World

Data Collection Survey on Road Asset Management Platform Technical Support

Final Report

September 2020

Japan International Cooperation Agency (JICA)

Japan Expressway International CO., LTD.
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- Abbreviation Table –

AASHTO	American Association of State Highway and Transportation Officials
AM	Asset Management
ADB	Asian Development Bank
BMS	Bridge Management system
BOT	Build Operate Transfer
BOOT	Build Own Operate Transfer
C/P	Counterpart
DB	Data Base
DBST	Double Bituminous Surface Treatment
DRIMS	Dynamic Response Intelligent Monitoring System
DPWT	Department of Public Works and Transport
EXMID	Expressway, Mega Bridge, and Investment Department
GIS	Geographic Information System
HDM-4	Fourth Highway Development and Management Model
i-DREAMS	intelligence-Dynamic Revolution for Asset Management system
ICT	Information and Communication Technology
IDI	Infrastructure Development Institute-Japan
IRI	International Roughness Index
ISO55001	A standard developed for the use of people or organizations involved in asset management
ITS	Intelligent Transport System
ITC	Institute de Technologie du Cambodia
JICA	Japan International Cooperation Agency
JEXWAY	Japan Expressway International CO., LTD.
JCC	Joint Coordination Committee
JAAM	Japan Association of Asset Management
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MPWT	Ministry of Public Works and Transport
MEF	Ministry of Economy and Finance
MOM	Maintenance Operation Meeting
ME	Maintenance Expert
MOTR	Ministry of Transport and Roads
E-/C-/W-NEXCO	East / Central / West Nippon Expressway Co., Ltd.
NE	Nippon Engineering Consultants Co., Ltd
ODA	Official Development Assistance
OJT	On-the-Job Training
PBC	Performance Based Contract
PDCA	Plan-Do-Check-Action
PDM	Project Design Matrix
PMS	Pavement Management System
PMU	Project Management Unit
RMF	Road Maintenance Fund
RMS/PRoMMS	Provincial Road Maintenance Management System
RID	Road Infrastructure Department
RMD	Road Maintenance Department
SIP	Cross-ministerial Strategic Innovation Promotion Program
TAM	Transportation Asset Management Guide
PLUAD/UAD	Main Roads Management Unit
UN	United Nations
WB	The World Bank

Chap. 1 Overview of the Survey

1.1 Background of the Survey

With the high demand for infrastructure development in developing countries, approximately 26 trillion dollars of demand for construction and improvement is forecasted in the Asia-Pacific region by 2030. In addition, these infrastructures, which Japan has supported in developing countries since the 1970s, will soon pass their 50th year and, given the demand for new construction projects, it is essential to reduce the cost by adopting the concept of preventive maintenance and the optimization of operations and maintenance. For this reason, Japan International Cooperation Agency:(hereinafter JICA) has been implementing technical cooperation projects in the Operation and Management of road infrastructure for each country as an effort to promote Road Asset Management (hereinafter Road AM) capabilities.

On the other hand, in "Operation and Maintenance of Infrastructure, Renovation and Management Techniques" (hereinafter SIP Infrastructure), a strategic innovation program promoted by the Japanese government, improvements at the maintenance level through preventive maintenance are expected to be realized at a low cost by using state-of-the-art information and robot technology and by establishing a systemized infrastructure management structure, which will lead to an engagement in the continued creation of a maintenance market as well as the promotion of overseas business operations.

In addition, JICA has set forth efforts to establish preventive Operation and Management of road infrastructure in developing countries and to realize effective and efficient road administration based on asset management methods in order to implement comprehensive initiatives on important development issues in the transportation sector. Under these circumstances, JICA launched the Road AM platform in October 2017 to centrally cover everything from state-of-the-art national initiatives by countries and highway companies related to road AM to regional initiatives by local governments, and also established a system to enable flexible responses to issues in developing countries.

In order to promote JICA's efforts of Road AM as well, it is necessary to investigate the trends of Road AM at home and overseas and to formulate a support plan for the establishment of Road AM in developing countries, while also organizing unified technical guides and manuals along with good examples of efforts for national Road AM and Technical Projects and acceptance of long-term trainees to universities within Japan.

Last year, JICA collected and analyzed various types of information from Pakistan, Ethiopia, and Kenya through the Data Collection Survey on Human Resource Development Program for Road Asset Management, and developed Road AM evaluation indicators, identified issues and formulated support plans. At the same time, JICA is accelerating the above initiatives by reviewing special programs for Road AM initiatives in Japan, group training and long-term training.

1.2 Purpose of the Survey

From the background described above, this Survey is based on Road AM in Cambodia, Laos, Bhutan, and Kyrgyzstan that contribute to strengthening Operation and Management capabilities.

- Confirm maintenance management ability
- Organize challenges for the establishment of Road AM
- Study a support plan for the establishment of Road AM

In the Solomon Islands and Zimbabwe,

- Follow-up on monitoring activities for group training in past year

Further

- Research the trends of national and overseas Road AM technology
- Systematization of group training in the road sector
- Organizing technical standards for each country created by the Technical Cooperation Project

- Support for the JICA national committee

1.3 Overview of the Survey

1) Name of the operation: Data Collection Survey on Road Asset management platform Technical Support
2) Contract period: From 10th September 2019 to 9th September 2020
3) Orderer: Japan International Cooperation Agency (JICA)
4) Contractor: Joint Enterprise
   JEXWAY: Japan Expressway International Co., Ltd.
   NE: Nippon Engineering Consultants Co., Ltd
   IDI: Infrastructure Development Institute-Japan
   W-NEXCO: West Nippon Expressway Co., Ltd

1.4 Items of the Survey

In accordance with the above-mentioned items, we completed a field survey in Cambodia in December, and adjusted the site survey schedule for other target countries. However, with the spread of COVID-19, the field survey was stopped except in Cambodia, and the contents of the business were changed.

The main changes to field surveys are that only Cambodia will implement "T3: Confirmation of achievement level of Road AM", "T4: Extraction of issues for Road AM fixing", and "T5: Development of support plans for Road AM settlement", while Laos and Kyrgyzstan will outline the technical cooperation projects and the status of their efforts.

For "T7: Systematization of group training in the road sector", we have added "NT7-2: Preparation of materials to select countries to follow-up on group training", "NT7-3: DBST Maintenance Management", "NT7-4: Pavement Maintenance Management", "NT7-5: Road Maintenance Database", and "NT7-6: Organization and Legal System in Road Administration".

For "T8: Organizing technical standards in each country created by the Technical Cooperation Project", we have added "NT8-2: Summary comparison of technical standards in each country","NT8-3: Comparative study of overseas road inspection and diagnostic manuals and road inspection and diagnostic standards in Japan","NT8-4: Comparative study of overseas bridge inspection and diagnostic manuals and bridge inspection and diagnostic standards in Japan"."T9: Follow-up of training monitoring by issue in past year" will be canceled.

1.4.1 Preparation of Business Plan and Explanation and Consultation of Inception Report T1⇒NT1 (Change task number)

JICA will approve a business plan (Japanese) and inception-report (English) that describes the implementation policy, content, implementation system, work plan, etc. of the survey and finalize with advice from members of the JICA national committee. After that, we will consult with local offices and technical project officials to share the purpose of the survey, how it was conducted, the system of implementation, and the outline of the survey.

The implementation period shall be during the period when the head of operations for each technical cooperation project has returned to Japan, and before the local travel is carried out, and the implementation location shall be JICA Headquarters.

1.4.2 Examination of Road AM Evaluation Method T2⇒NT2 (Change task number)

We will review the evaluation method model of the achievement of Road AM created in the past survey, and consider the addition and improvement of new evaluation items, while obtaining technical advice from members of the JICA national committee, officials of the Japan AM Association, and those involved in technical cooperation projects in the countries under investigation. Information gathering will be conducted through quantitative and qualitative interviews with existing documented surveys and interviews with technical cooperation project officials, Japanese road experts and their counterparts. In qualitative hearings, we focus on local issues that cannot be covered by quantitative hearings described later and measures in

technical cooperation projects and obtain reference information when understanding the local technical levels and systems, and formulating issue extraction and support plans. In the quantitative hearing, we will quantitatively clarify the areas where introduction of Road AM is progressing using the Road AM evaluation sheet, and the areas where introduction is delayed as well as areas that need to be enhanced in the future.

1.4.3 Confirmation of Achievement Level of Road AM T3⇒NT3 (Change task number)

To confirm the achievement of Road AM, use the evaluation sheet of Road AM. The items of evaluation should be broken down the specific level for scoring and covered comprehensively to compare with other countries using same evaluation sheet. Further, the score of middle items is the simple average score of the detail items in those fields, respectively. The score of large items is the simple average score of the middle items in those fields, respectively.

The achievement of the Road AM is evaluated from the viewpoint of whether the PDCA (Plan – Do – Check – Action: PDCA) of technical items such as inspection, diagnosis, repair plan, maintenance, repair work, and recording of roads is well-organized or operated such as through the organization, system, budget, funding, tender and contract system.

In the Transportation Asset Management Guide (hereinafter TAM guide), the score of each evaluation item is in five stages, from one point to five points. Level 1 is the initial stage, level 2 the awakening stage, level 3 the structured configuration stage, level 4 the development stage and level 5 the best practice. The evaluation levels are consistent throughout. The evaluation sheet is filled in by the technical cooperation project team and counterpart in the country, and the sheets of both are analyzed at the same time and differences are evaluated to reflect the actual situation by investigating the cause.

Change contents Changed only to field surveys in Cambodia, Laos and Kyrgyzstan will outline technical cooperation projects and summarize the status of their efforts.

1.4.4 Extraction of Issues for Road AM Fixing T4⇒NT4 (Change task number)

It is possible to systematically extract issues using the Road AM evaluation sheet described above.
In conjunction with the current issues, the contents of the middle and detail items include elements that can be used to extract the issues that need to be solved toward the establishment of Road AM after the end of the technical cooperation project, and we must consider that there are no leaks. For issues that have emerged during the PDCA cycle of Operation and Management, which requires research and development of repair, long-life, and inspection technologies, we will a draft research plan for conducting research at Japanese universities.

