,251	40,552	37,549	33,912	32,266
Ratio of expenditure to budget (%)	99.2%	100.0%	100.0%	96.8%	97.8%

Source: MORTH



Source: MORTH

Figure 5.2.2 Annual Budget for All Works except NHDP and the Total Length of NHs (FY2008-FY2012)

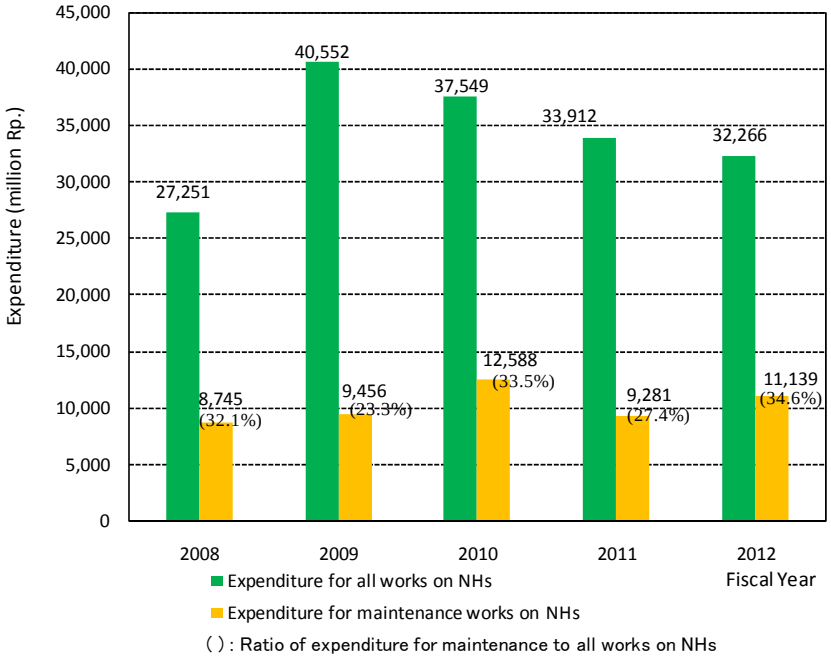
Annual expenditure for all works except NHDP, maintenance works and total length of NHs in FY2008 to FY2012 is shown in Table 5.2.3 and Figure 5.2.3. Annual expenditure for all works except NHDP tends to decrease yearly.

In addition, annual expenditure for maintenance works has accounted for only twenty four (24) - thirty five (35) % of the total for all works.

Table 5.2.3 Annual Expenditure for All Works except NHDP and Maintenance Works on NHs (FY2008-FY2012)

Items	Fiscal Year				
	2008	2009	2010	2011	2012
Expenditure for all works on NHs except NHDP (million Rp.)	27,251	40,552	37,549	33,912	32,266
Expenditure for maintenance works on NHs (million Rp.)	8,745	9,456	12,588	9,281	11,169
Ratio of expenditure for maintenance to all works on NHs (%)	32.1%	23.3%	33.5%	27.4%	34.6%

Source: MORTH



Source: MORTH

Figure 5.2.3 Annual Expenditure for All works and Maintenance Works on NHs (FY2008-FY2012)

5.3 Technologies / Skills

5.3.1 Standards / Manuals for Bridge Maintenance

Standards / Manuals of bridges have been compiled in Indian Road Congress (IRC). IRC for bridge design, construction, maintenance work and inspection are shown in Table 5.3.1.

Table 5.3.1 IRC for Bridge Design, Construction, Maintenance Work and Inspection

Name of IRC	Release Year	Contents
Manual for Highway Bridge Maintenance Inspection (IRC SP18-1996)	1996	・ Manual for implementation of bridge inspection ・Outline of initial inspection and preparation of initial inspection report ・Frequency of inspection, inspection method of each part, and preparation of inspection report
Guidelines for Inspection and Maintenance of Bridges (IRC SP35-1990)	1990	・Guideline for suggested bridge maintenance strategy regarding inspection, maintenance work, and planning ・This guideline is not adopted as a mandatory specification
Specifications for Road and Bridge Works 2013 (Fifth Revision)	2013	・Standard specification for all road and bridge works conducted by contractors and engineers in charge
Standard Specifications and Code of Practice for Road Bridges Section I (General Features of Design) (IRC 5-1998)	1998	・Standard specification and Code for design of road bridges ・Description of general features (clearance, width of carriageway, super-elevation, etc.) of bridge design
Standard Specifications and Code of Practice for Road Bridges Section II (Loads and Stresses) (IRC 6-2000)	2000	・Standard specifications and Code for design of road bridges ・Description of loads, forces, and stresses to be considered in designing road bridges and calculation methods ・Description of combination of loads and forces and allowable stress and calculation methods for these
Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (IRC 18-2000)	2000	・Design criteria for design of Prestressed Concrete (PC) road bridges (only application to Post-tensioned concrete) ・Description of structural design and structural calculation methods for PC road bridges
Standard Specifications and Code of Practice for Road Bridges Section III (Cement Concrete (Plain and Reinforced)) (IRC 21-2000)	2003	・ Standard specification and code for structural use of plain concrete and Reinforced Concrete (RC) in road bridges ・Description of structural design and structural calculation method for plain concrete and RC applied to road bridges
Standard Specifications and Code of Practice for Road Bridges Section Ⅶ (IRC 78-2000)	2000	・Standard specification and code for design of foundation and substructure of road bridges ・Description of structural design and structural calculation methods for foundations and substructure of bridges
Guidelines for The Design of Small Bridges and Culverts (IRC SP13-1998)	1998	・Guidelines for design of culverts and small bridges ・Description of design cautions for culverts and small bridges ・Description of structural design and structural calculation methods for culverts and small bridges

Source: JICA Survey Team

5.3.2 Special Vehicles / Equipment

(1) Mobile Inspection Unit

Assam PWD has owned six hundred (600) kg loading mobile inspection unit (inspection vehicle). The photos of this vehicle are shown in Figure 5.3.1.

This vehicle was purchased in 2006 by MORTH, and transferred to Assam PWD. When this vehicle was imported from Germany, some parts of the vehicle were broken, so German mechanics came to Assam state and fixed it. After this, periodical maintenance of this vehicle was conducted directly by the EE office of Assam PWD, and lend out to other civil EE offices, when they need to use.

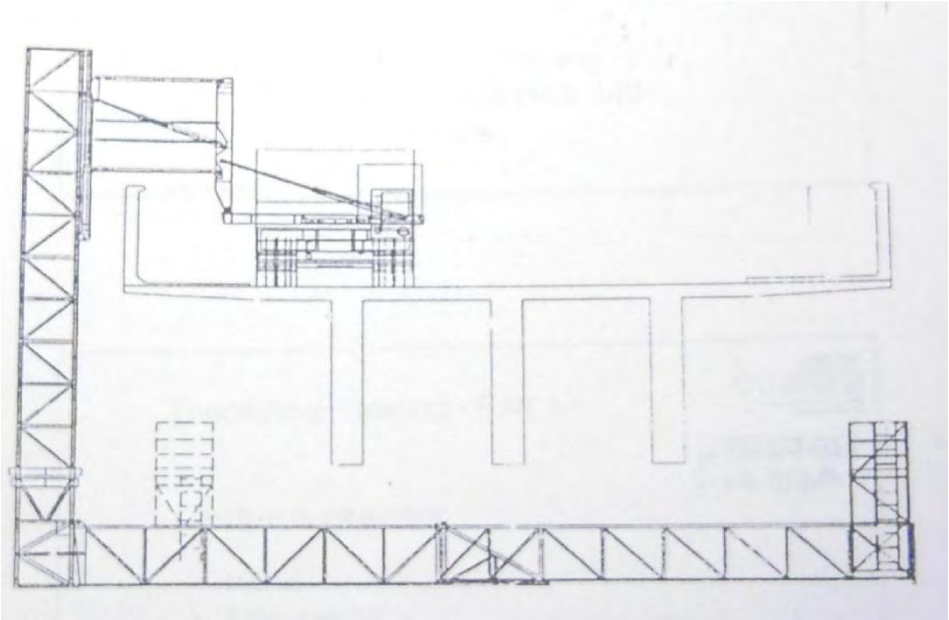
This vehicle can be used as shown in Figure 5.3.2. Currently this vehicle is used for periodic inspection of some bridges (about fifteen (15) bridges in 2012-2013) before and after the monsoon in Assam state and is not lent out to other states.

In other states, some PWD such as Maharashtra PWD and Tamil Nadu PWD, etc., owned mobile inspection unit from an interview with MORTH, although only Assam PWD owned it within 4PWDs.

In addition, Kerala PWD has sometimes borrowed it from Tamil Nadu PWD to inspect some inaccessible bridges.

Source: JICA Survey Team

Figure 5.3.1 Photos of Mobile Inspection Unit of Assam PWD



Source: JICA Survey Team

Figure 5.3.2 Method of Utilizing Mobile Inspection Unit

(2) Bridge Inspection Equipment

Assam PWD owns a great deal of equipment for bridge inspection, some of which is shown in Table 5.3.2 and Figure 5.3.3.

Bridge inspection equipment has been used for initial inspection and emergency inspection by engineers in Assam PWD.

At present, Assam PWD is considering introduction of manuals regarding utilization of this equipment for efficient bridge inspection.

