**Department of Rural Roads**
**Ministry of Transportation**
**Kingdom of Thailand**

# Kingdom of Thailand
# The Project for Bridge Master Plan and Bridge Maintenance Ability in Rural Area

# Final Report

**July 2013**

**Japan International Cooperation Agency**
**CHODAI Co., Ltd**
**Metropolitan Expressway Company Limited**

| EI |
|---|
| JR |
| 13-157(1) |

Table of Contents

## Abbreviations

| | |
|---|---|
| AADT | Average Annual Daily Traffic |
| AASHTO | American Association of State Highway and Transportation Officials |
| ADB | Asian Development Bank |
| AIT | Asian Institute of Technology |
| ARD | Office of Accelerated Rural Development |
| B | Baht |
| B/C | Benefit / Cost Ratio |
| BMA | Bangkok Metropolitan Administration |
| BMMS | Bridge Maintenance Management System |
| BMR | Bangkok Metropolitan Region |
| BOD | Biochemical Oxygen Demand |
| BQ | Bill of Quantity |
| CFRP | Carbon Fiber Reinforced Plastics |
| CMLT | Commission of Management of Land Traffic |
| C/S | Construction Supervision |
| D/D, DD | Detailed Design |
| DOH | Department of Highways |
| DRR | Department of Rural Roads |
| DVD | Digital Versatile Disk |
| EIA | Environment Impact Assessment |
| E/N | Exchange of Notes |
| EXAT | Expressway Authority of Thailand |
| F/S | Feasibility Study |
| GDP | Gross Domestic Products |
| GRDP | Gross Regional Domestic Products |
| GMS | Greater Mekong Sub-region |
| H | Height |
| HDPE | High Density Polyethylene |
| $H_{gc}$ | Height at Center |
| $H_{gs}$ | Height at Support (Bearing) |
| HIV | Human Immunodeficiency Virus |
| HWL | High Water Level |
| IBRD | International Bank for Reconstruction and Development |
| IRR | Industrial Ring Road |
| JBIC | Japan Bank for International Cooperation |

| | |
|---|---|
| JICA | Japan International Cooperation Agency |
| L | Length |
| L/A | Loan Agreement |
| L/C | Letter of Credit |
| LCC | Life Cycle Cost |
| $L_{max}$ | Maximum Length |
| M/C | Motor Cycle |
| MEA | Metropolitan Electronic Association |
| M/M | Man-Month |
| MOF | Ministry of Finance |
| MOI | Ministry of Interior |
| MOT | Ministry of Transport |
| MRT | Mass Rapid Transit |
| MRTA | Mass Rapid Transit Authority of Thailand |
| MSL | Mean Sea Level |
| NESDB | Office of the National Economic and Social Development Board |
| NESDP | National Socio－Economic Development Plan |
| NPV | Net Present Value |
| OD | Origin and Destination |
| ODA | Official Development Assistance |
| O&M | Operation and Maintenance |
| ONEP | Office of Natural Resources and Environmental Policy and Planning |
| OTP | Office of Transport and Traffic Policy and Planning |
| PC | Pre-stressed Concrete |
| PCC | Property Compensation Community |
| PCU | Passenger Car Unit |
| PDMO | Public Debt Management Office |
| PPP | Public and Private Partnership |
| P/Q | Pre-Qualification |
| PWD | Public Works Department |
| RAP | Resettlement Action Plan |
| ROW | Right of Way |
| SAPS | Special Assistance for Project Sustainability (JBIC) |
| SRT | State Railway of Thailand |
| TDMC | Transport Data and Model Center |
| TDML | Transport Data and Model Integrated with Multimodal Transport and Logistics |

| | |
|---|---|
| UTDP | Urban Transport Development Partnership |
| UTM | Universal Transverse Mercator |
| VAT | Value-added Tax |
| V/C (VCR) | Volume/ Capacity Ratio |
| VOC | Vehicle Operating Cost |
| VOT | Value of Time |
| WB | World Bank |

# Chapter 1 Introduction

## 1.1 Background

### 1.1.1 Road network in Thailand

According to the domestic freight traffic statistic corresponding to traffic route in 2005, it is shown, in a way of the unit of weight per distance, that road accounts for 104.164 billion ton/km (91%); seaway 4.772 billion ton/km (4%); rail 3.002 billion ton/km (3%); waterway or canal 2.323 billion ton/km (2%); and airway 34 million ton/km (1%), which indicates that road takes the most part.

In 2006 the number of registered vehicle– motorcycle excluded – cross the country reached to 916, which it shows that it doubled in a decade and motorization has been rapidly growing. According to the report presented in 2011 by OTP under MOT, 2.4 million people per day had traveled in 2010 and it is expected to increase to 3.07 million by 2020.

Around region close to Bangkok, the registered population was recorded nearly at 10 million but in fact over 17 million would be estimated. This reflects that since 1980s, rapid economic growth has been accelerating the increase of population concentration and automobiles, so urban traffic circumstances get more intensified. Besides, residential area expands gradually to the outskirts of metropolitan regions so car commuters grow to induce a certain serious congestion problem on the highway linking city to suburbs.

To mitigate the urbanization entailing such serious traffic problems the government of Thailand established the urbanization policy for making a shift of urban structure from centralization to decentralization. In addition to this policy, since the 7th five-year road development plan from 1992 to 1996 begun, city-to-city highway and fully separate 4-lane national road construction has been driven. At Bangkok metropolitan area, individual road department is also pushing ahead with projects of urban ring and radiating roads construction.

Thailand is connected with 51,535 km of national roads and 41,509 km of regional roads. Pavement on the roads is up to 100% and 82% done respectively. Road network density around Bangkok and its metropolitan area turns to be 0.88 km/km2 and 2.6 km/km2 which may stand in the great gap away from 3.5 km/km2 recommended usually in urban planning.

### 1.1.2 Bridge maintenance and management

Department of Rural Roads is mainly managing and controlling 40,000 km long road including more than 8,000 numbers of bridges. Currently, most of them are already damaged or being damaged due to lack of repair so that they are increasingly failing to give the appropriate road network service. Such status of road network service initiated budgeting about five or

seven million baht per year for repair and reinforcement, which may account for 20,000 or 40,000 baht per bridge but seems not enough to cover fully the cost of maintenance operation. Aside from lack of repair, flood disaster may often take place during rainy season coming every year and threaten road network function. Hence, bridge maintenance and management is essential for sustaining the service as well as preventing it from natural disaster.

As such, bridge maintenance and management plan for bridges in rural area should be developed and implemented on a long-term basis but the needed inspection data and record have not been integrated and efficiently controlled yet. Other facts like insufficient inspection activity, lack of damage assessment skill, and even absence of corrective action, are paying attention to the need for taking urgent action on a nationwide bridge inspection and data accumulation. Bridge Maintenance and Management System (BMMS) also needs to be developed for ensuring cost-effective maintenance activity.

Last year Bridge Maintenance and Management Plan Development Study for the Chao Phraya River has been achieved and DRR has developed a manual and a long-term plan on bridges over the Chao Phraya River, which now is taken in corrective action. DRR expects this manual is also able to help performing maintenance and management on bridges in rural area. Thus the present project aims at rectifying the manual for providing a proper repair solution for damaged bridges in rural area, giving technical assistance to inspection plan development, and supporting to the capacity improvement of maintenance and management through actual practice.

**(1) Inconsistency in inspection technique and inventory**

Bridge maintenance inventory and field note now on use seem to be inconsistent and complicated. What is worse, with regard to many bridges shorter than 50 m, the length of bridge needs to get inspection enforcedly every year, most of inspection record may be unidentified, even accounting for 80%. To do inspection, technician training and manual development must be done in advance, and then inspection results can be obtained in such appropriate manner.

**(2) Lack of bridge maintenance and management plan**

Annual inspection has been carried out by each district administration but not be followed so far by any maintenance and repair plan development in either district or DRR. Now that lack of inspection data in BMM system is also known, it means that maintenance plan has not been adequately developed and only quick repair is applied at the moment.

**(3) Problem in bridge maintenance and management system**

BMM is software which helps developing plan and giving information about priority level definition, based on plenty of data including inspection result, environmental factors, and other

bridge properties.

DRR owns its BMM developed up by Chulalongkorn University research team asked from DRR, and which is open to local department but seems to have some issues with making output inadequately.

- Complicated input interface
- Unclear management level
- Uncomfortable in defining the priority

**(4) Assistance to DRR for bridge maintenance and management enhancement**

Many of inspection data on local bridges have not been consolidated into a single management plan which would lead subsequently long-term maintenance and management plan. Lack of inspection period, capacity and even corrective maintenance now calls much attention to the importance of collecting data which would help applying PDCA cycle to bridge maintenance and management activity without delay cross the country.

Also issued is the need of operation and development of BMMS which will be able to provide a baseline to make up for lacking budget in bridge maintenance and management implementation.

Last year DRR conducted the study of bridge maintenance and management plan development on Chao Phraya River bridges, and delivered result of making development of inspection manual and long-term maintenance and management plan on river crossing bridges getting largely corrective maintenance done so far.

The manual is taking account of current state of bridge inspection in rural area and intends to reduce amount of labor and improve worker skill.

From the early stage of manual development DRR has been expecting to expand its application to management on many bridges in rural area. So this project is to offer assistance to bridge maintenance and management capacity improvement through pilot test and training program, as well as to help developing bridge inspection plan by upgrading the inspection manual for Chao Phraya River bridges already given last year.

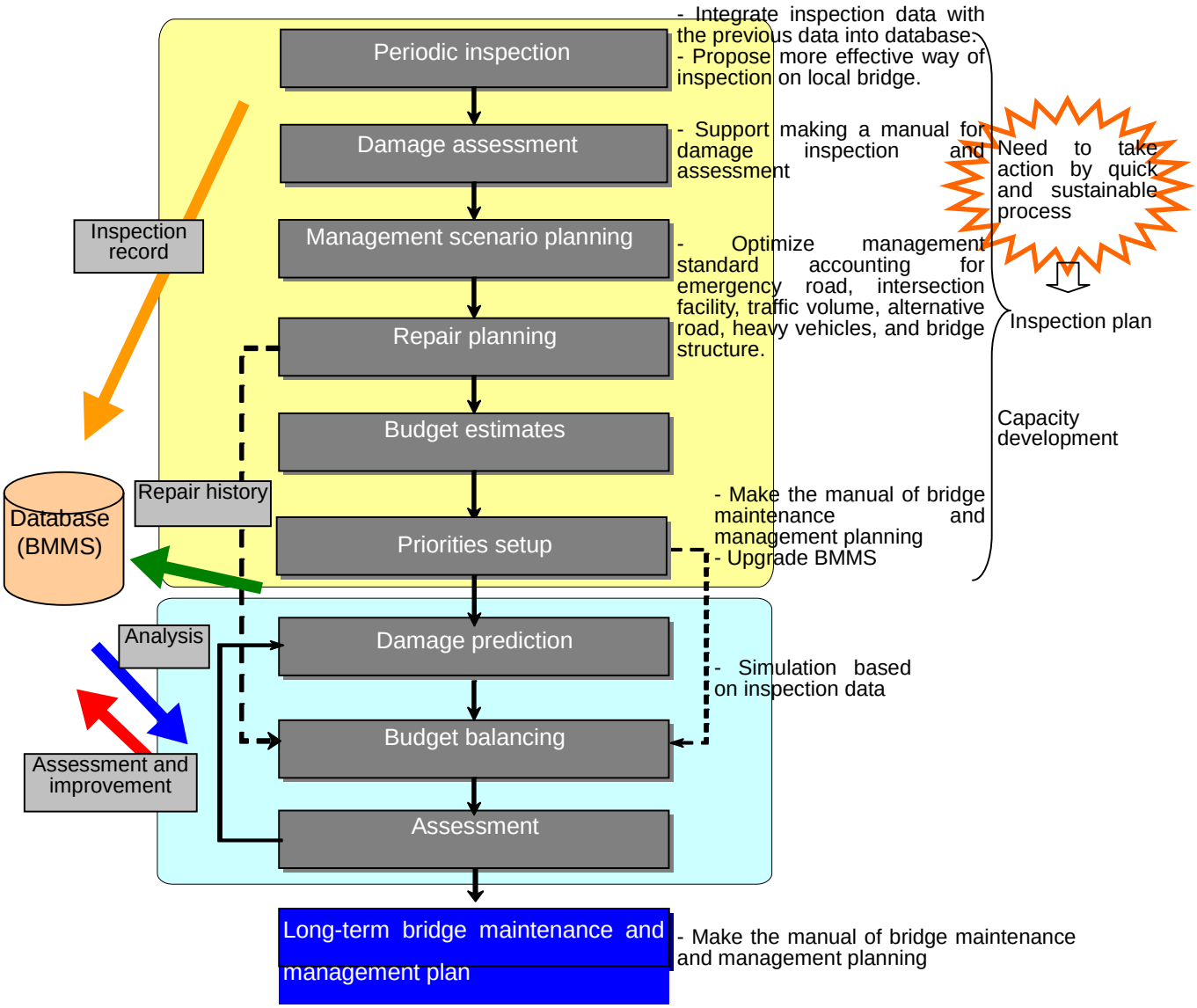



**Figure 1.1-1 Bridge maintenance and management plan**

### 1.1.3 Bridge master plan

In Thai, the primary national road network has been almost completed and other 400 km long city-to-city highway network is being developed as part of all 4,000km long highway network planned and recommended by JICA, but there are still many missing local road links.

To determine priority of road links highly required to be built across rural areas, DRR has developed individually a bridge master plan. This plan has been established in 2009, and based on that, the feasibility study is in progress.

According to this plan, DRR is ready to determine the high priority of developing missing road links including bridge in such a way that would figure out their locations within each 64

km2 area resulted from which the whole country is divided into a number of 8,000 small areas. This is quite different from the way the master plan was developed in Japan, and even may deliver a result just not accurate to the extent. For that reason, this master plan should be reviewed and its significance needs to be reassessed over all processes including how to set the priority of bridge in the feasibility study.

This survey is to provide advice and assistance to the master plan development based on the knowledge of Japan.

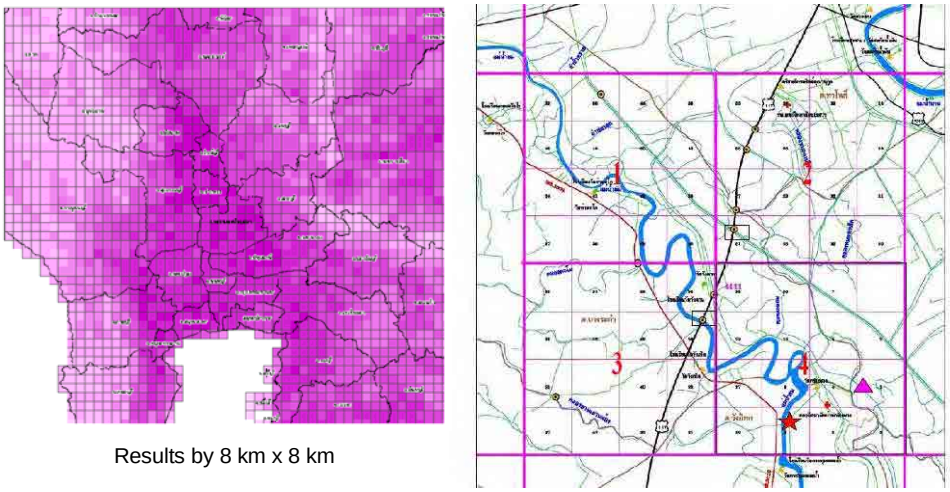



**Figure 1.1-2 Results by 8 km x 8 km and 1 km2**

### 1.1.4 Flood disaster recovery

To rebuild regions damaged by flood disaster, DRR has budgeted 4,000 million baht and now is implementing the budget.

DRR is aiming for the full recovery from the current damage and is counting on each local office for the way of recovery. Even though fully recovered, however, those regions might get damaged again by flood coming the next year. Therefore, it is necessary to enhance the durability of bridge and upgrade the function of approach road in order to be much more resistant against flood disaster. The Thai government has requested technical advice for preventive action.

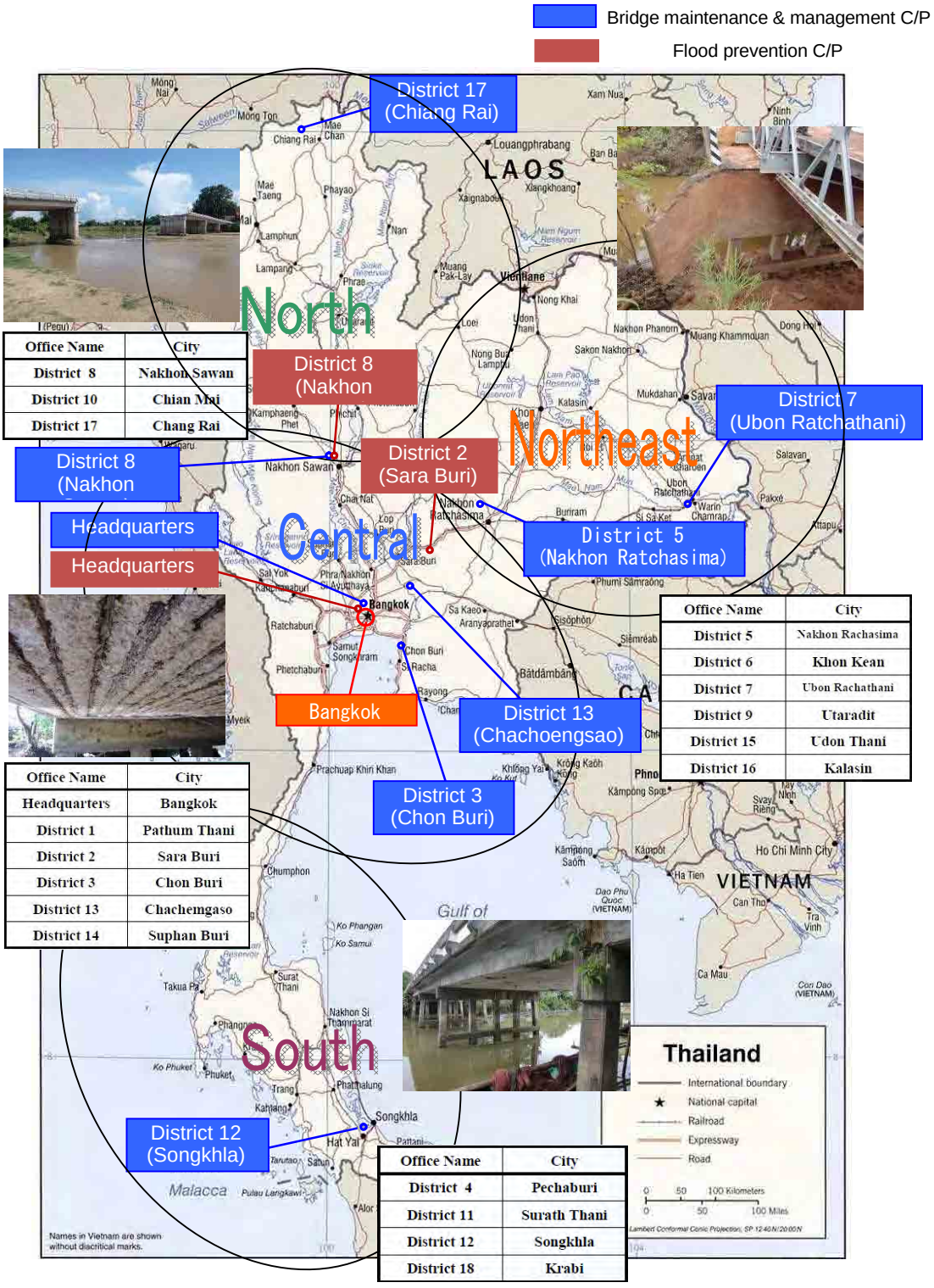
The present survey, based on the result of previous emergency inspection done, is to suggest how to inspect and assess the damaged bridge, and to provide the procedure of preventive action. Moreover, the capacity development activity which includes repair design for the damaged bridge considering the maintenance and management capacity of DRR would bring more sustainability to its capacity improvement.

## 1.2 Objectives

The objective of the survey is to give assistance to capacity development in bridge maintenance and management in Thailand, as well as to take the review of bridge master plan.

1) Develop bridge inspection plan for 8,000 bridges under DRR authority, and conduct bridge inspection pilot project.
2) Give assistance to BMMS development
3) Create seminar, workshop and training program
4) Summarize comments and advice obtained from reviewing bridge master plan made by DRR

## 1.3 Target region




| Office Name | City |
|---|---|
| District 8 | Nakhon Sawan |
| District 10 | Chian Mai |
| District 17 | Chang Rai |

| Office Name | City |
|---|---|
| Headquarters | Bangkok |
| District 1 | Pathum Thani |
| District 2 | Sara Buri |
| District 3 | Chon Buri |
| District 13 | Chachemgaso |
| District 14 | Suphan Buri |

| Office Name | City |
|---|---|
| District 5 | Nakhon Rachasima |
| District 6 | Khon Kean |
| District 7 | Ubon Rachathani |
| District 9 | Utaradit |
| District 15 | Udon Thani |
| District 16 | Kalasin |

| Office Name | City |
|---|---|
| District 4 | Pechaburi |
| District 11 | Surath Thani |
| District 12 | Songkhla |
| District 18 | Krabi |

**Figure 1.3-1 Target region**

### (1) Counterpart

Members in a counterpart are listed in Table 1.2.1. The first counterpart meeting was held in the DRR main office on April 30.

**Table 1.3-1 List of counterpart**

**List of DRR Counterparts**
Project: The Project for Bridge Master Plan and Bridge Maintenance Ability in Rural Area

| No. | Name | Position | Organization | Remarks |
|---|---|---|---|---|
| 1 | Mr.Chakree Bumrungwong | Civil Engineer (Senior Peofessional Level) | Bureau of Planning | Leader |
| 2 | Mr. Porapat Phu-ngamthong | Civil Engineer (Senior Peofessional Level) | Bureau of Rural Road 7 | Member |
| 3 | Mr. Kongpipop Arayarungsee | Civil Engineer (Senior Peofessional Level) | Bureau of Rural Road 5 | Member |
| 4 | Mr. Preecha Soparat | Civil Engineer (Professional Level) | Bureau of Planning | Member |
| 5 | Mr. Anuthep Udomkul | Civil Engineer (Professional Level) | Bureau of Rural Road 8 | Member |
| 6 | Ms. Chanida Kangkajit | Civil Engineer (Professional Level) | Bureau of Rural Road 12 | Member |
| 7 | Mr. Viriya Yokasingh | Civil Engineer (Practical Level) | Bureau of Rural Road 13 | Member |
| 8 | Mr. Theeraphong Meesri | Civil Engineer (Professional Level) | Bureau of Rural Road 17 | Member |
| 9 | Mr. Jakrawuth Chaisukung | Civil Engineer (Practical Level) | Bureau of Local Road Development | Member |
| 10 | Mr.Noppadon Siangboon | Civil Engineer (Practical Level) | Bureau of Road Maintenance | Member |
| 11 | Mr. Chanyuth Kongkert | Civil Engineer (Practical Level) | Bureau of Rural Road 3 | Member |

**List of DRR Counterparts for Flood Countermeasures Project**

| No. | Name | Work position | Organization | Remark |
|---|---|---|---|---|
| 1 | Mr. Kaiwan Watthana | Civil Engineer (Professional Level) | Bureau of Location and Design | Committee |
| 2 | Mr. Amnaj Pinphet | Civil Engineer (Professional Level) | Bureau of Rural Road No.2 (Saraburi) | Committee |
| 3 | Mr. Nopphadol Deeruak | Civil Engineer (Professional Level) | Bureau of Rural Road No.8 (Nakhonsawan) | Committee |
| 4 | Mr. Kijjakorn Pinlamai | Civil Engineer (Practitioner Level) | Bureau of Road Maintenance | Committee |
| 5 | Mr. Kosol Janmonta (Dr.) | Civil Engineer (Practitioner Level) | Bureau of Planning | Committee |
| 6 | Mr. Chutiphong Paraphantakul | Civil Engineer (Practitioner Level) | Bureau of Planning | Committee |


**Figure 1.3-2 first counter meeting**

## 1.4 Current Situations of Surveyed Country (Thailand)

### 1.4.1 Socio-Economic Situation

In recent years, Thailand's economic and social conditions were interrupted by a number of crises such as the political instability in 2010 and the catastrophic floods in 2011. However, the economic foundation still remains solid, owing to vibrant private consumption, public investment, high global demand for Thai exports, and a revived inflow of foreign direct investment and tourism (Thailand Competitiveness Report 2012).

In terms of transportation sector, according to the Thailand's Logistics Report 2011 of the Office of the National Economic and Social Development Board (NESDB), the volume of domestic freight transport in 2010 slightly increased to 507.9 million tons, an equivalence of 0.5 percent increase from 2009. The road transport shared about 82.6 percent, which outnumbered other modes of transportation. Therefore, it is evident that the road transport is still the main mode of freight transportation in Thailand.

### 1.4.2 Natural Environment and Regional Characteristic

The natural environment and characteristics of each region in Thailand are described in this section. These include (1) Land and Topography, (2) Climate, (3) Geology, (4) Rainfall, (5) River Flow, and (6) Earthquake.

#### (1) Land and Topography

Thailand is located in the Indochina peninsula with the total land area of about 512,000 $km^2$. As of 2012, the population is estimated to be approximately 67 million, with a growth rate of 0.54 percent per year. The country is agricultural-based, having the total agricultural area of about 265,200 $km^2$.

The topography of Thailand is shown in Fig. 1.4.1. The central region is relatively flat, but further to the north, the topography becomes mountainous terrain. Moreover, the northeast region is plateau area with the height of about 150m to 200m above sea level. At Nakhon Sawan province, located at the border of central and north regions, the rivers of Ping, Wang, Yom, Nan converge and form the Chao Phraya River, which is the largest river in Thailand. The Chao Phraya River basin covers an area of about 160,000 $km^2$ or approximately 1/3 of the country area.


**Figure 1.4.1 Topography Map of Thailand**

[Source 1: http://drjoy.wordpress.com/thailand/]
[Source 2: http://www5.famille.ne.jp/~poopiang/jp/flood.html]

### (2) Climate

The climate in Thailand is mainly divided into tropical monsoon climate in the south and savanna climate in the central and northward regions. Meanwhile, the season is divided into two distinct seasons: rainy and dry. During the middle of May to September, the southwest monsoon with moist air from the Indian Ocean flows and brings the rainy season. From November to April, the weather is dry because of the dry northwest monsoon. The temperature often reaches 40 °C at the end of the dry season from March to May.

The northern Thailand is relatively cool due to its mountainous area with high latitude. On the other hand, the weather in the southern region is hot and humid caused by the monsoon from the

Indian Ocean (Andaman Sea). The monthly average temperature (highest and lowest) and the climate distribution map of Thailand are shown in Figs. 1.4.2 and 1.4.3, respectively.

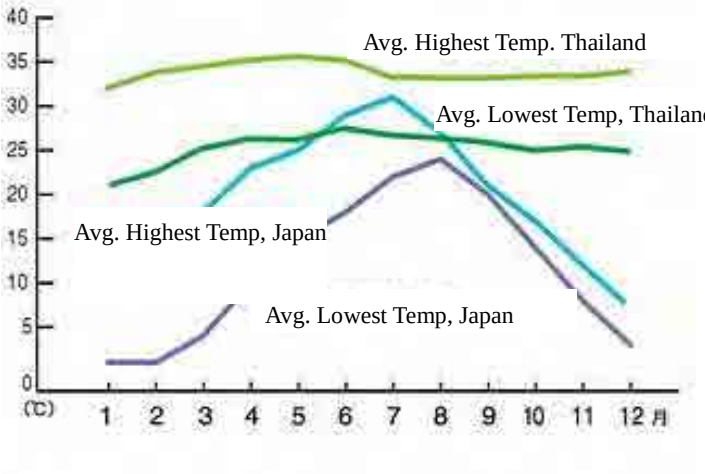



**Figure 1.4.2 Comparison of Temperature with Japan**

[Source: http//www.arukikata.co.jp/country/asia/TH_general_3.html]

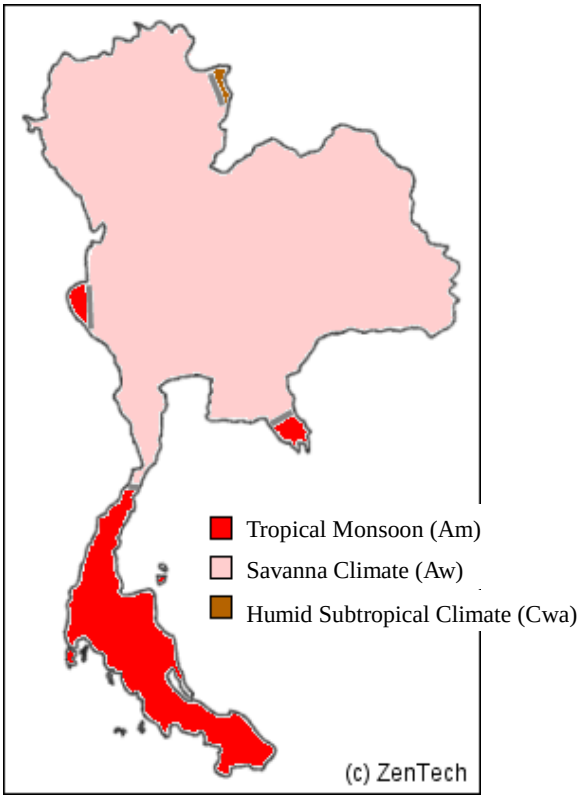



**Figure 1.4.3 Climate Distribution Map**

[Source: http://www2m.biglobe.ne.jp/%257EZenTech/world/information/kion/thailand.htm]

### (3) Geology

The geology of Thailand is shown in Figure 1.4.4. The central and lower of north regions, which were affected by the 2011 flood, are mainly covered by the quaternary sedimentary rocks.

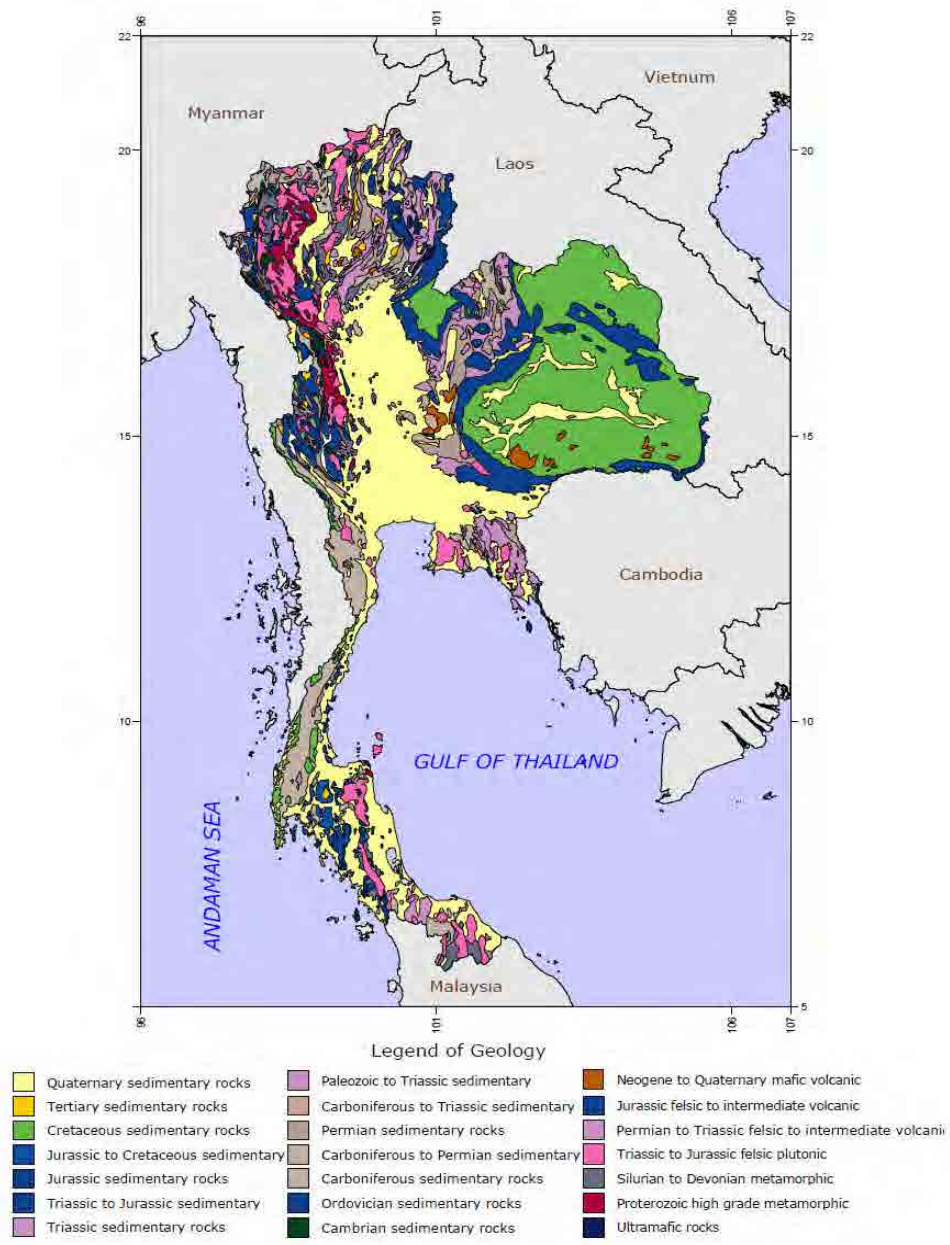



**Figure 1.4.4 Geological Map of Thailand**

[Source: Digital Map of East and Southeast Asia, 2004]

### (4) Rainfall

Rainfall in Thailand is shown in Table 1.4.1 and Fig. 1.4.5. By comparing the average monthly rainfall in 2011 with the mean value (1971~2000), the rainfall in 2011 was increased by 28% in a whole country, 26% in the central region, and 38% in the lower part of northern region.