Change contents Changed only to field surveys in Cambodia.

1.4.5 Development of Support Plans for Road AM Settlement T5⇒NT5 (Change task number)

Based on T3 and T4, the support plan after the completion of the technical cooperation project will be developed after having discussion with Japanese road experts and JICA officials. By effectively utilizing the training program, this plan proposes a medium- to long-term support plan while reducing the total cost of business expenses for each fiscal year.

Change contents Changed only to field surveys in Cambodia.

1.4.6 National and Overseas Trends Survey on Road AM T6⇒NT6 (Change task number)

Road administrators of local governments and highway companies in Japan, the United Nations (hereinafter UN), The World Bank (hereinafter WB), the Asian Development Bank (hereinafter ADB),will conduct an organized analysis of the literature and exchange opinions with the relevant parties, and gather initiatives and technologies that will be helpful in developing countries. More than two agencies will be interviewed, including the Ministry of Land, Infrastructure, Transport and Tourism, along with local

governments in Japan and highway companies.
Regarding the UN, WB, and ADB, we will conduct two or more reviews from reports or papers published externally by each agency. In addition, we will also look at the development status of technologies that are expected to be used in developing countries through research and development technologies and proprietors of universities, research institutes, private companies, etc.
Specifically, it is assumed that the agencies to be scoped for each of the following items is to be decided, through which we can grasp the latest trends.
Change contents For UN, WB, and ADB, two or more of the reports or papers published externally by each agency will be changed to five or more reviews.The list of national trends surveyed is shown in Table 1.1.

Table 1.1 List of domestic trends survey (Draft)

Organization	Points	Outline
MLIT/ Local government	General maintenance and management	Gathering information on "Road Maintenance Conference" initiatives conducted in 47 prefectures. The present situation and problems during the second round of bridge inspections are summarized.
Civil Engineering Research Institute	〃	Hearing on technical support being provided at Caesar, Structure Maintenance Research Center.
Expressway company	〃	Conducted a hearing on the management system of highway companies and maintenance management technology.
Utsunomiya City Sakura City	Pavement maintenance	Hearing on municipalities that have formulated repair plans to extend the life of pavement and on cost reduction measures for pavement maintenance and management, human resource development, and how to pass-on technology.
Niigata City	Bridge maintenance	Hearing on the activities of the Niigata City Bridge Asset Management Review Committee held in Niigata City, and the status, issues, and countermeasures for bridge maintenance and management held by local governments.
UN, WB, ADB	Reports and papers	Translate reports and papers on maintenance published by each institution and conduct two or more reviews.
Nagasaki University	Maintenance and human resource development	The Michimori Training Unit is being developed not only in Nagasaki but also in the Kansai region. Also hold hearings on development initiatives in these other regions.
Ryukyu University	〃	As part of the training of bridge inspection engineers, we conducted hearings on initiatives such as bridge inspector training and bridge maintenance master training.
Private companies, etc.	Utilization of new technologies	Among the new technologies described in the "Inspection Support Technical Performance Catalog (draft) as of February 2019" published by the Ministry of Land, Infrastructure, Transport and Tourism, (1) image measurement technology and (2) non-destructive inspection technology shall be collected and technical outlines shall be compiled.

1.4.7 Systematization of Group Training in the Road Sector T7⇒NT7-1 (Change task number)

JICA's 2019 road sector group training is 10 courses: ITS practice, bridge comprehensive, road administration, road maintenance, bridge maintenance, highway maintenance, urban road maintenance, environmentally sustainable urban transportation planning, business management in social infrastructure development, and infrastructure management system.

On the other hand, there is an issue with having a lot of overlap of the content in the training program of each course up to now. For example, (lectures) the introduction to Japanese Operation and Management, outline of Operation and Management and road administration, etc., (field) Civil Engineering Research Institute, mega bridges, etc., similar lectures and the same tour destination, etc. Similarly, there are cases where the content and destinations of lectures are duplicated in group training and country training, etc. included in the Technical Cooperation Project.

We will review the duplication of the content of these training sessions and organize group training from the viewpoint of maximizing the expression of the effectiveness of further training.

- We will understand the outline and curriculum provided by JICA, and organize and review the requirements for the content, timing, target organization of training participants, and target human resources, etc. and propose an economic and efficient training course setting and training curriculum.
- If necessary, we will consider proposing new training content for new issues and reforming and abolishing group training.

For example, the following proposals will be considered as a measure to systematize group training to the above purposes.

1) Based on the two courses of large classification (roads and bridges), we will organize and integrate training by classifying them in the middle classification (administration, planned construction, maintenance, etc.).
2) The content of the training is then divided into countries that have implemented the technical cooperation project and the countries that have not implemented it. (e.g., Beginner's, Intermediate, Advanced Courses)
3) Lectures and field destinations where the contents of the training are almost duplicated in different training courses are taken jointly as a common curriculum, and training is improved by jointly touring the field.
4) We will integrate Japanese training and group training, which are being implemented in the technical cooperation project related to roads and bridges.
5) Road and bridge maintenance and road administration will be reorganized into courses as “Road AM” to improve efficiency.

1.4.8 Preparation of Materials to Select Countries to Follow-up on Group Training NT7-2 (Additional)

In 2019, we collect and organize country reports and action plans prepared by trainees who participated in the “Road Maintenance” 5 courses, “Bridge Maintenance” course, and “Road AM” 2 courses, and create follow-up national selection materials for group training after the following year.

1.4.9 DBST Maintenance Management NT7-3 (Additional)

For the purpose of expanding the curriculum for “Management of Double Bituminous Surface Treatment (hereinafter DBST) paved roads”, which was highly needed in the training questionnaire for “Road AM” group training, we collect information from each trainee on the content of the training for “Road Maintenance” group training conducted in fiscal 2019.

In addition, JICA's past cooperation in simple paving and exchange of opinions with paving companies in Japan and overseas will be conducted, and the contents of the curriculum that can be implemented in the next year and in later training will be conducted.

1.4.10 Pavement Maintenance Management NT7-4 (Additional)

For the purpose of expanding the curriculum for "pavement maintenance management in accordance with the assortment of highways and living roads", which was highly needed according to the training questionnaire for "Road AM" group training, we collect information from each trainee on the content of the training for the "Road Maintenance" group training conducted in fiscal 2019.We will collect information from researchers on pavement, organize the procedures applied in Japan and examine the contents of the curriculum for training after the next fiscal year.

1.4.11 Road Maintenance DB NT7-5 (Additional)

In order to enhance the curriculum of the "Road Maintenance Database", which was highly needed according to the training questionnaire for "Road AM" by issue, we conduct hearings with road administrators in Japan and examine the contents of the curriculum that can be implemented in the next stage and beyond.

1.4.12 Organization and Legal System in Road Administration NT7-6 (Additional)

In Japan, the Basic Plan for Long-Life Infrastructure has been put together, and administrators of various infrastructure features, including local governments and private companies, are working together on strategic maintenance and renewal.
In the road field, we have established systems to ensure that infrastructure is properly maintained and maintained, and strategic maintenance and renewal is implemented through measures that related organizations should take.
We will examine the contents of the curriculum, which allows students to comprehensively understand the system and legal system in Road AM in Japan.

1.4.13 Organizing Technical Standards in Each Country Created by the Technical Cooperation Project T8⇒NT8-1 (Change task number)

In order to improve the efficiency of the project formation work of new technical cooperation projects, we will collect technical standards created in the technical cooperation projects implemented so far so that we can customize and utilize the projects to be implemented, and create basic materials necessary for the creation of applicable technical standards according to the technical level.

1.4.14 Summary Comparison of Technical Standards in Each Country NT8-2 (Additional)

Using the basic materials described above, we will summarize the outline of the technical cooperation project, the outline of the technical standards introduced and the scope of the introduction.
Furthermore, the description of the technical standards of inspection, diagnosis, maintenance, and repair of roads and bridges is roughly compared (comparison of the table of contents), to compare the technical level, etc.

1.4.15 Comparative Study of Overseas Road Inspection and Diagnostic Manuals and Road Inspection and Diagnostic Standards in Japan NT8-3 (Additional)

The road inspection and diagnostic manuals created in the Technical Cooperation Project are compared and examined according to the main study items described in the Road Inspection Diagnostic Technology Standards in Japan.

At the same time, we will summarize the issues for better quality manuals for road inspection and diagnostic manuals, which will be created in technical cooperation projects in the future.
Specifically, it is assumed that the following items are organized.

1） Summary of Japan's periodic road inspection technical materials, extraction of main items
2） Arrangement of road inspection and diagnostic manuals through technical cooperation projects
3） Comparative study with national standards

4） Future Issues

1.4.16 Comparative Study of Overseas Bridge Inspection and Diagnostic Manuals and Bridge Inspection and Diagnostic Standards in Japan NT8-4 (Additional)

The bridge inspection and diagnostic manuals created in the Technical Cooperation Project are compared and examined according to the main study items described in the Bridge Inspection and Diagnostic Technical Standards in Japan.

At the same time, we will summarize the issues for the “Bridge Inspection and Diagnosis Manual”, which will be created in the technical cooperation project in the future as a higher-quality manual.

Specifically, it is assumed that the following items are organized.

1) Summary of periodic Japanese bridge inspection technical materials, extraction of main items
2) Arrangement of bridge inspection and diagnostic manuals through technical cooperation projects
3) Comparative study with national standards
4) Future Issues

1.4.17 Follow-up of Training Monitoring by Issue in Past Year T9 (Cancel)

We will conduct follow-up activities for the monitoring activities of “Bridge Maintenance” group training conducted in the past year. The purpose of this activity is to confirm and follow the development status in the target country from a medium-term perspective after the implementation of the training “Bridge Maintenance” training (March 2016) (October to November 2016) of the monitoring activities (such as the implementation status of the action plan and the status of activities of trainees related to the dissemination and development of the technology obtained through the training).