Table 5.3.2 List of Bridge Inspection Equipment of Assam PWD

Name of Equipment	Year of Purchase	Quantity	Purpose of Usage
Rebound Hammer	April,2010	1*	・Measurement of compressive strength of concrete
Rebar Locator	April,2010	1*	・Estimation of location and diameter of rebar ・Measurement of thickness of cover concrete
Ultrasonic Pulse Velocity Meter	April,2010	1	・Estimation of homogeneity of concrete, presence of cracks, voids and other imperfections
Pile Integrity Tester	January,2011	1	・Estimation of integrity and length of concrete piles in soil
Cover Meter with Half-Cell Potentiometer	April,2010	1	・Measurement of corrosion depth of rebar in concrete structure
Permeability Tester	April,2010	1	・Inspection for permeability and absorption of concrete surface without cracks

* Another “Rebound Hammer” and “Rebar Locator” will be purchased this year

Source: JICA Survey Team

Rebound Hammer

Rebar Locater

Ultrasonic Pulse Velocity Meter

Pile Integrity Tester

Cover Meter with Half-Cell Potentiometer

Permeability Tester

Source: JICA Survey Team

Figure 5.3.3 Photos of Bridge Inspection Equipment of Assam PWD

(3) Bridge Maintenance Vehicles / Equipment

4ROs and 4PWDs do not own any maintenance vehicles and equipment for bridge maintenance works such as dump trucks, cleaning vehicles, vacuum vehicles, etc., because maintenance work requiring such vehicles or equipment is contracted out and conducted by the contractors. Only basic work, such as cleaning of road surfaces, etc., is carried out directly by laborers from the SD office.

5.3.3 Technical Training for Bridge Maintenance

Skills up measures for bridge maintenance are carried out by MORTH and PWDs. The current situation of technical training for bridge maintenance is summarized in Table 5.3.3.

Two (2) target PWDs (Assam, Kerala) has been used the national training program provided by the Indian Academy of Highway Engineers (IAHE) to improve techniques and skills of engineers in their offices.

IAHE is the institute under administrative control of MORTH. It is a collaborative body of both central government and state governments, and was set up for providing training of Highway engineers.

IAHE has provided training for highway or bridge engineers, totaling twenty eight (28) difference courses, carried out seventy two (72) times in FY2013. The training courses for highway and bridge maintenance are mentioned below as examples.

- Design, construction, maintenance and rehabilitation, and pavement evaluation techniques for flexible and rigid pavements
- HDM-IV with asset management and pavement preservation concepts in highway sector
- Planning, design, construction and operation of expressways
- Maintenance management system for highways and roads
- Modern trends in design and construction of bridges, evaluated structures, under passes and tunnels
- Bridge inspection, repair and rehabilitation
- Construction supervision and quality control for road and bridge project

Table 5.3.3 Current Situation of Technical Training for Bridge Maintenance

State	Training
Assam	IAHE has provided staff training. Central Road Research Institute (CRRI) has provided staff trainings regarding pavements, bridges, geotechnical engineering, and traffic and transportation planning.
Goa	-
Gujarat	The Staff Training College has provided staff training regarding geotechnical investigation, roads and buildings, and also new technologies.
Kerala	IAHE has provided staff training.

Source: JICA Survey Team

5.3.4 Financial and Technical Assistance Project for Bridge Maintenance

The financial and technical assistance project for bridge maintenance, which MORTH has conducted in the past five (5) years, is shown in Table 5.3.4. MORTH and NHAI have conducted a technical cooperation project for "Institutional Development Project on the Supervision for Highway and Expressway Operations, Management and Maintenance", through JICA.

Table 5.3.4 Foreign-Assisted Project related to Bridge Maintenance

Project	Agency	Period	Outline
Institutional Development Project on the Supervision for Highway and Expressway Operations, Management and Maintenance	JICA	January, 2012 – January, 2015 (3years)	This Project has been conducted to develop MORTH and NHAI's capacity regarding operation, management and maintenance of highways and expressways. The followings are the outputs of this project. ・Authorization and publication of performance evaluation manual with institutional set-up and evaluation criteria in MORTH and NHAI ・Publication of good practices compilation on operation, management and maintenance ・Publication of operation, management and maintenance

Source: JICA Survey Team

5.4 Current Situations of Bridge Operation and Maintenance on NHs

5.4.1 Length of Roads and Bridges on NHs

(1) Length of Roads

The total length of NHs is about seventy six thousand and eight hundred and eighteen (76,818) km (March, 2012). The state-wise length of NHs is shown in Table 5.4.1. In addition, the length of NHs managed by 4PWDs is shown in Table 5.4.2.

Table 5.4.1 State-Wise Length of NHs

	Name of State	National Highway No.	Total Length (km)
1	Andhra Pradesh	4, 5, 7, 9, 16, 18, 18A, 43, 63, 202, 205, 214, 214A, 219, 221, 222, 234	4,537
2	Arunachal Pradesh	52, 52A & 153, 229, 52B Ext.,37 Ext. & 315A	2,027
3	Assam	31, 31B, 31C, 36, 37, 37A, 38, 39, 44, 51, 52, 52A, 52B, 53, 54, 61, 62,151,152,153, 154, 127B & 315A	2,940
4	Bihar	2, 2C, 19, 28, 28A, 28B, 30, 30A, 31, 57, 57A, 77, 80, 81, 82, 83, 84, 85, 98, 99, 101, 102, 103, 104, 105, 106, 107, 110, 131A, 327Ext., 333, 527C	4,106
5	Chandigarh	21	24
6	Chhattisgarh	6, 12A, 16, 43, 78, 200,202, 216, 217, 111, 221 & 343	2,289
7	Delhi	1, 2, 8, 10 , 24 & 236	80
8	Goa	4A, 17, 17A & 17B	269
9	Gujarat	NE-I, 6, 8, 8A, 8B, 8C, 8D, 8E, 14, 15, 59, 113, 228, 76A, 360, 947 & 953	4,032
10	Haryana	1, 2, 8, 10, 21A, 22, 64, 65, 71, 71A, 72, 73, 73A, 71B, NE-II, 236 & 709 Ext.	1,633
11	Himachal Pradesh	1A, 20, 20A, 21, 21A, 22, 70, 72, 72B, 88, 73A & 305	1,506
12	Jammu & Kashmir	1A, 1B, 1C &1D	1,245
13	Jharkhand	2, 6, 23, 31, 32, 33, 75, 78, 80, 98, 99, 100, 114A, 333 & 343	2,170
14	Karnataka	4, 4A, 7, 9, 13, 17, 48, 63, 67, 206, 207,209, 212, 218 & 234	4,396
15	Kerala	17, 47, 47A, 47C, 49, 208, 212, 213, & 220	1,457
16	Madhya Pradesh	3, 7, 12, 12A, 25, 26, 26A, 27, 59, 59A, 69, 75, 76, 78, 86, 92, 26B, 69A,927A	5,064
17	Maharashtra	3, 4, 4B, 4C, 6, 7, 8, 9, 13, 16, 17, 50, 69, 204, 211, 222, 26B, 360	4,257
18	Manipur	39, 53, 150, 155, 102A, 102B & 137	1,317
19	Meghalaya	40, 44, 51, 62 & 127B	1,171
20	Mizoram	44A, 54, 54A, 54B, 150, 154 & 502A	1,027
21	Nagaland	36, 39, 61, 150 &,155	494
22	Orissa	5, 5A, 6, 23, 42, 43, 60, 75, 200, 201, 203, 203A, 215, 217 & 224	3,704
23	Pondicherry	45A & 66	53
24	Punjab	1, 1A, 10, 15, 20, 21, 22, 64, 70, 71, 72 & 95	1,557
25	Rajasthan	3, 8, 11, 11A, 11B,11C, 12, 14, 15, 65, 71B, 76, 79, 79A, 89, 90, 113, 112, 114, 116, 76B, 65A, 76A, 116A, 158, 162 Ext., 709Ext. & 927A	7,130
26	Sikkim	31A, 310	149
27	Tamil Nadu	4, 5, 7, 7A, 45, 45A, 45B, 45C, 46, 47, 47B, 49, 66, 67, 68, 205, 207, 208, 209, 210, 219, 220, 226, 226E, 227, 230, 234 & 532	4,943
28	Tripura	44 & 44A	400
29	Uttarakhand	58, 72, 72A, 72B, 73, 74, 87, 94, 108, 109, 123, 119, 121, & 125	2,042
30	Uttar Pradesh	2, 2A, 3, 7, 11, 12A, 19, 24, 24A, 24B, 25, 25A, 26, 27, 28, 28B, 28C, 29, 56, 56A, 56B, 58, 72A, 73, 74, 75, 76, 86, 87, 91, 91A, 92, 93, 96, 97, 119,231, 232, 232A, 233, 235, NE-II, 3A, 330A, 730, 730A, 931 & 931A	7,818
31	West Bengal	2, 2B, 6, 31, 31A, 31C, 31D, 32, 34, 35, 41, 55, 60, 60A, 80, 81, 117, 114A & 116B	2,681
32	Andaman & Nicobar	223	300
	Total		76,818

Note: The total length of NHs in this table shows all NHs in each state

Source: Annual Report 2012-13 (2013, MORTH)

Table 5.4.2 Length of NHs managed by 4PWDs

Name of State	No. of NH	Length of NHs managed by PWD (km)
Goa	4A	63.60
	17	147.80
	17A	16.00
	17B	12.20
Total		239.60
Gujarat	8A	191.74
	8A (Extn.)	171.00
	8C	44.42
	8E	260.10
	8E (Extn.)	208.70
	15	129.40
	56	402.00
	58	152.00
	113	39.00
	228	386.00
	848	67.60
Total		2,051.96

Name of State	No. of NH	Length of NHs managed by PWD (km)
Kerala	No Available	
Assam	31	146.00
	31B	19.66
	36	123.83
	37	585.63
	37A	23.10
	38	56.00
	39	106.78
	44	110.77
	51	22.00
	52	345.00
	52A	9.23
	52B	96.57
	53	73.55
	54	33.88
	61	17.51
	62	8.60
	151	14.00
	152	38.00
	153	23.70
	154	89.00
Total		1,942.81

Note1: The length of NHs in this table shows the length of NHs managed by PWD

Source: JICA Survey Team

(2) Length of Bridges

The Length and number of bridges on NHs have not been clearly understood by the SR&T (B) Section of MORTH, because statistical data and inspection results have not been reported to them periodically and appropriately.