**Table 1.4.1 Rainfall in Thailand (Comparison of Average Rainfall in Year 1971-2000 with Year 2011)**

| PART | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | 1 Jan - 31 Oct |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **NORTH (UPPER)** | | | | | | | | | | | |
| Rainfall amount (mm.) | 8.0 | 1.4 | 86.9 | 129.7 | 253.1 | 242.4 | 281.1 | 314.3 | 278.2 | 112.6 | 1707.7 |
| Departure from normal (mm.) | 1.1 | -7.9 | 65.5 | 56.3 | 85.4 | 96.5 | 89.6 | 74.6 | 76.7 | 8.1 | 545.9 |
| Departure from normal (%) | 16 | -85 | 306 | 77 | 51 | 66 | 47 | 31 | 38 | 8 | 47 |
| **NORTH (LOWER)** | | | | | | | | | | | |
| Rainfall amount (mm.) | 2.6 | 12.3 | 126.4 | 110.4 | 236.9 | 190.3 | 232.8 | 234.8 | 341.5 | 153.2 | 1641.2 |
| Departure from normal (mm.) | -2.4 | -1.2 | 98.6 | 47.2 | 57.7 | 33.2 | 64.7 | 23.8 | 118.4 | 11.5 | 451.5 |
| Departure from normal (%) | -48 | -9 | 355 | 75 | 32 | 21 | 39 | 11 | 53 | 8 | 38 |
| **NORTH** | | | | | | | | | | | |
| Rainfall amount (mm.) | 5.3 | 6.8 | 106.6 | 120.0 | 245.0 | 216.3 | 256.9 | 274.9 | 309.8 | 132.9 | 1674.5 |
| Departure from normal (mm.) | -0.6 | -4.6 | 82.0 | 51.7 | 71.6 | 64.8 | 77.1 | 49.6 | 97.5 | 9.8 | 498.9 |
| Departure from normal (%) | -10 | -40 | 333 | 76 | 41 | 43 | 43 | 22 | 46 | 8 | 42 |
| **NORTHEAST** | | | | | | | | | | | |
| Rainfall amount (mm.) | 0.2 | 15.1 | 23.1 | 79.0 | 201.1 | 187.2 | 319.8 | 324.8 | 352.2 | 182.5 | 1685.0 |
| Departure from normal (mm.) | -3.9 | -2.6 | -14.6 | -7.1 | 18.8 | -22.7 | 111.9 | 66.0 | 110.3 | 71.2 | 327.3 |
| Departure from normal (%) | -95 | -15 | -39 | -8 | 10 | -11 | 54 | 26 | 46 | 64 | 24 |
| **CENTRAL** | | | | | | | | | | | |
| Rainfall amount (mm.) | 1.4 | 21.5 | 123.8 | 112.9 | 222.6 | 165.8 | 214.9 | 211.8 | 256.9 | 177.0 | 1508.6 |
| Departure from normal (mm.) | -4.8 | 9.1 | 93.2 | 38.3 | 62.7 | 27.2 | 62.4 | 27.9 | -4.1 | -3.7 | 308.2 |
| Departure from normal (%) | -77 | 73 | 305 | 51 | 39 | 20 | 41 | 15 | -2 | -2 | 26 |
| **EAST** | | | | | | | | | | | |
| Rainfall amount (mm.) | 0.0 | 47.4 | 116.2 | 136.3 | 169.4 | 277.5 | 258.4 | 333.5 | 465.9 | 272.9 | 2077.5 |
| Departure from normal (mm.) | -14.7 | 18.4 | 61.6 | 40.0 | -42.0 | 5.3 | -7.5 | 22.0 | 132.7 | 44.5 | 260.3 |
| Departure from normal (%) | -100 | 63 | 113 | 42 | -20 | 2 | -3 | 7 | 40 | 20 | 14 |
| **SOUTH (EAST COAST)** | | | | | | | | | | | |
| Rainfall amount (mm.) | 176.8 | 20.7 | 557.0 | 63.9 | 124.8 | 121.4 | 141.4 | 157.6 | 122.3 | 241.3 | 1727.2 |
| Departure from normal (mm.) | 116.8 | -15.3 | 506.6 | -9.1 | -12.7 | 12.3 | 28.0 | 29.4 | -21.3 | -11.0 | 623.7 |
| Departure from normal (%) | 195 | -43 | 1005 | -13 | -9 | 11 | 25 | 23 | -15 | -4 | 57 |
| **SOUTH (WEST COAST)** | | | | | | | | | | | |
| Rainfall amount (mm.) | 63.7 | 20.1 | 424.2 | 118.0 | 267.1 | 231.7 | 361.9 | 461.3 | 446.9 | 308.0 | 2702.9 |
| Departure from normal (mm.) | 40.8 | -8.6 | 353.7 | -43.0 | -47.9 | -88.5 | 9.5 | 57.2 | 6.7 | -49.7 | 230.2 |
| Departure from normal (%) | 178 | -30 | 502 | -27 | -15 | -28 | 3 | 14 | 2 | -14 | 9 |
| **OVER COUNTRY** | | | | | | | | | | | |
| Rainfall amount (mm.) | 34.9 | 19.3 | 191.0 | 103.6 | 206.1 | 199.7 | 259.0 | 287.3 | 319.7 | 201.8 | 1822.4 |
| Departure from normal (mm.) | 18.2 | -1.5 | 150.3 | 17.0 | 18.6 | 10.0 | 57.4 | 44.6 | 67.0 | 17.8 | 399.4 |
| Departure from normal (%) | 109 | -7 | 369 | 20 | 10 | 5 | 29 | 18 | 27 | 10 | 28 |

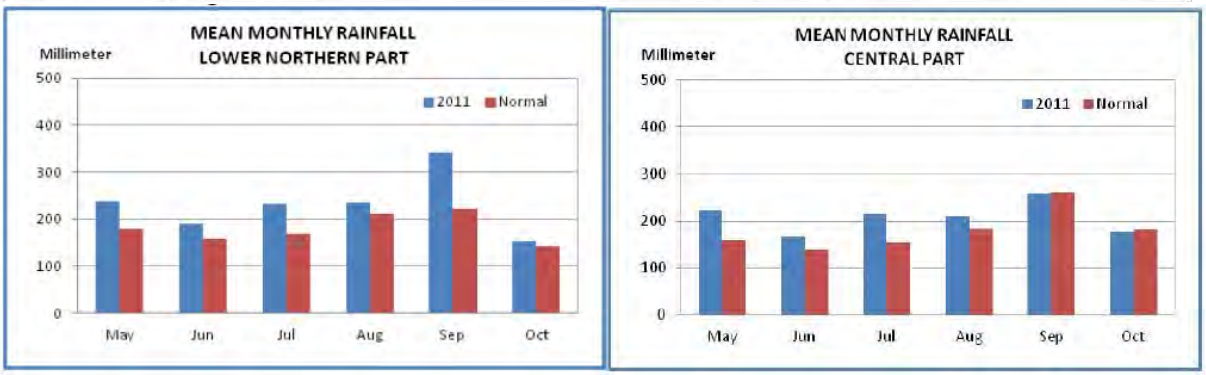



**Figure 1.4.5 Comparison of Rainfall in Central and Northern Regions of Thailand (Year 2011 & Average of Year 1971~2000)**

[Source: Thai Meteorological Department, 2 November 2011]

**(5) River Flow**

The average amount of surface runoff in a total of 25 basins (Fig. 1.4.6) in Thailand is about 213,423 million $m^3$ per year, as summarized in Table 1.4.2. Moreover, the amount of runoff mostly occurs in rainy season with the percentage of 85.7%, when compared to that in dry season.

**Table 1.4.2 Amount of Surface Runoff in Thailand**

| Region[*1] | Surface Runoff (million $m^3$) | | |
|---|---|---|---|
| | Dry Season | Rainy Season | Total |
| North | 7,624 | 30,943 | 38,567 |
| Northeast | 6,236 | 55,277 | 61,513 |
| Central | 3,692 | 21,284 | 24,975 |
| East | 2,607 | 21,275 | 23,882 |
| South | 10,264 | 54,222 | 64,486 |
| Total | 30,423 (14.3%) | 183,001 (85.7%) | 213,423 |

[Source: Created based on the data from Royal Irrigation Department]

[*1] The regions in Thailand are divided into 5 regions according to the climate condition.

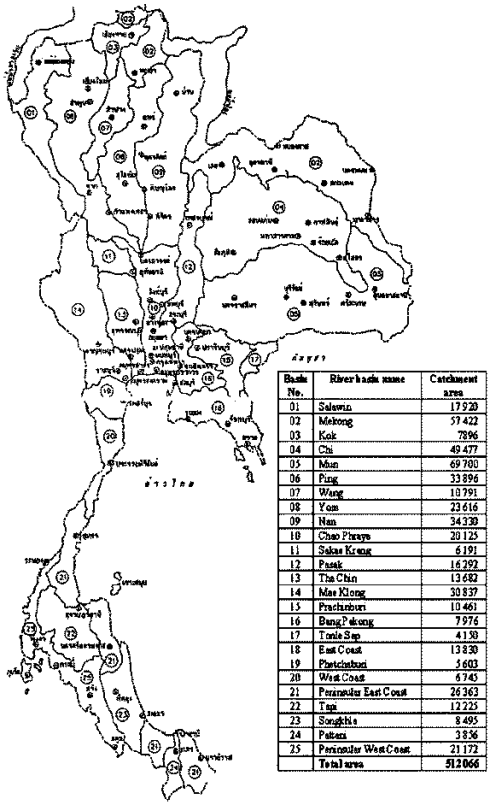



**Figure 1.4.6 Map of 25 River Basins in Thailand**

[Source: http://www.fao.org/docrep/004/AB776E/ab776e04.htm]

### (6) Earthquake

Although Thailand is not located directly on top of tectonic plate boundaries, there are a number of active faults concentrated in the northern and western regions, which can potentially trigger tremors. A survey conducted by the Department of Mineral Resources (DMR) revealed that there are 14 groups of active faults spread across 22 provinces in Thailand as shown in Fig. 1.4.7. Furthermore, mid-sized earthquakes with magnitude of 5.0-5.9 have occurred 8 times, 5 times in the north and 3 times in the west, over the past 40 years. Hence, the northern and western regions are the most earthquake-prone area as illustrated in Fig. 1.4.8.

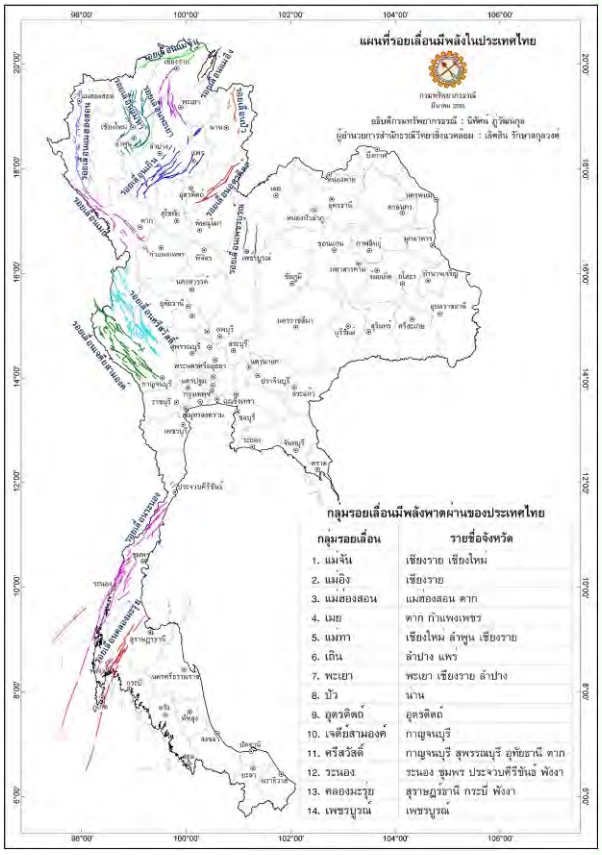



**Figure 1.4.7 Active Faults in Thailand**

[Source: Department of Mineral Resources, March 2012]

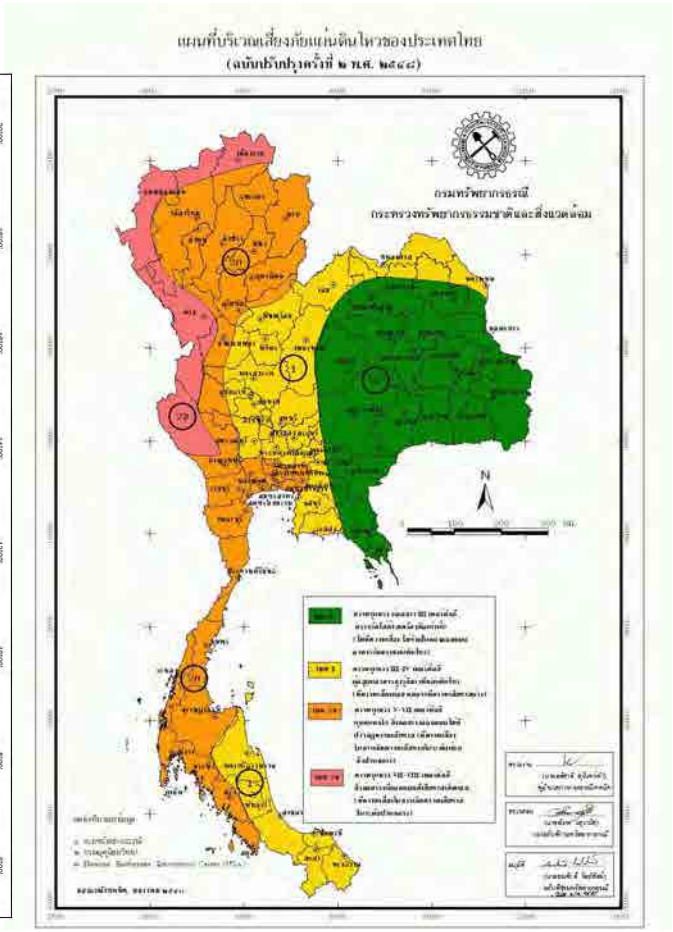



**Figure 1.4.8 Earthquake-Prone Area in Thailand**

[Source: Documents on ecological disasters, Department of Mineral Resources]

### 1.4.3 Current Situations of Road and Bridge

**(1) Overview**

Road transport in Thailand is the most developed transportation mode, with coverage throughout the country and linkages with the neighboring countries. Both freight and passenger transport in Thailand is now dominated by road network. Road type in Thailand can be categorized into national highway, motorway (inter-city expressway), rural road, local road, municipal road, and expressway. As of 2012, the total length of road is 188,170 km and the details of road length under responsibility by various governmental agencies are shown in Table 1.4.3. The numbers of bridges in the road network of each organization are summarized in Table 1.4.4.

**Table 1.4.3 Road Network in Thailand (2012)**

| Government Agency | Road Type | Length | |
|---|---|---|---|
| | | km | % |
| Department of Highways (DOH) | National Highway, Motorway | 67,511[*1] | 35.9 |
| Department of Rural Roads (DRR) | Rural Road | 41,509 | 22.1 |
| Local Administration | Local Road | 52,000 | 27.6 |
| Royal Irrigation Department (RID) | Local Road | 23,153 | 12.3 |
| Bangkok Metropolitan Administration (BMA) | Municipal Road | 3,789 | 2.0 |
| Expressway Authority of Thailand (EXAT) | Expressway | 208[*2] | 0.1 |
| Total | | 188,170 | 100 |

[Source: Modified based on Transport Statistics, MOT (2009)]

[*1] DOH Annual Report B.E.2554 (2011)

[*2] EXAT Annual Report B.E.2555 (2012)

**Table 1.4.4 Bridges in Road Network in Thailand**

| Agency | Bridge | |
|---|---|---|
| | Number | % |
| Department of Highways (DOH) | 8,443 | 28.8 |
| Department of Rural Roads (DRR) | 8,263 | 28.2 |
| Local Administration | 12,646 | 43.1 |
| Total | 29,352 | 100 |

[Source: Development of a Bridge Master Plan for Rural Road Network in Thailand (2010), DRR]

Over the past years, surface quality of major highways and some bridge structures have been deteriorating because of lack of budgets and inadequate maintenance, as well as frequent violations of axle load limits. Therefore, problems related to maintenance work of road and bridge structures have become much concerned recently, and more attention should be given on these issues so that the road and bridge network could be effectively and efficiently maintained.

### (2) Road and Bridge Related Governmental Agency

The government ministries that are related to road transport in Thailand mainly include 3 ministries: Ministry of Transport (MOT), Ministry of Interior (MOI), and Ministry of Agriculture and Cooperatives (MOAC), as shown in Fig. 1.4.9. Under the jurisdiction of each ministry, there are various governmental administrations and state enterprises, which are responsible for planning, construction, and maintenance of the road network throughout the country.

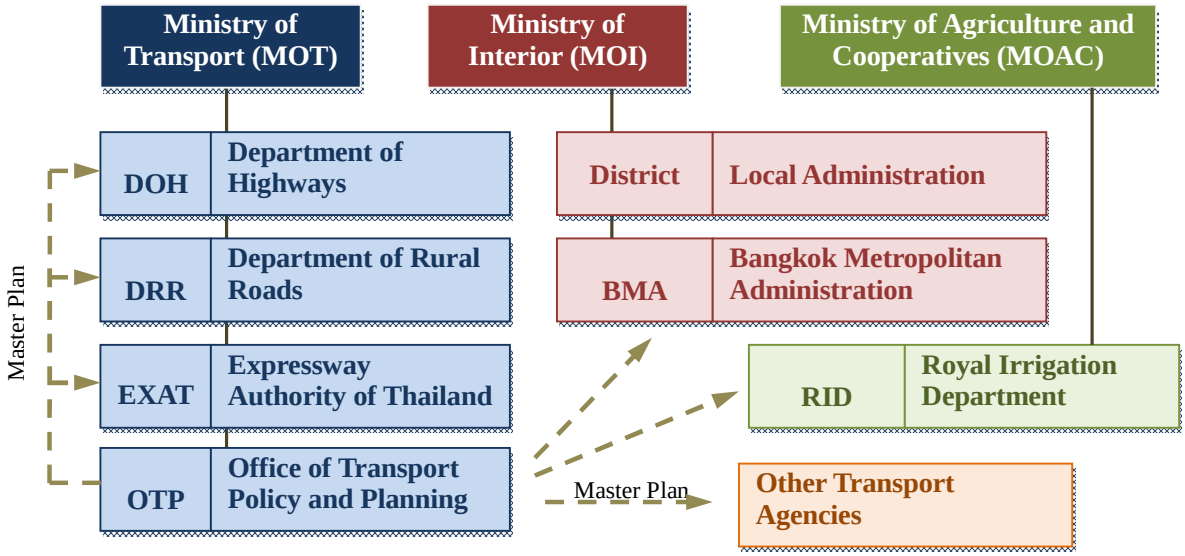



**Figure 1.4.9 Governmental Agencies related to Road Network in Thailand**

[Source: Created based on MOT Annual Report B.E.2553 (2010)]

#### Ministry of Transport (MOT)

In 2002, the Reorganization of Ministries, Government Agencies and Departments, B.E. 2545 (2002) Act stipulated that the Ministry of Transport (the former Ministry of Communications) would have overall responsibility for transportation, transportation related business, traffic planning, and transport infrastructure development. At present, MOT is composed of 8 government administrations and 13 state enterprises as shown in Fig. 1.4.10.

The budget appropriation in MOT and organizations related to road and bridge structures are

shown in Table 1.4.5. It can be observed that the budget of MOT is increasing with year and the Department of Highways (DOH) has the largest share of budget, which is approximately 50% of the total budget.

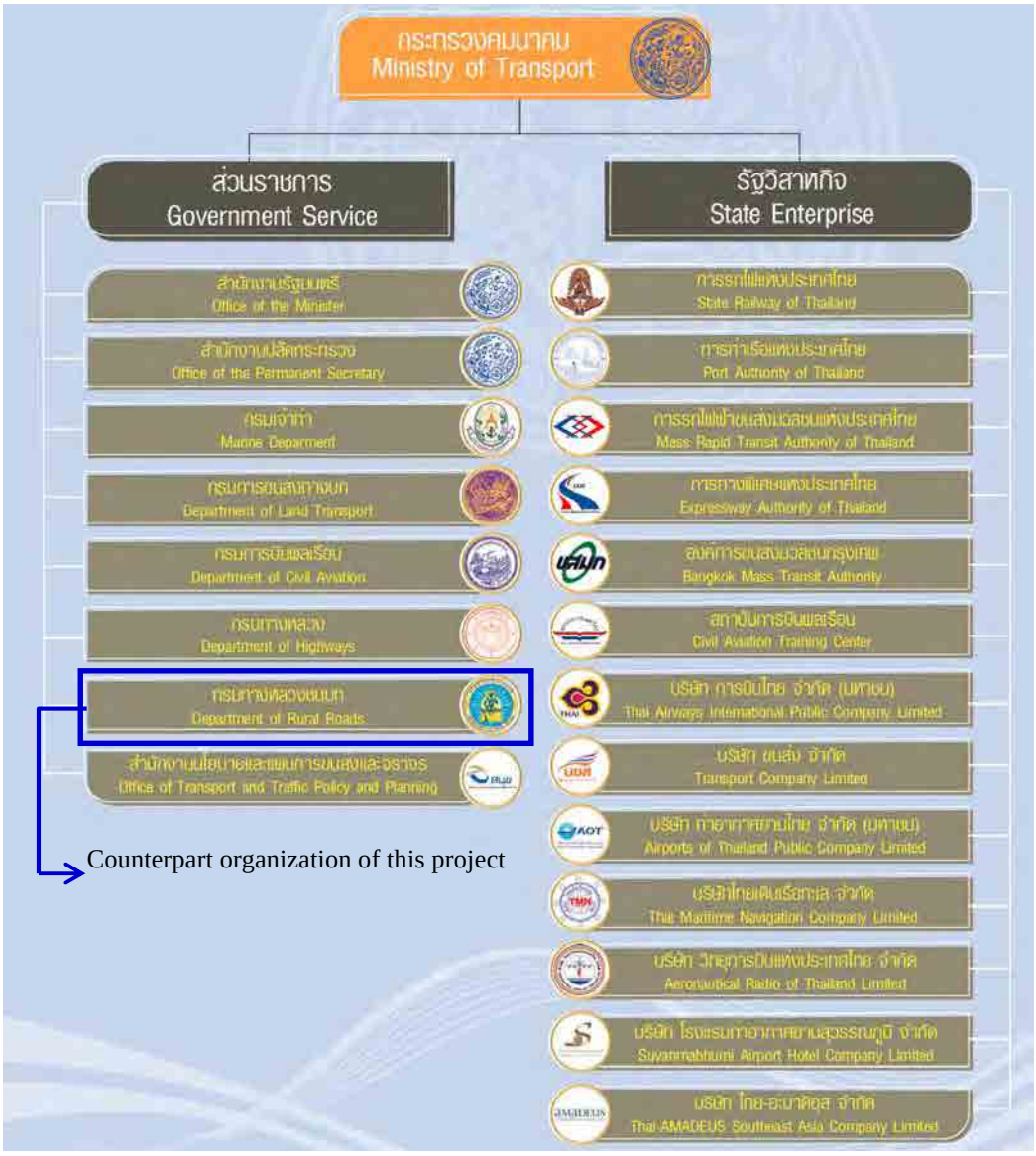



**Figure 1.4.10 Organization Chart of MOT**

[Source: OTP Annual Report (Year 2009)]

**Table 1.4.5 Budget Appropriation of MOT and Other Organizations (FY 2010 to FY 2012)**

(in million baht)

| Ministry/Department | Budget Appropriation | | |
|---|---|---|---|
| | FY 2010 | FY 2011 | FY 2012 |
| Ministry of Transport (MOT) | 54,041.6 | 80,354.0 | 88,852.7 |
| Department of Rural Roads (DRR) | 20,436.2 | 25,078.3 | 29,597.1 |
| Department of Highways (DOH) | 26,385.9 | 46,999.5 | 50,422.1 |
| Office of Transport and Traffic Policy and Planning (OTP) | 548.3 | 408.5 | 464.1 |
| Expressway Authority of Thailand (EXAT) | 7,036.0 | 8,131.4 | 4,488.8 |

[Source: Thailand's Budget in Brief Fiscal Year 2011- 2012, Bureau of the Budget]

As of 2010, the number of personnel in MOT and other organizations related to road and bridge are summarized in Tables 1.4.6 and 1.4.7 for Governmental Service and State Enterprise, respectively. It is clear that DOH has the largest number of personnel, which is about 50% of the total personnel in MOT. This number is more than 3 times when compared to that of Department of Rural Roads (DRR).

**Table 1.4.6 Personnel in Each Organization (Governmental Service)**

| Organization | Number (person) | | | |
|---|---|---|---|---|
| | Government Official | Permanent Employee | Government Employee | Total |
| Ministry of Transport (MOT) | 15,576 | 4,302 | 11,327 | 31,205 |
| Department of Rural Roads (DRR) | 1,825 | 1,375 | 1,399 | 4,599 |
| Department of Highways (DOH) | 7,408 | 804 | 7,295 | 15,507 |
| Office of Transport and Traffic Policy and Planning (OTP) | 192 | 49 | 38 | 279 |

[Source: MOT Annual Report B.E.2553 (2010)]

**Table 1.4.7 Personnel in Each Organization (State Enterprise)**

| Organization | Number (person) | | |
|---|---|---|---|
| | Permanent Employee | Temporary Employee | Total |
| Expressway Authority of Thailand (EXAT) | 4,081 | 522 | 4,603 |

[Source: MOT Annual Report B.E.2553 (2010)]

**Office of Transport and Traffic Policy and Planning (OTP)**

The Office of Transport and Traffic Policy and Planning (OTP) is an agency responsible for formulating master plans and strategies for the development of transport systems, including those concerning safety and environment. Its principal missions are to formulate policies, to prepare strategies for the development of transport and traffic systems, to lay down measures and set standards regarding transport and traffic, to promote safety and environment in transport and traffic areas, to drive the implementation of policies and plans to achieve successful results.

The OTP has prepared the Master Plan for Transport and Traffic System Development (2011-2020) of MOT. The OTP has also analyzed and assessed the feasibility and possibility on finance, economic and engineering including the environment impact assessment for the investment projects of the governmental agencies and state enterprises or joint ventures with the private sector. The recent projects related to road transport are the Expressway Project Srirat - the Outer Ring Road, Bangkok of EXAT and the Motorway Project between Bang Pa In - Sara Buri - Nakhon Ratchasima of DOH.

Bureau of Regional Transport and Traffic Systems Promotion (BRP) of OTP has also prepared a master plan for transportation and traffic in the regional area (76 provinces). In FY 2011, the master plans were totally completed for 76 provinces and have been delivered to the relevant agencies in each province.

**Department of Highways (DOH)**

The Department of Highways (DOH) is a governmental administration under the jurisdiction of MOT. The DOH is responsible for constructing the extensive highway infrastructure network throughout the country, including the links with neighboring countries. The organization of DOH is shown in Fig. 1.4.11. The maintenance of highway is another duty of DOH, since it provides convenience and safety for road users. As of 2011, the total length of highway under the management of DOH is 67,511 km. Of which, the lengths of 66,068 km were opened to traffic and required adequate maintenance activities. The DOH's organizations for maintenance work include Bureau of Highways, Office of Highway, Highway District, and Highway Maintenance District, which have more than 120 locations throughout the country.

In fiscal year 2011, DOH was allocated the total budget of 21,355 million baht for highway maintenance. Out of which, the budget of 16,381 million baht was used for highway network maintenance, while the budget of 4,974 million baht was allocated for highway rehabilitation and improvement work [DOH Annual Report B.E. 2554 (2011)].

One section of the DOH's toll elevated road with a length of 22 km is now under operated and managed by a private company, Don Muang Tollway Co., Ltd. (DMT), under the concession agreement until year 2034.

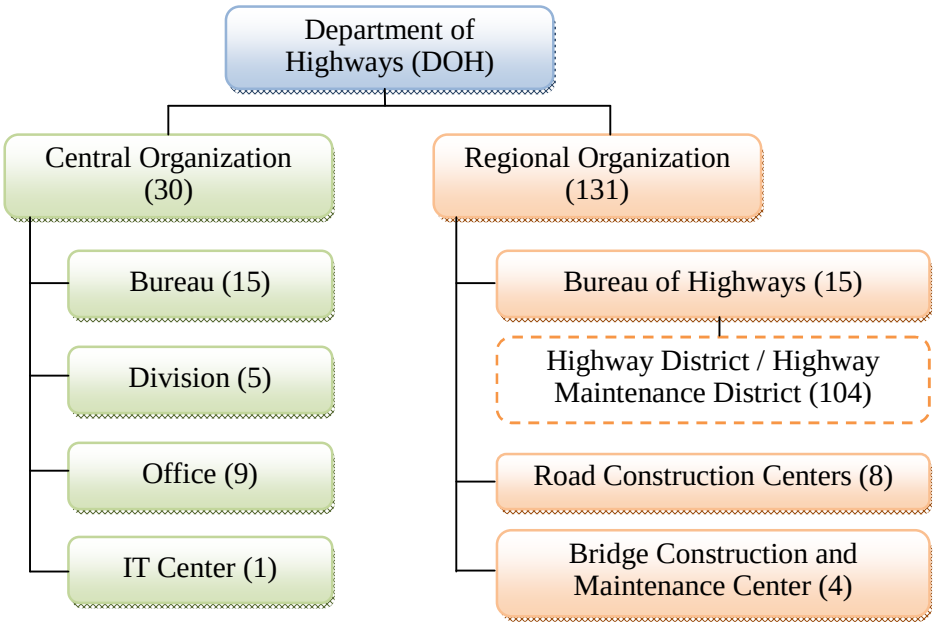



**Figure 1.4.11: Organization Chart of DOH**

[Source: Modified from DOH Annual Report B.E. 2554 (2011)]

**Department of Rural Roads (DRR)**

The Department of Rural Roads (DRR), which is the counterpart organization of this project, is a government agency under the jurisdiction of MOT. The overview and details of DRR are written and discussed in Chapter 2.

**Expressway Authority of Thailand (EXAT)**

Expressway Authority of Thailand (EXAT) is a governmental enterprise under the jurisdiction of MOT. The old name was Expressway and Rapid Transit Authority of Thailand (ETA) and was changed to the current name in 2008. The duties of EXAT are related to planning, construction and maintenance of expressway. As of 2012, EXAT has 12 departments, 34 divisions and the total employees of approximately 4,600. There are a total of 8 different routes of in-service expressways with a total length of 207.9 km, which are located in Bangkok and surrounding provinces. Two routes of EXAT's expressways are currently operated and managed by private companies, Bangkok Expressway Co., Ltd. (BECL) and Northern Bangkok Expressway Co., Ltd. (NECL) under the Built-Transfer-Operation (BTO) contracts.

The EXAT's organizations responsible for maintenance work of expressway structures include Bridge Maintenance Division and Road Maintenance Division in Maintenance Department. The budget for routine maintenance work in EXAT is summarized in Table 1.4.8. It can be seen that the budget for expressway structure is less than 5% of the total budget, which is

comparatively lower than the road surface. This is because most of expressway structures are concrete structures and relatively new, hence requiring less maintenance when compared to road pavement. Moreover, the costs of periodic or emergency inspection of large-scale bridges are not included in this budget.

**Table 1.4.8 Budget for Routine Maintenance Work in EXAT**

(unit: million baht)

| Fiscal Year | 2010 | 2011 | 2012 |
|---|---|---|---|
| Expressway structure | 6.0 | 4.2 | 4.0 |
| Road surface (pavement) | 212.7 | 129.9 | 85.6 |
| Total | 218.7 | 134.1 | 89.6 |

[Source: EXAT's document]

**(3) Development Plan of Road and Bridge**

In recent years, road and bridge network plan in each governmental agency has been generally developed based on the Master Plan for Transport and Traffic System Development (2011-2020) of OTP. This section describes the current situation of road network in Thailand, including the development plan in the future.

**National Highway (DOH)**

As of 2012, the total length of highway under the jurisdiction of DOH is 67,511 km. Of which, 66,068 km were opened to traffic. In fiscal year 2011, the highway development projects of DOH primarily include the expansion of major highways into 4 lanes ($2^{nd}$ phase) and increasing traffic lanes. In addition, the constructions of fly-over highway bridges over railroads and the development for continuous transportation and shipping were also implemented.

**Motorway (DOH)**

To boost the road infrastructure and to connect the East-West and North-South Economic Corridors, the Thai government is planning to construct 13 motorway projects with a total length of 4,150 km across the country (Fig. 1.4.12). The motorway is a toll road connecting between cities with controlled entrance and exit throughout the route. In 1996, the master plan for construction of motorway has been developed by DOH based on the studied results by Japan International Cooperation Agency (JICA) in 1991. The projects are to be completed in 2016. However, due to the economic crisis in 1997 and the requirement of huge budgets of 472,360 million Baht, only 2 motorways [Bankok-Chon Buri (82km) and Eastern Outer Ring Road (64 km)] are now open to traffic.

At present, the old master plan is now under review in order to determine the most appropriate network and to develop a new master plan for 2 phases: 10 years (2011-2021) and 20 years (2012-2031). Furthermore, an action plan including the feasibility study of the type of investment is now under preparation.

**Road Connection with Neighboring Countries (DOH)**

Road networks including bridge structures have been constructed by DOH in order to connect the country's internal road network with those of neighboring countries (Economic Corridors) and to promote Thailand as the center of provincial land transport. These include (1) Highway Development among Countries in Greater Mekong Sub-region Cooperation (GMS Cooperation), (2) ASEAN Highway Network, and (3) ASIAN Highway Network (Figs. 1.4.13 and 1.4.14).


**Figure 1.4.12 Motorway Development Plan of DOH**
[Source: http://www.thaimotorway.com]

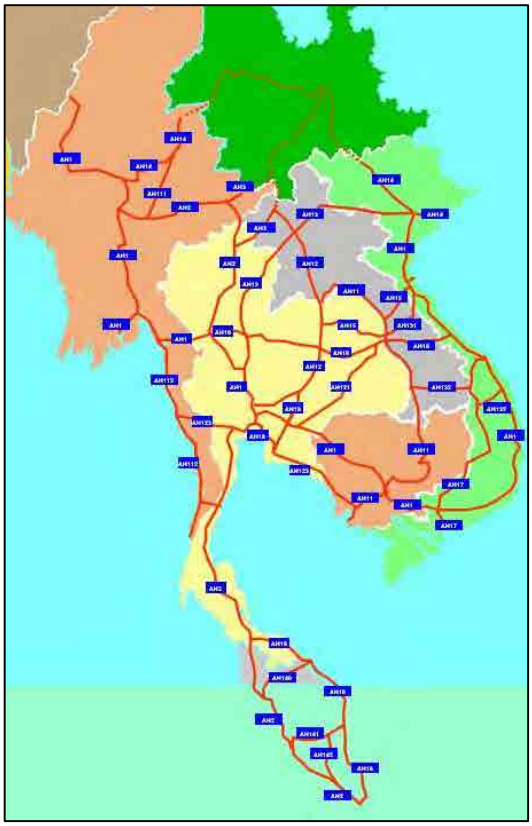


**Figure 1.4.13 ASEAN Highway Network**
[Source: DOH Annual Report B.E.2554 (2011)]


**Figure 1.4.14 Nine Economic Corridors in 1997**
[Source: DOH Annual Report B.E.2554 (2011)]

**Expressway (EXAT, DOH)**

In regards to the expressway system in Bangkok and its surrounding provinces, there are a total of 9 routes, which are owned by EXAT (8 routes) and DOH (1 route), as shown in Tables 1.4.9 and 1.4.10, respectively. As illustrated in Fig. 1.4.15, the total length of EXAT's expressway opened to service is now 207.9 km. The Sri Rat Expressway (38.4 km) was constructed and operated by BECL under the concession contract with EXAT. Similarly, the Udon Ratthaya Expressway (32.0 km) in the northern area of Bangkok was constructed and managed by NECL under the concession contract with EXAT. The Don Muang Tollway (Uttarapimuk Elevated Tollway), which is owned by DOH, has a total length of 28.0 km and its first section (22.0 km) was constructed and operated by Don Muang Tollway Public Co., Ltd. (DMT) under the concession contract with DOH until 2034.

Regarding the project under construction, BECL has signed the concession agreement for construction, operation and maintenance of the Si Rat-Outer Ring Road Expressway Project (17 km) with EXAT, with the concession period of 30 years on September 14, 2012. Moreover, the feasibility study of the extension of Don Muang Tollway (17 km) to Ayutthaya, the Northern of

Bangkok, is now under implementation by DOH. The construction of this project is planned to start in 2014 and finish in 2017.

**Table 1.4.9 Expressway Network of EXAT**

| Expressway Route | Length (km) | Owner | Operator |
|---|---|---|---|
| 1. Chaloem Maha Nakhon | 27.1 | EXAT | EXAT |
| 2. Sri Rat | 38.4 | EXAT | BECL |
| 3. Chalong Rat | 18.7 | EXAT | EXAT |
| 4. Udon Ratthaya | 32.0 | EXAT | NECL |
| 5. Burapha Withi | 55.0 | EXAT | EXAT |
| 6. Bang Na-At Narong (S1) | 4.7 | EXAT | EXAT |
| 7. Kanchanapisek (Bang Pli-Suksawad) | 22.5 | EXAT | EXAT |
| 8. Ramindra-Outer Bangkok Ring Road | 9.5 | EXAT | EXAT |
| Total | 207.9 | - | - |

[Source: EXAT Annual Report 2011]

**Table 1.4.10 Expressway Network of DOH**

| Expressway Route | Section | Length (km) | Owner | Operator |
|---|---|---|---|---|
| 9. Don Muang Tollway (Uttarapimuk) | 1 | 22.0 | DOH | DMT |
| | 2 | 6.0 | DOH | DOH |
| Total | | 28.0 | - | - |

[Source: DMT Annual Report 2011]

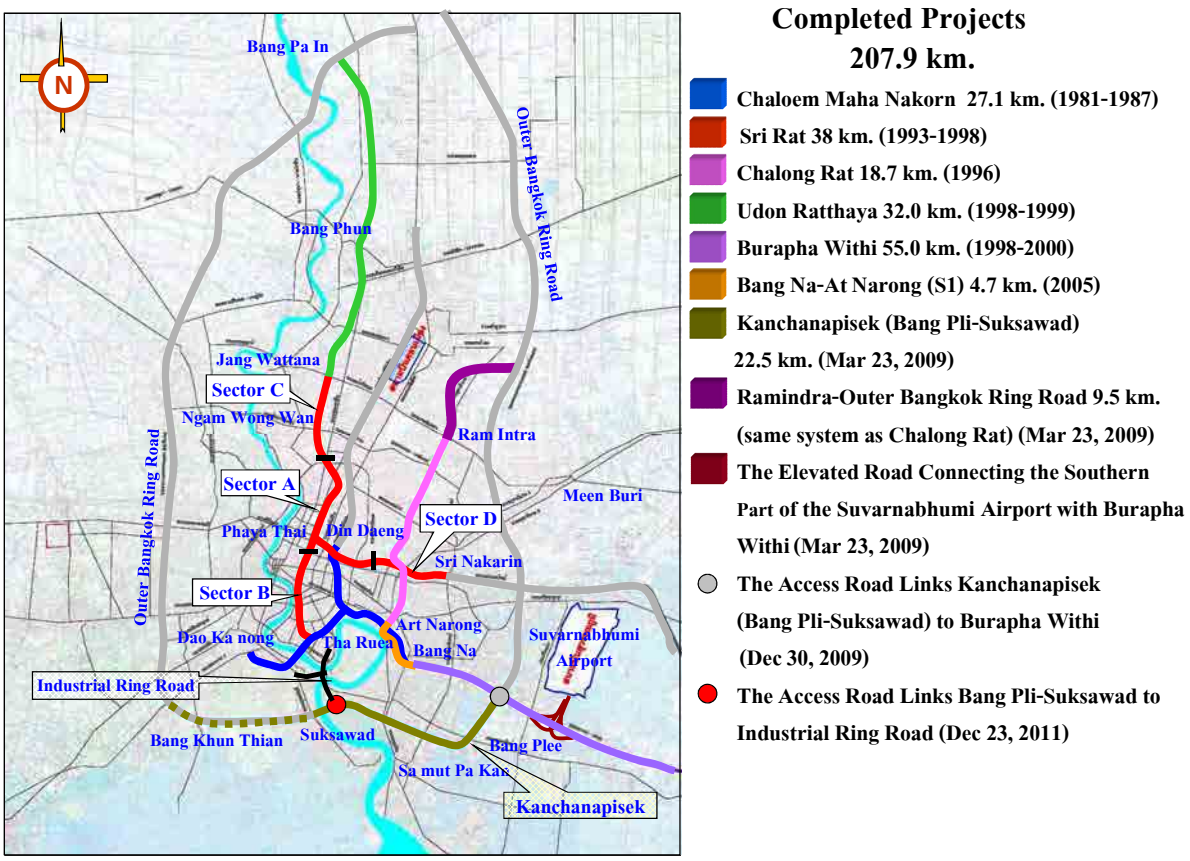



**Figure 1.4.15 Map of Expressway Network of EXAT**
[Source: EXAT's Document]

**Rural Roads (DRR)**

As of 2012, the rural roads with a total length of 41,509 km are under the jurisdiction of DRR. In the network, there are more than 8,000 bridges in regional area and 12 bridges crossing Chao Phraya River in Bangkok and its surrounding area. Regarding the ongoing project, a bridge crossing Chao Phraya River in Nonthaburi Province (Fig. 1.4.16), which will be the first extradosed prestressed concrete bridge in Thailand once completed, is now under construction by the supervision of DRR. Moreover, feasibility studies of some bridges in regional area that have high priority ranking in the Bridge Master Plan developed by DRR are now under implementation.