Target countries: Solomon Islands, Zimbabwe.

1）Preparation before field surveys

After fully grasping the results of monitoring activities conducted in the past year and the individual circumstances of the target country, we will confirm the status of activities and current issues after monitoring of group training progress by e-mail, TV conference, etc., in accordance with the items of the common questionnaire that was prepared in advance.

2）Local follow-up activities:

a）Hearing with the supervisors of trainees and their supervisors

Check the progress of the action plan and understand the activities. In addition to changes to the action plan at the implementation review stage, we will also confirm the status of the organization's efforts, such as the dissemination activities of training content, such as holding a report meeting for trainees returning home, and the obligation to pass on the technology to successors.

b) Holding seminars aimed at improving the technical capabilities of the institutions to which the trainees belong

Based on the needs of the trainees, we will hold seminars consisting of programs that focus on the issues required in the target country.

c) Field visits aimed at understanding the status of Road AM in the target country

We will conduct on-site inspections of bridges with issues, such as bridges with remarkable deformations, to understand the damage and provide necessary advice.

3) Points to keep in mind when implementing

In confirming the issues, we will focus on the priority items that have been set based on the results of monitoring activities conducted in the past year, and after accurately understanding the individual circumstances of the target country in cooperation with the trainees. In addition, the merits of monitoring are explained well to the parties concerned, and the cooperation of the parties concerned will be obtained.

1.4.18 Support for the JICA National Committee T10⇒NT9 (Change task number)

The above findings will be reported to the National Support Committee and advice and comments from experts will be reflected in future Road AM follow-up activities.

1.4.19 Report Preparation T11⇒NT10 (Change task number)

The above survey results are summarized as a report.
Figure 1.1 shows a flowchart (initial) of the entire business that clearly describes activities and results. Figure 1.2 shows a flowchart (Change).

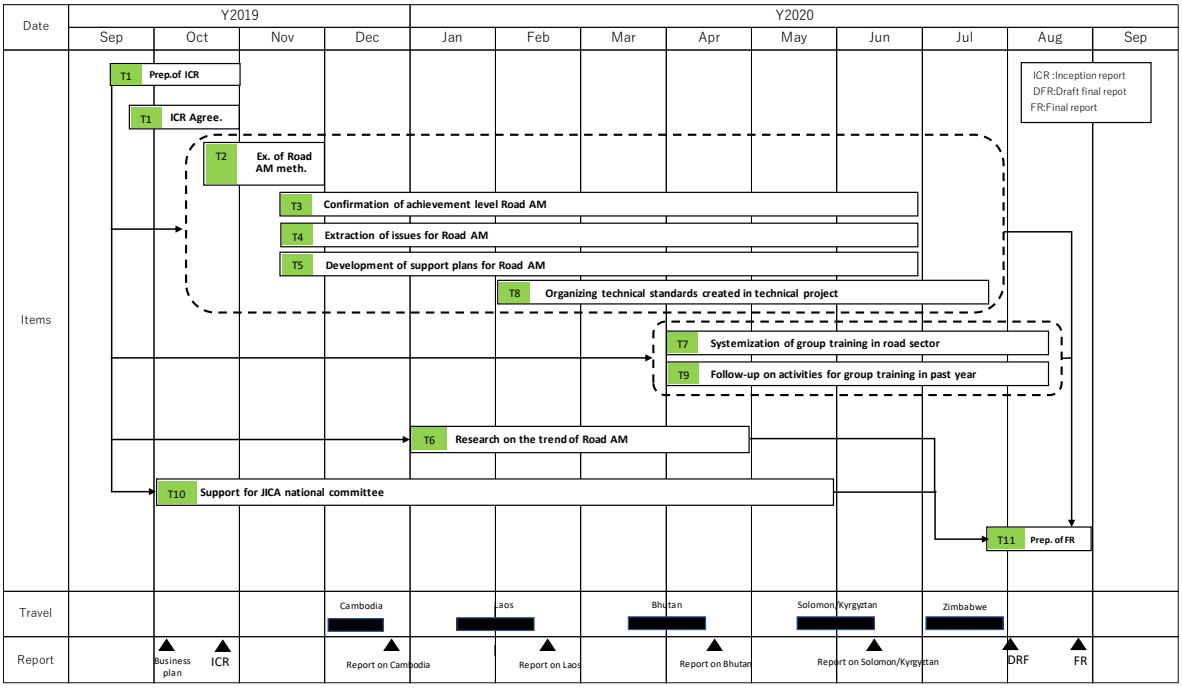


Figure 1.1 Entire Flowchart (Initial)

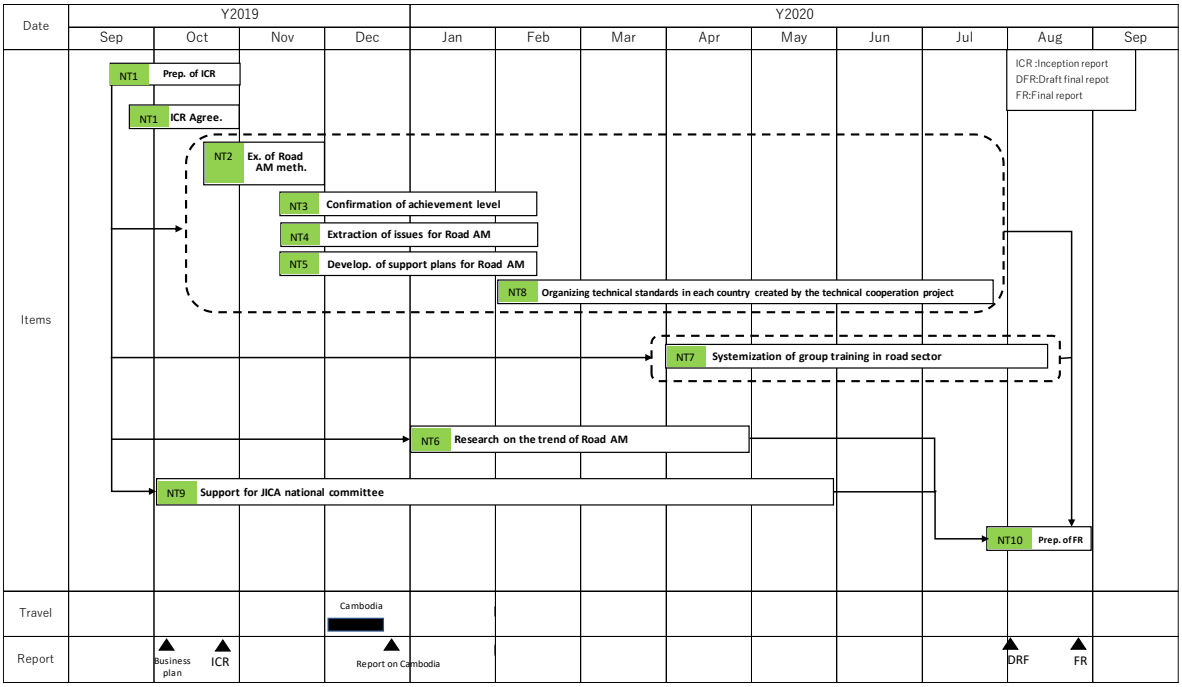


Figure 1.2 Entire Flowchart (Change)

1.5 Site Surveyed

The sites surveyed initially are shown in Table 1.2.
Table 1.3 shows the sites to be changed.

Table 1.2 Sites surveyed (Initial)

Name	Target projects	Region
Cambodia	Project for Strengthening Capacity for Maintenance of Roads and Bridges (Implemented)	All
Laos	Project for Improvement of the Road Management Capability (Implemented)	All
Bhutan	Project for Capacity Development in Construction and Maintenance of Bridges (On-going)	All
Kyrgyzstan	Project for Capacity Development for Road Disaster Prevention Management (Implemented)	All
Solomon Islands	JICA Group Training on Bridge Maintenance in 2016	All
Zimbabwe	JICA Group Training on Bridge Maintenance in 2016	All

Table 1.3 Survey site (change)

Name	Target projects	Region
Cambodia	Project for Strengthening Capacity for Maintenance of Roads and Bridges (Implemented)	All
Laos	Project for Improvement of the Road Management Capability (Implemented)	All
Kyrgyzstan	Project for Capacity Development for Road Disaster Prevention Management (Implemented)	All

1.6 Other Country Agencies

Originally, the target organization of the other country is shown in Table 1.4.

Table 1.5 shows the target organizations of the country that will be changed.

Table 1.4 Target organizations in the applicable country (Initial)

Country	Name
Cambodia	Ministry of Public Works and Transport
Laos	Ministry of Public Works and Transport
Bhutan	Department of Roads, Ministry of Works, and Human Settlement
Kyrgyzstan	Ministry of Transport and Communications
Solomon Islands	Ministry of Infrastructure Development
Zimbabwe	Ministry of Transport, Communication, and Infrastructural Development

Table 1.5 Target organizations in the applicable country (Change)

Country	Name
Cambodia	Ministry of Public Works and Transport
Laos	Ministry of Public Works and Transport
Kyrgyzstan	Ministry of Transport and Communications

1.7 Survey Team

Table 1.6 Consultant team

Position	Name	Company
Leader/Road Asset Management 1	Akira Okamoto	JEXWAY
Road Asset Management 2	Ikuo Harasaki	NE
Support Program Review 1	Hiroshi Warita	JEXWAY
Support Program Review 2	Takehiko Tsuji	IDI
Information Gathering 1	Hiroji Kasamatsu	W-NEXCO
Information Gathering 2	Toru Tsuchihashi	JEXWAY
Information Gathering 3	Gentaro Nagasawa (~2019.3)	IDI
	Yasushi Takahashi (2020.4~)	IDI
Follow-up Activities	Sachiyo Matsubayashi	NE
Domestic Support for JICA Committee	Naruhiko Kawada (~2020.6)	JEXWAY
	Masami Morita (2020.6~)	JEXWAY

Chap. 2 Road Infrastructure Maintenance Capacity Verification Method for the Target Countries

2.1 Target of the Chapter

We will review the evaluation method model for the achievement of Road AM created in past surveys, and consider the addition and improvement of new evaluation items while obtaining technical advice from members of the JICA national Committee, officials in the Japan AM Association and those involved in technical cooperation projects in the countries under investigation.