Therefore, the SR&T (B) Section decided to conduct condition a survey of bridges on NHs, and make a bridge inventory.

Consulting firms for condition survey have been selected by January, 2014. An outline of this condition survey is summarized in Table 5.4.3, and a bidding document for this survey is attached in Appendix 6.

Table 5.4.3 An Outline of Condition Survey of Bridges on NHs

Items	Contents
Name	Collection and analysis of bridge condition and bridge inventory data
Period	5years
Objective	Major / minor bridges on NHs except for those managed by NHAI
Purpose	Collection of bridge condition Development of inventory data
Frequency of inspection	Twice a year before and after monsoon
Remarks	Inspection is carried out using mobile inspection unit and inspection equipment

Source: Bidding document for Collection and analysis of bridge condition and bridge inventory data by MBIU or any other equipment for the purpose of the major / minor bridges on all NHs including those NHAI for a period (2013, MORTH)

(3) Length of Bridges on NHs managed by 4PWDs

Length of bridges on NHs managed by 4PWDs is shown in Table 5.4.4.

Table 5.4.4 Length of Bridges on NHs managed by 4PWDs

Name of State	No. of NH	Length of Bridges on NHs managed by PWD (km)
Goa	4A	3.67
	17	
	17A	
	17B	
Gujarat	8A	165.00
	8A (Extn.)	
	8C	
	8E	
	8E (Extn.)	
	15	
	56	
	58	
	113	
	228	
	848	

Name of State	No. of NH	Length of Bridges on NHs managed by PWD (km)
Kerala	Not Available	
Assam	31	23.67
	31B	
	36	
	37	
	37A	
	38	
	39	
	44	
	51	
	52	
	52A	
	52B	
	53	
	54	
	61	
	62	
	151	
	152	
	153	
	154	

Note: The length of bridges on NHs managed by Kerala PWD is not available due to defect in collected data.

Source: JICA Survey Team

(4) Number of Bridges on NHs managed by 4PWDs

Number of bridges on NHs by length is shown in Table 5.4.5.

In Goa state, there are seven (7) bridges length over one hundred (100) m (eleven point seven (11.7) % of the total), in Gujarat state, these are twenty four (24) (fifteen point nine (15.9) % of the total).

Table 5.4.5 Number of Bridges on NHs by Length

Bridge Length (m)	Number of Bridges on NHs managed by 4 PWDs *							
	Assam		Goa		Gujarat		Kerala	
	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)
L < 30	Not Available		51**	85.0%	58	38.4%	Not Available	
30 ≦ L ≦ 50					33	21.9%		
50 < L ≦ 100			2	3.3%	36	23.8%		
100 < L ≦200			1	1.7%	13	8.6%		
200 < L			6	10.0%	11	7.3%		
Total			60	100.0%	151	100.0%		

* The differences of Number of bridges between Table 5.4.5 to 5.4.7 is due to defects in collected data.

** Number of bridges less than 50m in Goa PWD is total of minor bridge.

Source: JICA Survey Team

(5) Types of Bridges on NHs managed by 4PWDs

Number of bridges by type is shown in Table 5.4.6. In 4PWDs, many bridges are RC structure.

Table 5.4.6 Number of Bridges by Type

Type of Bridge	Number of Bridges on NHs managed by 4 PWDs *							
	Assam		Goa		Gujarat		Kerala	
	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)
Reinforced Concrete (RC)	Not Available		2	22.2%	151	83.4%	Not Available	
Prestressed Concrete (PC)			7	77.8%	5	2.8%		
Steel (Plate / Box Girder)			0	0.0%	0	0.0%		
Others			0	0.0%	25	13.8%		
Total			9	100.0%	181	100.0%		

* The differences of Number of bridges between Table 5.4.5 to 5.4.7 is due to defects in collected data.

Source: JICA Survey Team

(6) Age of Bridges on NHs managed by 4PWDs

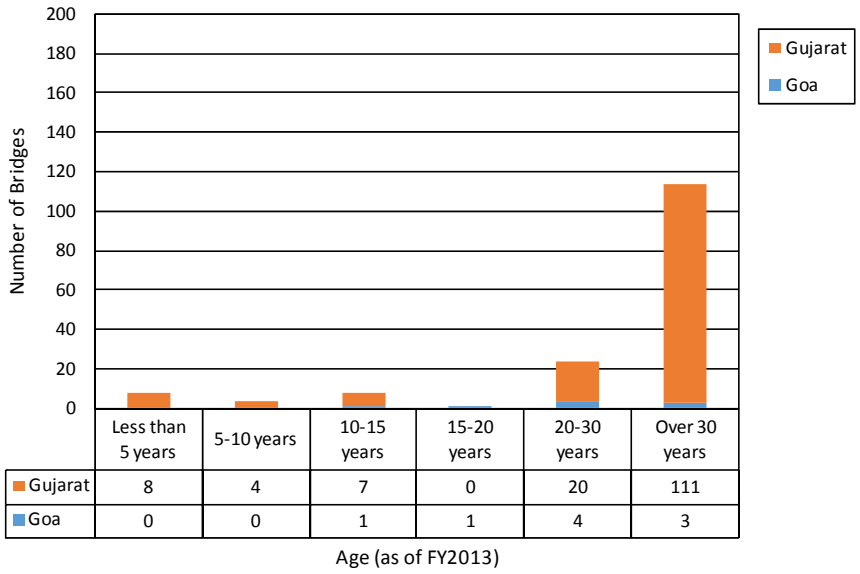
Number of bridges by age is shown in Table 5.4.7 and Figure 5.4.1. It turns out that over thirty (30) % of bridges managed by 4PWDs have been passed over thirty (30) years after construction.

Table 5.4.7 Number of Bridges by Age

Age (As of FY2013)	Number of Bridges managed by 4 PWDs *							
	Assam		Goa		Gujarat		Kerala	
	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)	Number of Bridges	Ratio (%)
Less than 5 years	Not Available		0	0.0%	8	5.3%	Not Available	
5-10 years			0	0.0%	4	2.7%		
10-15 years			1	11.1%	7	4.7%		
15-20 years			1	11.1%	0	0.0%		
20-30 years			4	44.5%	20	13.3%		
Over 30 years			3	33.3%	111	74.0%		
Total			9	100.0%	150	100.0%		

* The differences of Number of bridges between Table 5.4.5 to 5.4.7 is due to defects in collected data.

Source: JICA Survey Team



	Less than 5 years	5-10 years	10-15 years	15-20 years	20-30 years	Over 30 years
Gujarat	8	4	7	0	20	111
Goa	0	0	1	1	4	3

Source: JICA Survey Team

Figure 5.4.1 Number of Bridge by Age

(7) Comparison with Situation in Japan

The length of bridges by age on expressways in North-Eastern Japan managed by East Nippon Expressway Company Limited (hereinafter referred to as “NEXCO-East”) is shown in Table 5.4.8.

In Japan, expressways have been operating since 1963, and NEXCO-East has almost 50 years of construction and maintenance experience of expressways. Nowadays, they manage 3,677km of expressways, including 472 km of bridges (March, 2013).

A large number of bridges in Japan (with length totaling 96km, over 20% of the total) are now over 30 years old. The trend in the age of bridges is shown in Figure 5.4.2.

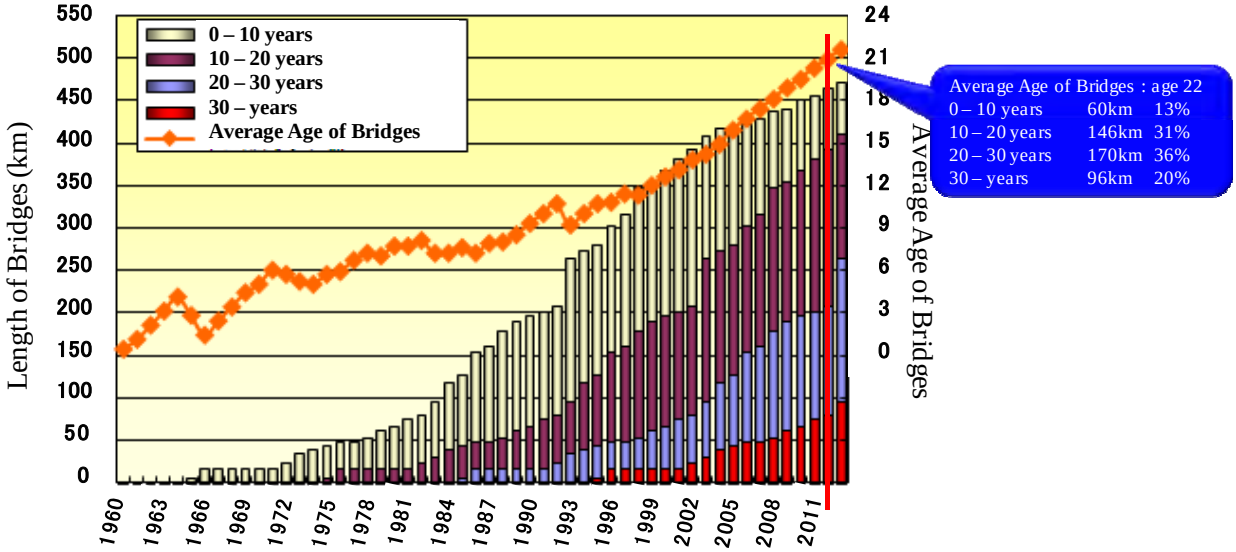
The deterioration of bridges on expressways in Japan is shown in Figure 5.4.3. This statistic is not only for NEXCO-East, but the total amount of all Japanese expressways managed by NEXCO-East, Central and West (hereinafter referred as to “3NEXCO”). Figure 5.4.3 shows deterioration of grade IV and V, which require rehabilitation or countermeasures, is rapidly increasing for bridges over thirty (30) years of age. A sample of the deterioration grade of slab deck is shown in Figure 5.4.4.