In addition, a large-scale suspension bridge crossing Chao Phraya River is now planning to be constructed in Samut Prakran Province (Fig. 1.4.17). This bridge is a part of the 6-lane elevated road project with the total length of 59 km, which will help connect the roads in western and eastern area, in the southern Bangkok area. The total cost of project is approximately 30,000 million Baht. According to the feasibility study carried out in 2012, the project is feasible but

requires further detailed study on the environmental impact. The details of road and bridge development plan in DRR are further described in Chapter 2.

**(4) Manuals and Standards Related to Road and Bridge**

There are many standards and manuals related to design, construction and maintenance of road and bridge structures in Thailand. Most of them have been developed based on ASSHTO standard and ACI Building Code by many groups of university professors and engineering consultant companies. The manuals and standards in DOH and EXAT are summarized in Table 1.4.11, and their covers are illustrated in Fig. 1.4.18. Regarding the manuals in DRR, the details are summarized and discussed in Chapter 2.

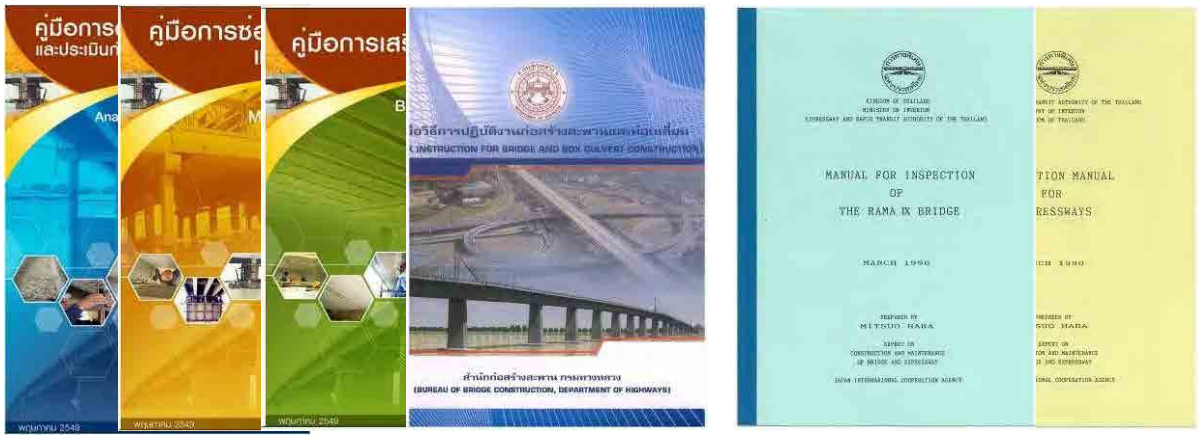
The EXAT's manuals listed in Table 1.4.11 have been prepared by the cooperation of JICA experts in 1990. Afterward, they have been revised and modified many times by EXAT to meet the changing circumstance.

**Figure 1.4.16 Nonthaburi Bridge Project**

**Figure 1.4.17 Project Map of Chao Phraya River Crossing Bridge and Link Roads (L=57km)**
[Source: DRR, TESCO Homepage]

**Table 1.4.11 List of Manuals and Standards related to Road and Bridge (DOH, EXAT)**

| Title | Date | Organization | Language |
|---|---|---|---|
| Specifications for Highway Construction | 2003 | DOH | Thai, English |
| Bridge Strengthening Manual | May 2006 | DOH | Thai |
| Bridge Inspection, Analysis and Evaluation Manual | May 2006 | DOH | Thai |
| Bridge Repair and Maintenance Manual | May 2006 | DOH | Thai |
| Work Instruction for Bridge and Box Culvert Construction | 2006 | DOH | Thai |
| Inspection Manual for Expressways | March 1990 | EXAT | English |
| Manual for Inspection of the Rama IX Bridge | March 1990 | EXAT | English |




**(a) DOH** **(b) EXAT**

**Figure 1.4.18 Manuals and Standards related to Road and Bridge (DOH, EXAT)**

# Chapter 2 Outline of DRR

## 2.1 Organization of DRR

As shown in Figure 2.1-1, the organization of DRR includes three Deputy Director-General and one Chief Engineer under the Director-General. In addition, there are 12 bureaus, 1 center and 3 offices in the headquarters. As regional offices of DRR, 18 Bureau of Rural Roads is placed in rural areas. Moreover, a total of 18 Bureaus of Rural Road were established in each region. Bureaus related to maintenance activities for bridges in rural area are indicated as the shaded in Figure 2.2-1.

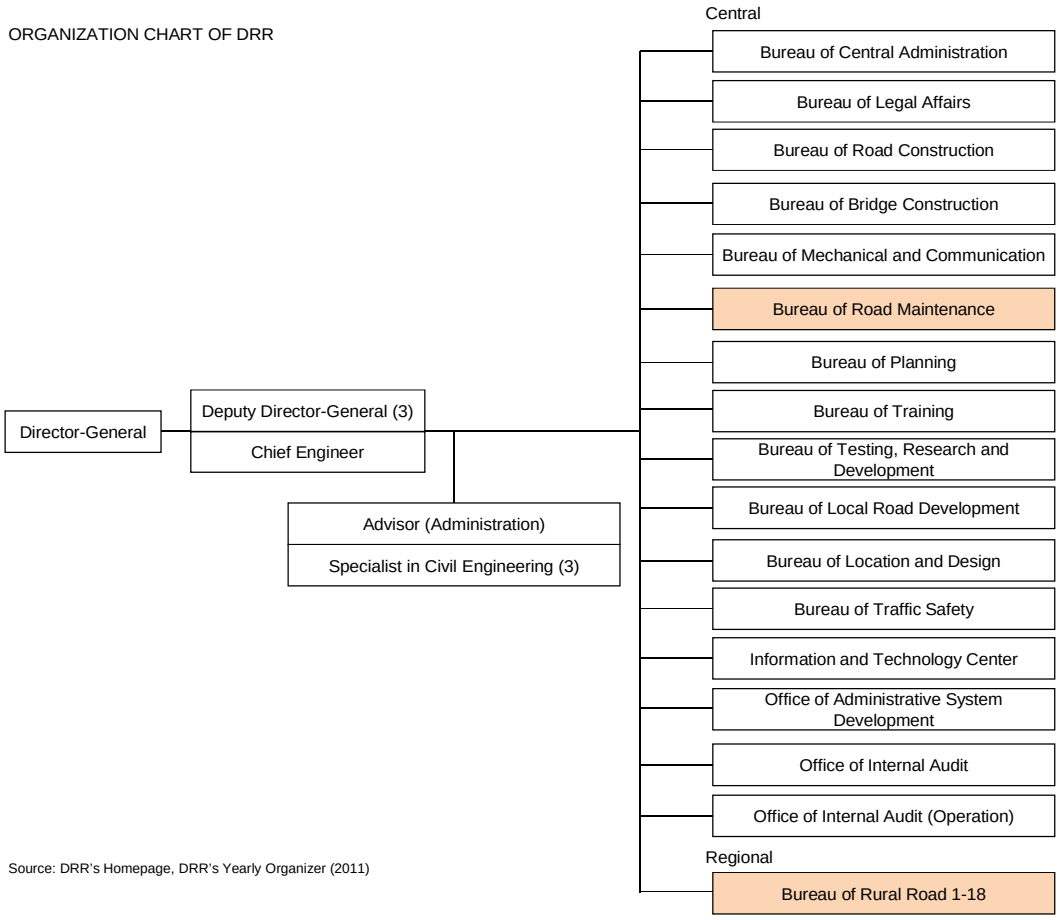



**Figure 2.1-1 Organization Chart of DRR**

The construction and maintenance works of roads and bridges in the Bangkok metropolitan are conducted by the headquarters, however, in the regions outside Bangkok (76 provinces), the construction and maintenance works are carried out by Bureaus of Rural Road which were established in 18 locations all over the country. Each Bureau of Rural Road is responsible for

the administration of 3 to 5 Offices of Provincial Rural Road.

The total number of staffs in DRR was 4,240 in fiscal year 2008, which consisted of government officials, permanent employees and government employees. The numbers of each staff are 1,713, 1,399, and 1,128, respectively. Working condition on both government officials and permanent employees is supposed to be life-long employment. However each group's educational level is different. Government officials received higher education than permanent employees. Permanent employees seem to be practitioners in the sites. On the other hand, governmental employees' working condition is revised every 4 years. The educational level of this group is broad range.

For the bridge maintenance works, engineers and technicians are involved in such a way that several technicians conduct the work under the instruction of one engineer. The main difference between engineers and technicians is that, while the former usually have an educational degree (Bachelor, Master, Doctor), it is not the case for the latter.

### (1) Headquarters of DRR

In the headquarters of DRR, the bridge maintenance works are responsibility of the Bureau of Road Maintenance, while the traffic operation works are responsibility of the Bureau of Road Safety. These two bureaus were established in March 2009 by splitting the former Bureau of Road Maintenance and Safety in order to deal with the increased amount of work. In addition, Bureau of Bridge Construction also implements the maintenance work of bridges.

The bureaus in the headquarters of DRR that are involved in the bridge inspection and maintenance works are as follows:

#### *1) Bureau of Bridge Construction*

The Bureau of Bridge Construction is composed of 5 divisions. One of them, the Industrial Ring Road Management Division, is responsible for the inspection and maintenance work of the industrial ring roads, including 2 cable-stayed bridges.

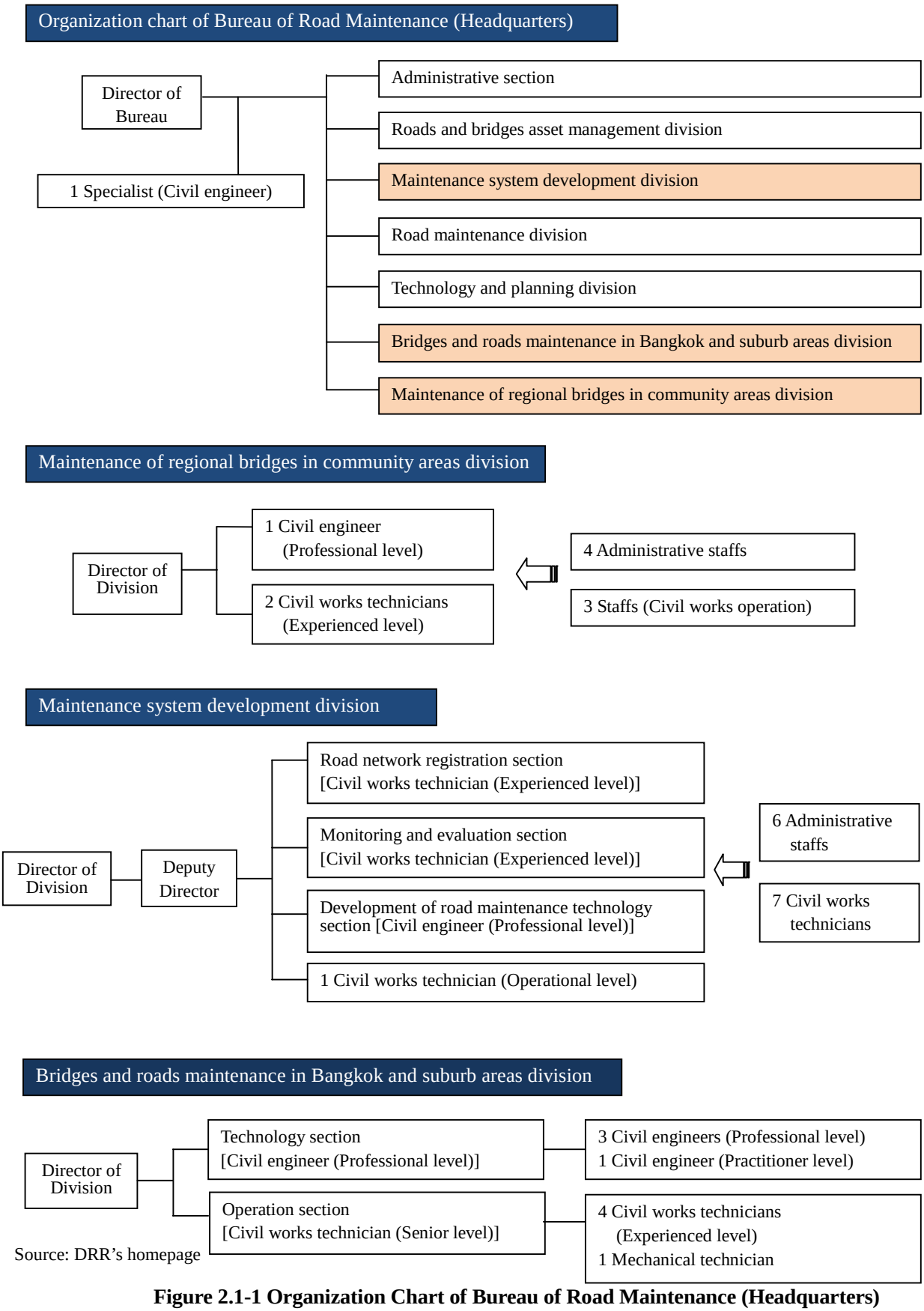
#### *2) Bureau of Road Maintenance*

As shown in Figure 2.1.2, the Bureau of Road Maintenance consists of 7 Section/Division. One of them, the Regional Bridge Maintenance in Community Division, is responsible for the management of bridges in rural area. The documents related to management of bridges from each Bureau of Rural Roads (1-18) will be submitted to this division. If necessary, the staffs of this division are dispatched to implement the site investigation of rural bridges.

Another division, the Bridge and Road Maintenance in Bangkok and Suburb Area Division, is involved in the maintenance works of roads and bridges in Bangkok metropolitan area. The bridges crossing the Chao Phraya River are also managed as a part of routes. Moreover, the Road Maintenance Division is responsible the development of manuals and software related to the maintenance work of DRR. In Figure 2.1-2, Some divisions in Bureau of Road

Maintenance related to bridge maintenance acrivities are indicated in the shaded boxes.

From Figure 2.1-2, it can be seen that, in the Maintenance of Regional Bridges in Community Areas Division, there are only 1 civil engineer (Professional level) and 2 civil works technicians (Experienced level) under the supervision of the director. The rest of the staffs are for administration and operation of civil works. It is clear that the number of civil engineer in this division is very few compared to that of other divisions, such as the Bridges and Roads Maintenance in Bangkok and Suburb Areas division, in which the total number of civil engineers is five, excluding the director (4 Professional level, 1 Practitioner level). Hence, it can be said that the shortage of staffs, particularly civil engineer, seems to be the most important issues that need to be solved in order to improve the management and maintenance work of DRR's bridges in regional areas.




Source: DRR's homepage

**Figure 2.1-1 Organization Chart of Bureau of Road Maintenance (Headquarters)**

## (2) Organization and Role of Bureau of Rural Road

As shown in Table 2.1-1, Bureaus of Rural Road 1-18 are located in each region throughout the country.

**Table 2.1-1 List of Bureau of Rural Road 1-18**

| Rural Road Bureau No. | Location | | Rural Road Bureau No. | Location | |
|---|---|---|---|---|---|
| | Province | Region | | Province | Region |
| 1 | Pathum Thani | Central | 10 | Chiang Mai | North |
| 2 | Saraburi | Central | 11 | Surat Thani | South |
| 3 | Chon Buri | East | 12 | Songkhla | South |
| 4 | Phetchaburi | West | 13 | Chachoengsao | East |
| 5 | Nakhon Ratchasima | Northeast | 14 | Suphan Buri | Central |
| 6 | Khon Kaen | Northeast | 15 | Udon Thani | Northeast |
| 7 | Ubon Rachathani | Northeast | 16 | Kalasin | Northeast |
| 8 | Nakhon Sawan | Central | 17 | Chiang Rai | North |
| 9 | Uttaradit | Central | 18 | Krabi | South |

The organization chart of Bureau of Rural Road was made, as shown in Figure2.1-3, based on the results of interview with the Director of Bureau of Rural Road 2 (Saraburi). Some sections related to bridge maintenance activities are indicated in the shaded boxes.

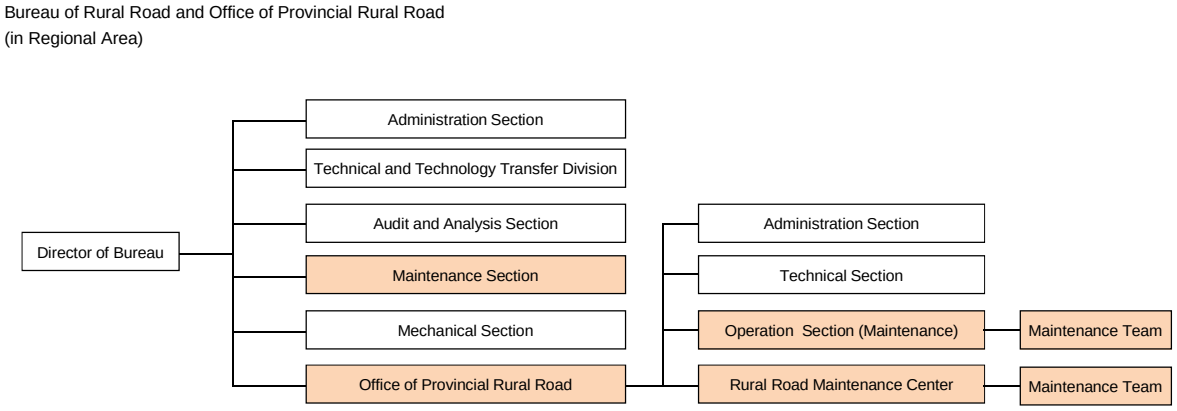



**Figure 2.1-3 Organization Chart of Bureau of Rural Road and Subsidiary**

The organizations under the Bureau Director include Administration Section, Technical and Technology Transfer Division, Audit and Analysis Section, Maintenance Section, Mechanical Section and Offices of Provincial Rural Road. For the Office of Provincial Rural Road, it consists of Administration Section, Technical Section, Operation Section (Maintenance) and Rural Road Maintenance Center. The Rural Road Maintenance Center in each province will be established if there are some difficulties in conducting the maintenance work by the provincial office only. (The Maintenance Center will be set up in case that the maintenance work is

necessary to be carried out in the area where it takes more than one hour to reach or the traveled distance is over 100 km from the provincial office)

In addition, it is necessary to have permission from the Director of Bureau before making any contact with other bureaus including the headquarters. The roles of Office of Provincial Rural Road, Bureau of Rural Road and Headquarters are shown in Table 2.1-2.

**Table 2.1-2 Roles of Office of Provincial Rural Road, Bureau of Rural Road and Headquarters**

| Item | Office of Provincial Rural Road | Bureau of Rural Road | Headquarters |
|---|---|---|---|
| New construction of road and bridge | Technical Section | Technical and Technology Transfer Division | Bureau of Planning, Bureau of Location and Design, Bureau of Road Construction, Bureau of Bridge Construction |
| Maintenance | Operation Section (Maintenance) | Maintenance Section | Bureau of Road Maintenance, Bureau of Bridge Construction |
| Traffic safety | Operation Section (Maintenance) | Maintenance Section | Bureau of Traffic Safety |
| Survey and inspection | Technical Section | Technical and Technology Transfer Division | Bureau of Testing Research and Development |

Most of bridge and road maintenance works including site inspection and storage of bridge inventory data are conducted by each Bureau of Rural Road. The survey, design, cost estimation and budget application for bridge and road maintenance works are prepared and submitted to the Bureau of Road Maintenance at the Headquarters for approval.

Concerning the scope of work, the planning and design of bridges with span length of 20m or less will be jointly conducted by the Technical and Technology Transfer Division in Bureau of Rural Road and the Technical Section in Office of Provincial Rural Roads. On the other hand, bridges with span length more than 20m will be mainly responsible by the Headquarters.

In addition, the definition of bridge in DRR is that the bridge length is more than 5m. At present, it seems that the data of name and location of all the bridges in DRR cannot be grasped. (The number of structures on rural roads except those located in BMA includes not only bridges but also other structures such as culverts.)

The number of bridges which can be confirmed up to 2012 and maintenance budged are as follows;

**Table 2.1-3 Bridges which are administrated by DRR**

| | Location | Number of Bridges | Maintenance Budget (2012) (Mil. Baht) |
|---|---|---|---|
| 1 | Crossing Chaophraya river | 12 | 170 |
| 2 | On the Rural Roads | 4,124 *1 | *2 |
| 3 | Outside of the Rural Road | 952 | 150 |

*1 Generally speaking, approximately 8,000 bridges seem to be administrated by DRR. 4,124 out of 8,000 are confirmed as a bridge. The remains are not confirmed as a bridge. They consist of bridge structure, box culvert, circle culvert or other structures.

*2 These bridges seem to be as a part of the rural roads, so they are administrated as a part of roads. The cost for maintaining those bridges is based on the length of them. It seems to fluctuate between 200 and 300 Baht per length of bridge.

## 2.2 Budget of DRR

### 2.2.1 Outline

The budgets of DRR are summarized in Table 2.2-1. The budget for fiscal year 2006 was increased by 20% compared to the previous year, however, it was decreased by about 18% in fiscal years 2007 and 2008, when compared with fiscal year 2006. In fiscal year 2009, it was increased to the same level of fiscal year 2006. The breakdown items for 1. Road and network development, 2. Operation and maintenance, and 3. Others (capacity development etc.) are also shown in the Table.

**Table 2.2-1 Transition of Annual budgets of DRR Including Personal Expenditure**

Unit: million Baht

| Fiscal Year | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|
| 1.Development Road and Network | 13,539.121 | 13,693.612 | 9,624.842 | 8,705.409 | 13,087.791 |
| 2.Operation and Maintenance | 4,127.736 | 5,179.868 | 5,752.207 | 6,436.451 | 6,853.131 |
| 3.Others | 95.212 | 2,568.560 | 2,481.813 | 2,162.513 | 2,429.051 |
| Total | 17,762.069 | 21,442.040 | 17,858.862 | 17,304.373 | 22,369.973 |

The budget allocation is approved by different organization, which is dependent on the amount of budget. This is summarized as shown in Table 2.2-2 according the results of interview with the Director of Bureau of Rural Road 2. For the projects that can be approved by the Director of Office of Provincial Rural Road, it is also necessary to make a report to the Director of Bureau of Rural Road.

**Table 2.2-2 Budget Allocation of DRR**

| Approval Authority | Budget |
|---|---|
| Thai Government (Cabinet Approval) | ≥ 50 Million Baht |
| Director-General of DRR | ≥ 30 Million Baht |
| Director of Bureau of Rural Road | ≥ 15 Million Baht |
| Director of Office of Provincial Rural Road | < 15 Million Baht |

## 2.3 Budget Decision Flow of DRR

### 2.3.1 Procedure for Budget Acquisition of DRR

Hearing survey was conducted to clarify budget request and budget distribution flow for DRR. A budget draft of DRR will be first made by each bureau office in Headquarter and will be submitted to BOP (Bureau of Planning). BOP will summarize all budget drafts which are made by each bureau and make one budget draft of DRR. BOP will not assess contents of the budget draft. Budget drafts which are submitted by each bureau will be assessed by a committee composed of each bureau staffs.

Budget draft of DRR should be admitted by Director-General, and will be submitted to BOB (Bureau of the Budget) in OPM (Office of Prime Minister). Budget Draft assessment will be done by BOB. While submitting budget draft from DRR to BOB, DRR does not have to make an explanation to MOT or MOF. The role of MOF is to inform credit limit that can be disbursed from BOB in coming fiscal year.

After assessing budget draft at BOB, it will go through the procedure of compilation, Cabinet decision, resolution and recognition of Diet, signature by the King, and then granted to DRR. Budget draft can be rejected or reduced. This procedure is the same for DOH.

### 2.3.2 Maintenance Budget of DRR

Above-mentioned procedure for budget acquisition is the same for maintenance budget of DRR. A budget draft of maintenance costs will be made by Bureau of Road Maintenance which is located in Headquarter. After admitted by director of the bureau, the budget draft will be submitted to BOP.

After acquiring the budget, Bureau of Road Maintenance will distribute the budget to each bureau of rural road. Budget for restoring flood damage was also made by Bureau of Road Maintenance, admitted by BOP, and submitted to BOB.

The transition of the maintenance cost for bridges in rural area and Bangkok. (See table2.3-1) In some years, the maintenance budgets for rural bridges are as same as big bridges around Bangkok. These are draft budget for those bridges but not the actual expenses

**Table 2.3-1 Maintenance budget for bridges at DRR**
**（Mil. Baht）**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| Rural Bridges | 50 | 56 | 55 | 90 | 90 | 135 | 140 | 170 |
| Bangkok Bridges | 50 | 70 | 80 | 103 | 70 | 135 | 140 | 170 |

### 2.3.3 Procedure for Implementing OTP（Office of Transport and Traffic Policy and Planning）

Under Ministry of Transport, there is OTP, which is the same apposition as DOH and DRR. This office does not engage in any project, just in charge of formulating drafts. Drafts made by this office will be submitted to Ministry of Transport, and then suggested to appropriate department such as DOH and DRR.

Drafts are investigated at each department such as DOH and DRR. If a plan is to be industrialized, budget draft should be made and submitted to BOB.

### 2.3.4 Budget for Projects Conducted only by Provinces

Budget for projects conducted only by provinces will be requested to Bureau of Local Road Development of DRR. This bureau will summarize budget drafts from each province, submit to MOT directly, by not going through BOP or Director-General, and then submitted to BOB by MOT. Procedure after submitting budget draft is the same as 2.1. (cf. Economic Situation of Thailand, 2011, 2012, Japanese Chamber of Commerce, Bangkok)

## 2.4 Present Situation of Maintenance in DRR

### 2.4.1 Manuals Relating to Maintenance in DRR

Inspection was carried out emergency at 10 provinces around Chaopraya River in order to investigate damages on bridges caused by flood in 2011. JICA Study Team conducted hearing survey about manuals that are used in provinces. It is found out that there is a gap between the contents of manuals and actual use. Further hearing survey was conducted, by getting information from related persons in Headquarter, to clarify the situation of manuals and actual use.

**Table 2.4-1 Manuals in DRR**

| No. | Organization | Titel | Date | Developer | Brief Details | Remarks |
|---|---|---|---|---|---|---|
| 1 | Bureau of Road Maintenance | Project for Development of Management System for DRR's Road Network (Phase 1) - Bridge Inspection and Evaluation Manual - | Feb. 2007 | Chulalongkorn University | ・Basic knowledge on bridge inspection work, guideline for inspection work (slab, superstructure, substrcture, bearing, drainage), BMMS (bridge inventory data, recording of inspection results, damage condition rating, bridge health index evaluation) | Collected in the previous survey |
| 2 | | Project for Maintenance and Management System Development for DRR's Bridges<br>- Manual for repair of RC bridge components due to deterioration of bridge structures and components<br>- Executive summary report<br>- BMMS<br>- Final report | Dec. 2009 | Chulalongkorn University | Report on the development of BMMS.<br>・Bridge repairing and strengthening manual<br>・Report (Abstract version)<br>・BMMS's user manual<br>・Report (Final version) | Collected in the previous survey |
| 3 | | Routine Maintenance Manual | Jun. 2011 | Chulalongkorn University | ・Routine inspection method, inspection form, repairing work planning, cost estimation, report preparation guideline (mainly for road)<br>・For bridge structures, only painting for barrier, repair of road division line, cleaning (approx. 1 page) | Distributed to regional office |
| 4 | Bureau of Local Road Development | Manual for Construction and Maintenance of Road | 2003(?) | DRR (?)<br>（since PWD） | ・ Guideline for construction work of road and bridge structures<br>・ Guideline for maintenance work of road structures | Distributed to regional office |
| 5 | | Bridge Inspection and Improvement Manual | Sep. 2007 | IMMS Co., Ltd. | ・Basic knowledge on bridge structure, health index evaluation, concrete deterioration, visual inspection method, report of inspection results, repair and strengthening method | Collected in the previous survey (Nov. 2005) |
| 6 | Bureau of Bridge Construction | The Industrial Ring Road Project - Inspection and Maintenance Manual - | Jan. 2008 | AEC, TEAM, TEC, INDEX, JMI | ・Manual for inspection and maintenance of IRR bridges (routine, periodic, special, emergency inspection) | Collected in the previous survey |
| 7 | Bureau of Testing, Research and Development | Study Project for Repair Method for Damages due to Material Deterioration and Service Life of Bridges in DRR's Road Network (Phase 2) - Final Report - | Sep. 2009 | Srinakarinwirot University | ・Repair and strengthening method, damage level evaluation, selection of repair method, cost estimation of repair work (unit price) | Collected in the previous survey |

・Manuals of DRR are made by outsourcing, by using contractors such as universities and consulting firms.

・Manuals created will be admitted by Director-General, then distributed to BRR. When distributing a manual, persons in charge in regional offices should come to Bangkok, attend seminar to understand the contents. If it is not likely enough to make them understand by just attending seminar, staffs of DRR may go to provinces to explain.

・Manuals can be downloaded from the homepage of DRR.

・There are many manuals relating to maintenance, but most of the contents are about road maintenance. Contents about bridge maintenance are very small. Therefore, manuals relating to roads are continuously used and manuals relating to bridges are likely to forgotten.

・Other reasons why manuals relating to bridges are likely to forgotten are: Manuals are not carried over at the time of replacement of personnel by personnel changes. : Manuals may become personal belongings. : Staffs take a lot of time to carry out the work of many others, do not have time to read the manual, etc.

・It is easier for staffs to notice damages on roads than bridges. They have experiences to repair roads, in response to requests from residents. However, bridges are thought as permanent structure. The idea that a bridge can be easily rebuilt in case it collapses also become a factor to make DRR staffs concern more on roads than bridges.

## 2.5 Status quo of local bridge maintenance

### 2.5.1 Relevant organizations and development plan

#### (1) Overview

Future plan of developing traffic and road network across country including road, port, rail and airline has been laid out by the Office of Transport and Traffic Policy and Planning (OTP) of the Ministry of Transport (MOT), and submitted to the government. Developing road network maintenance plan including trunk and rural roads is governed by the policy the OTP made. The OTP has developed the 2011-2020 Masterplan and released in recent. The DRR and other organizations in association with road maintenance are supposed to develop their own master plans by complying with the OTP policy.

#### (2) MOT and OTP

The MOT consists of 13 state enterprises and seven departments for government service as shown in Figure 2.5-1. The DOH and the DRR are subsidiary departments under the MOT, and the EXAT is one of state enterprises.

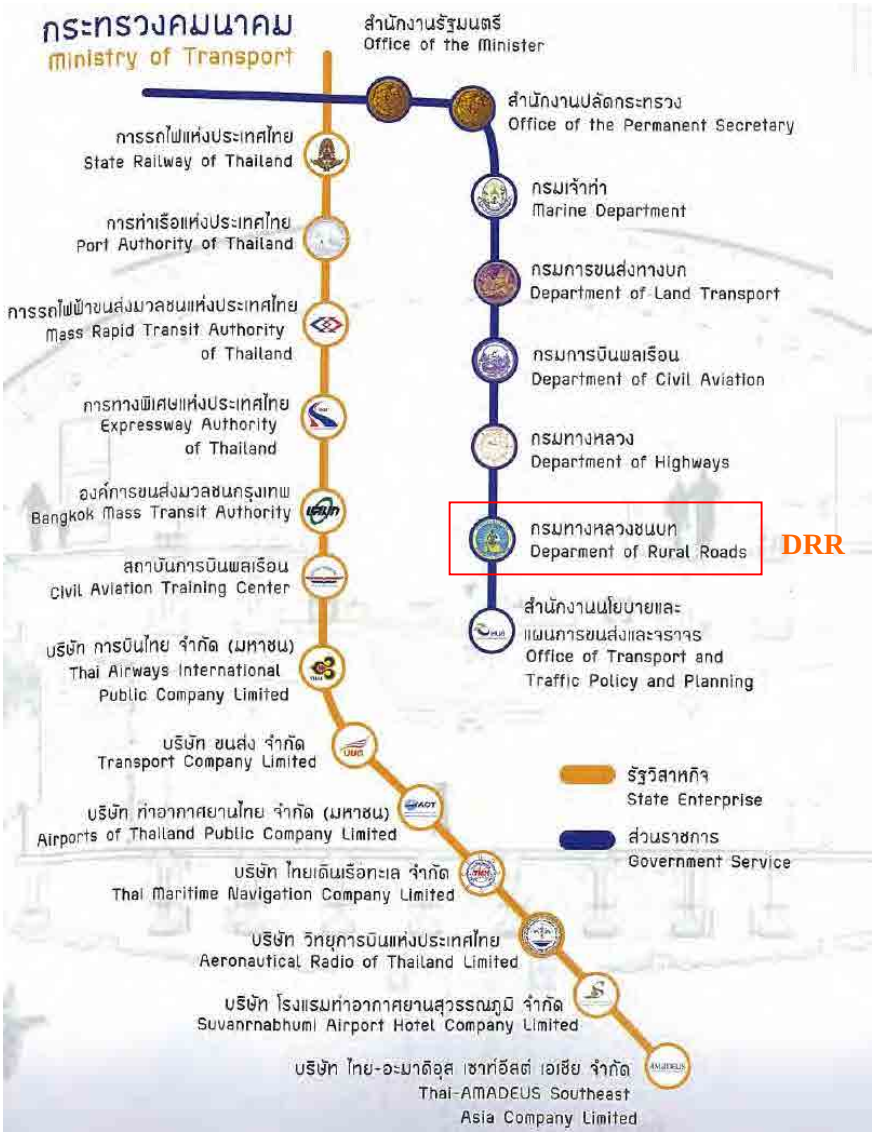



**Figure 2.5-1 Relevant organs in MOT (excerpted from 2010 OTP Annual report)**

### *1) Road sector development plan of MOT (OTP)*

Future plan of developing traffic and road network across country including road, port, rail and airline has been laid out by the OTP of the MOT, and submitted to the government. Earlier than 2002, road relevant organs had been separately controlled under other ministries. Since October in 2002 the EXAT has belonged to the MOT and the DRR has been newly established after the PWD and the ARD merged together. Hence, the OTP has been authorized to develop and manage the traffic and road network plan including trunk and rural roads.

In the process of developing 10-year Masterplan, at first, the OTP outlines policy or rule and present it to each organ, and then 13 state enterprises and seven departments give their agenda or requests to the OTP according their own future plans. Thus, based on them, the OTP lastly comes into developing the 10-year Masterplan.

The 10-year Masterplan does not detail about road route and road distance. According to the procedure of the policy the OTP made, relevant organs start developing road maintenance plan within the range of their scopes. Approval for their plans is authorized by not the OTP but the Policy and Strategy Bureau. It is realized that arrangement and cooperation between each organ becomes available since the DRR and the EXAT belonged to the MOT but not always much.

Therefore, the present survey is to study and examine the DRR Masterplan which is developed to carry out an actual plan for road maintenance. That plan is fundamentally made considering the MOT strategy, budget allocation, and the policy the OTP outlined for traffic and road network across country.

### 2.5.2 Current state of the DRR Masterplan

Planning Bureau of the DRR is reviewing the Masterplan in order to determine level of priority of road links planned to be built across country. This plan was developed in 2009 as a 10-year plan for the period from 2009 to 2018.