2.2 Overview

Based on the opinion that "if we can show the situation of infrastructure in each country with easy-to-understand indicators, this will be a better initiative" that was expressed at the preparatory meeting of the JICA national committee held on October 4, 2019 and in this business, we reviewed the Road AM evaluation sheet under the supervision of Dr. Fujiki of JAAM. Specifically, we added four small items in order to improve the evaluation accuracy, changed the description contents of 26 specifics according to the PDCA cycle, clarified the nine specifics that were unclear and changed the perfect score in five breakdown items to three points.

2.3 How to Check the Achievement Level of Road AM

The evaluation sheet for Road AM is used to confirm the achievement level of the Road AM. The evaluation items are broken down to a level where they can be evaluated and scored at a detailed level and, finally, set up comprehensively using the same items so that a comparison between multiple countries is possible.

Each score for middle items is the simple average of the details contained in the area and each score for large items shall be the simple average of the details contained in the area. The Road AM achievement level is to be evaluated by the evaluation items and contents of the Road AM evaluation sheet shown in Table 2.1.

Achievement levels should be set up in such a way that strengths can be developed, and weaknesses can be overcome through a support plan with the clarification of strengths and weaknesses by scoring the achievement levels for each item.

In Table 2.1, the evaluation items are divided into technical and operational items. The technical items evaluate whether the PDCA cycle of inspection, diagnosis, repair planning, repair implementation and recording for road maintenance management is functioning or not. The operational items evaluate the maintenance situation of the indispensable platform to strongly promote the PDCA cycle above in such fields as organization, human resources, financing, and system maintenance.

Table 2.1 Evaluation items and content

	Major Items	Content
Technical Items	Inspection	Check if inspections are regularly conducted using appropriate methods, content, and personnel.
	Diagnosis	Check if the cause is being investigated for the damages observed in the inspection and if a scale has been created to divide repairs according to urgency and importance.
	Repair Plan	Check if appropriate measures according to the cause and extent of the damage are being planned for the middle and long term. Check if the idea of preventive maintenance has been adopted.
	Maintenance Management	Check if daily maintenance (cleaning, mowing and small repairs) is carried out regularly in a proper manner.
	Repair Work	Check if planned measures are being carried out with high quality.

	Major Items	Content
	Record	Check if inspection and repair results are being properly recorded and stored and if aged deterioration is monitored.
Operational Items	Organization and Structure	Check if a necessary number of people with willingness and ability are employed and if they are working in cooperation with other departments to promote Road AM.
	Budget and Funding	Check if the budget is properly planned and the necessary funding is available. Also, check if the financial resources for road maintenance are secured.
	Bidding and Contract System	Check if the bidding and contract system has improved and the outsourcing of maintenance and repair work is effectively carried out after an appropriate estimation by the ordering party.
	System and DB	Check if the database (hereinafter DB) to manage assets has improved and if asset management is efficiently implemented using various systems.

Transportation Asset Management Guide (hereinafter TAM Guide) scores each item in five (5) stages on a scale of 1 - 5 (Level 1 being the initial stage, 2 being awakening stage, 3 being structured configuration stage, 4 being development stage and 5 being best practice). The definitions are shown in Table 2.2.

Note that among the breakdown items, there are some items that simply ask for presence/absence or implemented/not implemented and the goal of achievement for those items was level 3. In addition, the degree of achievement for the breakdown items calculated at level 3 was 100% when using level 3 as the basis, and the degree of achievement of breakdown items up to level 5 was calculated using level 5 as the basis.

In addition, the Japan Association of Asset Management (hereinafter JAAM) defined the five-step common maturity evaluation criteria as the basic concept of evaluation to be applied to all asset management processes. By this common maturity evaluation criteria, it is possible to develop the evaluation criteria in a common way for various processes in various fields.

Table 2.3 outlines the common maturity evaluation criteria based on the concept of the process.

Table 2.2 Evaluation item level definition[1]

Level	Definition
Level 1 Initial Stage	There is no effective technical support in asset management. Only data prescribed as duty is collected and they are not being used for communication between internal control and interested persons. Also, there are is internal flow concerning information about business results.
Level 2 Awakening Stage	Basic data collection and processing is performed. PMS and BMS, commercially available software, are being used for the mere purpose of controlling the database instead of using them as forecast or decision-making tools. Data collection beyond required items is being conducted to answer or tackle challenges from management. There is no internal flow concerning information about business results.

[1] AASHTO: TAM Guide (Transportation Asset Management Guide) 2011.1

Level	Definition
Level 3 Structured Configuration Stage	The information system forms the nucleus of the activity. Decision makers will be informed of the financial forecasts quantitatively and of the basic information about the mission of an organization. Within an organization, the data is processed vertically, from the bottom to the top, and the target is transmitted from the top to the bottom. Consistency in business results and communication have been promoted within the organization, but they are not summarized. Internal flow concerning information about business results is vertical.
Level 4 Development Stage	With the aim of implementing resource distribution and cost management, information about business results is used to manage on-going activities. The prediction model is used to predict the outcome of alternative proposals. The current and projected results are communicated to external stakeholders as a means of financing and securing desirable outcomes. The manager relies heavily on this information about business results. The internal flow concerning information about business results is both vertical and horizontal, and it is a prediction of the achievements of a decision.
Level 5 Best Practices	Information technology of asset management is used to regularly design new and more efficient tools and processes. Continuous improvement of informed decision-making and its quality is present at all levels of the organization. The internal flow concerning information about business results is both vertical and horizontal, and it is a continuous process of improvement.

Table 2.3 JAAM common maturity evaluations criteria [2]

Level 1 Indifference (no interest)
Organizations are indifferent to the systematic development of asset management. Lack of understanding of the interrelationships between processes often fails to manage forward-looking processes. Also, there is little formalization or documentation of processes. The organization produces normal output, which depends on the individual's ability.
Level 2 Beginner Ambitions (willingness)
Organizations are eager to develop asset management systematically. Because there is a certain understanding of the interrelationships of process activities, they may succeed in managing forward-looking processes. Process descriptions (inputs, outputs, standard procedures, etc.), activity poor, exist and are documented. Administrators know how they plan to process, how they are implementing the process and what they deliver.
Level 3 Intermediate Structure (structured)
Because organizations have a wide range of organizational developments in asset management, asset management is structured throughout the organization. There is a broad range of forward-looking process management based on an understanding of the interrelationships of process activities. Process descriptions (inputs, outputs, standard procedures, etc.) are formalized, documented, and applied to a wide range of organizations. The structure is managed for process performance and as quantitative a goal as possible.

[2] JAAM Maturity Assessment Subcommittee: Asset Management Process and Maturity Assessment for JAAM Guidebook Series Practitioners. Nikkei Construction News Co., Ltd. .2019.8.20.P32-P33

Level 4 Mastery (proficient)
(In addition to level 3 content) The organization's familiarity with asset management has led to an understanding of the interrelationships of sub-processes within the process. Quantitative prediction is done to some extent, and quantitative targeting of processes based on monitoring sub-processes is performed.
Level 5 Advanced Optimization (optimized)
(In addition to level 4 content) The organization's asset management is optimized for the organization's characteristics, delivering the best results without unnecessary functionality or cost. There is focus on managing organizational performance by analyzing data and improving it based on this. Process improvement is done in the following ways: -Process improvement by quantitative understanding of needs (expectations) -Quantitative approach by cause analysis to process variations and performance -Gradual and innovative improvements in process and technical aspects

The subject of each level, “optimized,” “proficient,” “structured,” “willingness,” and “no interest” regards the total organization that practices asset management. For example, regarding “no interest,” there may be employees who are interested in asset management and are practicing it in their work, even though the organization is not committed to asset management.

Within this criteria, from level 1 to level 3, from the situation in which the official process as an organization is not in place and, depending on the individual, the process is built into the organization and structured as a system with the official process being maintained and documented. Furthermore, from level 3 to level 5, from the state in which the process was in place with the aim of improving the quality of the output, continuous improvement is built into the process progresses and quantitative evaluation is possible, which shows the process of being optimized according to the characteristics and scale of the organization.

Although the maturity evaluation standards of these five stages are independently established in this guidebook, since it is a comprehensive review of the standards such as CMMI (Capability Maturity Model Integration) and the TAM guide, which has extensive evaluation experience overseas, it is a globally acceptable content.

Referring to these, the definition of the level of these survey items was determined in Table 2.4.

In the technical cooperation projects, we will promote support with the goal of reaching level 3.

The structural diagram of the evaluation sheet (example) is shown in Figure2.1, and the radar chart of the middle items (example) is shown in Figure2.2.

The blue line in the figure shows the current state, and the orange line shows the achievement forecast assumed five years after the end of the technical projects.

Table 2.4 Evaluation item level definition (This survey)

Level	Definition
Level 1 Initial Stage	There is no effective technical support in asset management. Inspection, diagnosis, planning of repair plans, maintenance, repair work and records are not implemented. Organization, budget and financing, bid/contract system, general systems and DB are not established. There is hardly any communication within or between organizations.