In India, almost fifty four (54) % of bridges on NHs managed by PWDs are passed over thirty (30) years, and it is forecasted that similar damages and conditions will appear on these bridges. This simple comparison shows that a condition survey including a detailed investigation of bridges is necessary and urgent task to maintain safe and reliable NHs as the first step of countermeasures against deterioration.

Table 5.4.8 Length of Bridges by Age on Expressways in North-Eastern Japan managed by NEXCO-East

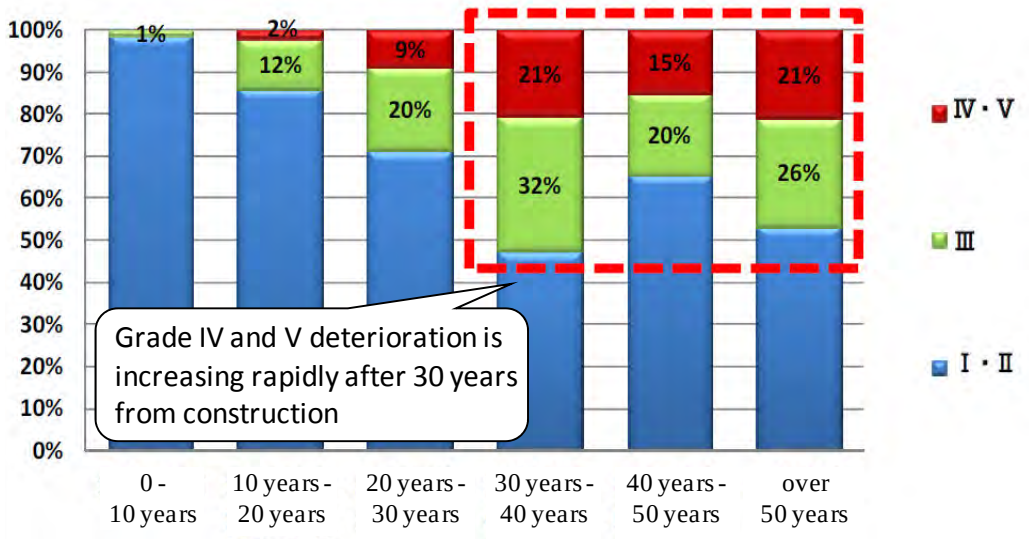
Age (As of FY2011)	Length of Bridges managed by NEXCO-East	Ratio (%)
0-10 years	60	12.7%
10-20 years	146	30.9%
20-30 years	170	36.0%
Over 30 years	96	20.3%
Total	472	100.0%

Source: JICA Survey Team



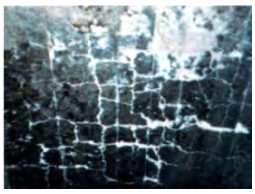
Source: JICA Survey Team

Figure 5.4.2 Trend in the Age of Bridges on Expressways in North-Eastern Japan, 2011



Source: NEXCO-East Home Page (http://www.e-nexco.co.jp/pressroom/committee/)

Figure 5.4.3 Deterioration Grade of Bridges by Age in FY2011

Grade	Sample Picture	Deformation/ Deterioration	Performance of Structures
Ⅰ		No damage	No problem
Ⅱ		Small cracks (One direction)	Load capacity, surface smoothness do not decrease
Ⅲ		Cracks (Two directions)	Caution for decrease of load capacity, surface smoothness
Ⅳ		Cracks+Free Lime (Two directions)	Load capacity, surface smoothness do not decrease gradually
Ⅴ		Many Grid Cracks + Free Lime	Load capacity, surface smoothness have serious problem

Source: JICA Survey Team

Figure 5.4.4 Sample of Deterioration Grade on Slab Deck

5.4.2 Implementation Procedures of Inspection, Routine Maintenance and Large-scale Rehabilitation

Bridge maintenance works have been classified into the following four (4) phases. Also, phase-wise bridge maintenance works are summarized in Table 5.4.9.

- Bridge inspection work
- Routine maintenance
- Large-scale maintenance (Planning)
- Large-scale maintenance (Works)

Table 5.4.9 Implementation Procedures of Bridge Maintenance

Category	Stage	Organization in Charge
Bridge inspection	Implementation of periodic inspection	SD office
	Arrangement of inspection results	SD office
	Evaluation of inspection results	SD office→EE→SE→CE
	Report of the inspection results	SD office→EE→SE→CE →RO→MORTH
	Random site survey and check of damage degree	RO
	Suggestion for approval of detailed investigation on damaged bridge	RO→MORTH
	Approval of inspection results (Instruction for detailed investigation)	MORTH
Routine maintenance	Implementation of routine maintenance work	SD office
Large-scale maintenance (Planning)	Preparation of tender document for selecting consultant firm	EE
	Selection of consultant	CE→SE→EE
	Implementation of detailed investigation	Consultant SD office
	Preparation of DPR including investigation result, rehabilitation plan, cost estimation, etc.	Consultant SD office
	Report of DPR	SD office→EE→SE→CE →RO→MORTH
	Approval of DPR	MORTH
Large-scale maintenance (works)	Preparation of budget for rehabilitation project	MORTH
	Preparation of tender document and implementation of bidding	EE
	Selection of contractor	CE →SE →EE
	Implementation of rehabilitation work	Contractor SD office
	Payments for contractor	RO→Contractor

Source: JICA Survey Team

5.4.3 Bridge Inspection

(1) Periodic Inspection

1) Implementation of Periodic Inspection

The current situation of periodic inspection is shown in Table 5.4.10.

Basically, periodic inspection has been carried out twice a year before and after the monsoon season by civil engineers in SD office. The method of periodic inspection is visual from a certain distance, and close-up inspection, inspection using hammer and crack width measurement, etc., are not

performed during periodic inspection. Visual inspection is also performed under the bridge mainly from nearby, and a ladder, or a boat and, etc., have been used occasionally.

In addition, combined inspection of roads and bridges are carried out, dedicated inspection of bridge is not carried out during periodic inspection in present.

In Goa state, the flatness of surface of Zuari Bridge and Borim Bridge has been measured twice a year, because deformation and vibration of the bridges were measured at center hinge, although Zuari bridge was rehabilitated in 1998 and 2003.

Table 5.4.10 Current Situation of Periodic Inspection of Bridges

State	Frequency	Inspection Method	Direct / Outsource
Assam	Twice a year	Visual inspection	Direct work
Goa	Once a month	Visual inspection	Direct work
	Twice a year	Levelling*	
Gujarat	Twice a year	Visual inspection	Direct work
Kerala	Twice a year	Visual inspection	Direct work

*Note: Flatness measurement of surface of Zuari Bridge and Borim Bridge

Source: JICA Survey Team

2) Arrangement of Inspection Results

Inspection results have been arranged in the format shown in Appendix 7.

3) Report and Evaluation of Inspection Results

Damage degree of bridge members is classified as “major”, “minor”, “fair” and “good” according to their condition, and initially determined by engineers of SD office.

Bridge inspection results have been reported to MORTH twice a year through EE, SE and CE of PWD and RO using the format in Appendix 7 in document form.

4) Random Site Survey and Check of Damage Degree

Random checks and site survey of damaged bridges have been carried out by EE, SE and CE of PWD and RO during the report of inspection results, and evaluation of damage degree has been fixed at that time.

RO has deliberated and judged the necessity for rehabilitation of the damaged bridge.

5) Suggestion for Approval of Detailed Investigation for Damaged Bridge

Detailed investigation of the damaged bridge has been suggested to MORTH by RO and PWD.

6) Approval of Inspection Results

The inspection results have been deliberated and judged by MORTH. A detailed investigation of the damaged bridge and selection of a consulting firm have been started after approval and instruction by MORTH.

7) Detailed Investigation

A detailed investigation, such as close-up inspection, inspection using equipment such as inspection hammer, measurement of crack width, etc., has not been conducted periodically.

A detailed investigation has been conducted after severe damage has been found, and approval and instruction has been given by MORTH.

(2) Routine Maintenance

1) Implementation of Routine Maintenance Works

The current situation of routine maintenance works of 4PWDs are shown in Table 5.4.11.

Only basic routine maintenance work (such as cleaning of drainage, expansion joints, surface of pavement and bearings) is carried out directly by laborers from the SD office, whereas periodic maintenance works are contracted out to the contractors. In addition, damaged road facilities such as pavements, expansion joints etc., have been replaced sporadically.

Table 5.4.11 Current Situation of Routine Maintenance Works

State	Frequency	Contents	Direct / Outsource
Assam	Once a year	Cleaning of drainage, expansion joints, surface of pavement and bearings, etc.	Direct Work
Goa	Once a week		Direct Work
Gujarat	Once a month		Direct Work
Kerala	Once a year		Direct Work

Source: JICA Survey Team

(3) Large-Scale Maintenance (Planning)

1) Preparation of a Tender Document, and Implementation of Bidding

EE is responsible for the preparation of tender documents including cost estimation, specifications, etc., for the implementation of a detailed survey. The tender process is also carried out by EE.