As a result of surveys done so far, the current state of the DRR Masterplan is as follows:

- Among 25 bridges reviewed during feasibility study, five bridges are under budgeting and two bridges have an approved budget. Other bridges are on the process of selection in the same way done before.
- Subsequently, feasibility study for every 25 bridges in all regions is supposed to be carried on, but this year there is no plan.
- For two bridges already selected, the DRR has requested to verify the result after construction. Plus, the DRR wants to apply widely a new way of selection following improvement of the procedure of assessment and selection by JICA.

## 2.6 Current state of flood prevention approach

The state of flood prevention approach has been described in Emergency Inspection Report submitted date in April 2012.

# Chapter 3 Capacity Assesment (CA) and Capacity Development (CD)

In this chapter, we discuss: Capacity Assessment (CA) of DRR staff with regard to bridge inspection, bridge maintenance/management and flood countermeasure; goal setting for Capacity Development (CD); finalization of the target group; and results and future issues. We also summarize the status of various activities for CD at the end of the chapter.

## 3.1 Capacity Assessment (CA)

In Chapter 2, we described the result of the survey regarding the current status of bridge maintenance and management by DRR. We assess the capacity of DRR staff with regard to bridge inspection, bridge maintenance/management and flood countermeasure based on the interview records and the result of the questionnaire survey in addition to the survey result described in Chapter 2.

During our CA, we conducted written surveys and interviews from the beginning of the project for the issues which could be covered by these methods, and summarized the results in Chapter 2. The assessment of DRR staff was conducted in a series of interviews and questionnaires whenever opportunities arose because it was not practical to meet the entire target DRR staff at one time.

The foregoing process is described in Figure 3.1. The horizontal axis of each chart shows the passage of time, while the vertical axis shows the ratio of DRR headquarters and Bureau of Rural Roads (BRR) staffs who were directly involved in the relevant activities.

- Bridge inspection

During the first half of the project, we developed a bridge inspection manual in consultation with the headquarters staff. Then (after May 2012), we visited BRR staff members to explain about the manual, and we conducted seminars and on-the-job training (OJT) as well. At these occasions, we conducted CA of BRR staff members who were in charge of actual bridge inspections.

- Long-term bridge maintenance and management

The main target group in this subject is the headquarters staff in charge of budget preparation,

and we conducted multiple discussions with them from the beginning. We conducted our CA at the occasion of a joint seminar with the relevant headquarters staff and C/P, which was held for the purpose of disseminating the knowledge of long-term bridge maintenance and management to C/P.

- Flood countermeasure

We conducted discussions with the headquarter staff, and also had meetings with BRR staff around the same time. Therefore, we conducted CA of the headquarters and BRR staffs for this subject earlier than that for bridge inspection and long-term bridge maintenance and management.

- Bridge planning

The target group of this subject is limited to the headquarters staff in some particular divisions. Moreover, all of the staff in the target group have studied abroad and hold either a master's or doctor's degree. Therefore, we excluded bridge planning from our CA and CD and instead provided our comments based on discussions with them.

In the following sections, we consider bridge inspection, long-term bridge maintenance and management and flood countermeasure as sub-projects of this project, and describe CA and CD for each sub-project. Please refer to Chapter 5, Chapter 6 and Chapter 8 for the content of work of these sub-projects. Also refer to Chapter 9 for the details of bridge planning and our comments on the subject.

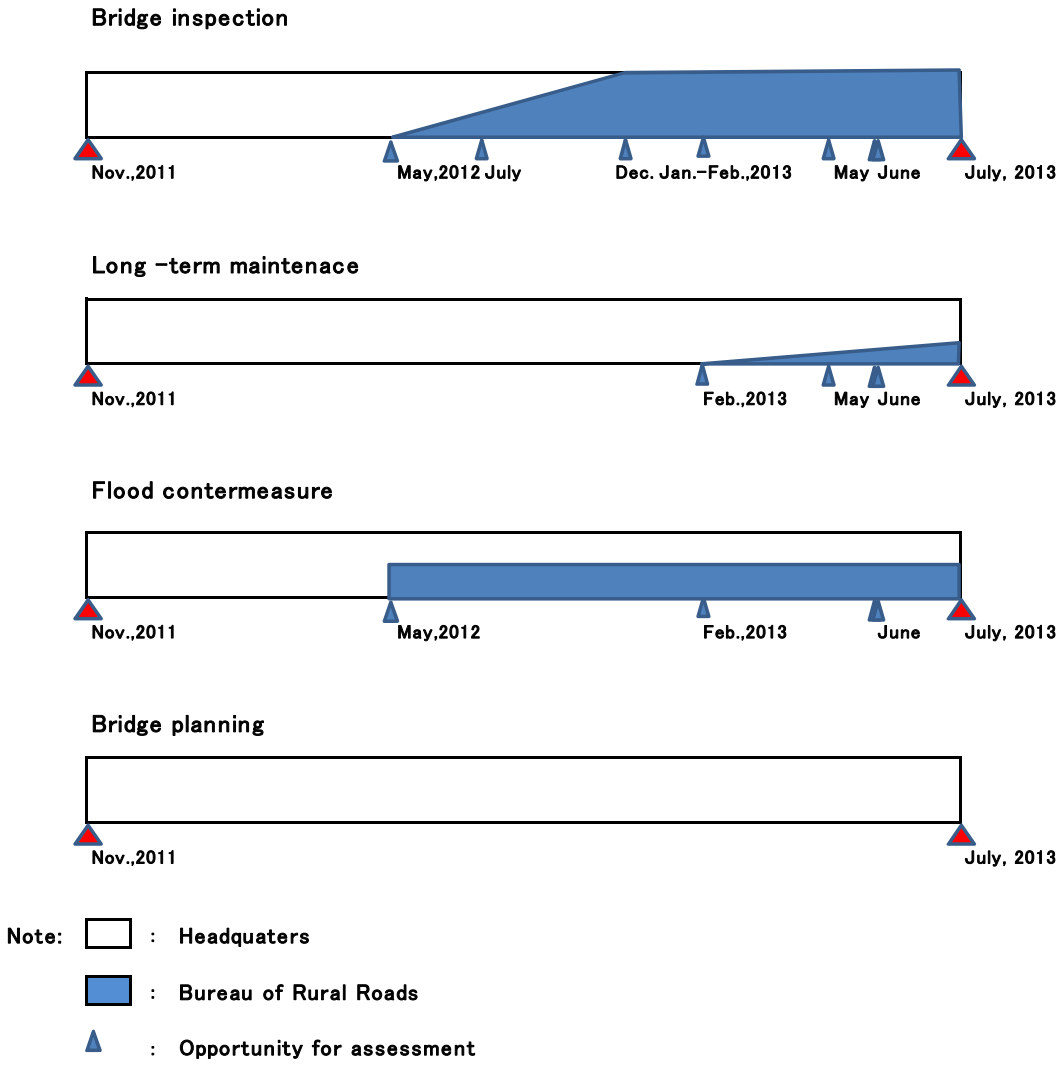



**Figure 3.1 Project time frame and ratio of the relevant DRR headquarters and BRR staffs**

### 3.1.1 Bridge inspection

As described above, with regard to bridge inspection, we conducted discussions with the headquarters staff during the first half of the project, and then worked with BRR staff after May 2012. We also began to provide seminars and OJT sessions to BRR staff on a full scale after November 2012. In this section, we summarize results of the surveys conducted at eight rural offices between May 2012 and February 2013.

## 1. Questionnaire survey

### (1) Knowledge of bridge inspection

Before surveying knowledge of bridge inspection, we asked the following questions in order to find out: whether the respondents recognize the possibility of bridge collapse; whether they recognize signs indicating progression of damages; and whether they understand both gradual and abrupt changes occurring to bridges after being completed (e.g. gradual changes caused by neutralization, salt damage and metal fatigue, and abrupt changes caused by a sudden external force such as flood and earthquake). We made the following observations by comparing the answers from the engineers and technicians surveyed.

Questions

Q1. Do you think there is any risk that any bridge collapses?
Q2. Do you think the new bridges that were constructed recently are different from those that were built more than 10 years ago?
Q3 Do you think the bridge deterioration proceeds gradually or abruptly?

The number of respondents

**Table 3.1-1 Affiliation of the respondents (knowledge of bridge inspection)**

| | Engineer | Technician | Other | Total | Response Date |
|---|---|---|---|---|---|
| BRR2 | 3 | 8 | 1 | 12 | 22/05/2012 |
| BRR3 | 3 | 6 | 1 | 10 | 27/07/2012 |
| BRR5 | 4 | 12 | 1 | 17 | 28/01/2013 |
| BRR7 | 2 | 9 | 4 | 15 | 30/07/2012 |
| BRR8 | 3 | 12 | | 15 | 17/12/2012 |
| BRR11 | 4 | 13 | | 17 | 14/02/2013 |
| BRR13 | 3 | 5 | | 8 | 13/12/2012 |
| BRR17 | 2 | 13 | | 15 | 24/07/2012 |
| Total | 24 | 78 | 7 | 109 | |

1) For Q1, nearly 90 percent of both engineers and technicians answer that there is a risk of bridge collapse.

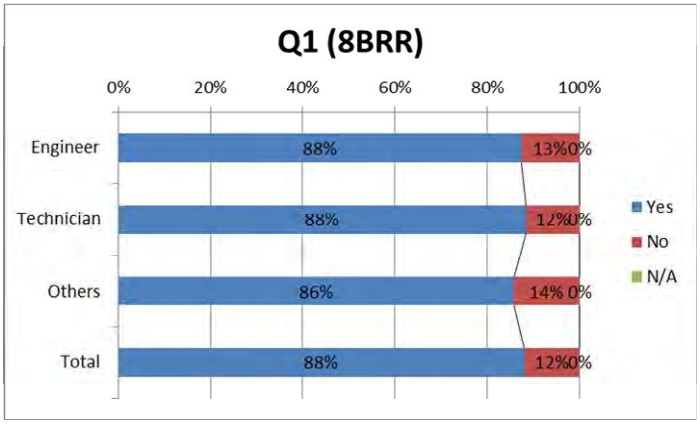



**Figure 3.1-1 Result of Q1 (Knowledge of bridge inspection)**

2) For Q2, nearly 80 percent of both engineers and technicians (although the percentage is slightly higher for technicians) answer that conditions of bridges may change with the passage of time.

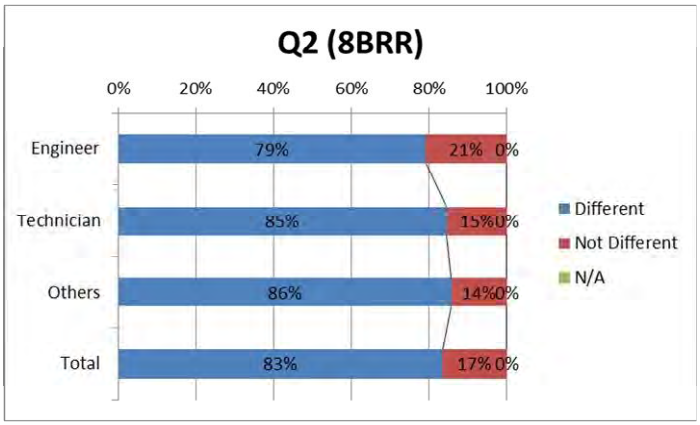



**Figure 3.1-2 Result of Q2 (Knowledge of bridge inspection)**

3) The answers to Q3 are significantly different between engineers and technicians. Approximately 70 percent of engineers recognize both gradual and abrupt changes, compared while the percentage is only 40 percent for technicians. The percentages of respondents who answer that the speed of changes is abrupt are very small for both engineers and technicians. On the contrary, 30 percent of engineers and 50 percent of technicians answer that the speed of changes is gradual.

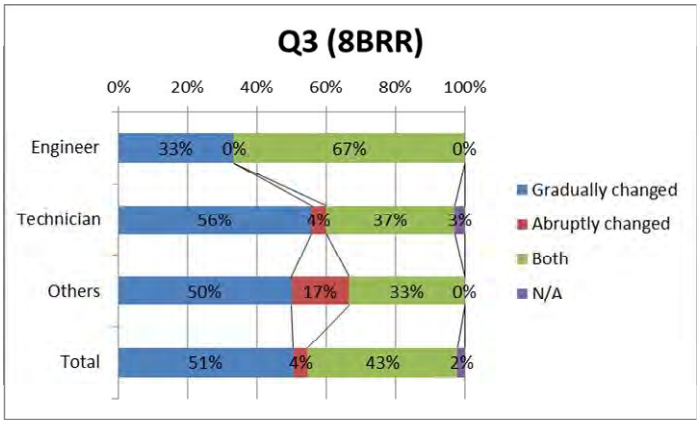



**Figure 3.1-3 Result of Q3 (Knowledge of bridge inspection)**

### (2) Experience of bridge inspection

We asked BRR staff in charge of bridge maintenance and management about their experience of bridge inspection to date.

Q1. Have you ever seen any damaged road or bridge?
Q2. Have you ever seen any document with records of damaged roads or bridges?
Q3. Have you ever seen any document (manuals) that specifies the method of inspection and recording of damaged roads or bridges?
(Response alternatives: Yes for both roads and bridges / Yes for roads only / Yes for bridges only / Not at all for both roads and bridges)

The number of respondents

**Table 3.1-2 Affiliation of the respondents (experience of bridge inspection)**

| | Engineer | Technician | Other | Total | Response Date |
|---|---|---|---|---|---|
| BRR2 | 2 | 10 | 2 | 14 | 22/05/2012 |
| BRR3 | 3 | 7 | 1 | 11 | 27/07/2012 |
| BRR5 | 4 | 12 | 1 | 17 | 28/01/2013 |
| BRR7 | 2 | 10 | 2 | 14 | 30/07/2012 |
| BRR8 | 4 | 14 | | 18 | 17/12/2012 |
| BRR11 | 4 | 13 | | 17 | 14/02/2013 |
| BRR13 | 3 | 5 | | 8 | 13/12/2012 |
| BRR17 | 1 | 12 | | 13 | 24/07/2012 |
| Total | 23 | 83 | 6 | 112 | |

1) The answers to Q1 are significantly different between engineers and technicians. Approximately 60 percent of engineers respond they have seen damaged bridges while the percentage is almost 100 percent for technicians.

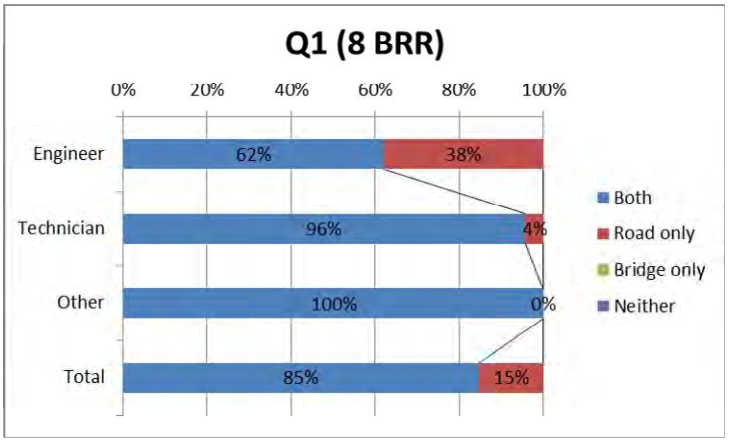



**Figure 3.1-4 Result of Q1 (Experience of bridge inspection)**

2) For Q2, nearly 70 percent of both engineers and technicians answer they have seen documents with records of damaged bridges. On the other hand, approximately 30 percent of both engineers and technicians respond they have seen records of damaged roads but never seen those of damaged bridges.

Also, ten percent of the respondents indicate they have neither seen documents with records of damaged roads nor bridges.

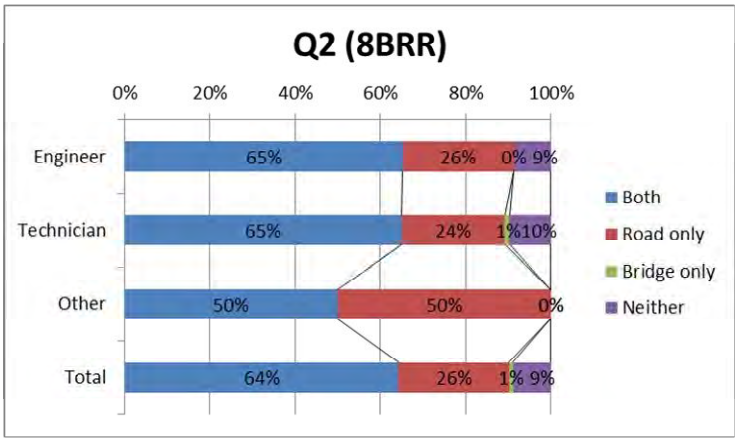



**Figure 3.1-5 Result of Q2 (Experience of bridge inspection)**

3) The purpose of Q3 is to find out whether the respondents recognize the existence of bridge

inspection manuals. More than 50 percent of engineers and 40 percent of technicians answer that they have seen manuals. At the same time, 40 percent of engineers and 30 percent of technicians answer they have seen only manuals for roads but never seen those for bridges. Meanwhile, 30 percent of technicians respond that they have seen neither manuals for roads nor those for bridges.

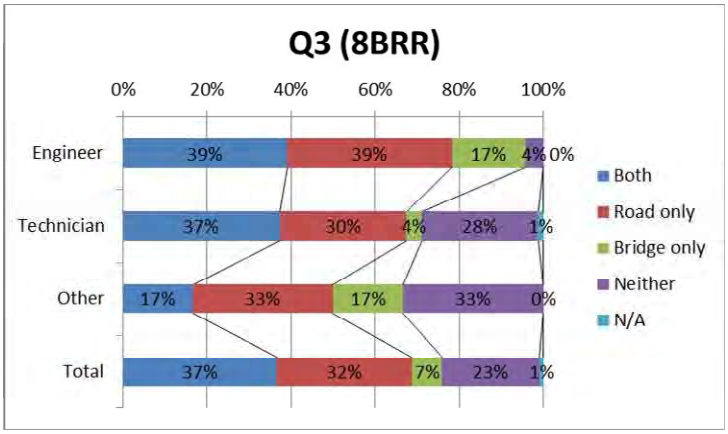



**Figure 3.1-6 Result of Q3 (Experience of bridge inspection)**

(3) Others

Other than the questions regarding their knowledge and experience of bridge inspection, we also asked in the questionnaire whether the respondents would use spreadsheets in their daily work. That is because the use of spreadsheets is indispensable for data input based on the result of bridge inspection, correction of the bridge data book and data input in the long-term bridge maintenance and management planning which will be discussed later in this chapter.

| |
|---|
| Q1 Do you use Microsoft Excel in your daily work?<br>[Yes/No] |

The respondents

**Table 3.1-3 Affiliation of the respondents (Spreadsheets)**

| | Engineer | Technician | Other | Total | Response Date |
|---|---|---|---|---|---|
| BRR2 | 2 | 10 | 2 | 14 | 22/05/2012 |
| BRR3 | 3 | 7 | 1 | 11 | 27/07/2012 |
| BRR5 | 4 | 12 | 1 | 17 | 28/01/2013 |
| BRR7 | 2 | 10 | 2 | 14 | 30/07/2012 |
| BRR8 | 4 | 14 | | 18 | 17/12/2012 |
| BRR11 | 4 | 13 | | 17 | 14/02/2013 |
| BRR13 | 3 | 5 | | 8 | 13/12/2012 |
| BRR17 | 1 | 12 | | 13 | 24/07/2012 |
| Total | 23 | 83 | 6 | 112 | |

4) For Q1, 90 percent of both engineers and technicians answer that they use Microsoft Excel in their daily work. On the other hand, 10 percent of engineers answer they do not use the spreadsheet.

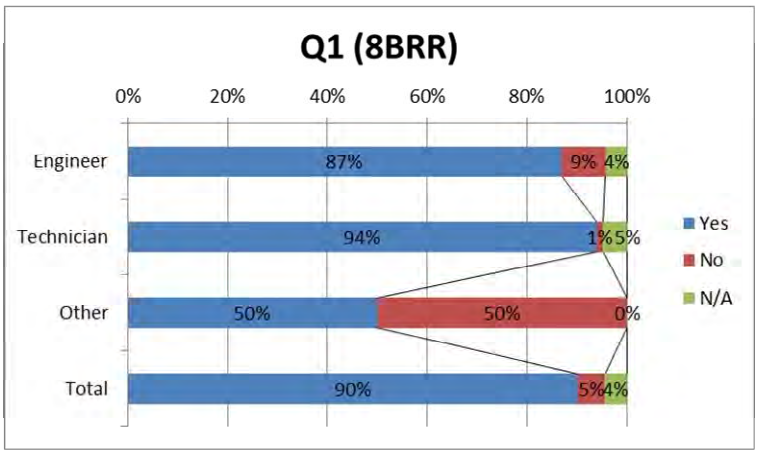



**Figure 3.1-7 Result of Q1 (Spreadsheets)**

(4) Summary

We made the following observations based on the result of the questionnaire survey and the survey result discussed in Chapter 2.

1) As to the question whether bridges have a risk of collapse, nearly 90 percent of the respondents recognize the risk.

2) As to changes of bridge conditions due to aging, nearly 80 percent of the respondents recognize deterioration of bridge conditions due to aging.

3) The answers are different between engineers and technicians regarding the speed of changes. While 70 percent of engineers recognize both gradual and abrupt changes, the percentage remains as low as 40 percent for technicians. It is also noted that both engineers and technicians are more aware of gradual changes. We assume these results are due to the gap in knowledge between engineers and technicians regarding bridge deterioration and causes of damages to bridges as well as no history of major bridge damages due to earthquakes in the past.

4) As to the question regarding actual observation of bridge damages, almost all of technicians answer they have seen bridge damages. However, 40 percent of engineers respond they have never seen damaged bridges in person. We assume it is because the engineers have more internal work while the technicians spend more time working on site.

5) Regarding bridge inspection records or similar documents, 70 percent of engineers have seen such documents. Considering the result of the previous question, ten percent of engineers have seen bridge damages in such documents. In contrary, although technicians have seen damaged bridges on site, approximately 30 percent of them have never seen documents with records of such damages. (It is deemed that these technicians, 30 percent of the total technicians, have never prepared inspection records, either.)

6) DRR staff can download multiple bridge inspection manuals from DRR homepage. However, approximately 50 percent of both engineers and technicians answer that they have never seen such manuals. We assume they do not recognize the existence of the manuals because bridge inspection is not conducted as part of their work.

7） We found that 90 percent of both engineers and technicians can use spreadsheets, indicating there is no problem in terms of performing spreadsheet-related tasks (e.g. input and correction of inspection records.)

## 2. Capacity (Bridge inspection)

In this section, we summarize the capacity regarding bridge inspection of BRR staff who are involved in bridge inspection as part of their work from the technical, core and organizational points of view as below.

(1) Technical capacity

DRR engineers hold a bachelor's degree or a higher degree, while DRR technicians are at least graduates of an industrial high school. Therefore, it is deemed they have general knowledge about civil engineering. We also find they have certain knowledge about the risk of bridge collapse and changes of bridge conditions due to aging. Meanwhile, we identify a gap in knowledge between engineers and technicians about the speed of changes in bridge conditions.
On the other hand, considering the level of their awareness about existence of bridge inspection manuals, both engineers and technicians do not seem to have sufficient knowledge about a series of bridge inspection work from identification of the condition to classification and documentation of the damages according to a certain standard.

(2) Core capacity

Although bridge inspections are not in place, BRR organizes staff teams (one team consists of one inspector and one driver) and they take pictures of bridges to review overall conditions of these bridges. It is our understanding that one BRR team takes pictures of two to three bridges per day depending on the locations of bridges. Such pictures are likely to be taken by technicians who mainly conduct work on site. However, it is difficult to conclude they are highly aware of bridge inspection because many of them have not seen documents with records of bridge damages (even though they have seen damaged bridges on site) and are not aware of the existence of bridge inspection manuals.
Similarly, we find engineers are not highly aware of bridge inspection, either, because as much as 40 percent of them have never seen damaged bridges on site.

(3) Organizational capacity

Although DRR has multiple bridge inspection manuals and they can be downloaded from DRR homepage, approximately half of BRR staff have not utilized them. We assume that is because bridge inspection has not been established as part of their work and therefore they have no

trouble in conducting their daily work without recognizing the existence of such manuals.

### 3.1.2 Long-term bridge maintenance and management planning

It is unlikely that there is knowledge about long-term bridge maintenance and management planning in DRR because: it is a new concept and different from the current practice employed by DRR; and because the subject is relevant only for a limited number of staff who belong to budget-related divisions within the area of bridge maintenance and management in the headquarters. In this sub-project, we conducted a questionnaire survey mainly asking about experience of budget planning to BRR engineers (C/P) as well as the headquarters staff in charge of bridge maintenance and management.

#### 1. Questionnaire survey

Date: February 20, 2013

Venue: Conference room 3, Headquarters

The number of respondents: 12 engineers (See below for their affiliations. All of the respondents are engineers.)

**Table 3.1-4 Affiliation of the respondents**

(Long-term bridge maintenance and management planning)

| Organization | Number of respondent |
|---|---|
| Bureau of Testing Research and Development | 2 |
| Bureau of Road Maintenance | 2 |
| Bureau of Bridge Construction | 2 |
| BRR3 | 1 |
| BRR5 | 1 |
| BRR8 | 1 |
| BRR12 | 1 |
| BRR13 | 1 |
| BRR17 | 1 |
| Total | 12 |

We asked three questions and requested a yes/no answer plus a reason for the answer.

(1) Q1: Experience of budget control

| Q1: Have you ever developed a budget plan for a road or a bridge? |
|---|

Answer

Eight respondents have experienced budget planning for bridges. Four have never been involved in budget planning.

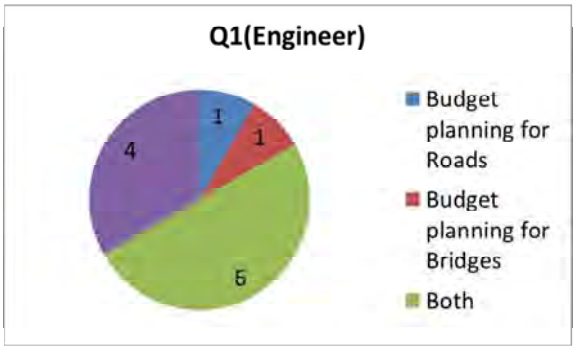



**Figure 3.1-8 Result of Q1**

(2) Q2: Data usage for bridge repair

| Q2: At the time of repairing a bridge, did you use the result of bridge inspection or basic specification data of the bridge? |
|---|

Answer

Among the 12 respondents, 10 used such data, and one did not use them. One did not answer this question.

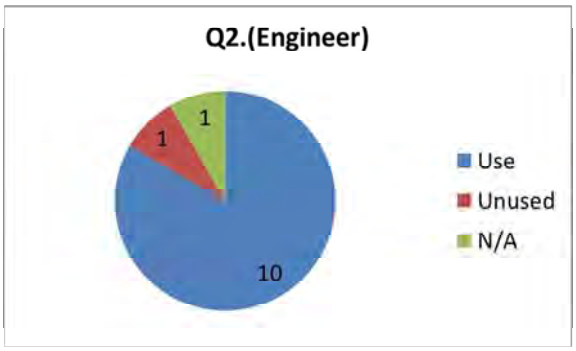



**Figure 3.1-9 Result of Q2**

The respondents who used data for bridge repairs were further asked the following question.

Q2-1: Why do you take actions such as repairing after identifying damages during a bridge inspection? Please describe the reason.

Answer

Seven out of 10 respondents who use data answered this question. Typical reasons are as follows: there are budget restraints; it is impossible to predict possible damages in the future; there are not sufficient data due to lack of bridge inspection and therefore identified damages are repaired first. One respondent who does not use data for repair/reinforcement mentioned the reason was due to lack of a system to accumulate such data.

(3) Q3: Relationship between maintenance/management cost and safety

Q3: Which of the following do you think represents the relationship between maintenance/management cost and safety?

a. The more maintenance/management cost is, the safer.

b. The less maintenance/management cost is, the safer.

c. There is no relationship between maintenance/management cost and safety.

Answer

Ten out of 12 respondents chose the answer a., which is a common-sense answer. Two respondents did not answer this question.

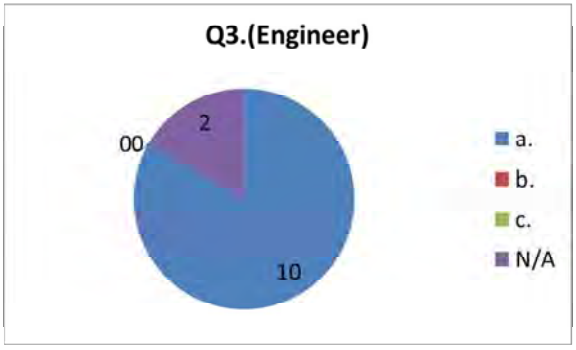



**Figure 3.1-10 Result of Q3**

(4) Summary

1) Sixty percent of engineers have experienced some kind of budget planning for bridges, while 30 percent of them have had no experience. This seems to indicate budget planning is

conducted by limited members of the staff.

2) Eighty percent of the respondents report that they use the basic information contained in the bridge data book or the results of bridge inspections for bridge maintenance and management.
3) For the reason of repair upon identification of damages, we expected a response such as fulfilling the responsibility as manager of roads. However, there was no such answer. Rather, the respondents indicate that repairs are conducted as damages are identified because of budget restraints and difficulty in understanding the actual damage situations of bridges under their management. This is an after-the-fact approach where repair and/or reinforcement are/is conducted after identification of damages. We found some negative opinions about prediction of future damages, which is a key concept in a long-term bridge maintenance and management planning based on preventive maintenance.
4) As to relationship between maintenance/management cost and safety, the respondents made a common-sense answer in general, although two respondents did not answer the question. However, it is unlikely for the respondents to imagine that safety level could be different even when the same amount is spent for maintenance/management work.

### 2. Capacity (Long-term bridge maintenance and management planning)

In this section, we summarize the capacity regarding long-term bridge maintenance and management planning of the headquarter staff and BRR staff (C/P) who are in charge of budget planning for bridge maintenance and management as part of their work from the technical, core and organizational points of view as below.

(1) Technical capacity

The concept of long-term bridge maintenance and management planning is new and currently not employed as part of DRR work. Therefore, it is difficult to assume that they have the knowledge.

(2) Core capacity

Similar to the technical capacity, it cannot be concluded that they are willing to replace the current method with the new concept or to incorporate some ideas in the new concept into the current practice.

(3) Organizational capacity

Although the senior management showed its interest in the relationship between the amount of budget and safety, it is quite unlikely that the whole organization is willing to change the current method because it is aligned with the current organizational practice as a whole.

## 3.1.3 Flood countermeasure

Different from the foregoing sub-projects, we conducted the flood countermeasure in cooperation with BRR staff. This is because the objectives of the sub-project were more specific compared to those of the other sub-projects. That is, the final work was conducted by applying an adequately selected flood countermeasure to a bridge damaged by a flood. Since the contents of work for flood countermeasure are also different between engineers and technicians, we discuss the results separately for these different job titles.

### 1. Questionnaire survey

Date: May 15, 2012
Venue: Provincial Office of Rural Road No.2 (Lopburi)
The number of respondents: 13 persons (See below for their affiliations and job titles.)

**Table 3.1-5 Affiliation of the respondents (Flood countermeasure)**

| | HQ | BRR8 | BRR2 | PO (Lopburi) | N/A |
|---|---|---|---|---|---|
| **Engineer** | 3 | 1 | 1 | 1 | |
| **Technician** | | | | 1 | 4 |
| **N/A** | | | | 1 | 1 |

In the questionnaire, respondents were asked nine questions. Below we describe the questions, answers to the questions and future actions related to the questions.

(1) Questions (Knowledge about flood countermeasure)

> Q1-1 Do you have enough knowledge for flood countermeasure?
> Q1-2 If you don't have enough knowledge, what kind of knowledge do you think you want to gain?
> Q1-3 How do you think you can gain those kinds of knowledge?

Answers

Q1-1) The survey asked respondents to make a self-assessment about their level of knowledge for flood countermeasure. Only two engineer respondents indicate that they have enough knowledge, and all of the other respondents answer they do not have enough knowledge.

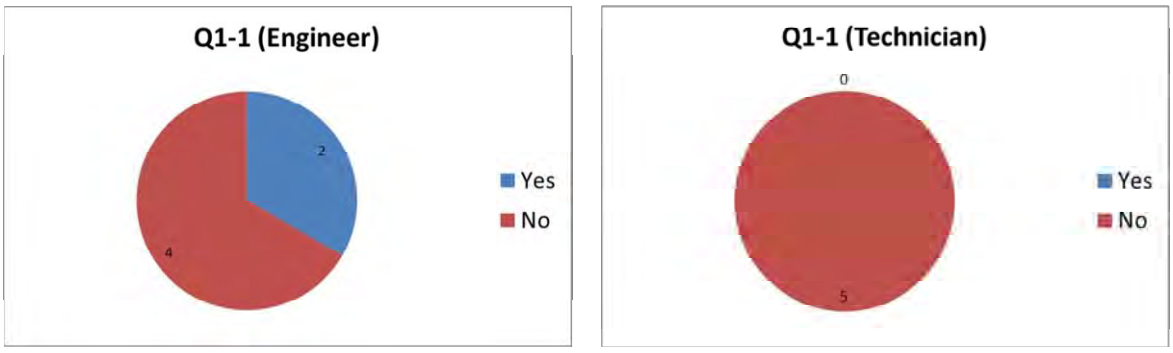



**Figure 3.1-11 Result of Q1-1**

Q1-2) When respondents were asked what kind of knowledge they wish to obtain, engineers indicated they would like to know flood countermeasure, how to repair bridges damaged by floods for each type of damages, and how to identify damages. On the other hand, technicians indicated knowledge about topography data (e.g. rivers and canals). The other respondents simply mentioned they would like to obtain technical knowledge.

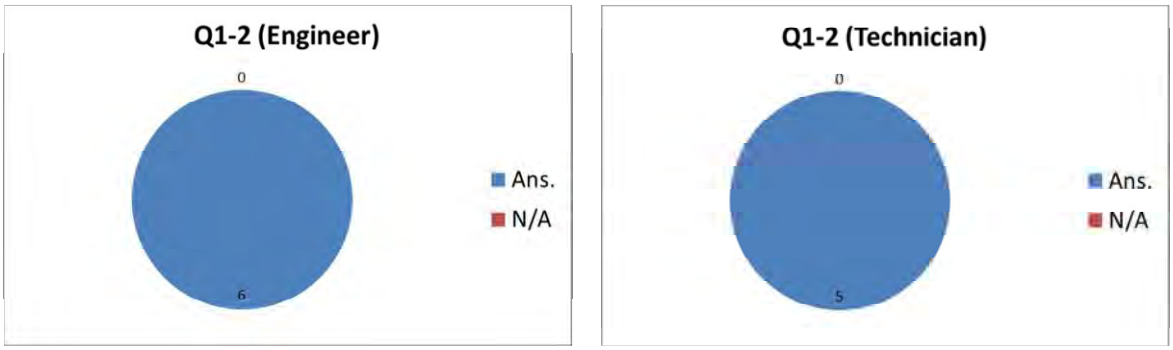



**Figure 3.1-12 Result of Q1-2**

Q1-3) When respondents were asked how they could obtain such knowledge, engineers pointed out sources such as JICA activities, advice from Royal Irrigation Department and other institutions/experts, and relevant books and documents. Meanwhile, technicians mentioned about training sessions including those at DRR, except for those who identified maps with a scale of 1 to 50,000/4000 and river surveys as sources of information. Others indicated training sessions led by DRR and relevant professionals.

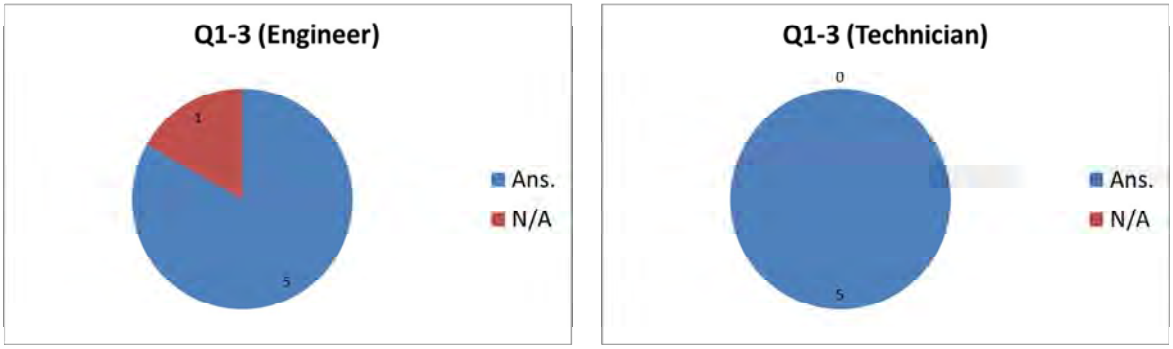



**Figure 3.1-13 Result of Q1-3**

(2) Questions (Support from relevant parties)

Q2-1 Do you think if you have enough support for flood countermeasure from persons in charge and relevant departments?
Q2-2 If you do not think the support is sufficient, what kind of support do you think is necessary?
Q2-3 To have enough support, what should relevant departments and persons in charge have done in your opinion?