Level	Definition
Level 2 Awakening Stage	Asset management collects and processes basic data. Inspection, diagnosis, planning of repair plans, maintenance, repair work and records are partially implemented. Organization, budget and financing, bid/contract system, overall systems and DB are partially established. Communication within or between organizations is limited.
Level 3 Structured Configuration Stage	Asset management system forms the nucleus of the organizational activity. Inspection, diagnosis, planning of repair plans, maintenance, repair work and records are implemented. Organization, budget and financing, bid/contract system, overall systems and DB are established. Communication has been promoted within or between organizations, but it is not systemized.
Level 4 Development Stage	Asset management system is being used for resource allocation, cost management and business result management. Inspection, diagnosis, planning of repair plans, maintenance, repair work and records are being systematically operated. Organization, budget and financing, bid/contract system, overall systems and DB are established and are being systematically operated. Communication has been promoted within or between organizations.
Level 5 Best Practices	Information technology of asset management is used to regularly design new and more efficient tools and processes. Inspection, diagnosis, planning of repair plans, maintenance, repair work and records are being systematically operated. Organization, budget and financing, bid/contract system, overall systems and DB are improved and being systematically operated. Communication has been promoted within or between organizations and is being improved continuously.

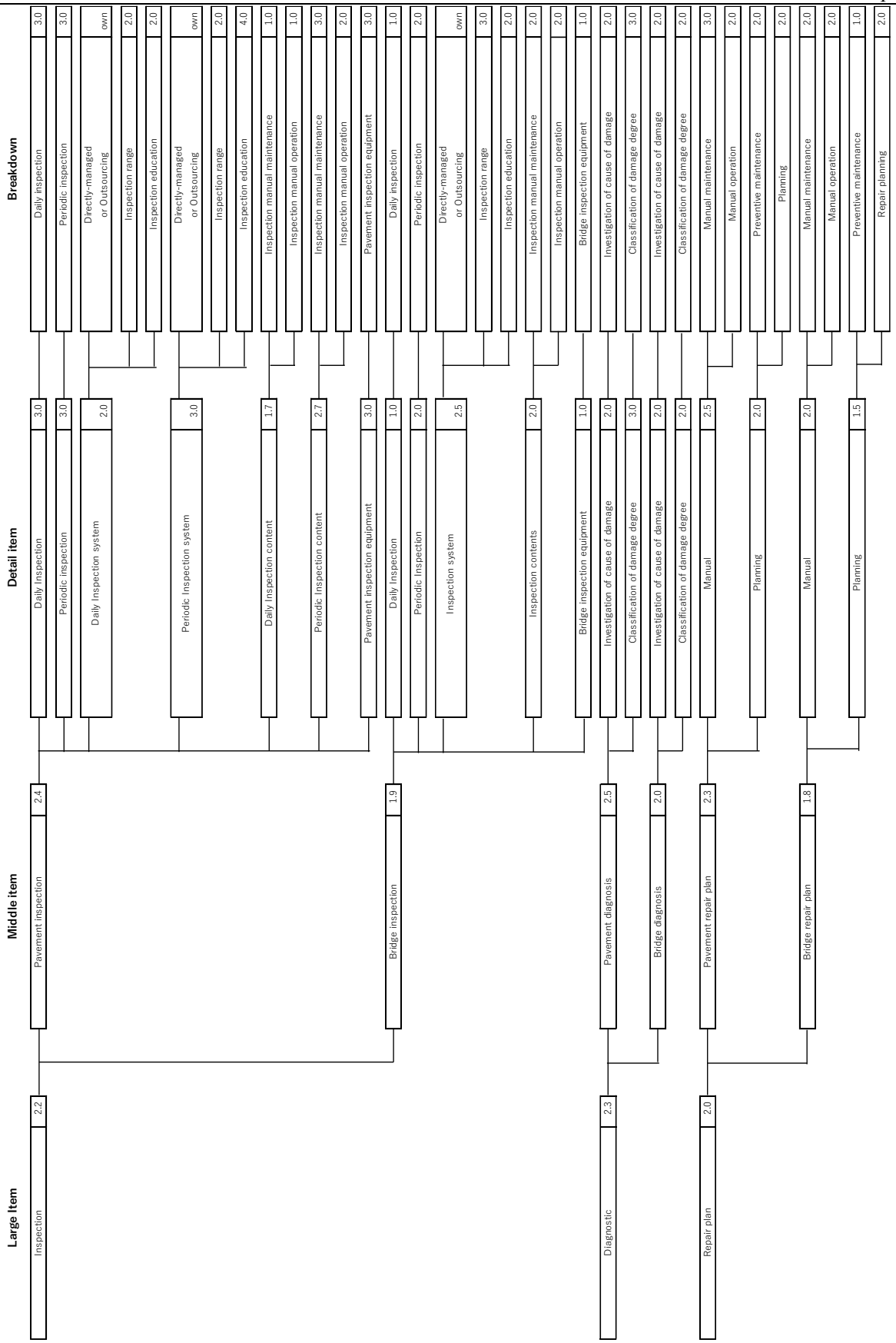
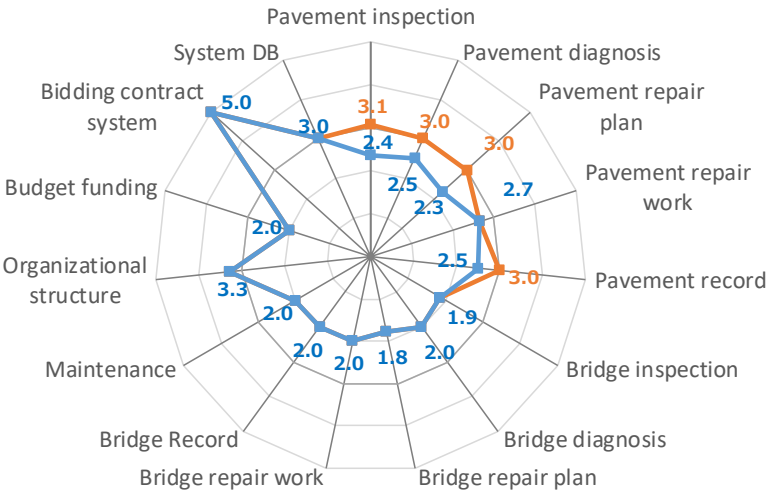


Figure2.1 Road AM indicator structural diagram (example)



Note: The blue line in the figure is the status, and the orange line is the expected achievement five years after the end of the technical project.

Figure2.2 Middle items radar chart (Example)

2.4 Road AM Evaluation Sheet Changes

As shown in Table 2.5, the Road AM Evaluation Sheet 2018 developed in "Data Collection Survey on Human Resource Development Program for Road Asset Managementthe 2018," consists of technical items to evaluate the viewpoint of checking whether the PDCA cycle for maintenance is going well, and the management items to perform the evaluations from the viewpoint of confirming whether the platform supporting PDCA of maintenance is in place.

Technical items are composed of 6 items, "inspection," "diagnosis," "repair plan," "maintenance," "repair work," and "record storage," of which the middle items contain 11 items, small items contain 34 items and the fine details total to 51 items. In addition, the management items are composed of 4 items: "organization, system," "budget, financing," "bid, contract system," and "systems and DB," of which the middle items contain 4 items, the small items contain 8 items and the fine details total to 17 items.

Table 2.5 Road AM evaluation sheet overview (2018)

	Major Items	Points of evaluation
Technical Items 6 items	Inspection	Set evaluation items from the viewpoint of checking whether the PDCA cycle on maintenance is going well. 5-step assessment (initial to best practices). Middle items: 11 Small items: 34 Fine details: 51 items. *Some evaluation items that ask whether they are available/not implemented or not carried out are perfect scores of 3 points.
	Diagnosis	
	Repair Plan	
	Maintenance Management	
	Repair Storage	
	Record keep	
Operational Items 4 items	Organization and Structure	Set evaluation items from the viewpoint of verifying that there is a platform in place to support the PDCA for maintenance. 5-step assessment (initial to best practices) Middle items: 4
	Budget and Funding	

	Major Items	Points of evaluation
	Bidding and Contract System	Small items: 8 Fine details: 17 *Some evaluation items that ask whether they are available/not implemented or not carried out are perfect scores of 3 points.
	Systems and DB	

Based on the opinion that "if we can show the situation of infrastructure in each country with easy-to-understand indicators, it will make for a better initiative" at the preparatory meeting of the JICA national committee held on October 4, 2019 and in this business, we reviewed the Road AM evaluation sheets under the supervision of Dr. Fujiki of JAAM. Specifically, we added four small items in order to improve the evaluation accuracy, changed the description content of 26 specifics according to the PDCA cycle, clarified the nine specifics that were unclear and changed the perfect score in five breakdown items to three points.

Thus, as shown in Table 2.6, technical items are composed of 6 items: "inspection," "diagnosis," "repair plan," "maintenance," "repair work," and "record storage," of which the middle items contain 11 items, small items contain 34 items and the finer details contain 51 items. In addition, the management items are composed of 4 items, "organization, system," "budget, financing," "bid, contract system," "systems and DB," of which the middle items contain 4 items, the small items contain 11 items and the fine details are 20 items.

Table 2.6 Road AM evaluation sheet overview (2019)

	Major Items	Points of evaluation
Technical Items 6 items	Inspection	Set evaluation items from the viewpoint of checking whether the PDCA cycle on maintenance is turning well. 5-step assessment (initial to best practices). Middle items: 11 Small items: 34 Fine details:51 items. *Some evaluation items that ask whether they are available/not implemented or not carried out are perfect scores of 3 points
	Diagnosis	
	Repair Plan	
	Maintenance Management	
	Repair Work	
	Record Storage	
Operational Items 4 items	Organization and Structure	Set evaluation items from the viewpoint of verifying that there is a platform in place to support the PDCA for maintenance. 5-step assessment (initial to best practices) Middle items: 4 Small items: 11 Finer details: 20 *Some evaluation items that ask whether they are available/not implemented or not carried out are perfect scores of 3 points.
	Budget and Funding	
	Bidding and Contract System	
	System and DB	

2.5 Notes on Field Surveys

Factors that are not considered in the evaluation sheet (such as the needs of the other country and human and institutional constraints) will be actively investigated by technical cooperation project experts, C/P, construction companies, consultants, etc., and will be reflected in issues, countermeasures, and Japanese support measures. In addition, the field survey will be investigated mainly on the matters shown in Table 2.7 below.