2) Selection of Consultant

Technical and financial proposals from bidders have been submitted to CE through EE and SE, and selection and evaluation of consultants are to be carried out by SE.

3) Implementation of Detailed Investigation

The selected consultant conducts a detailed investigation such as close-up inspection, using inspection equipment such as mobile inspection unit, and Schmidt hammer, etc., under supervision of the SD office.

4) Preparation of Detailed Project Report (DPR)

A DPR including detailed investigation results, rehabilitation plan, estimated cost, etc., has been prepared by the consultant under the direction of SD office.

5) Report of DPR

The DPR has been reported to MORTH through EE, SE, CE of PWD and RO.

6) Approval of Rehabilitation Project

DPR have been deliberated and judged by MORTH.

Implementation of a rehabilitation project for a damaged bridge has been approved by MORTH.

(4) Large-scale Maintenance (Works)

1) Preparation of Budget for Rehabilitation Project

A budget for the rehabilitation project has been prepared and allocated by MORTH.

2) Preparation of Tender Document and Implementation of Tender Process

A tender document for implementation of rehabilitation works is prepared by EE.

3) Selection of Contractor

Technical and financial proposals are submitted to CE through EE and SE by the bidder, and then the awarded contractor is decided by CE.

4) Implementation of Rehabilitation Works

The selected contractor starts rehabilitation works under supervision of the consultant and SD office.

5) Payments for Contractor

Certification of the rehabilitation works is submitted to RO by CE of PWD. Payment for the work is processed by RO.

6) Major and / or Ongoing Large-scale Bridge Rehabilitation Project

Major and/or ongoing rehabilitation projects are shown in the Table 5.4.12.

In Goa state, external cables for Zuari Bridge were installed in 1998 and in 2003 by Freyssinet Prestressed Concrete Co. (FPCC) to recover the displacement and fluctuation at the center hinges. A detailed investigation for installation of external cables for Zuari Bridge and design were carried out by the Central Road Research Institute (CRRI). However, de-stressed of installed external cables were founded in 2006; therefore additional rehabilitation (re-stressing) has been requested by Goa PWD to MORTH. The photos of Zuari Bridge are shown in Figure 5.4.5.

Large-scale bridge rehabilitation works are conducted by the contractor after approval of MORTH. Nevertheless the results / records of the rehabilitation works have not been accumulated.

Source: JICA Survey Team

Figure 5.4.5 Photos of Rehabilitation of Zuari Bridge in Goa State

Table 5.4.12 Major and/or Ongoing Bridge Maintenance Project

Name of State	Bridge Name	Project Cost (million Rp.)	Project Period	Source of Budget	Contractor	Description
Assam	Sadarghat Bridge (NH.53)	17.330	2012 (Completed)	MORTH	Freyssinet Prestressed Concrete Co. Ptv.Ltd.,Mumbai	・Replacement of expansion joint and bearings ・Length of bridge: 472.0m
Goa	Zuari Brdige (NH.17)	10.800	1998 (Completed)	MORTH	Freyssinet Prestressed Concrete Co. Ptv.Ltd.,Mumbai	・External prestressing of existing bridge for one span ・Length of bridge: 809.0m
		69.500	2003 (Completed)	MORTH	Freyssinet Prestressed Concrete Co. Ptv.Ltd.,Mumbai	・External prestressing of existing bridge for remaining span ・Length of bridge: 809.0m
	Borim Bridge (NH.17B)	100.000	Mar.2014-Aug.2015	MORTH	Freyssinet Prestressed Concrete Co. Ptv.Ltd.,Mumbai	・External prestressing of existing bridge for main span ・Replacement of bearings ・Repair for handrail ・Wearing coat ・Length of bridge: 410.6m
Gujarat	Medha Creek (NH.8E)	112.529	Jun.2012-Mar.2014	Gujarat State	Rebuild Struct Associate, Mumbai	・Repair for Superstructure ・Reinforcement and cement grouting for superstructure ・Length of bridge: 831.0m
	Rupen CD No.166/1 Datardi CD No.114/1 Shetrunji CD No.50/2 (NH.8E)	17.924	Feb.2013-Feb.2014	Gujarat State	Swastik Buliders, Upleta	・Repairs for Foundation, Sub structure & Superstructure etc. ・Length of bridge: 408.0m (Total)
	Titodi Bridge (NH.113 Dohad-Jhalod-Banswada	31.826	11months	MORTH	Royal Infra Engineering Ptv.Ltd. , Surat	・Replacement of existing bridge ・Length of bridge: unknown
	Suki Bridge (NH.113 Dohad-Jhalod-Banswada	36.639	11months	MORTH	Royal Infra Engineering Ptv.Ltd. , Surat	・Replacement of existing bridge ・Length of bridge: unknown
Kerala	Kottappuram Bridge (NH.17)	23.800	Feb.2012-Jul.2013	MORTH	Cherian Varkey Construction Co. Pvt.Ltd.	・Repairs for damaged pavement ・Replacement of expansion joint ・Length of bridge: unknown
	Chettuva Bridge (NH.17)	30.900	May.2013-Feb.2014	MORTH	Padmaja Specialities	・Repairs for damaged concrete surface of pier, pier caps, girder ,slabs and pavement ・Length of bridge: unknown
	Puduponnani Bridge (NH.17)	23.900	Apr.2013-Jan.2014	MORTH	Padmaja Specialities	・Repairs for damaged concrete surface of pier, pier caps, girder ,slabs and pavement ・Length of bridge: unknown

Source: JICA Survey Team

5.4.4 Others

(1) Performance Base Contract

A performance base contract for bridge maintenance are not conducted, because major rehabilitation and replacement works have been implemented project by project after approval of MORTH and decision of rehabilitation methods.

(2) Bridge Asset Management

Bridge asset management has not been introduced in MORTH and PWDs. Also, MORTH and PWDs have not had long- / middle- term bridge maintenance plan.

(3) Bridge Database and Bridge Management System

“Bridge Database” and “Bridge Management System” have not been introduced in MORTH and PWDs.

Bridge specifications, historical inspection records and bridge maintenance records have not been accumulated and sheared for superior engineers (EE, SE, and CE). These are only compiled in document form in SD office.

5.5 The Suggestions for Operation and Maintenance of Bridges on National Highways

5.5.1 Current Situations of Operation and Maintenance of Bridges on NHs

Current situations of operation and maintenance of bridges on NHs are summarized by the phases as shown in Table 5.5.1 and Table 5.5.2.

Table 5.5.1 Current Situations of Bridge Inspection

Phases	Items	Current situations
Bridge inspection	Periodic inspection	・Every bridge and structure has been directly inspected twice a year by civil engineers of the SD office ・Only visual inspection from a certain distance has been carried out ・Inspection of inaccessible places/members of bridges such as the underside of slabs, or above the river has not been carried out ・Periodic inspection by a competent qualified engineer has not been carried out although ”Manual for highway bridge maintenance inspection” mentions this requirement
	Detailed investigation	・Detailed and close-up investigation is not carried out periodically. It is conducted only after severe damages have been found ・Equipment and tools for detailed investigation such as inspection mobile unit, inspection hammers, non-destructive equipment etc. are not observed in MORTH and PWDs ・Some PWDs have owned inspection mobile unit and non-destructive equipment, however they have not been used appropriately
	Evaluation of damage	・Inspection results were initially evaluated by engineers in the SD office ・There are no clear, unified evaluation manuals, which means damages of bridges have been evaluated subjectively
	Accumulation of inspection results	・Inspection results have been prepared and arranged by the SD offices in a format attached in Appendix 7 ・Inspection results have been reported to MORTH through EE, SE and CE of PWD and RO in document form ・All inspection results have not been reported to MORTH, therefore the SR&T (B) Section have not understood the actual condition of all bridges ・Historical inspection data has not been accumulated, and is only understood by engineers in the SD office

Source: JICA Survey Team

Table 5.5.2 Current Situations of Bridge Operation and Maintenance

Phases	Items	Current situations
Operation and maintenance	Rehabilitation work	・Most of the regular bridge maintenance work is simple routine work, such as clearing of drainage and expansion joints etc. There are few duties relating to bridge repair. ・Even though severe damage has been found, rehabilitation work has not been started due to limited budget as well as the various conditions that need to be met in order to start rehabilitation work ・The bridge performance had already dropped below required levels at the time that severe damage was found, and as a result, large-scale rehabilitation work such as replacement or reconstruction would be necessary to restore the bridge to full functionality. ・It is important to find and repair damage in early stages to secure the longevity, safety and reliability
	Budget allocation and long/mid-term bridge maintenance plans	・A yearly combined maintenance budget is allocated for roads and bridges which means that most of it gets used on routine maintenance works. ・MORTH allocates a budget for large-scale rehabilitation works only after severe damage has appeared on the bridges. ・MORTH and PWDs do not have long/mid-term bridge maintenance plans. ・It is essential to develop long/mid-term bridge maintenance plans for efficient, effective and well-planned bridge maintenance.
	The awareness of bridge maintenance	・MORTH's staff are not motivated to repair bridges in early stages of disrepair ・MORTH's staff do not understand the condition of the bridges and roads on NHDP section although MORTH owns all of the assets
	Accumulation of knowledge and experience	・There are no engineers who concentrate on bridge maintenance on site ・Technologies and experience for bridge maintenance have not been accumulated. ・Evaluation and monitoring of rehabilitated bridges have not been conducted, therefore results/records of rehabilitation have not been accumulated in a proper manner.
	Update of bridge design standards	・No bridges in this Survey were found to be equipped with inspection passageways ・Proper establishment of design criteria for bridge construction is essential for effective bridge maintenance ・It is important to update bridge design standards periodically considering maintenance of bridges

Source: JICA Survey Team

5.5.2 Suggestions for Efficient Operation and Maintenance of Bridges

In Section 5.5.1 and Table 5.5.2, current situations of operation and maintenance of bridges on NHs are summarized by the phase. The suggestions for more effective and efficient operation and maintenance of bridges on NHs are sorted in Table 5.5.3 and Table 5.5.4.