Answers

Q2-1) When respondents were asked whether enough support was available, the majority of respondents in total answered that support was not enough. Only two engineers indicated they received enough support.

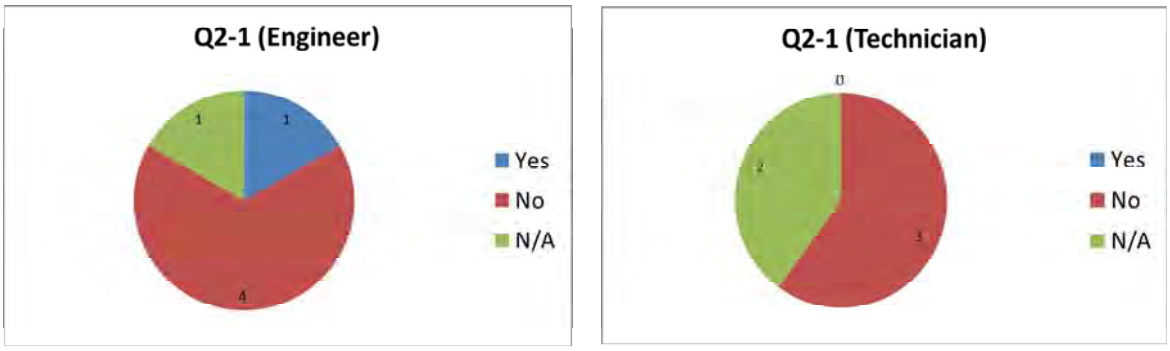



**Figure 3.1-14 Result of Q2-1**

Q2-2) When respondents were asked what kind of support they would like to have, engineers identified budget, standard drawings, engineering protection and countermeasure by type of damage. Technicians mentioned vehicles to access to the damaged area and increase in the number of staff members who would conduct inspections and damage assessments.

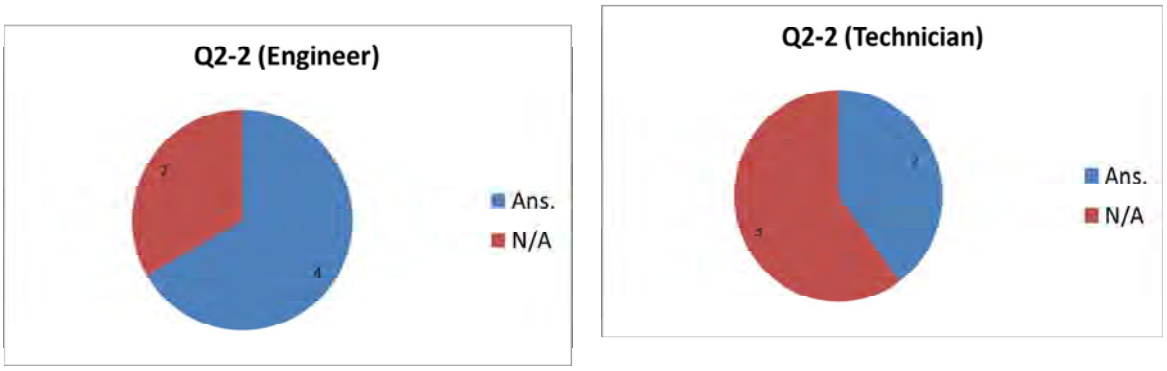



**Figure 3.1-15 Result of Q2-2**

Q2-3) As to desirable support from relevant departments and persons in charge, engineers mentioned provision of training courses, support during the actual work, establishment of an well-organized team, actions based on discussions among relevant parties and joint research with research institutions. On the other hand, some technicians mentioned necessity to understand the actual work of the inspector on site. The other technicians did not answer to the question.

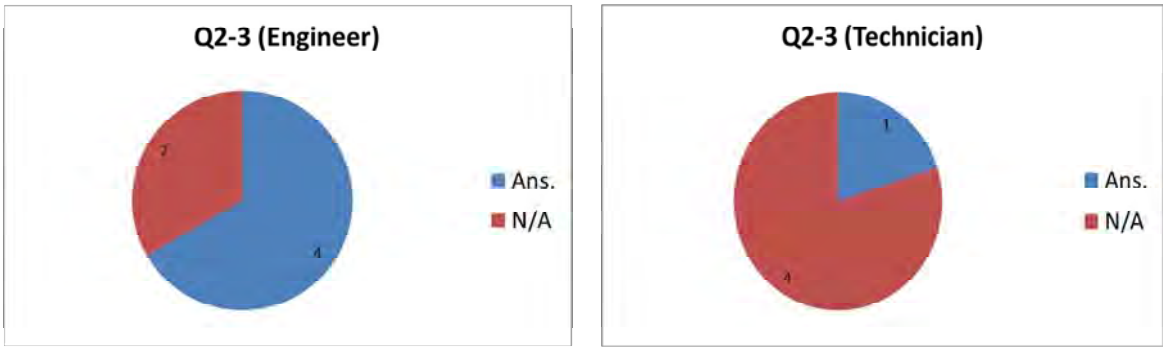



**Figure 3.1-16 Result of Q2-3**

(3) Questions (Flood in 2011)

| |
|---|
| Q3-1 Are you satisfied with your work about the flood in 2011? |
| Q3-2 If you are not satisfied, what do you think is the reason? |
| Q3-3 To get along well with your work, what do you think you can do? |

Answers

Q3-1) None of the respondents was satisfied with the actions taken at the time of the major flood disaster which occurred in 2011.

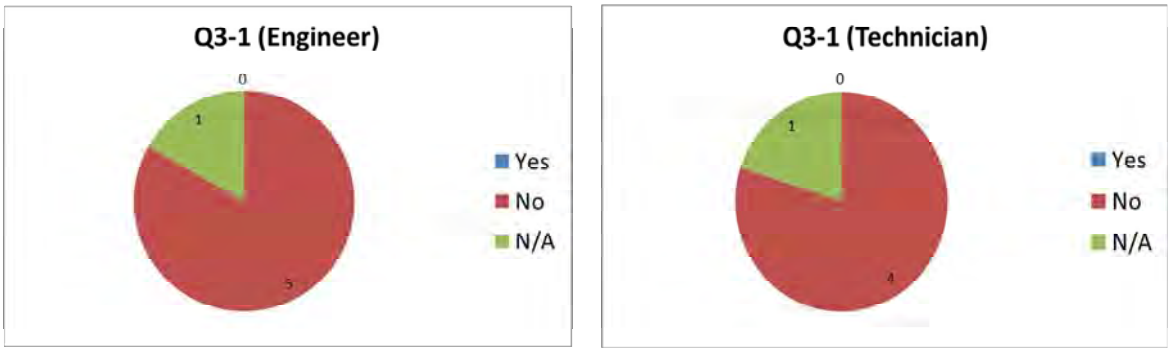



**Figure 3.1-17 Result of Q3-1**

Q3-2) As to the reason of their dissatisfaction, engineers mention the followings: not enough time was available before implementing the flood countermeasure; lack of skilled persons for flood countermeasures; and satisfactory measures could not be taken due to the unexpected scale of the flood. Meanwhile, technicians mention as follows: not enough information was available; the number of vehicles which could operate at the time of flood was not sufficient; and not enough flood countermeasure was prepared in advance of the event.

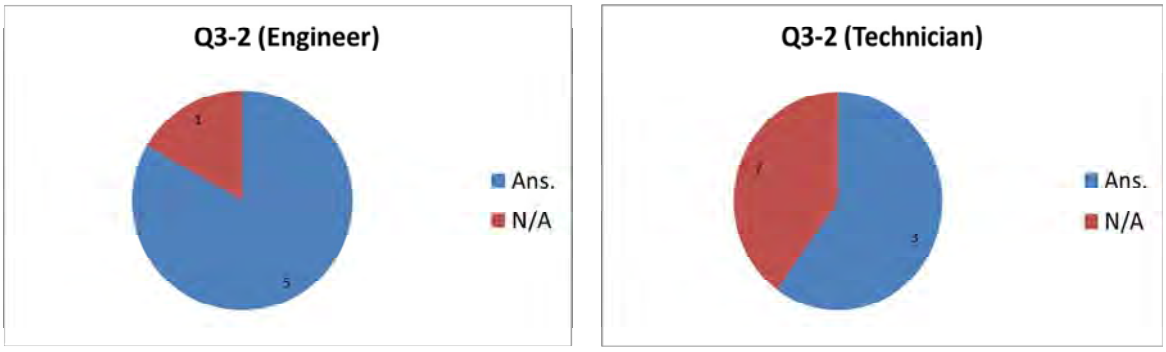



**Figure 3.1-18 Result of Q3-2**

Q3-3) No specific answer was given to the question what the respondents could do to do their work better. Both engineers and technicians reported answers such as obtaining knowledge about flood countermeasure and preparation of flood countermeasure in advance.

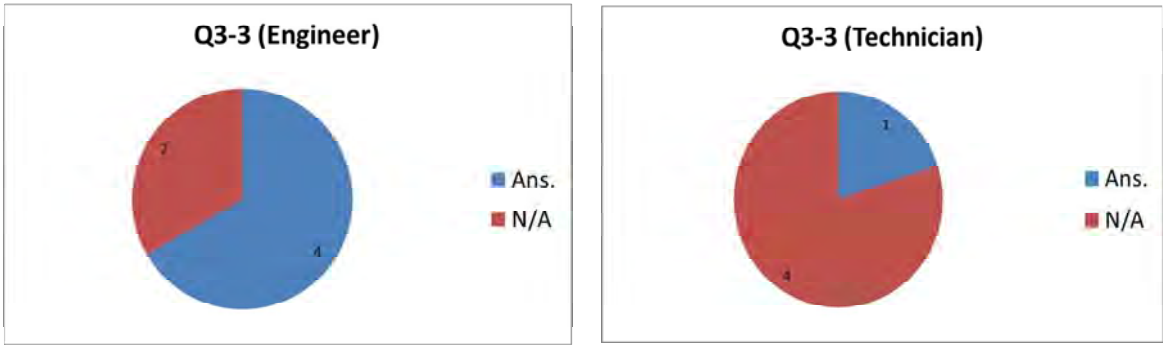



**Figure 3.1-19 Result of Q3-3**

(4) Summary

1) The majority of respondents answer they do not have enough knowledge about flood countermeasure. However, they sustain a certain amount of flood damages every year. Therefore, it is not clear whether they indicate their lack of experimental knowledge or academic knowledge about flood countermeasure.
2) As to the scope of knowledge they would like to obtain, engineers list specific knowledge such as technical methods for flood countermeasure and how to identify damages, while many of technicians provide an ambiguous answer (i.e. technical knowledge). We assume that this is due to the knowledge gap between engineers and technicians.
3) When asked how to obtain knowledge, some respondents answer they want to obtain it through this project. Many other respondents respond they want to do so through utilization

of relevant institutions and literature.

4) No technicians answer they received enough support at the time of the flood. A similar result is found for engineers.
5) For flood countermeasure, engineers wish to obtain technical support while technicians request human and equipment supports to work on site. One reason of the difference is due to the different contents of work between engineers and technicians.
6) When asked specifically what kind of support should be available from relevant departments and persons in charge, engineers pointed out a framework to increase knowledge and an improved decision-making process. Instead of a direct answer, some technicians provided a comment that the relevant parties should understand well about actual situations at site.
7) Regarding the level of satisfaction with the flood countermeasure taken at the time of the major flood in 2011, neither engineers nor technicians responded to this question were satisfied with their work.
8) As to the reason they were not satisfied with their work, engineers report insufficient preparation in advance and a lack of skilled human resources, while technicians indicate a lack of information and specific equipment. Considering the above answers, we estimate engineers are mainly in charge of internal management work while technicians are engaged in actual on-site maintenance work.
9) When respondents were asked what kind of actions would be necessary to conduct satisfactory countermeasure, they did not provide any specific idea as they did in the previous question. Both engineers and technicians mentioned acquiring knowledge and preparation in advance to take actions against floods.

## 2. Capacity (Flood countermeasure)

In this section, we summarized the capacity regarding flood countermeasure of BRR staff in charge of bridge inspection as part of their work as well as that of some headquarters staff from the technical, core and organizational aspects as below.

(1) Technical capacity

Because floods often occur in the region (the central part of Thailand), many staff members take some kind of responsibility and are involved in works of flood countermeasure. Still, many of engineers surveyed respond they do not have enough knowledge about flood countermeasure. However, their answers lack concreteness and they are unable to identify the area they have limited knowledge. Considering the above, we assume their current knowledge is sourced from their past experiences.

(2) Core capacity

They show a strong interest in flood countermeasure, and they are willing to take more appropriate measures based on their lessons learnt at the time of the major flood in 2011. In particular, technicians who seem to be mainly in charge of on-site work refer to quite specific things as necessary support. Therefore, we conclude their core capacity regarding flood countermeasure is high.

(3) Organizational capacity

The rivers, canals and irrigation canals where DRR bridges are located are controlled by Marine Department in Ministry of Transport and Royal Irrigation Department, respectively. In the case of Japan, when a structure is to be built within a river area, the party which controls roads needs to make a request for permission to the party which controls river. Receiving such a request, the river authority generally sets conditions in its response to the road authority, such as those relating to impediment of river flow (e.g. location and the number of bridge columns) as well as those relating to preservation of river characteristics as much as possible (e.g. engineering protections).

However, with regard to DRR bridges in the rural area, we observed various instances such as bridge constructions in the locations which increase impediment of river flow, bridge columns which accelerate scouring of river bed, and sagging of approach roads due to soil loss at the back of bridge abutments as the result of scouring and erosion. Such situations indicate a lack of collaboration between the road and the river authorities as mentioned in the previous paragraph.

## 3.2 Goal setting for Capacity Development (CD) and finalization of target group

Similar to CA, we developed goals of Capacity Development (CD) for each sub-project. This is because the knowledge, experience and the current work held by DRR staff involved in bridge inspection, long-term bridge maintenance and management, and flood countermeasure are different. In this section, we describe goals for each of these sub-projects (bridge inspection, long-term bridge maintenance and management planning, and flood countermeasure).

### 3.2.1 Goal setting for CD and finalization of target group (Bridge inspection)

We developed goals of CD based on the comparison between the current situation in Japan and that in DRR. First, we describe the current situation in Japan, then the goals developed for bridge inspection.

#### 1. Current situation of bridge inspection in Japan

(1) Bridge inspection manual

The Ministry of Land, Infrastructure, Transport and Tourism in Japan has prepared the following two manuals for bridge inspection: “Outline of regular bridge inspection (draft)” and ”Study on the basic survey of a highway bridge conditions.” The former covers highway bridges and mainly discusses about understanding of the damage situation and determination of a category for taking a countermeasure. The document requires an inspection within two years after a bridge is released for public use for the first time, and then within every five years in principle for the second inspection and onwards. This standard is applied for bridges under the control of the national government.

The latter document is proposed as a method to obtain basic information which is considered minimum requirement for understanding the degree of soundness of highway bridges.

There may be other manuals independently developed by road-related companies, prefectural governments and government-decreed cities.

(2) Level of diagnostic ability for concrete structures

There is no public qualification for bridge inspection to be conducted as a professional service. However, it is generally required that the person who conducts bridge inspections has 1) majored in civil engineering at senior high school or college and 2) experienced civil engineering-related work.

## 2. CD goals (Bridge inspection)

Keeping the forgoing situations in mind, we developed goals for bridge inspection as follows. Note that we developed separate goals for engineers and technicians since their level of knowledge and scope of work are different from each other. Also, for easier identification of the attainment level via external observation, we divided technical capacity into knowledge and skills which could be easily checked from external observation.

(1) Bridge inspection manual

In DRR, BRR staff teams take pictures of each bridge once a year and prepare a report for understanding of the bridge condition. In order to make the bridge maintenance and management planning discussed later in this chapter to be effective, it is necessary to utilize a manual whose level is at least equal to the aforementioned "Study on the basic survey of a highway bridge conditions."

In this project, we set the goal that the staff members are able to implement bridge inspections by utilizing a manual developed in line with the real situation in Thailand.

(2) Level of diagnostic ability for concrete structures

DRR has outsourced an inspection and evaluation work to a local consultant as to the large bridge over the Chao Phraya River which runs in the city of Bangkok. However, it seems that DRR has never outsourced any inspection and evaluation work for local bridges, which is likely to be the case continuously in the future.

Therefore, we assume that DRR engineers who will remain in the leading position after the project need to obtain knowledge about changes in bridge conditions. Furthermore, for trainees (engineers) who will be trained in Japan, we also set a goal of obtaining knowledge about bridge repair and reinforcement cases.

On the other hand, for technicians who are directly involved in the bridge inspection work, we set a goal of implementing bridge inspections based on a bridge inspection manual to be developed in this project and recording the inspection results. We set these goals because they are key capacities for implementation of constant bridge inspections even after the conclusion of the project.

The table below is the summary of the goals described in the previous paragraphs.

**Table 3.2-1 CD goals and target groups (Bridge inspection)**

| | Technical capacity | | Core capacity |
|---|---|---|---|
| | Knowledge | Skills | |
| Engineer | (1) Understanding of changes in bridge conditions<br>(2) On-site understanding of damage situations<br>(3)Recognition of the bridge inspection manual | (4) Lead bridge inspection/evaluation based on the manual | (6) Proactive implementation of bridge inspection |
| Technician | (1) Understanding of changes in bridge conditions<br>(3) Recognition of the bridge inspection manual | (5) Conduct bridge inspection/evaluation based on the manual | (6) Proactive implementation of bridge inspection |

### 3.2.2 Goal setting for CD and finalization of target group (Long-term bridge maintenance and management)

We developed CD goals and target groups based on the comparison between the current situation in Japan and that in DRR in terms of bridge maintenance and management.

#### 1. Current situation in Japan

In Japan, actions have been taken to lengthen the life of bridges. Under the circumstance, the necessity of running a countermeasure cycle which contains the following steps based on the result of bridge inspection: diagnosis of bridge conditions; development of a future plan for repair or replacement, etc. for each bridge; acquiring necessary budgets; implementation of the planned bridge replacement and preventive maintenance programs; and understanding about the level of bridge health based on further inspections.

In this countermeasure cycle, a plan which clearly describes a diagnosis of the bridge condition based on the inspection result and a future repair/replacement for each of the existing bridges (Bridge Repair Master Plan for Long-term Use) is developed.

Currently, many local governments are developing their repair master plan for long-term use

along with the progress of their bridge inspections. In order to survey the current situation regarding of the master plan development, the Ministry of Land, Infrastructure, Trade and Tourism conducted a questionnaire survey of local governments which had completed their master plan development. The result of the survey is as follows:

1) More than 90 percent of respondents heard the views of experts at the time of plan development.

2) Approximately 90 percent of respondents used a program, etc. to calculate the cost of bridge repair according to the level of bridge health and the repair locations.

3) More than 70 percent of respondents considered the bridge repair cost and future budget restraints.

As seen in the result, the majority of the local governments considered the bridge repair cost and future budget restraints according to the information on the level of bridge health and damage locations.

## 2. CD goals (Long-term bridge maintenance and management planning)

DRR allocates the budget for bridge maintenance and management in proportion to the length of the bridge. DRR also designs, calculates the cost and implements the repair work after actual damages are identified. These procedures work effectively to a certain extent under the condition of a limited number of available human resources.

However, under the budget restraints, it would be difficult to logically persuade the budget authorities in order to secure necessary budgets unless written documents are prepared which contain the calculation of costs for the necessary repair work in the future as well as a priority list of repair locations. It is not easy, however, to transfer from the current method, where repair costs are calculated after damage identification, to a new method, where such maintenance costs are calculated based on predicted future damages.

In order to achieve the transfer, it is necessary to meet conditions which are employed in most of the local governments in Japan. These conditions are 1) planning based on the level of bridge health and repair locations and 2) consideration of bridge maintenance costs and future budget restraints. To this end, it is effective to develop a simple system to meet these conditions which is operated by DRR in order to secure necessary budgets for bridge maintenance in the future.

We decided to name the above-mentioned system as BMMS (Bridge Maintenance Management System.) This is the name of a bridge maintenance and management system developed by DRR but currently not in use, and thus BRR staff has some familiarity with the name.

(1) Understanding and operation of BMMS

BMMS should have the following four functions:

1) Ledger
2) Input of the inspection result (the level of damage)
3) Identification of priority of repair work
4) Calculation of costs for repair work

With regard to BMMS, we set goals of general understanding of the entire functions and being familiar with the system operation.

The target groups in DRR are the headquarters staff involved in budget planning as part of their work and engineers (C/P).

The above goals are summarized in the table below.

### 3.2-2 CD goals and target groups (Long-term maintenance and management planning)

| | Technical capacity | | Core capacity |
|---|---|---|---|
| | Knowledge | Skills | |
| Engineers (those who are in charge of budget planning and C/P) | (1) Knowledge about preventive maintenance<br>(2) Priority setting of repair work based on the bridge inspection result /understanding of the process up to calculation of repair costs<br>(3) Understanding of the elements which constitute BMMS (e.g. Markov transition probability) | (4) Operation of developed simple BMMS | (5) Transformation of awareness from after-the-fact maintenance to preventive maintenance |

### 3.2.3 Goal setting for CD and finalization of target group (Flood countermeasure)

We developed CD goals and target groups for flood countermeasure according to the comparison between the current situation in Japan and that in DRR.

#### 1. Current situation in Japan

In Japan, we have the following knowledge based on our experiences of storm and flood damages over the years.

Among various bridge column shapes, pile bent piers tend to cause swirling currents. As a result, they often cause abnormal bridge pier scouring at the time of flooding. Pile bent piers also tend to cause impediment of river flow due to driftwood and rubbish from the upstream stuck around the piers. Therefore, use of pile bent piers of more than two lines at right angle to the stream is basically forbidden in Japan since 1980. As of 2012, employment of pile bent piers is restricted under the cabinet order concerning structural standards for river management facilities (Section 1 of Article 62).

Meanwhile, there are cases of soil erosion at the back of the bridge abutment when the bridge abutment is located in the water colliding front or in the river bank, causing negative impacts on surrounding roads and river banks. If a bridge abutment is to be located in such locations, it is necessary to conduct appropriate engineering protections so that such soil erosion will not happen.

(Reference) Specifications for Highway Bridges, Part IV Substructures (May 1980, March 2012)

As to existing pile bent piers, there are cases in Japan where such piers have been strengthened by reinforced concrete jacketing or steel jacketing to improve quake resistance. Since such reinforcement changes the shape of cross-sectional surface of the bridge column, reinforced pile bent piers tend to cause less bridge pier scouring.

#### 2. CD goals (Flood countermeasure)

Generally, local bridges in Thailand have pile bent piers, and their bridge abutments are often located in the river bank. The aforementioned damages have been identified in such bridge columns and around the bridge abutment. For the fundamental solution of the problems of bridge pier scouring and soil erosion, structural changes of bridge columns and abutments would be required. However, it is not practical to conduct such changes in a short to medium term for approximately as many as 8,000 existing bridges. Therefore, it is estimated that these bridges will be replaced with those with more desirable structures in a long run when they need

to be replaced due to aging.

The goal of this sub-project is to implement a series of tasks by DRR staff alone from investigation of the damage locations due to floods to design and implementation of the repair work so that the existing bridges and surrounding roads will have improved resistance in a short to medium term.

The DRR target groups are engineers (C/P) as well as engineers and technicians of BRR 2 who are in charge of the pilot construction.

The following table summarizes the above.

**3.2-3 CD goals and target groups (Flood countermeasure)**

| | Technical capacity | | Core capacity |
|---|---|---|---|
| | Knowledge | Skills | |
| Engineers (C/P and BRR2) | (1) Knowledge of countermeasure<br>(2) Knowledge of summary survey<br>(3) Knowledge of implementation control | (4) Lead summary survey<br>(5) Lead implementation control | (8) Proactive implementation of flood countermeasure |
| Technicians (BRR2) | (2) Knowledge of summary survey<br>(3) Knowledge of implementation control | (6) Implement summary survey<br>(7) Implement implementation control | (8) Proactive implementation of flood countermeasure |

## 3.3 CD results and issues

We observed CD changes by sub-projects described in the previous sections. In this section, we discuss the final results and future issues.

### 3.3.1 CD results and issues (Bridge inspection)

#### 1. Questionnaire survey

We assessed CD of the staff through three questions each for knowledge and experiment used in the questionnaire for CA. The respondents of the questionnaire survey for CD were those who belong to three BRRs (BRR 3, BRR7 and BRR 17) which received multiple seminars and OJT sessions. Note that we chose the target BRRs in consideration of a regional balance (BRR3 represents for the central part, BRR7 for the eastern part, and BRR 17 for the northern part of Thailand).

Questions

(1) Knowledge

Q1. Do you think there is any risk that any bridge collapses?
Q2. Do you think the new bridges that were constructed recently are different from those that were built more than 10 years ago?
Q3 Do you think the bridge deterioration proceeds gradually or abruptly?

Collect answers are as follows: Q1: Yes, Q2: Yes, Q3: Both (gradual and abrupt changes)

The number of respondents

**Table 3.3-1 Affiliation of the respondents (Knowledge of bridge inspection)**

1st seminar

| | Engineer | Technician | Other | Total | Response Date |
|---|---|---|---|---|---|
| BRR3 | 3 | 6 | 1 | 10 | 27/07/2012 |
| BRR7 | 2 | 9 | 4 | 15 | 30/07/2012 |
| BRR17 | 2 | 13 | 0 | 15 | 24/07/2012 |
| Total | 7 | 28 | 5 | 40 | |

2nd seminar

| | Engineer | Technician | Other | Total | Response Date |
|---|---|---|---|---|---|
| BRR3 | 2 | 2 | 1 | 5 | 25/01/2013 |
| BRR7 | 3 | 11 | 1 | 15 | 07/02/2013 |
| BRR17 | 5 | 7 | 0 | 12 | 31/01/2013 |
| Total | 10 | 20 | 2 | 32 | |

Answers

Q1) All of engineers came to recognize the risk of bridge collapse. However, the percentage of the correct answer by technicians went down by approximately 20 percent.

Q2) Percentage of the correct answer (bridges over 10 years old have different conditions compared to those of recently built bridges) slightly increased for both engineers and technicians.

Q3) No significant change was observed as to the speed of bridge deterioration for both engineers and technicians.

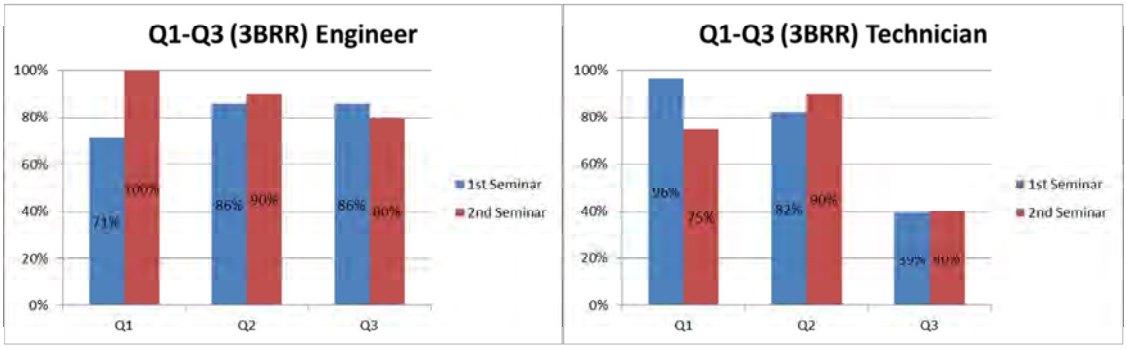



**Figure 3.3-1 Result of Q1-Q3**

Q1. Have you ever seen any damaged road or bridge?
Q2. Have you ever seen any document with records of damaged roads or bridges?
Q3. Have you ever seen any document (manual) that specifies the method of inspection and recording of damaged roads or bridges?
(Response alternatives: Yes for both roads and bridges / Yes for roads only / Yes for bridges only / Not at all for both roads and bridges)

Correct answers for Q1-Q3: “Yes for both roads and bridges” or “Yes for bridges only”

The number of respondents

**Table 3.3-1 Affiliation of the respondents (Experience of bridge inspection)**

1st seminar

| | Engineer | Technician | Other | Total | Response Date |
|---|---|---|---|---|---|
| BRR3 | 3 | 7 | 1 | 11 | 27/07/2012 |
| BRR7 | 2 | 10 | 2 | 14 | 30/07/2012 |
| BRR17 | 1 | 12 | 0 | 13 | 24/07/2012 |
| Total | 6 | 29 | 3 | 38 | |

2nd seminar

| | Engineer | Technician | Other | Total | Response Date |
|---|---|---|---|---|---|
| BRR3 | 2 | 2 | 1 | 5 | 25/01/2013 |
| BRR7 | 3 | 11 | 1 | 15 | 07/02/2013 |
| BRR17 | 5 | 7 | 0 | 12 | 31/01/2013 |
| Total | 10 | 20 | 2 | 32 | |

Answers

Q1) As to the question if they have seen actual damages on site, no change was observed for engineers, but the percentage of the correct answers by technician reached 100 percent.

Q2) Percentage of engineers who have seen documents of inspection results decreased, while that of technicians increased.

Q3) Percentages of respondents who recognize the existence of bridge inspection manuals increased both for engineers and technicians.

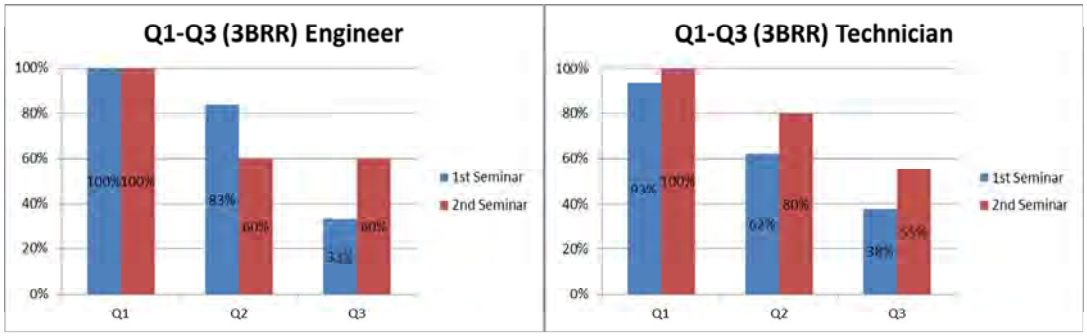



**Figure 3.3-2 Result of Q1-Q3**

(3) Summary

1) As to the risk of bridge collapse, the percentage of the correct answer by engineers increased (from 71 percent to 100 percent,) indicating that all engineers came to recognize the risk of bridge collapse. However, the percentage of the correct answer by technicians went down by

approximately 20 percent (from 96 percent to 75 percent.) Note that the average of eight BRRs at the phase of CA was 88 percent.

2) Both engineers and technicians who answered that bridges over 10 years old have different conditions compared to those of recently built bridges slightly increased, from 86 percent to 90 percent for engineers and from 82 to 90 percent for technicians, respectively.
3) As to the speed of bridge deterioration, the percentage of the correct answer by engineers slightly went down (from 86 percent to 80 percent.) However, the difference was minimal for technicians (from 39 percent to 40 percent.) The average of eight BRRs at the phase of CA was 37 percent, indicating the low rate of correct answer in general.
4) All engineers answer they have seen damages to bridges on site, and no change was observed before and after the survey. This percentage is significantly higher than the average (62 percent) of eight BRRs. The percentage of technicians who have seen damages to bridges on site slightly increased (from 93 percent to 100 percent), which was a desirable outcome because it is effective to observe the state of damages in person in order to understand the content of the bridge inspection manual.
5) The percentage of engineers who have seen documents of inspection results decreased (from 83 percent to 60 percent), while that of technicians increased (from 62 percent to 80 percent.)
6) The percentage of respondents who recognize the existence of bridge inspection manuals increased for both engineers and technicians (from 33 percent to 60 percent and from 38 percent to 55 percent, respectively.) This indicates the success of CD because recognition of the manual is indispensable in order to understand its content.

## 2. Results of interview at workshop

In this project, we developed a program for tablet computers so that DRR staff can conduct bridge inspections more easily by touch inputting the location of the bridge to be inspected as well as the type and degree of damages as instructed under the bridge inspection manual. Tablet computers installed with the program were provided to BRRs, and at that time each BRR was requested to conduct bridge inspections. Approximately two month after distribution of the tablet computers, we held a workshop at two BRRs.

The summary of interviews at the time of workshop is as follows:

- One out of two target BRRs conducted four bridge inspections and the inspection results were satisfactory. We were unable to obtain any inspection record from the other BRR.
- One of the roles of BRRs is to provide technical guidance to local public authorities. Both

BRRs interviewed showed their interest in using the system for providing such guidance.

- Improvement of usability was requested because the time required for input of bridge inspection results into the system was much more than that for the current BRR practice of taking pictures and preparing a report with those pictures.
- On-the-job training regarding bridge inspection was conducted within BRR for staff members of provincial road offices who had been unable to attend seminars and on-the-job training for bridge inspection.

See Chapter 5 for details of the workshop for bridge inspection.

## 3. Summary of CD results and issues (Bridge inspection)

The following table summarizes CD results and issues based on the questionnaire survey and interviews at the time of workshop, etc.

**Table 3.3-3 CD target items (Bridge inspection)**

| | Technical capacity | | Core capacity |
|---|---|---|---|
| | Knowledge | Skills | |
| Engineer | (1) Understanding of changes in bridge conditions<br>(2) On-site understanding of damage situations<br>(3)Recognition of the bridge inspection manual | (4) Lead bridge inspection/evaluation based on the manual | (6) Proactive implementation of bridge inspection |
| Technician | (1) Understanding of changes in bridge conditions<br>(3) Recognition of the bridge inspection manual | (5) Conduct bridge inspection/evaluation based on the manual | (6) Proactive implementation of bridge inspection |

(1) Understanding of changes in bridge conditions

As described in the foregoing paragraphs 1)-3), the percentages of recognition by respondents about the risk of bridge collapse, changes due to aging of the bridge, and the different speeds of changes (gradual/abrupt) have increased in general. However, regarding the different speeds of changes, the awareness level of technicians remained low throughout the phases from CA to the

final of CD, indicating little improvement during the project.

(2) On-site understanding of damage situations

In the phase of CA, the percentage of engineers who have seen bridge damages in person was lower than that of technicians (62 percent for engineers and 96 percent for technicians.) However, we were unable to observe changes in the CD survey because all engineers in the sample three BRRs we chose in consideration of a regional balance have seen bridge damages on site before and after the survey. However, we were able to identify improvement for technicians because the percentage of those who have seen damages on site increased to reach 100 percent in the end.

(3) Recognition of the bridge inspection manual

Both percentages of engineers and technicians who recognize the existence of bridge inspection manuals increased.

(4) Lead bridge inspection/assessment based on the manual

Based on the interview conducted at the workshop, the BRR which conducted bridge inspections and submitted the inspection records have provided guidance, indicating a clear change from the previous practice.

(5) Conduct bridge inspection/evaluation based on the manual

Based on the interview conducted at the workshop, bridge inspections were conducted. As mentioned before, we checked the record of the inspections as well.

(6) Proactive implementation of bridge inspection

At the time of workshop, a specific request for improvement of bridge inspection using tablet PCs was made during the interviews with two BRRs. We assume such a request could not have been made by BRR staff without their actual usage of the tablet PC. Both BRRs also showed their interest in providing technical guidance of bridge inspection to local public authorities in their region.

We consider these are the signs of proactive implementation of bridge inspection.

### 3.3.2 CD results and issues (Long-term bridge maintenance and management)

#### 1. Questionnaire survey

We conducted a questionnaire survey on bridge maintenance and management before holding a seminar.

Date: February 20, 2013

Venue: Conference room 3, Headquarters

The number of respondents: nine engineers (See below for their affiliations. All of the respondents are engineers.)

**Table 3.3-4 Affiliation of the respondents**

| Organization | Number of respondent |
|---|---|
| Bureau of Testing Research and Development | 1 |
| Bureau of Road Maintenance | 2 |
| Bureau of Bridge Construction | 1 |
| BRR5 | 1 |
| BRR8 | 1 |
| BRR12 | 1 |
| BRR13 | 1 |
| BRR17 | 1 |
| Total | 9 |

(1) Questions

Q1. Did you understand the concept and necessity of long-term bridge maintenance and management planning?

Q2. Did you understand that it is effective to use bridge inspection results and bridge data book in your long-term bridge maintenance and management plan?

Q3. Apart from the current budget plan for bridge maintenance and management, do you find the long-term bridge maintenance and management planning manual introduced in this project effective?

Q4. (A question regarding the appearance of the manual; see Chapter 6)

Q5. Did you understand how to use the software for developing a long-term bridge maintenance and management plan?

Q6. Did you understand the simulation for developing a long-term bridge maintenance and management plan?

Q7. Please provide your comments regarding the software for developing a long-term bridge maintenance and management plan.

(2) Answers

Q1) The majority of respondents answered they understood the concept and necessity of long-term bridge maintenance and management planning. One person who made a negative answer did not specify the reason. The person belongs to Bureau of Road Maintenance.