Table 2.7 Content of field surveys.

Project	Method	Target person of Meeting	Remarks
Understanding the Technical Project progress status	Questions about the content and status of Technical Projects	Technical Project expert, C/P	Limited to target areas of Technical Project
Understanding Road AM general challenges and grasping of the situation on a local level	Scoring by a Road AM evaluation sheet	Same as above and person in charge of Road AM in said country	Object domain of Technical Project is centered, but outside of its domain is covered wherever possible.
	Scoring by a qualitative sheet	Same as above	

Chap. 3 Current Status, Issues and Support Measures for Road AM in Cambodia

3.1 Target of the Chapter

We will investigate the background of Cambodia's road and bridge maintenance capabilities, provide an outline of road maintenance, technical cooperation projects, construction and maintenance capabilities and technical standards.

In addition, using the evaluation sheet for Road AM, we will confirm the degree of achievement for Road AM in Cambodia through hearings with the technical cooperation project team and counterpart.

In addition, we will extract issues for Road AM fixing and formulate a support plan.

3.2 Overview

JICA has developed a bridge maintenance cycle for the Ministry of Public Works and Transport (hereinafter MPWT) Road Infrastructure Department (hereinafter RID) that strengthens RID's ability to inspect roads and bridges as well as repair capabilities. From March 2015 to March 2018, a project was carried out to strengthen the capacity to maintain and manage roads and bridges such as the Department of Public Works and Transport (hereinafter DPWT) and related organizations.

As a result, the maintenance and management cycle of the bridges managed by RID, the strengthening of the inspection ability of the road and the bridge managed by RID, the strengthening of the repair capacity of the road and the bridge managed by RID and the spread of the maintenance cycle for roads and the bridges to DPWT and related organizations were achieved.

As a result of the field survey, we are generally satisfied with both bridges and pavement at level 3, which is aimed at JICA technical cooperation projects in the Road AM evaluation index.

However, the Pavement Management System (hereinafter PMS) that supports the maintenance and management of pavement has not been introduced, and the introduction of the system is necessary.

Further, it is necessary to improve the bridge repair capacity of DPWT that is carried out maintenance as well as the repair of pavement and bridges directly because it is limited currently.

The issue remains that it is necessary to introduce a DB system that can manage road maintenance information in an integrated manner. It is necessary either to expand the organization of the DPWT work force. introduce a method of outsourcing after training a domestic local company or set a national direction. It can be assumed that the maintenance and inspection technology for diagonal bridge cables such as those used on the Tsubasa bridge and the like are not available, and also that the ability for large-scale repair of steel and PC bridges, which will be required in the future, is lacking.

As a support measure, we will help by dispatching short-term experts and consultants so that we can build pavement DBs and develop and operate paving inspection, repair, and repair planning manuals.

In addition, trainees will be invited to Japan highway managers to improve pavement maintenance and management capabilities through OJT education, task-specific and country-specific training.

We provide support through the dispatch of short-term experts and consultants on system design, organizational planning, contracting methods and more.

For maintenance and inspection of mega-bridges and improvement of repair technology capabilities, we will provide support by dispatching short-term experts and consultants.

In addition, it is considered effective to invite trainees to Japanese highway management companies, research institutes, construction companies, etc. to improve the maintenance and management capabilities for mega-bridges through OJT education, task-specific and country-specific training.

3.3 Background of the Technical Cooperation Project[3]

In Cambodia, it is necessary to foster human resources responsible for road and bridge maintenance, secure financial resources, transfer technology, manage the least necessary roads and bridges in a more appropriate state and promote the facilitation of road transport in Cambodia.

The project aims to ensure that roads and bridges under the jurisdiction of the MPWT, are properly managed, and the RID at the MPWT aims to strengthen business management capabilities related to road and bridge maintenance.

This goal is consistent with Cambodia's development policy and needs as well as Japan's aid policy. Furthermore, it is highly valid because it is appropriate in the timing of the implementation and means.

In addition, regarding the road and bridge maintenance budget, the MPWT has negotiated with the Ministry of Economy and Finance (hereinafter MEF), and the budget proposal was approved. Through the project, regular and quantitative assessment methods for roads and bridges have been introduced that enable the monitoring of three-year budget plans and annual fluctuations based on data. It has been judged that the effectiveness and the impact are high due to improvements such as regular inspections of bridges which were not inspected before the project, and the budget for bridge repair and replacement newly being newly implemented.

In terms of efficiency, the project period was as planned but the input of Japanese experts to achieve the project target was 6.1% higher than initially intended.

The DPWT decided early in the project to expand from 3 selected locations to 25 locations. All these locations were equivalent to DPWT, and efficiency was achieved utilizing IT technology. This decision was made to achieve the project goals. Although the plan was executed, the efficiency was judged to have been moderate.

As for sustainability, the policy on roads and bridges is still maintained and finance is slated to be high through the project as a result of the newly approved budget for road bridge maintenance, including the costs associated with periodic inspections and the cost of training the MPWT engineers.

On the other hand, because of the traffic of overloaded vehicles, river flooding, problems with the initial structure quality, such as deterioration of the old remaining bridges, the necessity and importance of the maintenance and management of roads and bridges is further increased.

In Cambodia, the MPWT is responsible for the maintenance and management of infrastructure, of which RID oversees planning and management, and DPWT oversees implementation. For bridges the framework for bridge maintenance, including basic operations such as bridge ledgers, periodic inspections, inspection records, etc., has not been maintained and the necessary budget adjustments have not been made.

For this reason, the development of basic information and human resources, the acquisition of inspection and repair techniques and the maintenance of necessary equipment were strongly required to implement bridge maintenance appropriately.

With regard to roads, the basic work related to maintenance has reached a level where RID can perform the work by itself, but budget shortfalls are chronic and it is necessary to construct a more systematic method of maintenance as well as a systematic budget demand method.

Under these circumstances, MPWT requested the Japanese government to develop technical cooperation projects to improve the capabilities of the administrative staff responsible for roads and bridges, and JICA launched the ”Project to Strengthen The Maintenance and Management Capabilities of Cambodian Roads and Bridges” in April 2015.

[3] JICA: Project to Strengthen Maintenance and Management Capacity for Roads and Bridges in Cambodia Project Final Report (Summary of Japanese Text). February 2018

3.4 Overview of Road Maintenance in Cambodia

3.4.1 Length of National and State Roads in Operation[4]

In Cambodia, roads are the main means of transportation for passenger and freight transportation.

Cambodia's road network is 58,400 km long, of which 7,248 km is designated as national highways.

Many of these road networks were built between 1920 and 30, and many were damaged by the civil war after 1970, resulting in them temporarily not being able to fully function as a transport network.

As a result, after the end of the civil war, restoration and renovation of national highway has been carried out support from many countries including Japan, and currently the single-digit national highways have almost been fully paved, and the renovation of the double-digit national highways are taking center stage. Since 2000, about half of the existing bridges (about 1,000 bridges) have been renovated and new bridges have been developed. In addition, the development of the Long Bridge, which crosses the Mekong River, etc., has also been promoted.

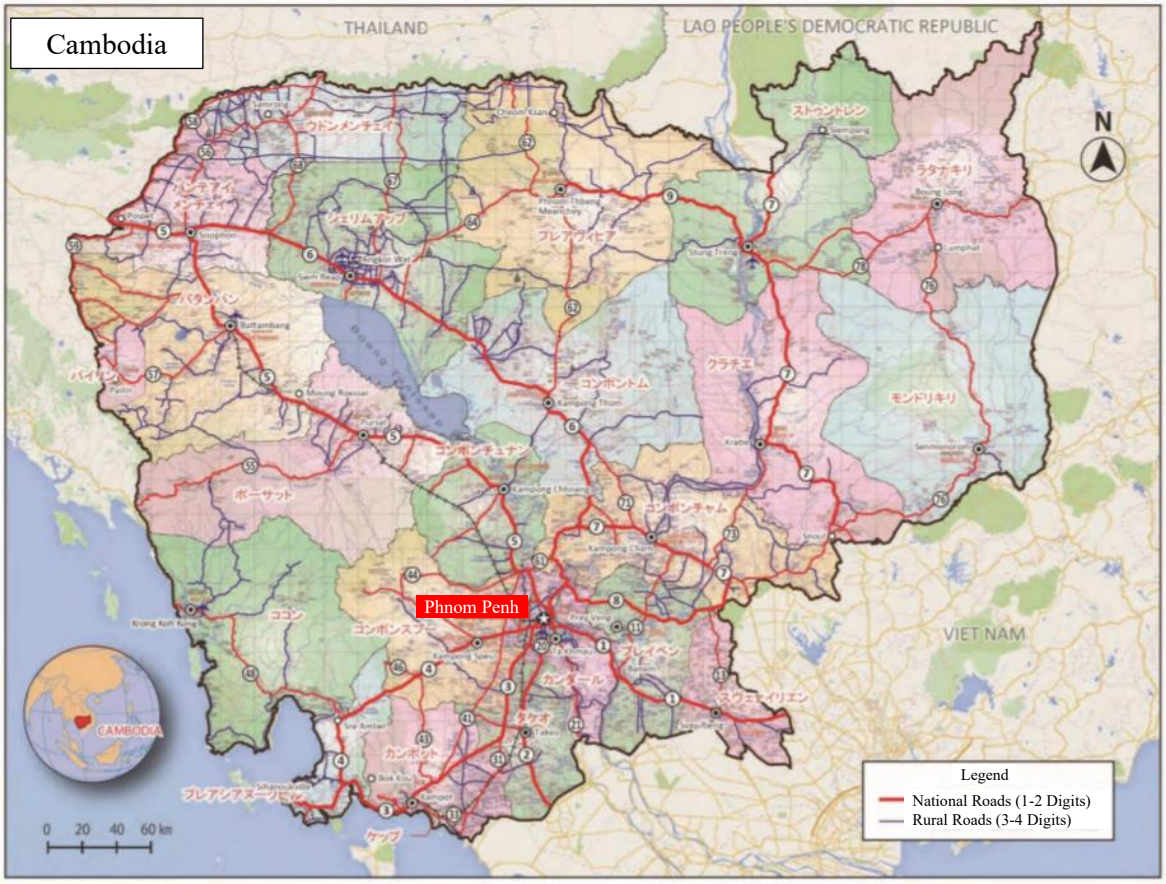


Figure3.1 Cambodia road network map

3.4.2 MPWT Organizational Structure

The organizational structure of MPWT is shown in Figure3.2.