Table 5.5.3 Suggestions for Efficient Operation and Maintenance of Bridges on NHs

(Bridge Inspection)

Phases	Items	Suggestions
Bridge inspection	Periodic inspection	・Improvement and update of bridge inspection manuals, and their technical guidelines ・Procurement of bridge inspection mobile units and inspection equipment ・Development of more efficient inspection methods (non-destructive inspection)
	Detailed investigation	
	Evaluation of damage	・Development of damages evaluation manuals, and their technical guidelines
	Accumulation of inspection results	・Development of bridge database, bridge management system and their operational guidelines ・Development of comprehensive management system for roads and bridges

Source: JICA Survey Team

Table 5.5.4 Suggestions for Efficient Operation and Maintenance of Bridges on NHs

(Bridge Operation and Maintenance)

Phase	Issues	Suggestions
Operation and maintenance	Rehabilitation work	・Development of operation and maintenance manuals for bridges including evaluation and monitoring methods after rehabilitation etc., and their respective guidelines
	Budget allocation and long-/mid-term bridge maintenance plans	・Diffuse the concept of "Bridge management cycle (PDCA cycle)” ・Development of bridge database, bridge management system and their operational guidelines ・Development of long- / mid-term bridge maintenance plans based on inspection results, damage evaluation of bridges and predicting future degrees of soundness
	The awareness of bridge maintenance	・Recognition of the importance of bridge operation and maintenance ・Development of suitable management system for bridge maintenance of NHs operated by concessionaires
	Accumulation of knowledge and experience	・Diffuse the concept of "Bridge management cycle (PDCA cycle) ・Development of bridge management system ・Establish books / reference material accumulated from bridge maintenance, rehabilitations and retrofitting work
	Update of bridge design standards	・Improvement of bridge design standards.

Source: JICA Survey Team

5.5.3 Current Situation of Technical Cooperation Project Conducted through JICA

Currently, MORTH and NHAI have been conducting a technical cooperation project for "the Institutional Development Project on the supervision for Highway and Expressway Operation, Maintenance and Management" through JICA, and Japanese experts have been dispatched to both MORTH and NHAI. Through this technical cooperation project, maintenance and management knowledge and skills for "Inspection" and "Damage Evaluation" are expected to improve.

Operation and maintenance knowledge and skills of bridges on NHs 1) to be conducted already in India, 2) to expect achievement through JICA's ongoing technical cooperation project have been shown and are summarized in Table 5.5.5.

Table 5.5.5 Current Situation and Expected Outputs of Current Technical Cooperation Project

Items	Contents
Current bridge maintenance situation of India	・Visual-base periodic inspection ・Condition survey for all bridges ・Detailed investigation after severe damages were found ・Rehabilitation and countermeasures for severe damages
Developing under ongoing technical cooperation project	・Authorization and publication of performance evaluation manual along with the institutional set-up and evaluation criteria in MORTH and NHAI ・Publication of good practices compilation on operation, management and maintenance ・Update the chapter regarding operation and maintenance of existing expressway guideline ・As the preparation of introduction of preventive maintenance for reducing maintenance costs ・Periodic inspection scheme to recognize initial damage ・Evaluation methods of the initial damage (how / when / where rehabilitation should be carried out)

Source: JICA Survey Team

5.5.4 Priorities

The current situations and suggestions extracted and summarized in section 5.5.1 and 5.5.2 have been prioritized and are given in Table 5.5.6. Although all suggestions are high priority, it should be considered to keep the well-balanced budget to make it realize the efficient and effective maintenance work. In addition, it is also important to monitor, evaluate and manage the situations of bridge maintenance of NHs operated by concessionaires through NHDP scheme.

Therefore it can be proposed that "development of long-/mid-term maintenance plan" and "development of suitable management system for bridge maintenance of NHs operated by concessionaires" have the highest priority.

Table 5.5.6 Priorities for Operation and Maintenance of Bridges on NHs

Phase	Items	Solutions	Priority
Bridge inspection	Periodic inspection Detailed investigation	Bridge inspection manuals Technical guidelines	High
		Bridge inspection mobile units Inspection equipment	High / Normal
		More efficient inspection methods	Low
	Evaluation of damage	Evaluation manuals Technical guidelines	Normal
	Accumulation of inspection results	Bridge database Bridge management system Operational guidelines	High
		Comprehensive management system for roads and bridges	Low
Operation and maintenance	Rehabilitation work	Operation and maintenance manuals Evaluation and monitoring methods Technical guidelines	Normal
	Budget allocation long / mid-term bridge maintenance plan	Diffuse the concept of "bridge management cycle (PDCA cycle)"	High
		Bridge database Bridge management system Operational guidelines	High
		Long-term maintenance plan Mid-term maintenance plan	High
	The awareness of bridge maintenance	Recognition of the importance of bridge operation and maintenance	High
		Bridge management system suitable for NHs operated by concessionaires	High
	Accumulation of knowledge and experience	Diffuse the concept of "bridge management cycle (PDCA cycle)"	High
		Bridge database Bridge management system Operational guidelines	High
		Establish books / reference material accumulated from bridge maintenance	Normal
	Update of bridge design standards	Improvement of bridge design standards.	Normal

Source: JICA Survey Team

5.5.5 Benefit from the Proposed Solutions

Through conducting the proposed solutions, 1) development of bridge maintenance plan and 2) management of bridge maintenance of NHs operated by concessionaires, Three (3) major benefits will be expected to attain as well as being able to maintain and monitor the bridges appropriately.

(1) Extension of life-span and improvement of safety and reassurance of bridges

Life-span of bridges as well as highways infrastructure itself, can be extended by conducting maintenance work in appropriate timing, place and method based on the developed plans in suggestions, and also to monitor the condition of existing bridges including bridges operated by the concessionaires through NHDP scheme, instead of large-scale rehabilitation work such as replacement and/or reconstruction etc.

In addition, 1) bridge performance dropping below a required level, 2) load limit, speed limit and traffic closures usually enforced due to deteriorated bridges can be prevented. In other words, safer, more reliable and more comfortable Highways can be maintained.

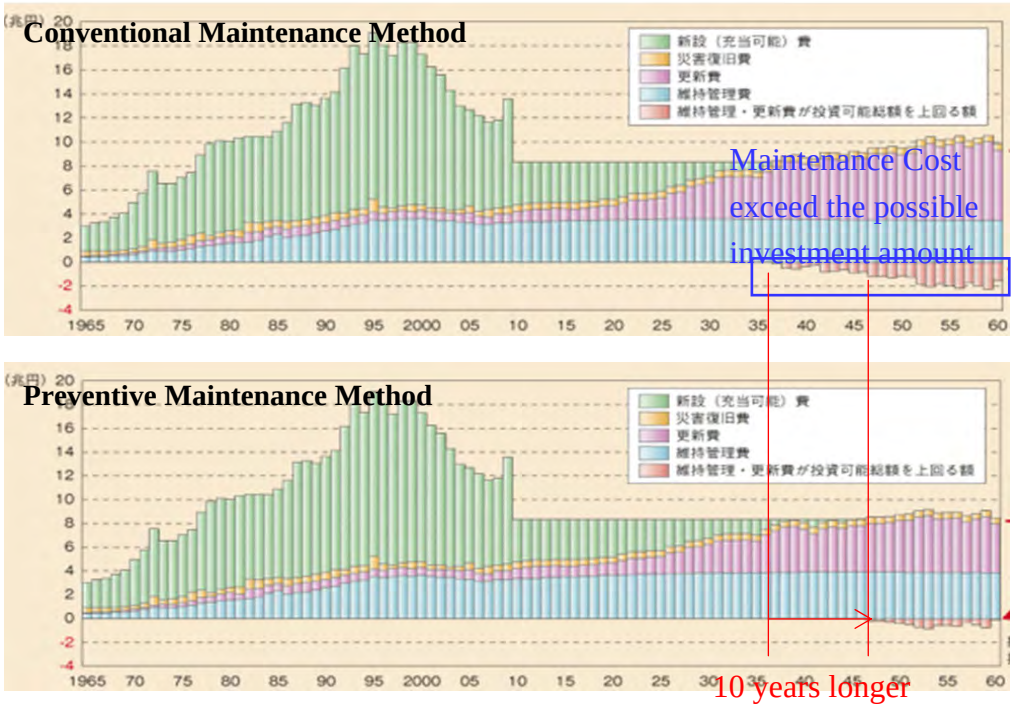
(2) Minimization and Equalization of annual maintenance budget of bridges

Large-scale rehabilitation work such as bridge reconstruction and superstructure replacement requires an extensive budget. In order to avoid such large-scale rehabilitation, the appropriate and periodic inspections are required to find damage and deterioration as early as possible, and to conduct small scale rehabilitation before the damage becomes unmanageable.

Figure 5.5.1 shows a comparison of rough estimates for maintenance costs between “conventional maintenance method (to conduct rehabilitation after severe damage is found)” and “preventive maintenance method (to conduct rehabilitation at appropriate timing, place and method based on bridge maintenance plan)”.

These trial, very rough cost estimations were conducted by MLIT (Ministry of Land, Infrastructure, Transport and Tourism) in 2010, and the maintenance cost of infrastructures is forecast to exceed possible investment amount within twenty (20) years. However this can be delayed by about ten (10) years and the total exceeded cost can be reduced by about one fifth (1/5) of conventional maintenance methods, when preventive maintenance method are applied.