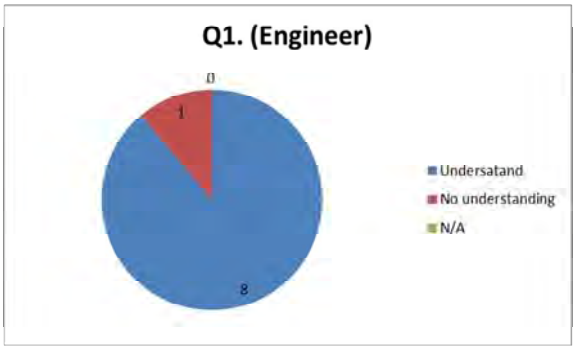



**Figure 3.3-3 Result of Q1**

Q2) Many of respondents answered they understood the effectiveness of using bridge inspection results and bridge data book in their long-term bridge maintenance and management plan. One person who made a negative answer belongs to BRR and one person who did not answer the question belongs to Bureau of Road Maintenance. Both did not provide the reason in detail.

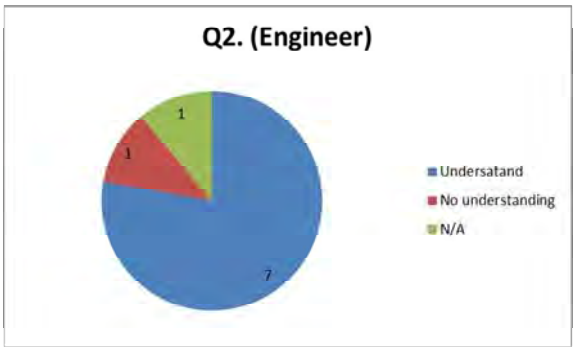



**Figure 3.3-4 Result of Q2**

Q3) Many of respondents answered they found the long-term bridge maintenance and management planning manual effective apart from the current budget plan for bridge maintenance/management. Two persons who did not answer the question belong to BRR and Bureau of Road Maintenance. The person from BRR did not provide any reason, but the person from Bureau of Road Maintenance mentioned that he would not answer the question because it would take time to learn the content.

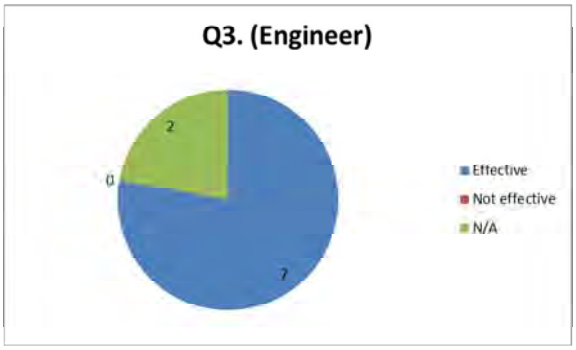



**Figure 3.3-5 Result of Q3**

Q5) Many of respondents answered they understood how to use the software for developing a long-term bridge maintenance and management plan. One person who made a negative answer belongs to Bureau of Road Maintenance and indicated there was not enough time to understand the content. One person who did not answer the question also belongs to Bureau of Road Maintenance and mentioned that more time was necessary.

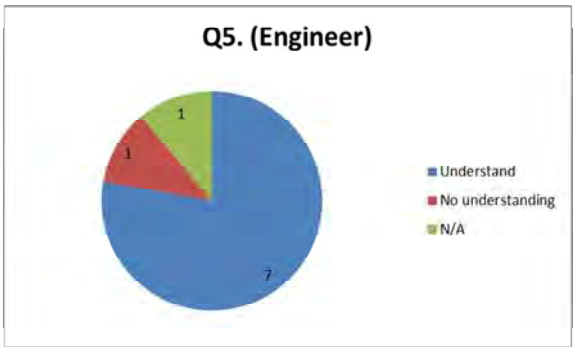



**Figure 3.3-6 Result of Q5**

Q6) More than half of respondents understood the simulation for developing a long-term bridge maintenance and management plan. All of those who made a negative answer belong to BRR, and provided reasons such as difficulty of calculation as well as unclear explanation of how to use the calculation result in a decision making process.

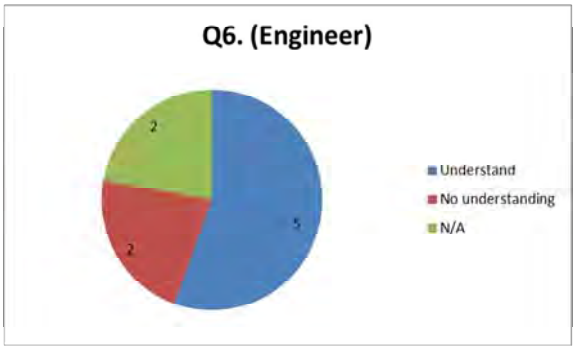



**Figure 3.3-7 Result of Q6**

Q7) Six respondents provided comments about the software for developing a long-term bridge maintenance and management plan. They are listed below:

- Data collection via tablet PC works well and it is easy to use.
- Further training in actual situations is necessary for better understanding of the software.
- The explanation was sufficient for understanding of the outline.
- The software is effective for developing a specific bridge maintenance and management plan.
- I feel it is not difficult to understand the software, so it could be used in the actual operation if there is any opportunity.
- It should be integrated to the system operated by Bureau of Road Maintenance.
- The time spent for explanation was too short. Much more training is necessary.

Three respondents did not answer the question (two belong to Bureau of Road Maintenance and one belongs to BRR.) One person from Bureau of Road Maintenance indicated that more learning would be necessary. The others did not make any comment.

Q8) All respondents but one answered they understood the relationship between the maintenance/management cost and bridge safety. The person who made a negative answer belongs to Bureau of Road Maintenance, and did not specify the reason.

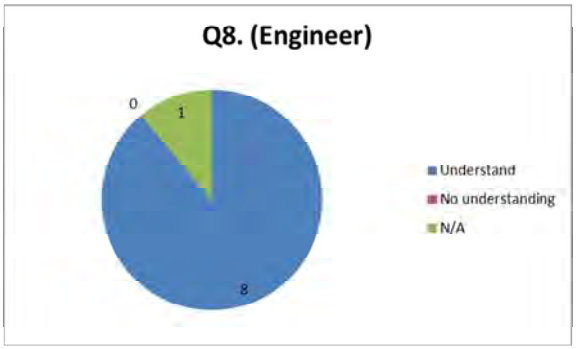



**Figure 3.3-8 Result of Q8**

(3) Summary

The concept of long-term bridge maintenance and management planning is generally understood, but understanding of the software for planning and how to conduct a simulation based on the software did not reach a satisfactory level. Multiple respondents mentioned about necessity of training about usage of the software. Meanwhile, it can be concluded that the relationship between the maintenance/management cost and bridge safety is generally understood by the respondents.

## 2. Summary of CD results and issues (Long-term bridge maintenance and management planning)

**Table 3.3-5 CD target items (Long-term bridge maintenance and management planning)**

| | Technical capacity | | Core capacity |
|---|---|---|---|
| | Knowledge | Skills | |
| Engineers (those who are in charge of budget planning and C/P) | (1) Knowledge about preventive maintenance<br>(2) Priority setting of repair work based on the bridge inspection result /understanding of the process up to calculation of repair costs<br>(3) Understanding of the elements which constitute BMMS (e.g. Markov transition probability) | (4) Operation of developed simple BMMS | (5) Transformation of awareness from after-the-fact maintenance to preventive maintenance |

As to CD results and issues, we made the following observations based on the mentioned questionnaire records.

(1) Knowledge about preventive maintenance

We conclude that the concept of preventive maintenance is well understood.

(2) Priority setting of repair work based on the bridge inspection result/understanding of the process up to calculation of the repair costs

Although the concept of the procedures seems to be understood, further training is necessary to understand specific procedures. Therefore we carried out the practice on specific procedure at the training in Japan. As the results of the practice, we conclude that all trainees including the staff of Bureau of Road Maintenance could manage the procedure successfully.

(3) Understanding of the elements which constitute BMMS (e.g. Markov transition probability)

Elements of BMMS seem to be understood to a certain extent. Some respondents expressed their wish to understand the process of Markov transition better through manual calculations.

(4) Operation of developed simple BMMS

Understanding of BMMS operation has not reached a sufficient level. However we gave them practices at training in Japan. After the training for the operation, we could conclude that they can enhance the capacity for operation up to practical level.

(5) Transformation from after-the-fact maintenance to preventive maintenance

Although we expect preventive maintenance will be well utilized once it is in place, there is no sign of strong intention for the transformation.

### 3.3.3 CD results and issues (Flood countermeasure)

## 1. Questionnaire survey

(1) Collection of comments regarding seminar on flood countermeasure

The survey respondents were requested to provide their opinions mainly about the content of the seminar at the end of the seminar on flood countermeasure.

Date: May 15, 2012

Venue: Provincial Office of Rural Road No.2 (Lopburi)

The number of respondents: 13 people (See the following table for their associations and type of work such as engineer and technician.

**Table 3.3-6 Affiliation of the respondents**

| | HQ | BRR2 | BRR8 | PO (Lopburi) | N/A |
|---|---|---|---|---|---|
| **Engineer** | 3 | 1 | 1 | 1 | |
| **Technician** | | | | 1 | 4 |
| **N/A** | | | | 1 | 1 |

1) Questions

Q4-1 Are you satisfied with today's seminar and technical advices you received?
Q4-2 If you are not satisfied, please list the point(s) you are not satisfied.
Q4-3 If you are not satisfied today, what kind of seminar or technical advices would you like to receive in the future?

2) Answers

Q4-1) One engineer answered he was not satisfied with the seminar on flood countermeasure.

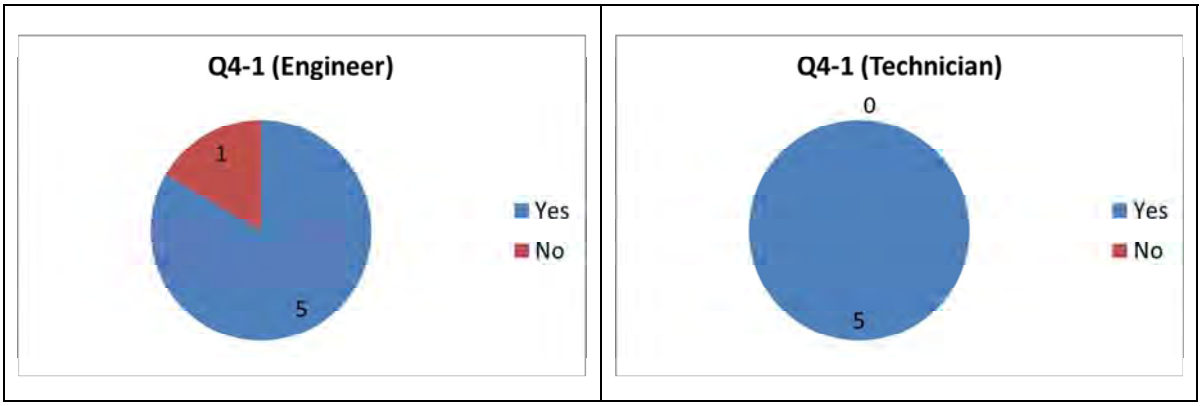



**Figure 3.3-9 Result of Q4-1**

Q4-2) The engineer who answered he was not satisfied with the seminar reported the content of the document for explanation was not clear and the amount of the document was not enough. There was no other comment.

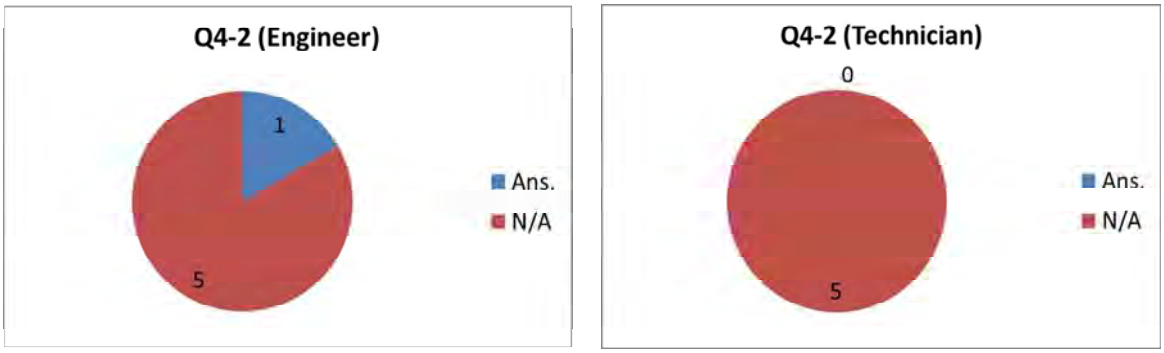



**Figure 3.3-10 Result of Q4-2**

Q4-3) Engineers provided the following comments: the duration time of the seminar was appropriate; more figures and pictures would be desirable; and manuals written in Thai would be easy to understand and could be used directly on site. In contrast, there was a comment from a technician that the seminar content should be improved so that it would be easier to understand. The engineer who answered the seminar was unsatisfactory in Q4-1 did not answer this question.

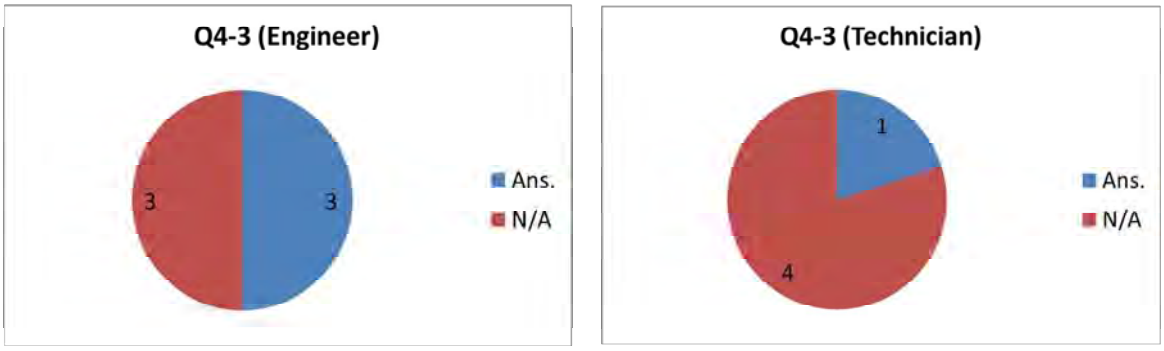



**Figure 3.3-11 Result of Q4-3**

3) Summary

In general, the seminar was well received by the participants. In future seminars, it seems to be necessary to use a manual written in Thai and to include a lot of figures and pictures in it for better understanding of the participants.

(2) Summary survey

We held a seminar and OJT sessions on summary survey during the three-day period from May

15 to May 17.

Please see Chapter 8 for details. Below are the questions and their answers provided to and from the participants at the end of the OJT session of the day.

1) Questions

Q1-1 Do you wish to use the summary survey method for other bridges?
Q1-2 Was today's training difficult for you?

2) Affiliation of the respondents

Following table shows affiliation of the participants regarding the three-day seminar.

**Table 3.3-7 Affiliation of the respondents**

May 15, 2012

| | Engineer | Technician | Other | N/A | Total |
|---|---|---|---|---|---|
| HQ | 1 | | | 1 | 2 |
| BRR2 | 1 | | | 1 | 2 |
| BRR8 | 1 | | | 1 | 2 |
| P.O.(Lopburi) | | 2 | | 1 | 3 |
| N/A | | | | 2 | 2 |
| Total | 3 | 2 | | 6 | 11 |

May 16, 2012

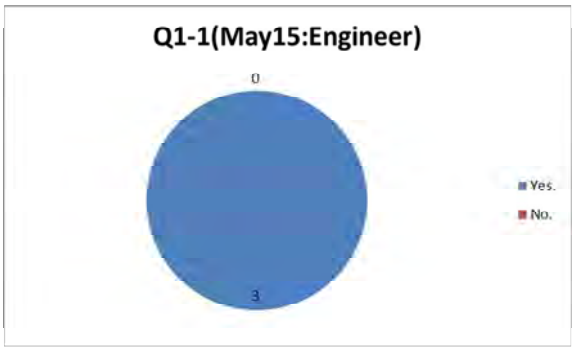
| | Engineer | Technician | Other | N/A | Total |
|---|---|---|---|---|---|
| HQ | 2 | | | 3 | 5 |
| BRR2 | | | | 1 | 1 |
| BRR8 | | | | | |
| P.O.(Lopburi) | | 3 | | | 3 |
| P.O.(Singburi) | | 1 | | | 1 |
| P.O.(Saraburi) | | 1 | | | 1 |
| P.O.(Chainat) | | 1 | | 1 | 2 |
| N/A | | | | | |
| Total | 2 | 6 | | 5 | 13 |

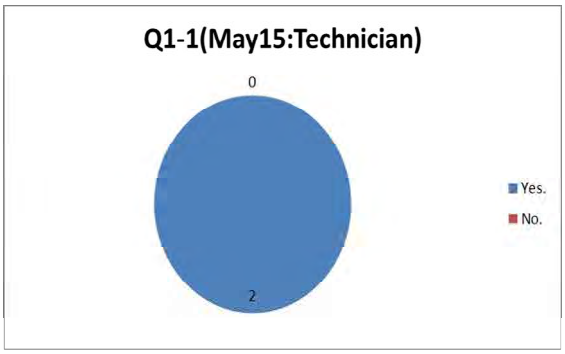
May 17, 2012

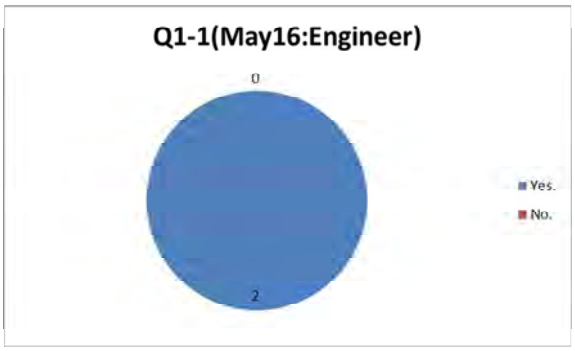
| | Engineer | Technician | Other | N/A | Total |
|---|---|---|---|---|---|
| HQ | 1 | | | 3 | 4 |
| BRR2 | 1 | | | | 1 |
| BRR8 | | | | | |
| P.O.(Lopburi) | | 3 | | 3 | 6 |
| P.O.(Singburi) | | | | | 0 |
| P.O.(Saraburi) | | | | | 0 |
| P.O.(Chainat) | | | | | 0 |
| N/A | | | 2 | | 2 |
| Total | 2 | 3 | 2 | 6 | 13 |

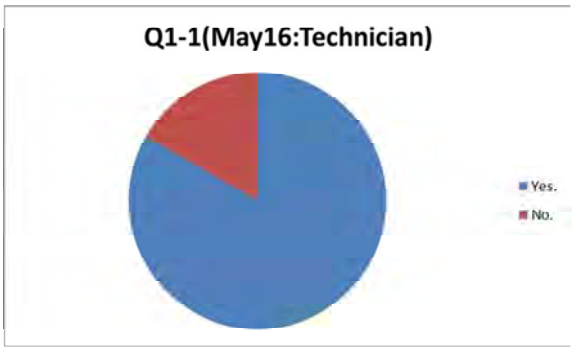
3) Answers

Q1-1) All but one of the participants answer they want to use the method for other bridges.



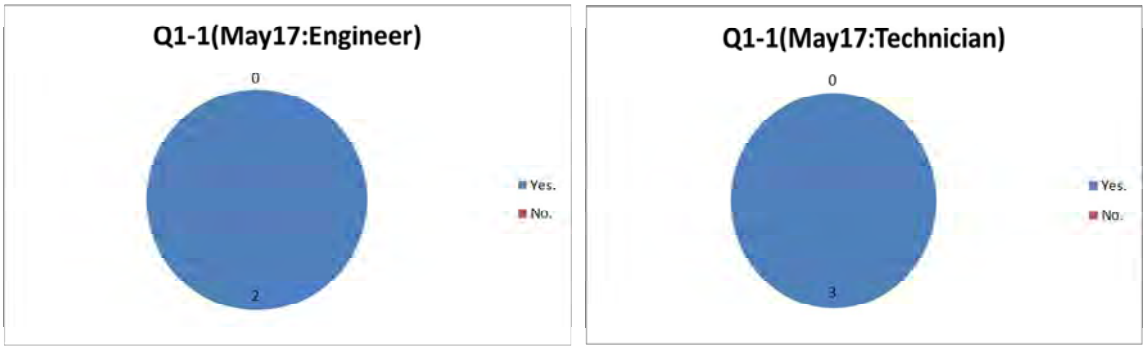
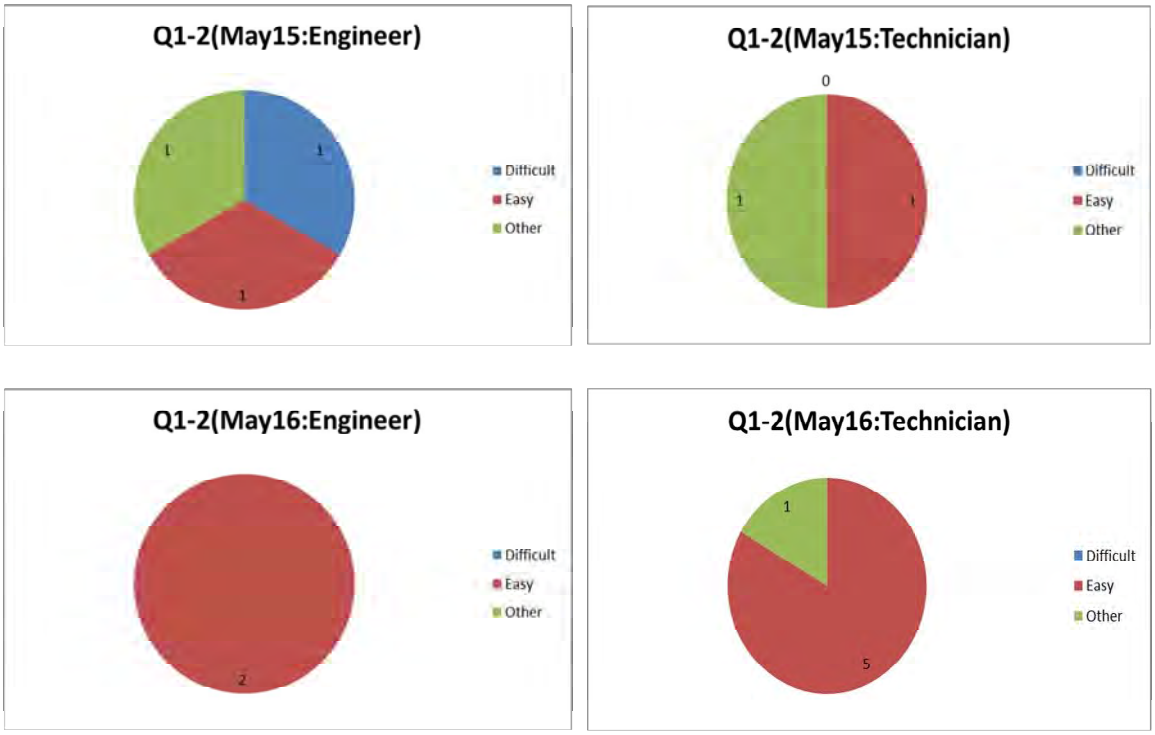



**Figure 3.3-12 Result of Q1-1**

Q1-2) All but one of the participants answer the training was not difficult. Another technician answers that the training was neither difficult nor easy.



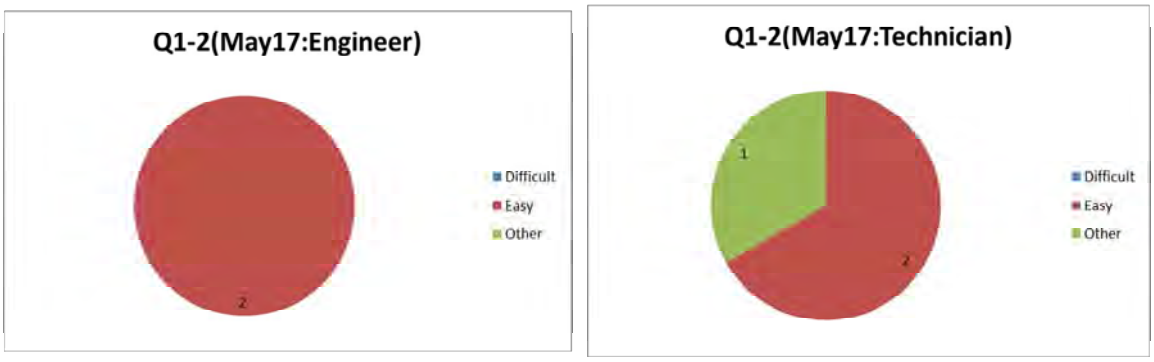



**Figure 3.3-13 Result of Q1-2**

4) Summary

Among those who answered they want to use the summary survey method introduced in the seminar/OJT to other bridges, four participants each day answered with specific bridges and routes where the bridges are located.

Below is the list of reasons provided by those who answered the summary survey is difficult:

- In the summary survey, acceptable error range is quite large and it takes time. This method should be used only for preliminary surveys. Altitude and topographic surveys should also be conducted.
- There is no bridge in Singburi which has been damaged by a flood.

Below is the list of reasons why the seminar was difficult:

- A damage survey may not be conducted appropriately unless obtaining the knowledge.
- A survey method with low accuracy may need to be conducted repeatedly in order to obtain a sufficient result to be used for repair designing.

Generally, the concept of summary survey is easy to understand. In fact, after the OJT sessions, it was able to be conducted by DRR staff themselves. On the other hand, some participants expressed a concern about accuracy of the summary survey. Therefore, it is necessary to articulate how topographic data obtained in summary surveys are utilized in repair designing.

(3) Pilot project

Date: February 21, 2013

Venue: Provincial Office of Rural Road No.2 (Lopburi)

1) Questions

Q1 Did you understand the concept and necessity of flood countermeasure employed in the pilot project?
Q2 Did you understand the design diagram and implementation steps of the pilot project?
Q3 Do you think the flood countermeasure quick manual is useful for assessment of damages by floods, construction for flood countermeasure and calculation of the construction cost?

We asked participants of the meeting the above three questions with regard to discussions about the pilot project and the quick manual. Please see Chapter 8 for the contents of the pilot project and the quick manual.

2) Affiliation of the respondents

Affiliation of the respondents was as follows.

**Table 3.3-8 Affiliation of the respondents**

| | Engineer | Technician | N/A | Total |
|---|---|---|---|---|
| HQ | 1 | | | 1 |
| BRR2 | 2 | 2 | | 4 |
| P.O.(Lopburi) | 1 | | | 1 |
| N/A | | | 1 | 1 |
| Total | 4 | 2 | 1 | 7 |

3) Answers

Q1) Except for one person who did not answer the question, all respondents answered that they understood the concept and necessity of flood countermeasure.

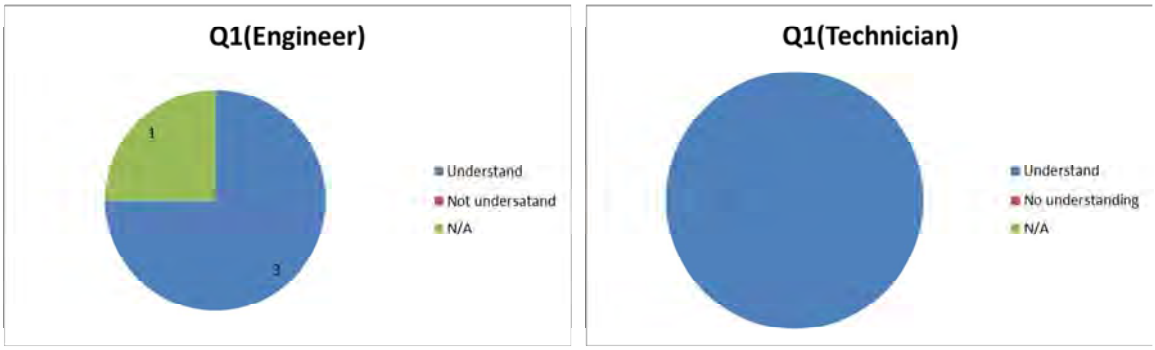



**Figure 3.3-14 Result of Q1**

Q2) Except for one person who did not answer the question, and another person who answered

that he would provide his answer later, all respondents answered that they understood the design diagram and implementation steps of the pilot project.

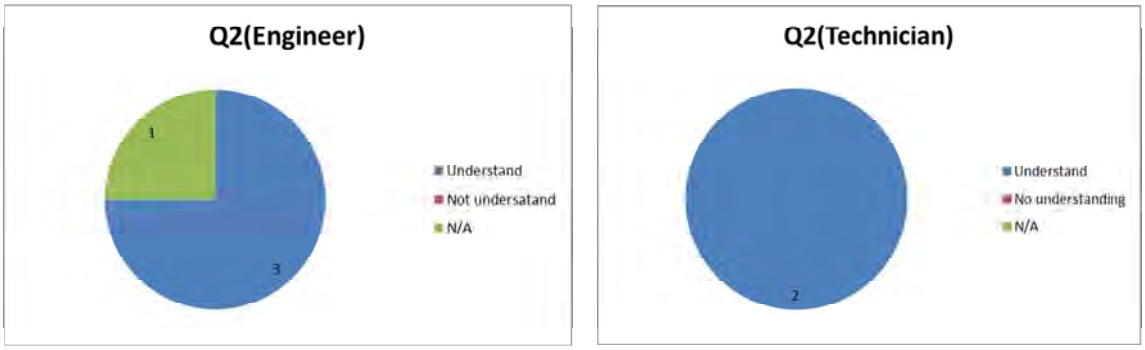



**Figure 3.3-15 Result of Q2**

Q3) Except for two respondents who did not answer the question, all answered that the flood countermeasure quick manual is useful for assessment of damages by floods, construction for flood countermeasure and calculation of the construction cost.

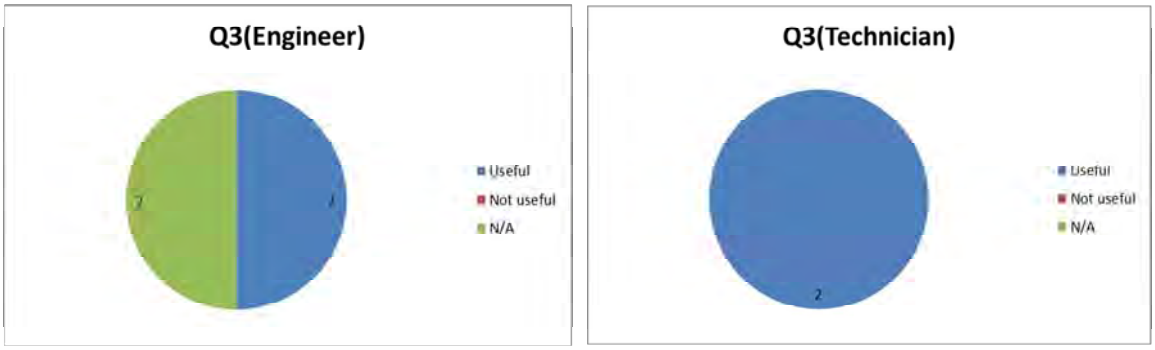



**Figure 3.3-16 Result of Q3**

(4) Discussion

1) As to Q1, respondents reported that the concept of flood countermeasure is necessary for securing safety of bridge users, efficient budget implementation, prevention of bridge pier scouring, restoration of bridge functions to the original state, etc.
2) For Q2, the following two comments were made:
   - Implementation procedures and applicable techniques vary depending on the construction site.
   - It is easy to understand the implementation procedures. However, the type and shape of the materials are unclear.

3) For Q3, the following two comments were made:
   - The flood countermeasure quick manual could be applied to other projects.
   - It is useful for investigation of major damages and assessment of the cause of damages.

Based on the above observations, it is possible to conclude that the participants generally obtained understanding about the significance of taking the flood countermeasure as well as the design diagram and the implementation step chart for the pilot project.

## 2. Summary of CD results and issues (Flood countermeasure)

**Table 3.3-9 CD target items (Flood countermeasure)**

| | Technical capacity | | Core capacity |
|---|---|---|---|
| | Knowledge | Skills | |
| Engineers (C/P, BRR2 and BRR 8) | (1) Knowledge of countermeasure<br>(2) Knowledge of summary survey<br>(3) Knowledge of implementation control | (4) Lead summary survey<br>(5)Lead implementation control | (8) Proactive implementation of flood countermeasure |
| Technicians (BRR2 and BRR 8) | (2) Knowledge of summary survey<br>(3) Knowledge of implementation control | (6) Implement summary survey<br>(7) Implement implementation control | (8) Proactive implementation of flood countermeasure |

As to CD results and issues, we made the following observations based on the mentioned questioner records and behavior observation.

(1) Knowledge of countermeasure

We conclude that participants are gradually gaining the knowledge since the phase of the manual development.

(2) Knowledge of summary survey

We conclude that participants have knowledge about how to conduct the summary survey according to the practical training (to be mentioned later). We also made the above conclusion because the engineers provided guidance to the intern students (university students) who were on the educational practical training at DRR and prepared a VCR about the procedures of the summary survey during the OJT on summary survey, and also because the engineers prepared a draft of the section about summary survey which was included at the beginning of the aforementioned manual.

(3) Knowledge of implementation control

Judging from the conversations in Q and A session of seminars held during the pilot project period, we could observe that their knowledge regarding this field progressed up to practical level.

(4) Lead summary survey

Engineers provided guidance to technicians and summary survey was conducted during the

OJT sessions.

(5) Lead implementation control

During the pilot project period, we confirmed that supervisors of the BRR could instruct subordinates in proper manner by behavior observation.

(6) Implement summary survey

A summary survey was conducted to two bridges through guidance of engineers and support of technicians.

(7) Implement implementation control

During the pilot project period, we confirmed that they could instruct contractors in proper manner by behavior observation.

(8) Proactive implementation of flood countermeasure

During the OJT sessions on summary survey, participants were asked if they would like to utilize the method employed in the project. Multiple participants responded yes to the question by referring to specific bridges and routes.

As to the pilot project, DRR conducted a detailed survey, and JST developed a detailed design diagram and construction volume chart based on the survey. Then DRR conducted a calculation based on these JST documents and ordered the construction.

Based on the above observation, we conclude that they have a proactive attitude to take flood countermeasure.

## 3.4 Organizational change

For DRR to use the successful results from the aforementioned sub-projects in a systematic manner, it is necessary to make sure that all staff members in DRR recognize the manuals.

DRR has a system that applicable standards can be downloaded from its homepage. However, mere existence of standards in the homepage does not necessarily mean they are actually used. Therefore we have conducted seminars and OJT sessions at BRRs.

By the end of the current project, we made further efforts through training in Japan and workshops so that the percentage of recognition about the manuals was expanded in the organization.

For these activities, director of road maintenance mentioned that the results of this project was useful for us and used them after the end of this project.

## 3.5 Various Educational Activities for CD

In this project, various educational activities have been carried out to improve capacity of DRR's staff on bridge inspection, long-term maintenance planning, and flood countermeasures. See appropriate chapters to receive more details of each seminar, OJT, workshop and other conferences.

**Table 3.5-1 Summary of educational activities**

| Subject | Activity type | Number of times | Gross number of participants |
|---|---|---|---|
| Bridge inspection | Seminar | 13 | 226 |
| | OJT | 17 | 249 * |
| Long-term maintenance planning | Seminar | 8 | 156 |
| | OJT | 1 | 21 |
| | International conference | 1 | 60 |
| Flood countermeasures | Seminar | 7 | 87 |
| | OJT | 4 | 47 |
| Bridge planning | International conference | 1 | 60 |
| | Project meeting | 1 | 200 |
| Bridge inspection /Long-term maintenance planning / Flood countermeasures | Training in Japan | 1 | 5 |
| Bridge inspection / Long-term maintenance planning / Flood countermeasures | Workshop | 6 | 287 |
| Total | Seminar | 28 | 469 |
| | OJT | 22 | 317 |
| | Workshop | 6 | 287 |
| | Training in Japan | 1 | 5 |
| | International conference | 2 | 120 |
| | Project meeting | 1 | 200 |

※ 27 bridges have been inspected.

### 3.5.1 Seminar / OJT

Lecture and Q & A session have been provided by JST in the form of seminar. Practical training and OJT have also been conducted as needed basis.