The department in charge of Road AM at MPWT is RID and will be the infrastructure of the General Department of Techniques. RID oversees the maintenance and management of roads and bridges at the

[4] JICA: Project to Strengthen Maintenance and Management Capacity for Roads and Bridges in Cambodia Project Final Report (Summary of Japanese Text). February 2018

national level, and develops maintenance plans, secures budgets, maintains inspection manuals and databases, and collects and diagnoses inspection results.

In addition, there is the DPWT as an organization that conducts inspections of roads and bridges and implements simple repair work according to their manuals.

DPWT has 25 locations throughout all 24 provinces and Phnom Penh in Cambodia.

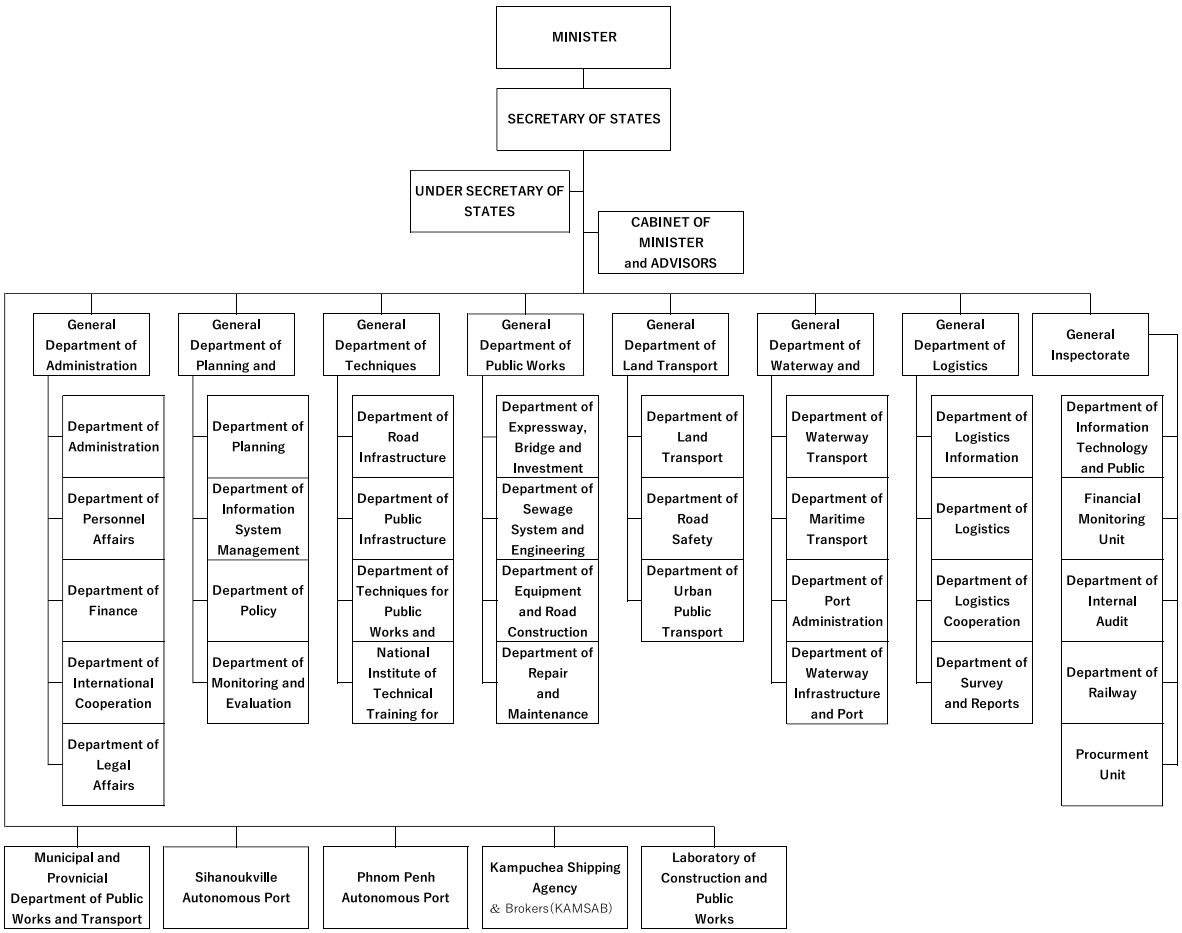


Figure3.2 MPWT organization chart[5]

Apart from the management of national roads and separate from RID, Expressway, Mega Bridge, and Investment Department (hereinafter EXMID) is in charge of the management of highways connecting Phnom Penh and Sihanoukville, which are currently under Chinese-supported BOT, as well as the maintenance and management of 16 long bridges (1 suspension bridge and 15 cable-stayed bridges) built with support from Japan and other countries.

In the MPWT, there are several deputy ministers present for each donor, and under each deputy minister there is a project management unit (hereinafter PMU). The director-general of each department is mainly the head of PMU.

Because PMU staff are appointed full-time by the members of each department, information on each donor project is not shared across the PMUs.

[5] Obtained from RID

3.4.3 Road Maintenance Budget[6]

In the budget related to road maintenance, RID conducts condition evaluations based on visual inspection results and formulates an annual budget. Here, the efficiency improvement of road inspection was achieved by measuring the International Roughness Index (hereinafter IRI) using the DRIMS system introduced by the previous technical cooperation project.

On the other hand, for bridges, inventory of existing bridges had not been developed before the implementation of the road and bridge maintenance capability enhancement project. After that, inspections for all bridges were carried out by all 25 DPWTs according to the technical cooperation project, and the condition evaluations of the bridges were also carried out.

By utilizing this, the program budget requested by MEF has been able to respond to budget requests for multiple years, and the budget for inspection, repair, and replacement under bridge maintenance is allowed. This situation is still maintained today.

The conceptual diagram of the bridge maintenance cycle introduced by the Technical Cooperation Project is shown in Figure3.3, and Table 3.1 shows the country's road maintenance budget for the past three years (2017-2019).

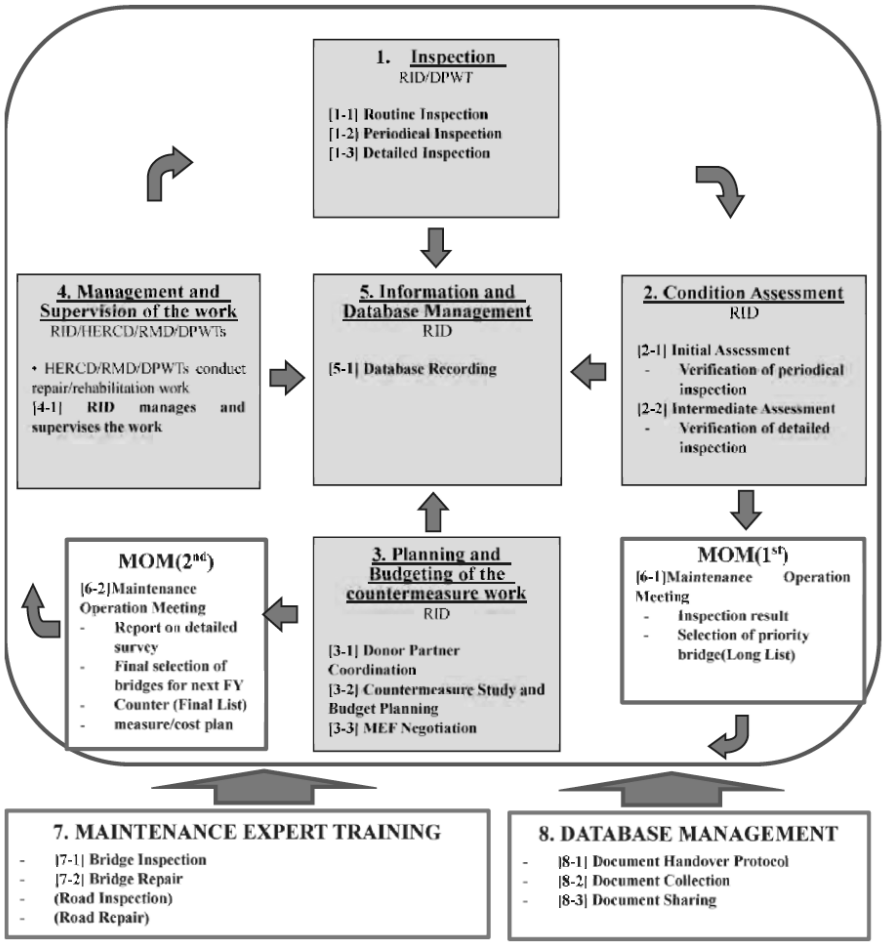


Figure3.3 Conceptual diagram of bridge maintenance cycle

[6] JICA: Project to Strengthen Maintenance and Management Capacity for Roads and Bridges in Cambodia Project Final Report (Summary of Japanese Text). February 2018】

Table 3.1 Road maintenance budget (2017-2019)[7]

	2017	2018	2019
Road Length	9,466.77 km	10,181.83Km	9,478.70 Km
Budget	337.59 million US	34.686 Million US	38.138 Million US

3.5 Overview of Technical Cooperation Projects[8]

3.5.1 Overall Goal

The overall goal is to ensure that roads and bridges are properly managed by MPWT. To achieve the top goals, the results of the project will be spread throughout the MPWT and road and bridge maintenance cycle construction will be implemented as part of RID and DPWT operations.