Also, the current highway network in India has been expanded and improved rapidly based on the twelfth (12th) five (5) years plan. The bridges would have deteriorated at the same rate if they had been constructed at around the same time. This means that almost all bridges will be deteriorated thereby making the maintenance budget increase rapidly in the next thirty (30) or forty (40) years.



Source: White Paper on Land, Infrastructure, Transport and Tourism in 2010 by MLIT, Japan

Figure 5.5.1 Comparison of Rough Cost Estimations of Bridge Maintenance

In addition, a sufficient rehabilitation budget would be necessary for emergency maintenance such as reconstruction of fallen bridges, replacement of superstructures etc. These accidents occur suddenly, and management of maintenance has been difficult.

Instead, the annual maintenance budget for bridges can be controlled and equalized to develop maintenance plans, conduct maintenance plans based on development plans and also conduct periodic inspection and monitoring.

(3) Enhancement of Accountability

Bridge management plans will be developed based on a logical and rational prediction of future soundness of bridges. Therefore, accountability (why rehabilitation should be conducted) for nations and road users will be enhanced.

5.5.6 Introduction of Technical Cooperation Project for Bridge Operation and Maintenance from Abroad

The awareness of efficient and well-planned operation and maintenance of bridges has been recently increasing in many countries, and technical cooperation projects have been conducted, especially development of long/mid-term bridge maintenance plans through JICA. In this section, some examples of ongoing technical cooperation projects in other countries by JICA are introduced.

(1) The Project for Capacity Development on Bridge Maintenance and Management

(Mongolia, 2013-2015)

1) Background of the project

The MRT (Ministry of Roads and Transport) operates and manages 11,136km of roads, including 375 bridges, and UBC (Ulaanbaatar city) operates and manages 460km and 67 bridges.

These bridges were constructed before the 1960's and are currently significantly deteriorated, but adequate maintenance of bridges has not been carried out due to budget-limitations and lack of skilled engineers, although only minor repairs and urgent rehabilitation were implemented.

In addition, management of bridge maintenance has not been developed, also proper maintenance management system have not been introduced.

2) Project Purpose

To improve MRT's and UBC's capacity for planning bridge maintenance.

3) Outputs of the Project

- Wide understanding of concept of "Bridge management cycle"; development of guidelines and manuals regarding inspection, evaluation, priority assessment and selection of appropriate measures
- Development of database systems for recording bridge data in UBC and nation-wide.
- Development of a national policy on maintenance and management
- Training of staff members related to bridge/structure maintenance and management in MRT and UBC (conducted by the Mongolian side)

(2) The Project for Capacity Development for Maintenance and Management of Bridges and Tunnels (Kyrgyzstan, 2013-2015)

1) Background of the project

MOTC (Ministry of Transport and Communications) is responsible for the operation and management of 18,803km of roads, including 1,729 bridges and 5 tunnels.

Most of the road network was constructed during the Soviet era. After gaining independence in 1991, many Russian technicians left Kyrgyzstan, road maintenance activities have not been carried out adequately due to the budget provided to the road rector being insufficient.

The low level of financing for road repair and maintenance has led to an annual loss of approximately 200km of road surface. The worsening road conditions are hindering smooth trade with neighboring countries and the transportation of freight.

In addition, maintenance management of bridges and tunnels has been carried out without proper plans and maintenance management routines for bridges and tunnels based on periodical inspections have not been established.

2) Project Purpose

To improve MOTC's capacity for maintaining cost estimations of bridges and tunnels on the basis of inspection results.

3) Outputs of the Project

- Clear identification of demarcation of MOTC's HQ and relevant organizations with necessary staffing for managing bridges and tunnels
- Development of a database system to record information on bridges and tunnels ready for maintenance planning
- Enhancement of capacity of routine maintenance, inspection and condition rating of bridges and tunnels
- Enhancement of capacity of MOTC's HQ and relevant organizations for preparing maintenance management plans on bridges and tunnels

Photographs of Kyrgyz technical cooperation project are shown in Figure 5.5.2.

Source: JICA Home Page (http://www.jica.go.jp/oda/project/1200296/field.html)

Figure 5.5.2 Photographs of the Kyrgyzstani Technical Cooperation Project

6. PROPOSAL OF FUTURE JAPANESE SUPPORT

6.1 Outline of the Future Japanese Support

The following two items can be considered for the Japanese Support Project in consideration of the issues facing road and bridge rehabilitation in India.

- Road and Bridge Rehabilitation
- Bridge Operation and Maintenance

6.1.1 Road and Bridge Rehabilitation

The major issues for road and bridge in India are as follows:

- A number of road bridges has put in an unsafe condition, since they has not been maintained efficiently for 30 - 40 years after their construction.
- Number of total bridges or bridges requiring maintenance can not be grasped accurately, since bridge ledgers and as-built drawings have not been managed correctly.
- There is no enough technology for bridge maintenance, since new construction has been mainly implemented in India.

In the ING-IABSE presentation, many questions regarding bridge maintenance technique were thrown from the Indian bridge engineers. There is high interest in bridge maintenance technique in India.

Mahatma Ghandhi Bridge in Bihar State is in a serious condition for center hinge connection, and there are many same type of bridges in India. Thus, the technical transfer regarding center hinge connection will be very important in India.

It is proposed that implementation of rehabilitation program for the selected bridges in the second field survey of this study.

(1) Summary of the Project

Summary of new bridge construction and existing bridge rehabilitation project including following items is shown in Table 6.1.2.

- New Bridge Construction: 3 bridges (Badarpurghat Bridge, Zuari Bridge, Borim Bridge)

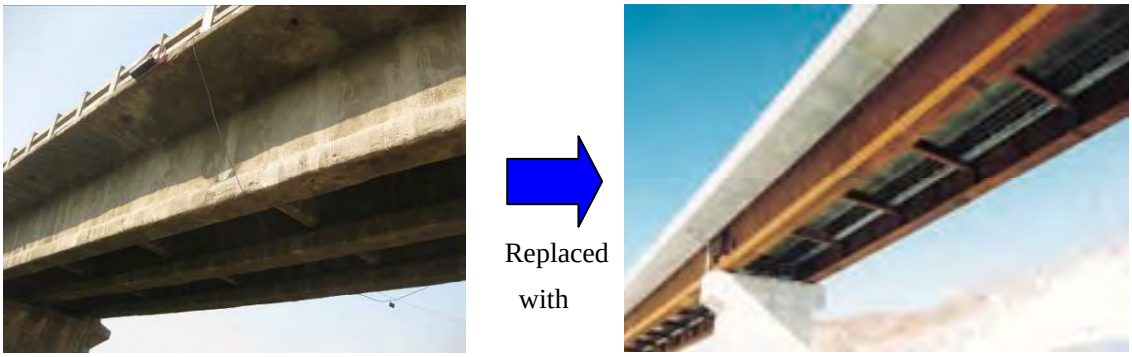
- Replacement of the Superstructure: 5 bridges (Kaliabhomora Bridge, Mahe Bridge, Valapattanam Bridge Perumba Bridge, Shetrunji Bridge)
- Connection of Center Hinge (PC Box girder Bridge): 2 bridges (Zuari Bridge, Borim Bridge)
- Reinforcement by Carbon Fiber: 1 bridge (Valapattanam Bridge)

Total project cost of existing bridge rehabilitation is approximately 4.6 billion Japanese Yen (2.8 billion Indian Rupee). Adoption of steel girder in the replacement of the superstructure work will shorten the work period. In addition adoption of weathering steel will minimize the maintenance cost. It is required to close the road for a few months during work period of center hinge connection, although it is very difficult to close 2 bridges in Goa State because of the high traffic volume on the bridges. Thus it is planned that center hinge connection of the existing bridges will be implemented after the new bridge construction is completed. It is also planned that Badarpurghat Bridge will be replaced since the piers of this bridge has been settling down, and rehabilitation is not effective. The project cost of this replacement, i.e. new construction, is approximately 9.6 billion Japanese Yen (5.8 billion Indian Rupee). Connection of the center hinge or replacement of the superstructure using weathering steel is a Japanese modern technology.