**1) Bridge inspection**

**Table 3.5-2 Educational activity summary on bridge inspection**

| No | Date | Venue | Participants | Contents |
|---|---|---|---|---|
| 1 | May 22, 2012 | BRR2 | 15 | -Explanation / Q & A session on bridge inspection and the evaluation manual (Draft Ver.1) |
| 2 | July 24, 2012 | BRR17 | 15 | -Explanation about basic knowledge of bridge structures and bridge inspection<br>-Explanation / Q & A session on bridge inspection and the evaluation manual (Draft Ver.3)<br>-OJT for bridge inspection (One bridge) |
| 3 | July 27, 2012 | BRR3 | 16 | -Explanation about basic knowledge of bridge structures and bridge inspection<br>-Explanation / Q & A session on bridge inspection and the evaluation manual (Draft Ver.3)<br>-OJT for bridge inspection (One bridge) |
| 4 | July 30, 2012 | BRR7 | 25 | -Explanation about basic knowledge of bridge structures and bridge inspection<br>-Explanation / Q & A session on bridge inspection and the evaluation manual (Draft Ver.3)<br>-OJT for bridge inspection (Two bridges) |
| 5 | Dec. 7, 2012 | HQ | 7 | -Explanation / Q & A session on bridge inspection, the evaluation manual (Draft Ver.4) and input format of inspection record<br>-OJT for bridge inspection (One bridge) |
| 6 | Dec. 13, 2012 | BRR13 | 14 | -Explanation / Q & A session on bridge inspection, the evaluation manual (Draft |

| | | | | |
|---|---|---|---|---|
| | | | | Ver.4) and input format of inspection record<br>-OJT on bridge inspection (One bridge) |
| 7 | Dec. 14, 2012 | BRR13 | 10 | -OJT on bridge inspection (One bridge)<br>-Explanation / Q & A session on inspection result checking and creation means of recording form for inspection result |
| 8 | Dec. 17, 2012 | BRR8 | 19 | -Explanation / Q & A session on bridge inspection, the evaluation manual (Draft Ver.4) and input format of inspection record<br>-OJT on bridge inspection (One bridge) |
| 9 | Dec. 18, 2012 | BRR8 | 15 | -OJT on bridge inspection (One bridge)<br>-Explanation / Q & A session on inspection result checking and creation means of recording form for inspection result |
| 10 | Jan. 24, 2013 | BRR3 | 17 | -Explanation / Q & A session on bridge inspection, the evaluation manual (Draft Ver.4) and input format of inspection record<br>-OJT on bridge inspection (One bridge) |
| 11 | Jan. 25, 2013 | BRR3 | 11 | -OJT on bridge inspection (Two bridges)<br>-Explanation / Q & A session on inspection result checking and creation means of recording form for inspection result |
| 12 | Jan. 28, 2013 | BRR5 | 22 | -Explanation, Q & A session and practical training on bridge inspection, the evaluation manual (Draft Ver.4) and input format of inspection record |
| 13 | Jan. 29, 2013 | BRR5 | 17 | -OJT on bridge inspection (One bridge)<br>-Explanation / Q & A session on inspection result checking and creation means of recording form for inspection result |
| 14 | Jan. 31, 2013 | BRR17 | 16 | -Explanation, Q & A session and practical training on bridge inspection, the evaluation manual (Draft Ver.4) and input format of |

| | | | | |
|---|---|---|---|---|
| | | | | inspection record |
| 15 | Feb. 1, 2013 | BRR17 | 16 | -OJT on bridge inspection (Five bridges)<br>-Explanation / Q & A session on inspection result checking and creation means of recording form for inspection result |
| 16 | Feb. 7, 2013 | BRR7 | 20 | -Explanation / Q & A session and practical training on bridge inspection and the evaluation manual (Draft Ver.4)<br>-Explanation / Q & A session on creation means of recording form for inspection result<br>-OJT on bridge inspection (One bridge)<br>-Inspection result checking |
| 17 | Feb. 8, 2013 | BRR7 | 5 | -OJT on bridge inspection (One bridge)<br>-Inspection result checking |
| 18 | Feb. 14, 2013 | BRR11 | 21 | -Explanation / Q & A session and practical training on bridge inspection and the evaluation manual (Draft Ver.4)<br>-Explanation / Q & A session on creation means of recording form for inspection result<br>-OJT on bridge inspection (Three bridges) |
| 19 | Feb. 15, 2013 | BRR11 | 2 | -OJT on bridge inspection (Two bridges)<br>-Inspection result checking |
| 20 | Apr.29, 2013 | BRR10 | 19 | -Explanation / Q & A session and practical training on bridge inspection and the evaluation manual (Draft Ver.4)<br>-Explanation / Q & A session on creation means of recording form for inspection result<br>-OJT on bridge inspection (Two bridges) |
| Total | Seminar | 13 times | 226 | |

| | | | | |
|---|---|---|---|---|
| | OJT | 17 times | 249 | 27 bridges have been inspected. |

**2) Long-term maintenance planning**

**Table 3.5-3 Educational activity summary on Long-term maintenance planning**

| No | Date | Venue | Participants | Contents |
|---|---|---|---|---|
| 1 | Jan. 30, 2012 | HQ | 6 | -Explanation about long-term maintenance planning policy |
| 2 | Dec. 13, 2012 | BRR13 | 14 | -Outline of long-term maintenance planning and systems (BMMS) for the planning |
| 3 | Dec. 17, 2012 | BRR8 | 19 | -Outline of long-term maintenance planning and systems (BMMS) for the planning |
| 4 | Jan. 24, 2013 | BRR3 | 17 | -Outline of long-term maintenance planning and systems (BMMS) for the planning |
| 5 | Jan. 28, 2013 | BRR5 | 22 | -Outline of long-term maintenance planning and systems (BMMS) for the planning |
| 6 | Jan. 31, 2013 | BRR17 | 16 | -Outline of long-term maintenance planning and systems (BMMS) for the planning |
| 7 | Feb. 7, 2013 | BRR7 | 20 | -Outline of long-term maintenance planning and systems (BMMS) for the planning |
| 8 | Feb. 14, 2013 | BRR11 | 21 | -Outline of long-term maintenance planning and systems (BMMS) for the planning |
| 9 | Feb. 20, 2013 | HQ | 21 | -Explanation about long-term maintenance planning<br>-Practical training on budget simulation software |
| Total | Seminar | 8 times | 156 | |
| | OJT | 1 time | 21 | |

**3) Flood countermeasures**

**Table 3.5-4 Educational activity summaries on flood countermeasures**

| No | Date | Venue | Participants | Contents |
|---|---|---|---|---|
| 1 | May 15, 2012 | BRR2 | 13 | -Explanation and Q & A session on flood countermeasures (field work)<br>-On-site OJT of a fast measurement for flood damage checking |
| 2 | May 16, 2012 | BRR2 | 13 | -On-site OJT of a fast measurement for flood damage checking |
| 3 | May 17, 2012 | BRR2 | 13 | -On-site OJT of a fast measurement for flood damage checking |
| 4 | May 18, 2012 | Kanchanaburi | 8 | -OJT and advices on construction work of embankment around a newly built bridge |
| 5 | May 22, 2012 | BRR2 | 20 | -Seminar on flood countermeasures<br>-Discussion on selecting a pilot bridge |
| 6 | July 25, 2012 | BRR2 | 14 | -Explanation and Q & A session on the draft of flood countermeasure manual |
| 7 | Feb. 18, 2013 | BRR2 | 8 | -Explanation about the quick manual of flood countermeasures<br>- Q & A session on an order placement of pilot project and its estimation status |
| 8 | Feb. 21, 2013 | BRR2 | 6 | -Explanation about the quick manual of flood countermeasures<br>- Q & A session on an order placement of pilot project and its estimation status |
| 9 | Jun. 12, 2013 | BRR2 | 8 | -Explanation about the construction supervision on gabion |
| 10 | Jun.19, 2013 | BRR2 | 18 | -Explanation about the construction supervision on gabion<br>-Explanation about the quick manual of flood countermeasures |
| Total | Seminar | 7 times | 87 | |

| | | | | |
|---|---|---|---|---|
| | OJT | 4 times | 47 | |

### 3.5.2 Workshop

Achievement report and discussion have been carried out by DRR in the form of workshop.

Lectures and Q & A session have also been provided by JST as needed basis.

**Table 3.5-5 Activity summary at the workshops**

| No | Date | Venue | Participants | Contents |
|---|---|---|---|---|
| 1 | Feb. 11, 2013 | BRR8 | 20 | - Achievement report of the bridge inspection by DRR staff<br>- Opinion exchange and Q & A session |
| 2 | Feb. 18, 2013 | BRR13 | 5 | Same as above |
| 3 | Apr. 24, 2013 | BRR13 | 7 | Same as above |
| 4 | Apr. 25, 2013 | BRR5 | 11 | Same as above |
| 5 | Apr. 26, 2013 | BRR8 | 11 | Same as above |
| 6 | Jun. 24, 2013 | HQ (satellite broadcasting | 233 | - Explanation, drilling and Q and A session regarding the following subjects<br>- Bridge inspection and evaluation<br>- Record by using Tablet PC<br>- Long-term maintenance<br>- Flood countermeasures<br>- Results of the training in Japan and application to daily activities |
| Total | | | 287 | |

### 3.5.3 Training in Japan

The Training in Japan was conducted from May 20 to 25 (six days), inviting five trainees. This training focused on the importance of grasping the present situation of structures, through on-site OJT, by direct visual examination and hammering examination with the aim of bridge maintenance. In addition, lecture and practical work on repair, reinforcing material, and construction method for concrete were also provided since the most regional bridges of DRR are concrete bridge. Training on countermeasures for scouring and erosion of bridges and their surrounding areas (flood countermeasures) was added because these are predominant reasons of bridge damages observed in the rural area of Thailand. Table 3.5-6 shows the affiliation of the trainees participated in the said training in Japan.

**Table 3.5-6 Affiliation of the trainees**

| No. | Position | Organization |
|---|---|---|
| 1 | Civil Engineer (Senior Professional Level) | Bureau of Rural Roads 7 |
| 2 | Civil Engineer (Professional Level) | Bureau of Rural Roads 12 |
| 3 | Civil Engineer (Professional Level) | Bureau of Rural Roads 17 |
| 4 | Civil Engineer (Practitioner Level) | Bureau of Road Maintenance |
| 5 | Civil Engineer (Practitioner Level) | Bureau of Rural Roads 3 |

Table 3.5-7 describes the dates, venues and contents of the training in Japan.

**Table 3.5-7 Summary of the training in Japan**

| No | Date | Venue | Contents | Syllabus |
|---|---|---|---|---|
| 1 | May 20, 2013 | JICA Tokyo | Bridge inspection / Non-destructive inspection | ※ Presentation of actual highway bridge inspections in urban area<br>※ Explanation about characteristics and relationship of visual examination from distance, direct visual examination, hammering examination and various non-destructive examinations |
| 2 | May 20, 2013 | Metropolitan | Bridge | ※ Practical training on visual |

| | | | | |
|---|---|---|---|---|
| | | Expressway (on site) | inspection / Non-destructive inspection | examination from distance, direct visual examination, hammering examination and non-destructive examinations using an actual bridge<br>※ Practical training on the process from direct visual examination to input of inspection results into a tablet PC |
| 3 | May 21, 2013 | Nichireki | Waterproofing for floorboard / Pavement of the bridge surface | ・ Explanation about waterproofing for floorboard of road bridges and pavement of the bridge surface<br>・ Practical training on implementation of major waterproofing methods (coating-type/sheeting type) and observation of performance testing of their waterproofing function<br>・ Explanation about differences of pavement materials for the bridge surface by presenting and letting the trainees touch the materials |
| 4 | May 22, 2013 | JICA Tokyo | Long-term maintenance plan | ・ Provision of knowledge necessary for developing a long-term maintenance plan<br>・ Practical training on running the software up to budget calculation |
| 5 | May 22, 2013 | JICA Tokyo | Flood | ・ Provision of basic |

| | | | | |
|---|---|---|---|---|
| | | | countermeasure | knowledge about flood countermeasure<br>・ Presentation of actual damages due to floods in Japan |
| 6 | May 22, 2013 | Construction Technology Exhibition Center | Flood countermeasure | ・ Introduction of the latest technology in Japan regarding flood countermeasure and road maintenance |
| 7 | May 23, 2013 | Public Works Research Institute | Bridge maintenance | ・ Introduction of activities conducted by Public Works Research Institute (i.e. CAESAR and ICHARM)<br>・ Presentation about the actual bridge maintenance and control situation in Japan<br>・ Presentation of bridge scouring cases and their countermeasures in Japan<br>・ Presentation of tsunami-damaged bridges due to the Great East Japan Earthquake and their repair/reconstruction work<br>・ Presentation of salt damages |
| 8 | May 23, 2013 | Public Works Research Institute | Flood countermeasure | ・ Provision of basic knowledge on the river control method related to bridges in Japan<br>・ Provision of comments on bridges damaged by floods in Thailand |
| 9 | May 24, 2013 | DENKA | Repair and | ・ Introduction and practical |

| | | | | |
|---|---|---|---|---|
| | | (DENKI KAGAKU KOGYO) | reinforcement method / Materials | training on bridge repair and reinforcement method / materials (e.g. restoration materials for cross-sections and combined waterproofing) |
| 10 | May 25, 2013 | JICA Tokyo | Long-term maintenance plan | ・ Provision of basic knowledge about database<br>・ Provision of knowledge necessary for developing a long-term maintenance plan<br>・ Practical training on running the software up to budget calculation |
| 11 | May 25, 2013 | In Tokyo | Bridge maintenance | ・ Observation tour of bridges over the Sumida River and Tokyo Bay to obtain knowledge about bridge maintenance |

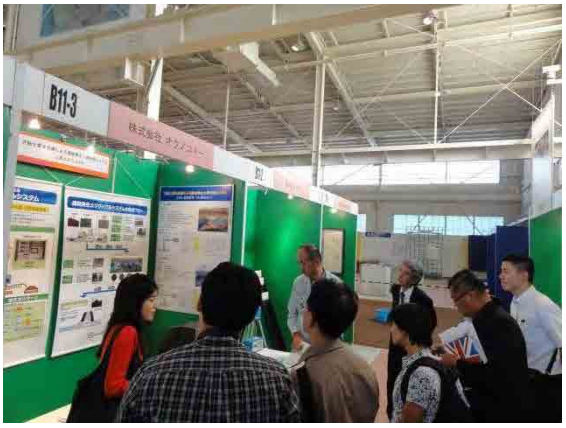
Attached below are the pictures taken during the training in Japan.

No. 2 Bridge inspection / Non-destructive inspection (Practical training)

No.3 Waterproofing for floorboard / Pavement of the bridge surface (Lecture)

No. 4 Long-term maintenance plan (Practical training)

No. 6 Construction Technology Exhibition Center (Observation tour)




No.7 Bridge maintenance (Lecture)

No.9 Repair and reinforcement method / Materials (Practical training)

**Pic. 3-5-1 Training in Japan**

During the evaluation session held at the end of the training, the trainees made the following comments with regard to utilization of the knowledge and experience they obtained during the training.

- I would like to share the knowledge I obtained during the training in Japan with colleagues in my organization.
- I recognized the necessity of developing a long-term maintenance plan and building database. I would like to communicate it to decision-making officers in my organization.
- I would like to conduct practical training on bridge inspection in the future.
- I would like to consider employment of repair and reinforcement methods/materials in Thailand, with paying attention to their economic performance.

・I would like to examine possible scouring problems of existing bridges as well as consider scouring countermeasures to possible scouring at the time of planning of a bridge.

Based on the above comments, we conclude that the technological transfer we aimed for the training in Japan has been successfully achieved.

### 3.5.4 International Conference

Two lectures were carried out at the 2nd International Conference held from April 25 to 27, 2012, organized by DRR.

**Table 3.5-8 Activity summary at the international conferences**

| No | Date | Venue | Participants | Contents |
|---|---|---|---|---|
| 1 | April 25, 2012 | RAMA Gardens Hotel | 60 | Description of a long-term maintenance plan in Japan (Bridge maintenance) |
| 2 | April 25, 2012 | RAMA Gardens Hotel | 60 | Description of design and maintenance of a long-span bridge in Japan (Bridge planning) |
| Total | | | 120 | |

*April 25, 2012* *The 2nd International Symposium on Rural Roads 2012*

| Time | Activity / Topic | Lecturer / Expert |
|---|---|---|
| 8:00 AM - 8:30 AM | *Symposium Registration* | |
| 8:30 AM - 8:40 AM | Opening Ceremony / Welcome Address | |
| 8:40 AM - 9:00 AM | Key Note Address | Mr.Chamroon Tangpaisalkit |
| 9:00 AM - 9:20 AM | Country Report (Thailand) | Dr.Maitree Srinaravat |
| 9:20 AM - 9:40 AM | Road and Bridge Development in Laos | Mr. Saysomephanh LYTENGBLIACHUA / Mr.Somnuk MEKTAKUL |
| 9:40 AM - 10:00 AM | Rural Road and Road Safety Measures in Myanmar | Mr. Wai Lin Aung / Mr. Myang Win |
| 10:00 AM - 10:15AM | *Coffee Break* | |
| 10:15 AM - 10:40 AM | Roads and Bridges Development in Cambodia | Mr. NAY Chamnang / Mr.CHAO Sopheak Phibal |
| 10:40 AM - 11:05 AM | Development of Asian Rural Roads | Mr. Paul Anthony Evans from UNESCAP |
| 11:05 AM - 11:30 AM | Materials for Improved Durability of Concrete Structures | Prof. Tatsuya Tsubaki (Yokohama National University) |
| 11:30 AM - 11:55 AM | Load Testing for Road Foundations | Prof.Tatsunori Matsumoto (Kanazawa University) |
| 12:00 PM - 1:00 PM | *Lunch Break* | |
| 1:00 PM - 1:25 PM | Bridge Maintenance and PWRI activities | Mr.Yoshiki Tanaka ( Public Works Research Institute) |
| 1:25 PM - 1:50 PM | Tokyo Metropolitan Expressway - Maintenance Works | Mr.Hiroshi Kojima (Tokyo Metropolitan Expressway) |
| 1:50 PM - 2:15 PM | Introduction of Long Term Bridge Maintenance | Dr.Hiroshi Kudou |
| 2:15 PM - 2:40 PM | Design and maintenance of Long-Span Bridge | Dr.Haruki Akiyama |
| 2:40 PM - 2:55 PM | *Coffee Break* | |
| | 3D Geo-Spatial Data Infrastructure: Key IT Platform for | |



**Pic. 3-5-2 Lecture**

### 3.5.5 Project Meeting

Description of planning, design and maintenance of a suspension bridge was carried out in the conference held by DRR. At the conference, Minister of MOT was invited.

**Table 3.5-9 Activity summary at the project meeting**

| No | Date | Venue | Participants | Contents |
|---|---|---|---|---|
| 1 | Feb.22, 2013 | Rama Gardens Hotel | 200 | Description of planning, design and maintenance of a suspension bridge |
| Total | | | 200 | |

# Chapter 4 Assistance to Development of Bridge Maintenance and Management Plan in Rural Area

## 4.1 Assistance to budget planning

### 4.1.1 Financial issue on bridge maintenance and management

According to interviews, DRR is budgeting an amount of 34,000 baht/km for road maintenance and management but which may not likely to cover fully the cost of maintenance operation on road bridge. Most amount of the budget is only for maintaining road network so that other bridge repair and inspection activities have not been adequately performed yet. Now aging bridges in rural area are significantly growing, so that they need to get repaired under the balanced budget.

### 4.1.2 Objective of survey

DRR is aware well of budgetary deficit regarding bridge maintenance and management. Since any nationwide bridge inspection is not attempted yet it is hard to determine the amount of budget for performing necessary activities related to bridge inspection. Determining budget should reflect on damage growth on the long-term basis and take account of bridge maintenance and management plan on the level of management baseline.

Accordingly, the present survey is to introduce the procedure of developing bridge maintenance and management plan, and to develop BMMS (Bridge Maintenance and Management System) which can support to develop long-term plan and determine budget in the appropriate manner.

The BMMS will basically consist of two parts: database for saving inspection data; and budget estimation simulation process for developing repair plan based on inspection data.

#### (1) Action plan for budgeting

DRR normally takes control of allocating the amount of budget by considering demand from each district regarding inspection task and its cost.

In Japan, the long term-based repair regulation has been framed in order to give budget aid to local entities that are able to execute properly bridge maintenance task over years, as followed by an obligatory bridge maintenance and management plan. This regulation allows them to aggregate inspection data of many bridges.

Likewise, once such long term-based bridge maintenance and management plan is obligatorily made considering the inspection results in every district, DRR can make the transition to the periodic inspection activities and the balanced budget determination with ease.

Therefore, the present survey makes it possible for each district to develop the proper budget plan. The procedure of developing bridge maintenance and management plan can be expected after the survey is finished as followings:

- Implement routine inspection in 18 district offices
- Develop budget plan on the long term basis for each district by the means of budget estimation simulation software
- Submit budget plan to DRR main office
- Appraise budget plan in DRR main office, if necessary, which can instruct budget re-estimation.
- Integrate overall budget plans in DRR main office

To succeed the above procedure, the survey team provides the service as followings:

- Create and deliver a manual including the procedure of developing long term-based maintenance and management plan
- Open a seminar about the procedure of developing long term-based maintenance and management plan
- Develop software for budget estimation simulation
- Give a lecture after distributing budget estimation simulation software to local offices

## 4.2 Inspection manual development

### 4.2.1 Issue on inspection manual

DRR is using a bridge register and inspection record sheets that include information about bridge properties. Some of bridges with span more than 50m have been summarized along with their properties and inspection record but not uniformly. Damage has been also described inconsistently by each inspector. This then may induce the lack of data necessary for developing long term-based maintenance and management plan.

### 4.2.2 Action plan for inspection manual development

The survey includes making reviews of the old bridge register and inspection record sheets as well as current inspection activities of DRR, and thus will develop both inspection manual and bridge register form that can be updated easily and steadily.

Through the 2nd on-site survey done before, some opinions about the draft of inspection manual have been obtained, and the next 3rd on-site survey is going to be carried out by opening a seminar to gather other opinion from local offices about the revised one.

Moreover, in recent, received from DRR are many digitalized data including bridge information, which will be reviewed and improved for easier use through the process of a pilot

bridge inspection task.

## 4.3 Training and technical aid

A bridge inspection technique becomes learnable under actual tasks through the next steps: the third and fifth on-site trainings; training in Japan; and OJT. Other effective tools and equipment, e.g. bridge checker and data input system, can be introduced to make inspections more efficient. As requested from DRR, the use of inspection tools and equipment will play a key role in encouraging carrying on proper inspection task.

## 4.4 Assistance to bridge inspection planning

Accumulating data is essential to develop the long term-based bridge maintenance and management plan. The survey team is going to assist in developing inspection plan can deal with 8,000 bridges being under control of DRR.

DRR is on the process of application for budget of bridge inspection task on 2,000 bridges with the use of bridge checker, which is a special vehicle for bridge inspection. The task will involve in applying the inspection manual developed by the survey team, and using the customized tablet PC.

The survey team will give overall supports to inspection technique application and software development for tablet PC. Therefore, it can be expected that the result of this full-scale bridge inspection task contributes to developing more specific bridge inspection plan than before.

# Chapter 5 Preparation of Bridge Inspection and Evaluation Manual, and positive inspection of bridges

## 5.1 Preparation of Bridge Inspection and Evaluation Manual

### 5.1.1 Outline

It is necessary to understand the conditions of existing bridges in order to maintain and manage them adequately. As a manual to understand the actual conditions, this Bridge Inspection and Evaluation Manual were made.

In the stage while preparing the Bridge Inspection and Evaluation Manual, draft Ver.1 - 4 have been prepared. After the preparation of draft Ver.1, seminars, questionnaire, and hearing about this manual have been practiced in head office and several bureau of rural road in DRR using each version. By the repeated improvement based on these results and studies on the manuals of relevant authorities, Bridge inspection and evaluation manual was made. Outline of each version of Bridge Inspection and Evaluation Manual are explained here.

### 5.1.2 Investigation results of manuals of related organization

The following manuals concerning the study, inspection and the evaluation of bridges in Thailand were investigated.

- Procedure for Construction Management of RC Bridges and Condition Evaluation including Maintenance Method (Bureau of Road Maintenance, Public Works Department, August 2000)

- Manual for bridge inspection and evaluation (Bureau of Road Maintenance, DRR / Institute of Transportation, Chulalongkorn University, February 2007)

- Manual for Bridge Maintenance Work (for Bridges in DRR's Road Network) (Bureau of Testing, Research and Development, DRR / Civil Engineering Department, Srinakarin University, August 2008)

- Bridge Inspection and Improvement Manual (Bureau of Bridge Construction, DOH, November 2005)

The outline of each manual is described as follows. The investigation result is shown in Appendix 3-2.

- PWD manual is mainly for new construction of bridge, and only few details were specified regarding the bridge inspection work. The inspection form is not too complicated and the damage rating is simply categorized into 3 levels (Good, Fair, Poor). However, most damages are only the concrete structures (cracking, corrosion), even for the substructures, which should have other types of damages such as settlement, movement, scouring, etc.

- The manual by CU seems to be fully developed and covers all the necessary procedures for bridge inspection work. However, the damage rating is divided into 6 levels and many detailed items are required to be inspected and input, which may be quite complicated for the DRR staffs in regional offices. In addition, there were no sample pictures of each level of damages, which may cause the inspector difficult to evaluate the damage level.
- The manual by SU was intentionally developed for the project on repairing of damaged bridges in DRR's route, which was sponsored by Bureau of Testing, Research and Development. Therefore, not only the bridge inspection work, but also the repairing method and rough estimation of repairing work were also provided. Regarding the bridge inspection and evaluation, the damages were mainly focused on only the concrete structures, such as cracking, efflorescence, and the damage level was simplified into 4 levels (A, B, C, D).
- The contents of manual in DOH are quite similar to those of CU and SU's ones, which were mainly referenced from the manual by the National Bridge Inspection Standards (NBIS). Therefore, the inspected items also include waterway apart from deck slab, superstructure and substructure. Similar to the manual by CU, the damage level is categorized into 6 levels and no sample pictures for each level of damages were illustrated.

### 5.1.3 Outline of Bridge Inspection and Evaluation Manual (draft Ver.1)

In the preparation of Bridge Inspection and Evaluation Manual (draft Ver.1), it was studied based on "Basic Data Collection Procedure Concerning the Road Bridges (Draft)" (Apr.2007) (hereafter, called "Data Collection Procedure (Draft)") issued by Ministry of Land, Infrastructure and Transport as the reference document for checking the bridges in Japan.

"Data Collection Procedure (Draft)" is the one settled to solve the budget and technical problems in local authority referring to "Periodic Checking Procedure of Bridges (Draft)" of the Ministry of Land, Infrastructure and Transport of Japan. It is deemed that the issues that DRR has now is the same as in local government in Japan, and it is effective to refer it when checking the local bridges in Thailand as the solution.

Moreover, "Bridge inspection and Evaluation Manual" applying to the bridges on Chao Phraya River managed by DRR was made in "A survey for the bridge maintenance planning (The Chao Phraya River Crossing Bridges) (2010-2011) ". This manual was made by the review of actual situation of the bridges on Chao Phraya River while it is based on "Data Collection Procedure (Draft)".

By the above reasons, "Bridge Inspection and Evaluation Manual Ver.1 (draft)" was made considering the type of local bridges and the damage situation referring to "Data Collection Procedure (Draft)", "Checking and Evaluation Manual" applied to bridges on Chao Phraya

River, the standard design information of DRR and the information obtained from the site survey of local bridges during emergency inspection of flooding.

### 5.1.4 Composition of Bridge Inspection and Evaluation Manual (draft Ver.1)

The Bridge Inspection and Evaluation Manual (draft Ver.1) was simplified for necessity in the viewpoint of spreading to local bridges following to the basic composition shown on “Data collection procedure (Draft)” or “Bridge inspection and evaluation manual” applied to the bridges on Chao Phraya river such as checking method, evaluation of damages or inspection results.

The Bridge Inspection and Evaluation Manual (draft Ver.1) is made assumed to be used for mainly periodic inspection. In particular, the purpose of this manual is that the staff of DRR understands the damaged situation of their controlled bridges by visual observation once every five years, and input the inspection data to the bridge maintenance and management system. This manual may be used for the periodic inspection or emergency inspection. However it is not the intended purpose of this manual. Detailed inspection such as by non-destructive inspection etc. are not described because these should be practiced when necessary after the study of periodic inspection results, and these are different studies in its nature.

### 5.1.5 Review considering the application to local bridges

"Data collection procedure (Draft)" and "Bridge Inspection and Evaluation Manual" intended for Chao Phraya River were reviewed considering the application of these to the local bridges when preparing Bridge Inspection and Evaluation Manual (draft Ver.1) was made. Details are described as follows.

#### (1) Targeted bridge types

It is presumed that the most of local bridges were constructed in accordance with standard design drawing * of DRR as the results of observation at inspection of local bridge in the past years and the results of hearing at local road office in each province. Therefore it was limited to the types shown on standard design drawing of DRR covered by the Bridge Inspection and Evaluation manual Ver.1 (draft). In particular, upper structures are 4 types consisting of slab bridges, plank girder bridges, box girder bridges and PC girder bridges of I section. Bridge piers are 4 types consisting of T-shape (circular and oval sections), portal shape rigid frame pier, pile bent pier and wall type pier. For the concrete bridges built not in accordance with the standard design, the inspection items are set up to enable to inspect applying this manual.

#### (2) Reorganization of check items

Check items were reviewed considering the situation of local bridges.

- Deletion of items concerning the steel bridges

The most of local bridges are concrete bridges (RC structure or PC structure) in accordance with standard design, and steel bridges were a little. The items concerning the steel bridges were deleted for the convenience of users. For the steel bridges or cable-stayed bridges, these can be inspected, evaluated its damages and recorded the results in accordance with Bridge Inspection and Evaluation Manuals applied to Chao Phraya River bridges prepared previously.

- Addition of damage classification of inter-filling concrete

In the previous inspection results, water leak from the inter-filling concrete was found in local bridges. Not only existence of dropping of inter-filling concrete, an evaluation in the course before inter-filling drop will be caused should be added. Accordingly the existence of water leak from inter-concrete is added as an item in dropping of slab, and these are evaluated.

- Items concerning abnormal PC bonding

The damage in PC bonding part affects serious damage for the bridge conditions. So it is necessary to inspect the concrete of PC bonding by focusing on. Therefore the PC bonding is set for independent item.

- Additional inspection items concerning the change of the understructure

As the result of an emergency inspection at the flood, the scour of the bridge piers, and damages in front and back sides of substructure were remarkable in local bridges. These damages are evaluated by one item in "Data Collection Procedure (Draft)". In the results of damage analysis in the emergency inspection at the flood, the inspection items were added since the progress of damages was classified into several kinds.

- Addition of items concerning drain facilities

If the drainage facilities do not function well, the water goes under the girder as the leaked water, and it affects the members comprising the bridges. Accordingly, items for drainage facilities were added.

As the result, 14 check items were defined as shown on Table 5.1-1. Example of the classification of evaluation is shown on Figure 5.1-1.

**Table 5.1-1 Items and observation position of visual inspection**

| Kind of damage | | Classification of evaluation |
|---|---|---|
| Concrete | (1) Cracking, water leakage and free lime | a - e |
| | (2) Rebar exposure | a - e |
| | (3) Pop-outs of deck | a - e |
| | (4) Deck cracking | a - e |
| | (5) Damages at the anchorages of pre-stressing tendons | a - e |
| Others | (6) Unevenness of road surface | a - e |
| | (7) Functional damage of bearings | a - e |
| | (8) Scouring riverbed around abutments & piers | a - e |
| | (9) Damages & collapse of river revetments near abutments | a - e |
| | (10) Damages behind abutments | a - e |
| | (11) Settlement, movement, inclination in substructures | a - e |
| | (12) Damages in barriers | a - e |
| | (13) Damages in expansion joints | a - e |
| | (14) Damages in drainages | a - e |

| **Damage level b** | **Damage level b** |
|---|---|
|  |  |
| Partial rebar exposure | Partial rebar exposure |
| **Damage level c** | **Damage level c** |
|  |  |
| Partial rebar corrosion | Superficial rebar exposure in the wide range |
| **Damage level e** | **Damage level e** |
|  |  |
| Rebar corrosion in the wide range | Rebar corrosion in the wide range |

**Figure 5.1-1 Classification of evaluation (e.g.) (Rebar exposure)**

## (3) Method of inspection

The inspection followed the visual observation of the previous method. The general apparatus carried when checking was reviewed from the viewpoint of necessity in local bridges. Moreover, the flow chart showing the procedure of inspection was added.

### (4) Evaluation of inspection results

The evaluation method of the inspection result follows the "Data collection procedure (Draft)", and it is classified into maximum 5 grades to enable the common evaluation regardless of inspectors.

### (5) Correction meeting the actual situation of local bridges

The target bridges in this manual are that of the bridges build in accordance with the standard design. Accordingly, the figure showing the example of cracks followed the structure shown in the standard design. Also, both of steel bearing (pot bearing and disk bearing) and rubber bearing (laminated rubber bearing) shown on standard design are covered. For the expansion unit, butt joint and non drainage joint were added. Photographs were replaced with the photographs taken in Thailand as much as possible.

### (6) Recording format of check results

For the recording format of inspection result, the descriptions were minimized in order to let understand the actual situation of bridges easily. The format was simplified to fill each bridge because the most of local bridges are the middle or small scale with a long span.

As the practical method, the minimum recording sheet in each bridge is limited to 4 sheets. It was decided to fill the check location (name of bridge, route name and coordinate), date of checking and checker without filling other information

- The first sheet shall be the general drawing of a bridge (plan, side view and section), and fill all the member numbers and damages of upper structure, and the location marking of the taken photographs shall be filled on the drawing.
- The second sheet shows the elevation of lower structure and side view with all member numbers and damaged part.
- The third sheet shall be filled with photos captured the damaged parts, member numbers, photo numbers, comments as necessary and evaluation class of damages.
- The fourth shall be filled with the evaluation level of each member in the form of a table.

*The standard design drawings: Structures shown on 2 kinds of standard design drawings are covered in below manuals.

-Standard design drawings of the bridges of 30m span or less (2010).

Bureau of Location and Design, DRR, Standard Drawing for Bridges and Building Section 3 Bridge Work for Vehicles 2010

-Standard design drawings of the bridges of 20m span or less (September, 2010)

Bureau of Location and Design, Department of Rural Roads, Ministry of Transport, Bridge Standard Drawing for Construction Work of Rural Road, September 2010

### 5.1.6 Improvement in Bridge inspection and evaluation manual (Draft Ver.2)

Considering the opinions in the seminar, the results of analysis of questionnaire and study results of manuals of relevant organizations, the Bridge Inspection and Evaluation Manual (draft Ver.1) were amended and Ver.2 were made.

Improved parts from Bridge inspection and evaluation manual (Draft Ver.1) are described below.

#### (1) Classification of damages and evaluation items

- The degree of damages has been expressed by the alphabet “a-e”, however it was replaced with the digits “5 - 1”, which are normal in Thailand.
- Photographs for evaluation example have been changed for easy understanding. Practically, it seems that the figures in addition to photographs or additional panoramic view and near view of photographs as necessary.
- Supporting facilities such as walkway or lightings were added since these were included in the standard design or manuals of relevant organizations.

#### (2) Timings of inspection

- It was clearly described that the timings of inspection are preferred in dry season (drought period) in order to improve the accuracy of inspection and efficiency.

#### (3) Equipment and tools

- Minimum and recommended performance and specifications of check equipment or tools were proposed. As a result, any variations of check results caused by the difference of the persons for checking can be prevented.
- Considering the inspection from the river in much water dosage, a boat was added as the facility for approaching.
- The descriptions how to use the crack scales are added.

#### (4) Appearance

- The character font, figure and the photograph were enlarged for improvement of readability.

#### (5) Preparation of quick manual

Considering the convenience for the inspectors working at site, a simplified manual “Quick Manual” was made. It was made extracting the minimum information as necessary from Bridge inspection and evaluation manual. It is made in order to simply describe what sequence the structures are checked at site, and how to evaluate it. It shows the inspector’ s standing position, what to see, and what the inspectors should pay attention when checking with the photographs minimizing sentences for easy understanding of procedure. It was made considering the image displaying on the screen of tablet PC.

### 5.1.7 Improvement of Bridge Inspection and Evaluation Manual (draft Ver.3)

Based on Bridge inspection and evaluation manual (draft Ver.2), it was discussed mainly with C/P. Draft Ver.3 was made thinking of the opinions raised in the discussion.

Improved part from Bridge Inspection and Evaluation Manual (draft Ver.2) are described below.

#### (1) Change of composition

In the Bridge Inspection and Evaluation Manual (draft Ver.1) and (draft Ver.2), these were made in the sequence from main members (superstructure and substructure) to attached facilities, which have not necessarily been composed of the sequence following to the inspection. In the simplified "Quick manual" made in (draft Ver.2), it was described in the sequence of inspection improving this issue. As the result, DRR evaluated that descriptions in the quick manual are very easy to understand. After the discussion with DRR, it was concluded that it leads to understanding of the inspectors if the Bridge Inspection and Evaluation Manual also comprises following to the sequence of inspection. For such purpose, it was described in the sequence of inspection, and the composition of contents was changed. In addition, descriptions of inspection sequence and from what position the members are observed were added.

#### (2) Deletion of normal inspection

In order to make clear that this is the manual for periodic inspection, edition for normal inspection was deleted.

#### (3) Change of damage classification

Indications were changed to "1" for the light damage, and "5" for serious damage for easy understanding.