Table 6.1.1 Proposal of Projects

State	NH No.	Bridge Name	Bridge Basic Data	Result of Survey	Proposal of Rehabilitation		Estimated Project Cost (thousand yen)	Estimated Project Cost (thousand rupees)
Assam	NH37A	Kaliabhomora Bridge	Bridge type: PC Box (Gerber Girder) + RC T Bridge length: 3,105m Span length: 67.5 - 120.0m Width: 10.5m (2 lane)	Differential displacement has been observed in 8 of the 24 girder sites in the central portion of the span.	Replacement of Gerber Girders with Steel Girder (Weatherig Steel)	Existing Bridge	JPY 576,000	INR 349,000
	NH44	Badarpurghat Bridge	Bridge type: PC Box (Centre Hinge) Bridge length: 359.44m Span length: 30.04 - 108.50m Width: 10.5m (2 lane)	Differential displacement on gapslab has occured. Subsidence of the pier itself has also been observed.	New Bridge Construction	New Bridge	JPY 2,255,000	INR 1,366,000
Goa	NH17	Zuari Bridge	Bridge type: PC Box (Centre Hinge) Bridge length: 809m Span length: 36.0 - 121.0m Width: 7.5m (2 lane)	Differential displacement of about 1.5cm at the centerhinge was observed.	New Bridge Construction and Connection of Centre Hinge	New Bridge	JPY 4,805,500	INR 2,913,000
						Existing Bridge	JPY 316,000	INR 192,000
	NH17B	Borim Bridge	Bridge type: PC Box (Centre Hinge) Bridge length: 411m Span length: 20.0 - 122.0m Width: 7.5m (2 lane)	Differential displacement of about 1.5cm at the centerhinge was observed.	New Bridge Construction and Connection of Centre Hinge	New Bridge	JPY 2,492,000	INR 1,510,000
						Existing Bridge	JPY 79,000	INR 48,000
Kerala	NH17	Mahe Bridge	Bridge type: RC T Bridge length: 117m Span length: 23.4m Width: 8.50m (2 lane)	Cracks have appeared on main girder and deck slabs, and bearings have sustained damage.	Replacement of Superstructure with Steel Girders	Existing Bridge	JPY 483,400	INR 291,000
		Valapattanam Bridge	Bridge type: RC Box Bridge length: 420.77m Span length: 8.3 - 31.09m Width: 10.2m (2 lane)	Large-scale peeling, rebar exposure and rebar corrosion were observed.	Replacement of Superstructure with Steel Reinforcement of Piers using Carbon Fiber	Existing Bridge	JPY 1,731,400	INR 1,048,000
		Perumba Bridge	Bridge type: RC T Bridge length: 146.8m Span length: 8.0 - 23.1m Width: 6.7 m (2 lane)	Cracking and free lime in main girder and slab were observed.	Replacement of Superstructure with Steel Girders	Existing Bridge	JPY 584,400	INR 353,000
Gujarat	NH8E	Shetrunji Bridge	Bridge type: RC T Bridge length: 240m Span length: 10.0m Width: 7.5m (2 lane)	The third span in the superstructure has been reinforced with concrete spraying due to its collapse resulting from vehicular overloading in 2009, but low-quality concrete has been used, so it is difficult to say whether it has been properly	Replacement of Superstructure with Steel Girders	Existing Bridge	JPY 853,400	INR 518,000
Total							JPY 14,176,100	INR 8,588,000

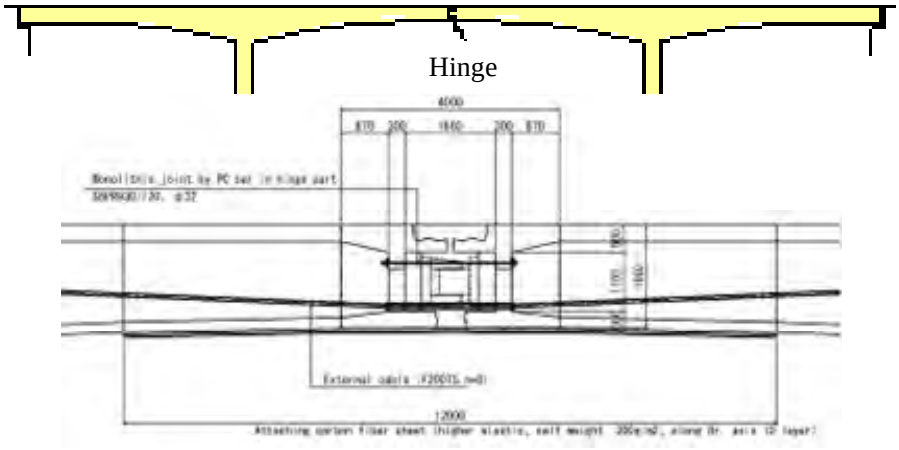
Images of the rehabilitation method are shown in Figure 6.1.1 to Figure 6.1.3.



Existing RC Girder (Shetrunju Bridge) New Steel Girder

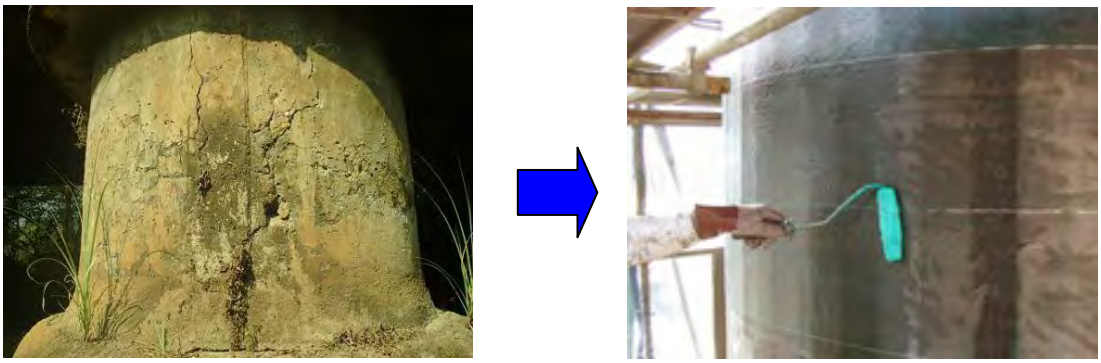
Source: JICA Survey Team

Figure 6.1.1 Replacement of Superstructure



Source: JICA Survey Team

Figure 6.1.2 Centre Hinge Connection



Source: JICA Survey Team

Figure 6.1.3 Repair of Substructure by Carbon Fiber

6.1.2 Bridge Operation and Maintenance

The current condition and technology-level of bridge operation and maintenance on NHs in India have been confirmed in the survey, and several suggestions and recommendations are proposed to achieve more efficient and effective maintenance.

It is recommended to improve technologies and capability in India for more efficient and effective bridge maintenance. This is summarized below.

(1) Efficient and Systematic Bridge Maintenance

With regards to the state of bridge maintenance, the following is known:

- Visual inspection is carried out twice a year
- Inspection of inaccessible places such the lower surfaces of slabs is not being carried out
- Detailed inspection such as close-up inspection or inspection using hammers or non-destructive tools etc. is not carried out periodically (carried out only after severe damage is found)
- Inspection results are evaluated by inspectors subjectively (There are no clear standards or manuals to evaluate inspection results)
- Inspection results are arranged and reported to MORTH in form of documents
- Not all inspection results are reported to MORTH

It is necessary to fully understand all bridge conditions and damage progress to achieve efficient bridge maintenance. Therefore, the following must be performed.

- Implementation of periodic detailed inspection
- Development and operation of standardized manuals of inspection and evaluation of damage and soundness
- Development of efficient methods to report and share inspection results to relevant engineers (for example, the use of a Bridge Management System (BMS))

(2) Change of Policy from Breakdown Maintenance to preventive Maintenance and Development of Long-/mid- term Bridge Maintenance Plans

Currently, with regards to the current methods of breakdown maintenance (methods to rehabilitate bridges after severe damage is found), the following general problems are being experienced.

- A large maintenance cost and many man hours are required to satisfactorily rehabilitate bridges.
- Once damage appears, the performance-level of bridges drops. Therefore, the safety and reliability of these bridges cannot be guaranteed.

- Road users are inconvenienced due to road closures, loading limits, and speed limits.

Therefore it is necessary to develop a “long/mid-term bridge maintenance plan” based on the periodic detailed inspection, evaluation of damage and soundness and prediction of future soundness etc. and also to conduct rehabilitation works efficiently and preventively before damage becomes severe.

Also, the development of a Bridge Management System (BMS) is also necessary, because a huge amount of data and extensive works are required to develop the maintenance plan.

In addition, it has been stated about highway bridges in Japan that “soundness of bridges can be recovered through partial rehabilitation, but because of harsh environments, the performance does not recover to the level it was at the time of construction, and deterioration speed increases with aging” in “Suggestions and Recommendations regarding the Future of Long-Term Management and Renewal of Expressway Assets” in January 2014.

With this in mind, it is desired to understand the cause of bridge deterioration in India accurately, and to plan and implement appropriate large-scale renewals and rehabilitations preventively.

(3) Suitable Monitoring and Evaluation System for NHs managed and operated by Concessionaires

Currently, the maintenance of bridges on NHs is managed and operated by concessionaires. MORTH and NHAI are not made fully aware of the state of this maintenance.

From experiences of Japanese expressways, we know that bridge damage progresses gradually and becomes obvious after approximately 30 years from construction. This implied that severe damage of bridges will not appear during concession period or just after the transfer of assets from MORTH, however damage will appear after this period.

While our experiences do not apply directly to the Indian situation, it is clear that bridge damage progresses over long periods. Therefore it is necessary to develop efficient methods to monitor the condition of bridges managed by concessionaires and to evaluate these concessionaires based on these findings.

6.2 Recommendation

In case of project formation for Japanese companies to entry in India, recommendations are follows.

(1) Application of STEP

Japanese companies are clearly disadvantageous for the entry of the project by QCBS as well QBS. Because bridge construction skill of the Indian leading construction companies exceed the certain level. Therefore, the entry to be limited to Japanese companies is desirable by project formulation by bilateral tide.

(2) Application of Japanese Technical Specification

In case that the application of bilateral ties is difficultly applied, it is preferable to apply the technical specification of which is held exclusively and substantially limited to the Japanese firm. The techniques which has not been endorsed by Indian standard might not be permitted using in Japanese Yen Loan project. As shown in Chapter 3, it is necessary to propose prior consent for the specification of specific Japanese tecquique in the projects of MORTH.

(3) Formulation of Pilot Project

In India, EPC and DB project are generally used however it is necessary to obtain the construction permission to authorize the participation for public works upon establishment of association or Joint Venture with the General Contractor.

High risk for financial loss is anticipated if any critical problem is happened during the implementation of the project since the scale of sole project is relatively larger than domestic project in Japan. Japanese firm seems to situate himself in currently negative spiral not to participate the market of India in hedging the risk.

Japanese firm needs to acquire the know-how for the actual status of public works in India by conducting the pilot project. The pilot project should be an appropriate scale to motivate the Japanese firm for the participation to the market of India as well as to let them understand the process for the official permission of MORTH. It should be useful to facilitate the procedure of acquisition of MORTH’s permission.