#### (4) Addition of figures with explanation to the photos of damaged example

To assist the understanding of inspectors, figures with explanations were added to the photographs for damage classification as much as possible.

### 5.1.8 Improvement in Bridge inspection and Evaluation Manual (draft Ver.4)

Based on the Bridge inspection and Evaluation Manual (draft Ver.3), opinions of managers of Bureau of Road Maintenance in DRR have been obtained after the discussions. Considering these results, opinions of bureau of rural road, and answers to questionnaire, overall review of descriptions have been made for easy understanding. The Bridge

inspection and Evaluation Manual (draft Ver.4) was made reflecting these.

Improved part from Bridge inspection and Evaluation Manual (draft Ver.3) are described below.

### (1) Review of descriptions

Requests for improvement of descriptions in Bridge inspection and Evaluation Manual (draft Ver.3), expression and further recording method of inspection results have been obtained from the manager of Regional Bridge Maintenance Division, Bureau of Road Maintenance of DRR who is one of C/P, and other managers in Bureau of Road Maintenance. Considering these, correction and addition of descriptions were made overall document in order to easier understanding. Major correction and additions are as follows.

- Study items when each bridge is inspected are indicated clearly.
- Timing of inspection is strongly indicated in an independent section.
- A vehicle for bridge inspection introduced by DRR after the next fiscal year was added.
- Approach roads are added as an inspection item and indicated it clearly.
- It was clearly indicated that the boat should be used after the confirmation of safety based on the water velocity and water volume.
- Numbering of span number was changed to the method like 01, 02 from the starting point.
- Inspection sheet is separated into above structure and under structure “superstructure” and “substructure” respectively in accordance with the classification method which has been used in DRR until now.

### (2) Damages specially attention is required were defined

Damages which may affect the safety of bridges were ranked as “Special attention is required”, and the evaluation method of inspection results by the engineers were clearly indicated.

## 5.1.9 Contents of the Bridge Inspection and Evaluation Manual

Composition of Bridge Inspection and Evaluation Manual made in accordance with the above description is briefly explained along with table of contents.

I Common
- 1. Application
- 2. Purpose of inspection
- 3. Types of inspection
  - 3.1 Routine inspection
  - 3.2 Periodic inspection

3.3 Emergency inspection

3.4 Advanced inspection

[General description]

Indicating the scope of Bridge Inspection and Evaluation Manual and purpose of inspection, the work flow of positioning, inspection, evaluation, long term maintenance plan, repairs and data control flow of each inspection item are described.

Inspection consists of four kinds, i.e., routine inspection, periodic inspection, emergency inspection and advanced inspection depending on the purpose of inspection. It is described intending to choose the appropriate inspection by understanding the features of each inspection.

II Periodic inspection

1. Inspection work

1.1 Preparation of inspection plan

1.2 Methods and subjects of inspection

1.3 Timing of inspection

1.4 Inspection personnel

1.5 Equipment for inspection

1.6 Frequency of inspection

1.7 Inspection procedure

[General description]

Preparation before inspection and work procedure are described. It is intended smooth inspection indicating the required preparation, inspection methods, applicable structure and inspection procedure at site, by understanding this section.

2. Grasp of damage condition and evaluation of damage

2.1 Grasp of damage condition

2.2 Evaluation of damage

[General description]

Characteristic of damages, relation with other damages, the parts to be inspected, classification of damage evaluation and example photos of damages are listed in each kind of damages to be inspected. When the damage is found, it is evaluated referring to the description in this section. Kind of damages are listed below.

(1) Settlement, movement, inclination of substructures

(2) Unevenness of road surface

(3) Damages in expansion joints

(4) Damages in barriers

(5) Damages in drainages

(6) Damages in sidewalk

(7) Damages in attached facility

(8) Damages behind abutments

(9) Damages on river revetments near abutments

(10) Scouring riverbed around abutments & piers

(11) Damages at the anchorages of pre-stressed tendons

(12) Cracking, water leakage and free lime

(13) Pop-outs of deck

(14) Deck cracking

(15) Rebar exposure

(16) Functional damage of bearings

3. Inspection records

3.1 Recording guide for the inspection results

3.2 Recording forms and recorded examples

[General description]

Information to be filled when recording the inspection results, how to fill the member numbers, recording format and example of recording are described. Inspection results can be recorded in the unified format if these descriptions are followed.

4. Evaluation on urgency of damage class 5

4.1 Evaluation approach to urgency of damage class 5

[General description]

Classification method of urgency evaluation of the damages classified into class 5 is described. It is prescribed that any damage in evaluation class 5 shall be re-evaluated by the engineer who has specialized expertise in the viewpoint to avoid the risks.

## 5.2 Inspection of a Pilot Bridge

In order to improve the bridge maintenance and management capabilities of DRR, the applicable bridges were designated, and inspection was conducted on them as the pilot

project. In this bridge inspection, on-the-job training was practiced to the DRR engineers.

### 5.2.1 Purpose of Bridge Inspection

It is required to understand the current situation of a bridge in the set up of long term maintenance plan and control plan on it. For this purpose, inspection of pilot bridges has been conducted in order to transfer the technology through OJT, aware the necessity of bridge inspection, and learn about the Bridge Inspection and Evaluation Manual.

### 5.2.2 Selection of Pilot Bridges

Pilot bridges were selected considering the type of bridges, degree of damages, conditions of the site etc. In order to transfer the technology through OJT of the pilot bridges inspection and learn the technology efficiently, it was also considered that inspection methods are easy to understand regardless of length of DRR engineers' experience. According to these policies, pilot bridges were selected discussing with C/P of each bureau of rural road. Aspects considered in the selection of pilot bridges are described below.

- Girder bridges and slab bridges built in accordance with standard design of DRR are selected.
- Selected from the bridges mainly damaged by the scour or salt located in flood or coastal area.
- Selected mainly from the small sized concrete bridges of about 10m span consists of 3 spans, which are local bridges often seen.
- Selected mainly from the bridges which can access below the bridge easily, low river water level and no grass or bush under the bridge since the direct observation looking up the inspecting girders from below bridge leads to the better understanding.

Selected bridges to be inspected by these methods are listed in Table 5.2-1. Although inspection of pilot bridges has been conducted at 27 bridges, 22 bridges inspected and record with tablet PC are described below.

**Table 5.2-1 Number of Inspected Bridges**

[Unit : Bridges]

| Bureau of Rural Road | Plank girder | I-type Girder | Slab bridge | Total |
|---|---|---|---|---|
| Bureau of Rural Road 3 (Chonburi) | 2 | - | 1 | 3 |
| Bureau of Rural Road 5 (Nakhon Ratchasima) | - | - | 1 | 1 |
| Bureau of Rural Road 7 (Ubonratchatani) | - | - | 2 | 2 |
| Bureau of Rural Road 8 (Nakhon Sawan) | 2 | - | - | 2 |
| Bureau of Rural Road 11 (Ranong) | 3 | - | 2 | 5 |
| Bureau of Rural Road 13 (Chachoengsao) | 2 | - | - | 2 |
| Bureau of Rural Road 17 (Chiangrai) | 1 | 2 | 2 | 5 |
| Bureau of Rural Road 10 (Chiangrai) | 2 | - | - | 2 |
| Total | 12 | 2 | 8 | 22 |

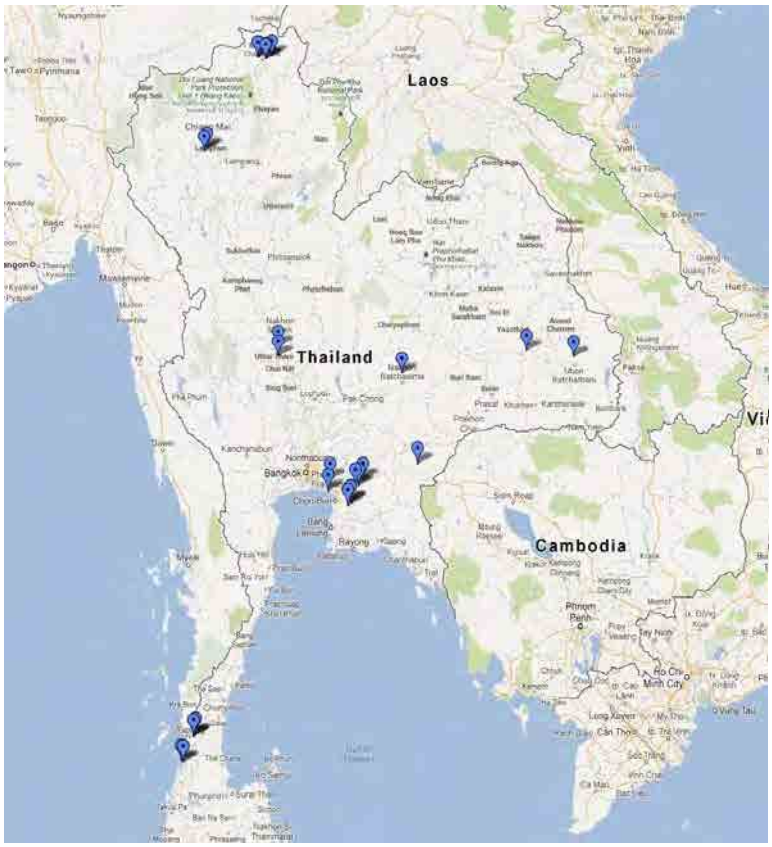



**Figure 5.2-1 Map of pilot bridge**

### 5.2.3 Inspection Methods of Bridges

Based on Bridge Inspection and Evaluation Manual, inspection has been carried out by visual observation in principle. Ends of girders, supports and the members nearby were observed approaching as close as possible. Where the approach is difficult, inspection was conducted using the bridge checker and high performance digital camera described later in addition to the observation with telescope or binocular. Further, non-destructive inspection devices were used in the inspection.

Damages found in inspection were evaluated and recorded in accordance with Bridge Inspection and Evaluation Manual. Inspection results were recorded in the tablet PC for bridge inspection described later.

### 5.2.4 Results of Bridge Inspection

General description of inspection results are shown in Table 5.2-2. Inspection results of 4 bridges solely carried out by DRR themselves in Bureau of Rural Road 13 are also described hereunder.

**Table 5.2-2 List of Inspection Results**

| No. | Bureau of Rural Road | Bridge code* | Route No. | Length (m) | Width (m) | Number of spans | Main damage | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cracking | Rebar exposure | Scouring | River revetments | Salt damage | Settlement | Surface of bridge |
| 1 | 3 Chonburi | TH-1 | 3026 | 30 | 10 | 3 | | | ✓ | | | | |
| 2 | 3 Chonburi | TH-2 | 4004 | 30 | 10 | 3 | | | | ✓ | | | ✓ |
| 3 | 3 Chonburi | TH-3 | 4004 | 20 | 10 | 2 | ✓ | ✓ | | | | | ✓ |
| 4 | 5 Nakhon Ratchasima | TH-2 | 3023 | 30 | 11 | 3 | ✓ | ✓ | | | | | ✓ |
| 5 | 7 Ubonratchatani | TH-2 | 3002 | 12 | 9 | 1 | | | ✓ | | | | ✓ |
| 6 | 7 Ubonratchatani | TH-3 | 4034 | 130 | 10 | 13 | | ✓ | ✓ | | | ✓ | ✓ |
| 7 | 8 Nakhon Sawan | TH-1 | 5002 | 20 | 10 | 2 | ✓ | | | | | | ✓ |
| 8 | 8 Nakhon Sawan | TH-2 | 3099 | 40 | 10 | 5 | | | ✓ | ✓ | | | |
| 9 | 11 Suratani (Ranong) | TH-2 | 4001 | 20 | 10 | 3 | ✓ | | ✓ | | | | ✓ |
| 10 | 11 Suratani (Ranong) | TH-3 | 4001 | 20 | 10 | 3 | | | ✓ | | | | |
| 11 | 11 Suratani (Ranong) | TH-4 | 4001 | 10 | 9 | 1 | | ✓ | ✓ | ✓ | | | ✓ |
| 12 | 11 Suratani (Ranong) | TH-5 | 1037 | 30 | 8 | 3 | ✓ | ✓ | ✓ | | ✓ | | |
| 13 | 11 Suratani (Ranong) | TH-6 | 1037 | 30 | 8 | 3 | ✓ | ✓ | ✓ | | ✓ | | |
| 14 | 13 Chachoengsao | TH-2 | 4012 | 42 | 9 | 5 | ✓ | ✓ | ✓ | | | | ✓ |
| 15 | 13 Chachoengsao | TH-4 | 3010 | 18 | 9 | 2 | | | | ✓ | | | ✓ |
| 16 | 17 Chiangrai | TH-2 | 4044 | 35 | 10 | 3 | | | | ✓ | | | ✓ |
| 17 | 17 Chiangrai | TH-3 | 4044 | 24 | 10 | 3 | ✓ | | ✓ | | | | ✓ |
| 18 | 17 Chiangrai | TH-4 | 3000 | 24 | 10 | 3 | | | ✓ | ✓ | | | |
| 19 | 17 Chiangrai | TH-5 | 4013 | 70 | 11 | 4 | | | | ✓ | | | |
| 20 | 17 Chiangrai | TH-6 | 4013 | 60 | 11 | 5 | ✓ | | ✓ | | | | |
| 21 | 10 Chiangmai | TH-6 | 006 | 220 | 10 | 12 | ✓ | ✓ | ✓ | | | | |
| 22 | 10 Chiangmai | TH-4 | 4022 | 30 | 10 | 3 | | | | | | | ✓ |
| | (DRR's own inspection) | | | | | | | | | | | | |
| 23 | 13 Chachoengsao | TH-6 | 4033 | 35 | 9 | 5 | ✓ | | ✓ | ✓ | | | ✓ |
| 24 | 13 Chachoengsao | TH-7 | 4017 | 30 | 8 | 3 | | | ✓ | | | | ✓ |
| 25 | 13 Chachoengsao | TH-8 | 4015 | 30 | 7 | 3 | ✓ | ✓ | ✓ | | | | ✓ |
| 26 | 13 Chachoengsao | TH-9 | - | 20 | 9 | 3 | ✓ | ✓ | | | ✓ | | ✓ |

*Bridge code is tentative number.

Major damages found are described hereunder. Inspection sheets were made to record the detailed inspection results in accordance with Bridge Inspection and Evaluation Manual. Refer to Appendix-4.

### (1) Cracking

Cracks were found at 13 bridges. Most of these are the cracks in the axial direction of pile bent pier. Figure 5.2-2 is a bridge located inland.

| | |
|---|---|
|  |  |
| Bureau of Rural Road 5 TH-2<br>(Damage level 3) | Bureau of Rural Road 5 TH-2<br>(Damage level 3) |

**Figure 5.2-2 Example of Damages (Cracking)**

### (2) Rebar exposure

Rebar exposure were found at 10 bridges. An example shown on Figure 5.2-3 is of a bridge located inland. It is inferred the damages caused by the bad workmanship when casting the concrete during construction. Rebar exposure caused by the salt damage is described later.

| | |
|---|---|
|  |  |
| Bureau of Rural Road 3 TH-3<br>(Damage level 3) | Bureau of Rural Road 3 TH-3<br>(Damage level 3) |

**Figure 5.2-3 Example of Damages (Rebar exposure)**

### (3) Scouring

Scouring or river stack inhibition was found at 17 bridges. Figure 5.2-4 shows an example.

| | |
|---|---|
|  |  |
| Bureau of Rural Road 10 TH-6<br>(Damage level 5) | Bureau of Rural Road 10 TH-6<br>(Damage level 5) |

**Figure 5.2-4 Example of Damages (Scouring)**

### (4) Damage of river revetments

Damages of the bank protection were found at 8 bridges. According to the DRR staff, bank protection was damaged by the increase of water volume and where the flow velocity is relatively fast in rainy season every year as shown on Figure 5.2-5.

| | |
|---|---|
|  |  |
| Bureau of Rural Road 17 TH-4<br>(Damage level 5) | Bureau of Rural Road 17 TH-4<br>(Damage level 5) |

**Figure 5.2-5 Example of Damages (River revetments)**

### (5) Salt damage

Salt damages were found at 3 bridges. An example shown on Figure 5.2-6 is a bridge for flow observatory of a river located approx. 1km from the coast. Cracks along with rebar caused by the salt damage and falling down of concrete in a wide area caused by the corrosion

of rebar were found.

| | |
|---|---|
|  |  |
| Bureau of Rural Road 11 TH-6<br>(Damage level 5) | Bureau of Rural Road 11 TH-6<br>(Damage level 5) |

**Figure 5.2-6 Example of Damages (Salt damage)**

## (6) Settlement

Damage caused by settlement was found at a bridge belonging to Bureau of Rural Road 7 (Sisaket Province) as shown on Figure 5.2-7. According to the DRR staff, settlement has been caused for quite long time. Corrective repairs such as rising of transverse beam of piers or correction of irregular surface of road have been found. Gaps or cracks at bridge railing caused by the settlement were found. Aging measurement of settlement has not been carried out. It was advised that settlement should be measured periodically at first, and check that settlement is continued or converged.

| | |
|---|---|
|  |  |
| Bureau of Rural Road 7 TH-3<br>(Damage level 5) | Bureau of Rural Road 7 TH-3<br>(Damage level 5) |

**Figure 5.2-7 Example of Damages (Settlement)**

### (7) Damages on the surface of bridge

Damages above the road surface were found at 17 bridges. Most of these are the damage of bridge railing and gap of the road surface at the connection to approach road. Figure 5.2-8 shows the examples.

| | |
|---|---|
|  |  |
| Bureau of Rural Road 3 TH-3<br>(Damage level 3) | Bureau of Rural Road 11 TH-4<br>(Damage level 3) |

**Figure 5.2-8 Example of Damages (Surface of bridge)**

## 5.2.5 Input to BMMS

Inspection results are recorded using the tablet PC for bridge inspection described later. In the tablet PC, it is designed that the input data is taken into BMMS directly, and the actual input data at this inspection was taken into BMMS directly.

## 5.2.6 Conclusion

In the inspected 22 pilot bridges and 4 bridges inspected by DRR themselves, it was found from the inspection results that any damage were caused at all bridges. Example photographs of damages collected through the inspection of pilot bridges have been reflected to the Bridge Inspection and Evaluation Manual.

## 5.3 Implementation of Technical Transfer Concerning Bridge Inspection

Seminars have been conducted at headquarter and Bureau of Rural Road targeted to the engineers in charge of maintenance and management of DRR's bridges adjusting the timing to the opportunity of pilot bridges' inspection, and OJT of bridge inspection have been practiced. By these activities, technology has been transferred. Details of seminars are described hereunder. Seminars have been conducted several times adjusting the timing of Bridge Inspection and Evaluation Manual preparation, which is aimed to fit the actual situation in Thailand. Bridge Inspection and Evaluation Manual has been improved based on the opinions raised in the seminars and the answers to the questionnaire. For the results of analysis of answers to the questionnaire in each seminar, refer to Appendix 3-1.

### 5.3.1 Seminar concerning the Bridge inspection and evaluation manual (draft Ver.1)

A seminar concerning the Bridge Inspection and Evaluation Manual (draft Ver.1) was held on May 22, 2012 at the meeting room of Bureau of Rural Road 2 located in Saraburi province. The purposes of this seminar are to deepen the understanding of bridge inspection, and explanation of Bridge Inspection and Evaluation Manual (Draft Ver.1). The participants from DRR are 15 persons who belong to the head quarter, Bureau of Rural Road 2 and Office of Provincial Rural Road in each province (Saraburi, Chainat, Singburi and Lopburi) under the control of Bureau of Rural Road 2.

In the seminar, "Bridge Inspection and Evaluation Manual (draft Ver.1)" (Thai version) was distributed from The Study Team to the participants of DRR, and it was explained based on the leaflet (Thai version) which describes the outline of the manual.

The brief contents of documents used in the seminar are as follows:

- Basic knowledge of bridge structures: importance of bridge, difference between bridge and road, component of bridge structure, deterioration and service life, bridge inspection work
- Bridge inspection and evaluation manual (Draft Ver.1): sequence of bridge inspection, damage rating and evaluation, inspection results record)
- Comments and suggestions

**Figure 5.3-1 Situation of seminar (Bureau of Rural Road (2) Saraburi)**

### 5.3.2 Seminar and OJT concerning the Bridge inspection and Evaluation Manual (draft Ver.3)

For the further improvement of manual through the practical checking, and to learn the knowledge concerting the inspection of bridges, the Bridge inspection and Evaluation Manual, seminars were held at the several bureau of rural road. Three departments were nominated from bureau of rural road where C/P belongs to (Table 5.3-1). In the seminars, ”Bridge inspection and Evaluation Manual (draft Ver.3)” (Thai version) was distributed to the participants by the study team and explained, and OJT was held with the actual bridges. Also, questionnaire concerning the bridge inspections and the manual was practiced.

**Table 5.3-1 Overview of seminar and OJT at Bureau of Rural Road**

| Visiting place | Date | Participants |
|---|---|---|
| Bureau of Rural Road 17 (Chiangrai) | 24/07/2012 | DRR 15 persons<br>JICA Study Team 4 persons |
| Bureau of Rural Road 3 (Chonburi) | 27/07/2012 | DRR 16 persons<br>JICA Study Team 3 persons |
| Bureau of Rural Road 7 (Ubonratchatani) | 30/07/2012 | DRR 25 persons<br>JICA Study Team 3 persons |

Seminar (Bureau of Rural Road 7)

OJT on site (Bureau of Rural Road 3)

**Figure 5.3-2 Situation of seminar and OJT at Bureau of Rural Road**

### 5.3.3 Seminar and OJT concerning the Bridge inspection and Evaluation Manual (draft Ver.4)

A seminar was held in headquarter and bureau of rural road in order to practice positive inspection and OJT based on the Bridge inspection and Evaluation Manual (Ver.4). Several bureau of rural road have been selected from the bureau of rural road where C/P is belonging to (Table 5.3-2). In this seminar, the Bridge inspection and Evaluation Manual (draft Ver.4) (Thai version) was distributed by Study Team and explained to the participants and OJT for bridge inspection was held with the actual bridges. (Table 5.3-3) In this seminar and OJT, inspections using tablet PC for bridge inspection, bridge checker, non-destructive testing equipment, and digital camera were practiced. Also, questionnaire concerning bridge inspection and manual were given.

**Table 5.3-2 Outline of seminars**

| Place | Date | Participants |
|---|---|---|
| DRR head office | 07/12/2012 | DRR 14 persons<br>JICA Study Team 7 persons |
| Bureau of Rural Road 13 (Chachoengsao) | 13-14/12/2012 | DRR 14 persons<br>JICA Study Team 4 persons |
| Bureau of Rural Road 8 (Nakhon Sawan) | 17-18/12/2012 | DRR 19 persons<br>JICA Study Team 4 persons |
| Bureau of Rural Road 13 (Chonburi) | 24-25/01/2013 | DRR 17 persons<br>JICA Study Team 3 persons |
| Bureau of Rural Road 5 (Nakhon Ratchasima) | 28-29/01/2013 | DRR 22 persons<br>JICA Study Team 4 persons |
| Bureau of Rural Road 17 (Chiang Rai) | 31/01-01/02/2013 | DRR 16 persons<br>JICA Study Team 4 persons |
| Bureau of Rural Road 7 (Ubonratchatani) | 07-08/02/2013 | DRR 20 persons<br>JICA Study Team 4 persons |
| Bureau of Rural Road 11 (Ranong) | 14-15/02/2013 | DRR 21 persons<br>JICA Study Team 2 persons |
| Bureau of Rural Road 10 (Chiangmai) | 29-30/04/2013 | DRR 19 persons<br>(Including five C/P who participate training in Japan)<br>JICA Study Team 2 persons |

**Table 5.3-3 Overview of Seminar and OJT at Bureau of Rural Road (example)**

| | | |
|---|---|---|
| 1st day | AM | 【Lecture】<br>- Explanation of overall project<br>- Explanation of Study, Bridge inspection and Evaluation Manual<br>- Explanation of inspection method using tablet PC. |
| | PM | 【OJT of bridge inspection on site】<br>- Inspection by visual observation and using bridge inspection tablet PC and bridge checker, non-destructive testing equipment, and digital camera. |
| 2nd day | AM | 【OJT of bridge inspection on site】<br>- Inspection by visual observation and using bridge inspection tablet PC and bridge checker, non-destructive testing equipment, and digital camera. |
| | PM | 【Lecture】<br>- Evaluation method of damages, reporting of inspection results, and questions and answers, etc. |

Seminar (Bureau of Rural Road 8)

OJT on site (Bureau of Rural Road 8)

OJT on site (Bureau of Rural Road 5)

OJT on site (Bureau of Rural Road 3)

**Figure 5.3-3 Situation of seminar and OJT**

### 5.3.4 Workshop

Workshop was held in total 5 times at bureau of rural road where had been held the seminar and OJT. Presentations and discussion by DRR staff were carried out, and lectures and question-and-answer session were held if necessary. The main contents of the workshop are as follows.

- Explanation of the status of implementation of bridge inspection (DRR)
- Explanation of the improvement about the bridge inspection and evaluation manual (JICA Study Team)
- Explanation of the improvement about the application of Tablet PC for bridge inspection (JICA Study Team)
- Introduction of bridge inspection method in Japan (JICA Study Team)

**Table 5.3-4 Outline of workshop**

| Place | Date | Participants |
|---|---|---|
| Bureau of Rural Road 8<br>(Nakhon Sawan) | 11/02/2013 | DRR 20 persons<br>JICA Study Team 2 persons |
| Bureau of Rural Road 13<br>(Chachoengsao) | 18/02/2013 | DRR 5 persons<br>JICA Study Team 2 persons |
| Bureau of Rural Road 13<br>(Chachoengsao) | 24/04/2013 | DRR 7 persons<br>JICA Study Team 2 persons |
| Bureau of Rural Road 5<br>(Nakhon Ratchasima) | 25/04/2013 | DRR 11 persons<br>JICA Study Team 2 persons |
| Bureau of Rural Road 8<br>(Nakhon Sawan) | 26/04/2013 | DRR 11 persons<br>JICA Study Team 2 persons |

Bureau of Rural Road 5

Bureau of Rural Road 8

**Figure 5.3-4 Situation of workshop**

## 5.4 Introduction of New Technology and Giving Technical Advices

The following new technologies are introduced, and technical advices concerning the inspection methods were given in order to realize effective inspection in visual observation, and improve the accuracy in inspection.

### 5.4.1 Simplified Recording Method of Inspection Results

#### (1) Tablet PC for Bridge Inspection

Bridge Inspection and Evaluation Manual defines the recording format of inspection results. If a recording format in the form of paper is used for bridge inspection, it is required to evaluate the damages referring the Bridge Inspection and Evaluation Manual (or Quick Manual) at site, damaged parts and its evaluation results are recorded, photographs of damages are captured, and the recording document are prepared in the office using PC after the inspection. In order to reduce the work volume, an inspection method using the tablet PC for bridge inspection was introduced.

Tablet PC for bridge inspection was so made as to enable to refer the information necessary for the recording of inspection results which is based on Bridge Inspection and Evaluation Manual, and input them by PC itself. Major works which can be done with the tablet PC for bridge inspection are described as follows.

- Import of information concerning the specifications of bridges, checking them at site and input them to the PC.
- Automatic member numbering of bridges to be inspected based on input dimensions and automatic display.
- Damage example photographs shown in the Bridge Inspection and Evaluation Manual (Quick Manual) are stored in tablet PC. Based on it, inspectors evaluate the damages

comparing the actual damages with the example photographs of damages displayed on the screen of PC, and input them to the PC.

- Marking the position of damages where these are caused in the member.
- Capturing the photographs of the damages.
- Automatic print out of recorded inspection results (excel format)

In addition to efficient work realized by the input volume reduction, it can improve the quality of inspections because the unified input not fluctuated by the experience of inspectors is considered if the data is input using the tablet PC at site. Details of tablet PC for bridge inspection are described in Chapter 6.

| | |
|---|---|
|  |  |
| Bureau of Rural Road 8 | Bureau of Rural Road 13 |

**Figure 5.4-1 Bridge Inspection Using the Tablet PC for Bridge Inspection**

### 5.4.2 Accuracy Improvement of Visual Observation

In the visual observation in bridges inspection, it is the basis to observe the objects directly. However it may be sometimes difficult to observe directly depending on the site conditions. In such case, the binoculars or telescopes are used for inspection. Below devices and tools are introduced since the use of these can improve the accuracy of inspection results.

#### (1) Bridge Checker and Pole Camera

In the inspection of members under the girders, it is the basis to observe them from under the girder directly. However access of the inspectors to the space under the girder may sometimes be difficult. For example, the space under the girders are limited by the high water level, it is difficult to inspect under the girder even on the boat. An effective bridge inspection method applied to these cases using the bridge checker was introduced. The bridge checker was used in the inspection of pilot bridges.

The bridge checker is the equipment that a digital camera is attached to the end of arm, it is

closed to an object for inspection, the image captured by the digital camera is displayed on the monitor screen on hand, and capture the photographs of damages on the bridge.

By the use of bridge checker, it can inspect in the same accuracy as the visual observation closing to the inspection objects. It can also be used as the pole camera for the inspection at high positions if the arm portion is converted.

The instruction manual of bridge checker is attached in Appendix 2-2.

| | |
|---|---|
|  |  |
| Inspection using the bridge checker | Use as the pole camera |
|  |  |
| Checking through monitor screen | Photograph taken by the bridge checker |

**Figure 5.4-2 Inspection Using the Bridge Checker and Pole camera**

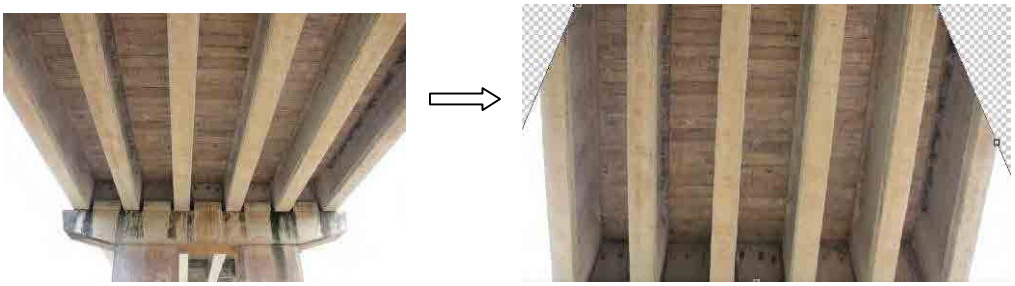
## (2) High Performance Digital Camera

It is desired to observe the objects as close as possible in the visual observation. However it may be sometimes difficult to close to the object if the space under the girder is too high, i.e., distance from the water level to the bottom of bridge is long. If the damage is spread to the wider area, the overall understanding of damages is effective for appropriate evaluation and policy set up for the measures. In such case, the damage situation of structure can be captured by high resolution (number of pixel) or high telescopic performance digital camera, and the

use of image processor software realizes more accurate understanding of situation and appropriate evaluation. This method was introduced through the inspection of pilot bridges.

Examples of perspective transforming process and splicing function using the image processing software are shown on Figure 5.4-3. It was introduced that by the application of these methods, the perspective transforming process when taking periodic capturing of photographs makes easy understanding of aging progress of damages, and outline of overall damages can be recorded if the damages are spread in wide area. Explanatory materials and image processing method are attached to Appendix 2-2.

Perspective transforming process of images (Example)



Splicing of images

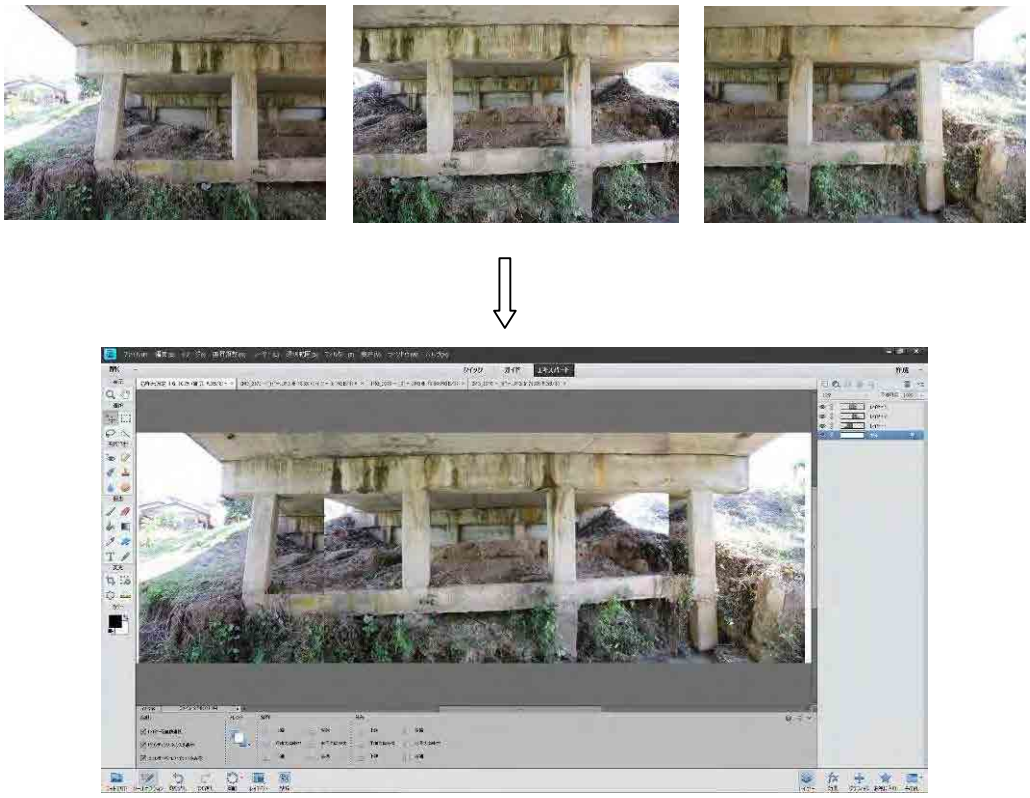


**Figure 5.4-3 Inspection Using High Performance Digital Camera**

**（Example of Image Processing）**

### 5.4.3 Nondestructive Inspection Tools

Cracks appeared in the surface or rebar exposure can be checked by visual observation in the concrete structure, however internal conditions cannot be inspected by the visual observation. It is absolutely necessary to understand the conditions of concrete structure more in details for setting up of measures to be taken for damages. For this purpose, nondestructive inspection methods of concrete structure to know the conditions of concrete structure described below were introduced at the time of inspection of pilot bridges.

#### (1) Rebound Hammer

Rebound hammer is a tool to presume the strength of concrete by the measurement of strength of returned shock when hitting the concrete surface. This is the simplest method to measure the strength without destructing the concrete. Using the rebound hammer, compressive strength of bridge railing, slab and pier were measured at the inspection of pilot bridges.

Rebound hammer is to obtain the compressive strength applying the correlation between degree of reaction when concrete is hit and compressive strength. The hammer contained in it hits the concrete activated by the spring, the value of rebound degree obtained when rebounds is substituted into the strength estimate equation, and then presume the compressive strength of concrete. Comparing with presumed concrete strength and design strength, it can be used for the evaluation whether the damages are caused by the concrete strength or not. Instructions manual and data sheet format are attached in Appendix 2-2.

#### (2) Rebar Search Equipment

Rebar search equipment is to presume the position of rebar in the concrete. It was introduced using the rebar search equipment of electro-magnetic induction method which can be obtained in Thailand. Rebar position in bridge railing, slab and pier were measured, concrete cover thickness was measured and the rebar size was presumed.

Features of rebar searching by the electro-magnetic induction method are that the diameter of rebar can be estimated, and the rebar position can be presumed even there are air spaces or honey combs in the concrete. Electromotive force of coil varies by the variation of magnetic induction when the magnetic induction, which is generated by the application of electric current in the coil contained in the equipment, spreads into the rebar. Position of rebar, concrete cover thickness and the diameter of rebar can be measured by capturing this variation as the signal, and be processed in the equipment.

Comparing measurement value and design value, it can be used to estimate whether the rebar is placed in the right position or not, or presume the causal relation with the damages. Also, it can be used to avoid the damage of rebar by the advance measurement of rebar position when the concrete surface is drilled for repair. Operating instructions and data sheet

format are attached to Appendix 2-2.

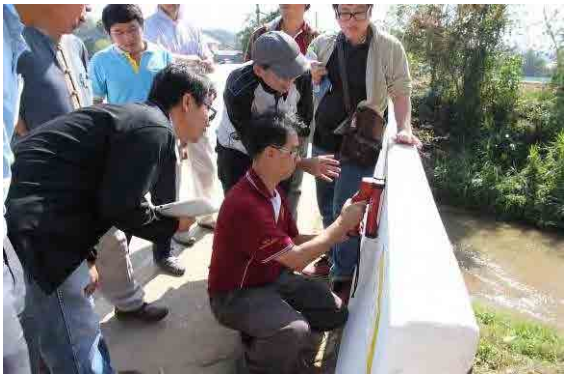
| | |
|---|---|
|  |  |
| Rebound hammer | Rebar Searching Equipment |

**Figure 5.4-4 Inspection Using the Nondestructive Tools**