Table 3.2 shows the results indicators, goals after three years, and activity plans set through consultation with RID for project design matrix (hereinafter PDM).

Table 3.2 Performance indicators and activity planning for overall goals

Indicators	3-year goals	Activity plan
The road and bridge database are updated every year.	[Road] 1) Data collection of major roads ➢ Target 5,000km/year →5,000km x 3 year 2) Increase in DRIMS team ➢ 4 teams in RID, DPWT to 4 teams 3) Maintenance and management of DRIMS equipment	1) Clarification of responsibility, Partial transfer of responsibility for inspection to DPWT 2) Annual road survey using DRIMS ➢ DRIMS for 5,000km/year 3) Road inspection using DRIMS to secure budget
	[Bridge] 1) Bridge inspection target (3 years): Number of bridges for periodic inspection: 1,500 Detailed inspection: 20 2) Measuring use of database system servers 3) System improvements File Maker License Renewal 4) Data sharing Data sharing within MPWT	1) Clarification of responsibility for work, Partial transfer of responsibility for inspection to DPWT 2) Database management, establishment of official heads in charge of road inventory management 3) Establishment of auxiliary staff for database management personnel 4) Securing budget for bridge inspections
The road and bridge maintenance plans are updated every year based on the inspection results.	[Roads/Bridges] 1) Maintenance plan ➢ Maintenance list updated 3 times 2) Implementation of regular maintenance meetings	1) Conducting inspections as a basis for the plan for (1) and related 2) In accordance with the creation of a three-year plan

[7] Obtained from RID

[8] JICA: Project to Strengthen Maintenance and Management Capacity for Roads and Bridges in Cambodia Project Final Report (Summary of Japanese Text). February 2018

Indicators	3-year goals	Activity plan
	➢ FY 2018: Twice. ➢ FY 2019: Twice. ➢ FY 2020: Twice. 6 times in total	3) Awareness of the three-year plan (RID→DPWT)
Road and bridge repairs are carried out in accordance with the manual based on the road and bridge maintenance plan under the supervision of RID	1) Improved bridge condition ➢ 2020 SD63[9] Bridges→48 bridges (5 bridges replacements / year x 3 years = 15 bridges, thus SD bridges decrease from 63 to 48) [10] D167 Bridge →143 bridges (8 bridge repairs / year x 3 years = 24 bridges, thus D bridges decrease from 167 to 143)[11] ➢ Assume carbon fiber sheet construction method[12]	1) Securing bridge repair budgets 2) Continue to improve bridge repair skills through regular Maintenance Expert (ME) training) 3) Leveraging the methods introduced in the project ➢ Crack sealing (bridge) ➢ Carbon fiber sheet method (bridge) ➢ Room temperature material (road)
Road maintenance manuals, road repair manuals, bridge maintenance manuals and bridge repair manuals are updated regularly.	1) Distribution and dissemination of road and bridge repair manuals to DPWT ➢ 10 Manuals/DPWT10 2) Review of maintenance manuals (including job codes) ➢ Once/3 years 3) Implementation of ME training ➢ Once / year × 3 years = 3 times	1) Set up periodic training for maintenance within RID and DPWT 2) Selection of review groups responsible for reviewing manuals/guidelines (about 3 RID members) 3) Budget request for expenses required for ME training

3.5.2 Goals of the Technical Cooperation Project

The project goal is to strengthen RID's management capabilities for road and bridge maintenance.

Figure3.4 shows the mechanism for achieving project goals. Table shows the status of achieving the target based on indicators.

[9] From the bridge inspection results of the technical cooperation project, the damage condition was divided into four ranks: SD, D, O, and N in order of degree of damage.

[10] The number of elapsed years increase in damaged bridges is difficult to predict and is less than overseas city support according to road renovations done by the SDB and China. Therefore, the annual increase in the number of damaged bridges is not considered.

[11] The number of elapsed years increase in damaged bridges is difficult to predict and is less than overseas city support according to road renovations done by the SDB and China Therefore, the annual increase in the number of damaged bridges is not taken into account.

[12] Same as above

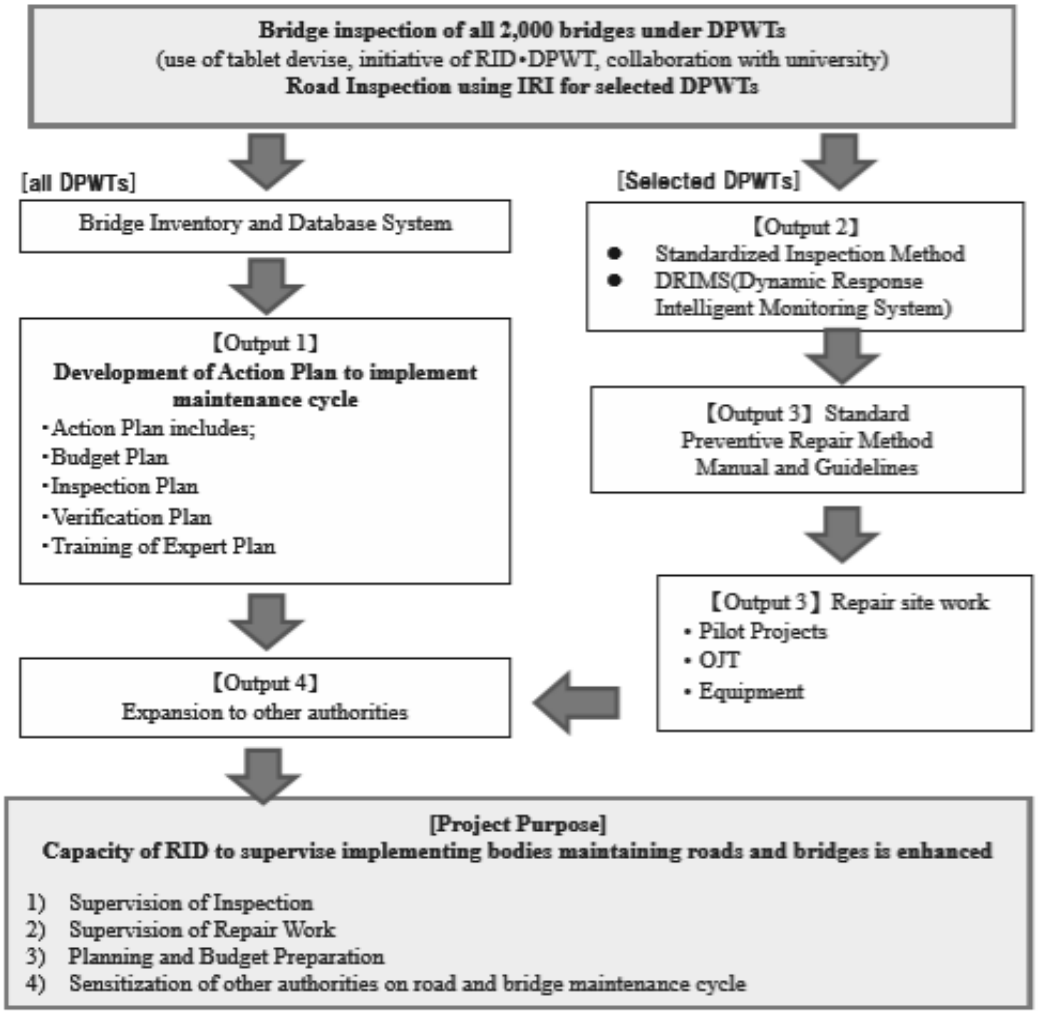


Figure3.4 The Connection between the results and the project goals

Table 3.3 Achievements based on indicators

Indicators	Achievement status (January 2018)	Related outcomes and other impacts
Inspection results of three target DPWTs are approved by RID in accordance with the documentation created in the project	[Roads] All single-digit national highways were inspected according to the manual using DRIMS. In addition, all Kandal and Takeo roads were inspected manually. In this way, RID can evaluate road conditions using standardized and objective methods, and it is now possible to teach within DPWTs. [Bridges] Completed inspection of bridges managed by all DPWTs, and a bridge inventory and inspection database were completed (2,389 bridges) Bridge inspection will be carried out by DPWT in the future in a method that is desirable for RID and under RID	[Related achievements] Achievement 2 ME Training

Indicators	Achievement status (January 2018)	Related outcomes and other impacts
	supervision. With insufficient expertise and experience, a bridge inspection system in the form of a question checklist contributes to the calibration of diagnostic results. Inspection results were confirmed by MOM (May 2017) In this way, RID has developed a framework and method that can confirm the inspection results through DPWT and reflect them in the maintenance plan.	
Repair results in two target DPWTs are approved by RID according to the project manual	[Roads] [Bridges] Road and bridge repair manuals and guidelines have been developed. RID can supervise construction using these manuals	[Related achievements] Achievement 3 Pilot Project Phnom Penh DPWT Kandal DPWT Preh Sianouk DPWT ME training
The above two DPWTs will develop their 2018 budget within a predetermined period	The bridge inventory and inspection results, for which RID developed a three-year bridge maintenance plan with the support of the JICA project, were used to formulate this plan.	[Related achievements] Achievement 1
Road and bridge maintenance cycles are shared with relevant agencies at the final seminar	Sharing with relevant organizations in MPWT HERCD, SPIED, PWRC, RMD DPWT All DPWT (25) MEF Institute de Technologie du Cambodia (Institute de Technologie du Cambodia: ITC) Through this project, the practical and strong relationship between RID and ITC has deepened.	[Related achievements] Achievement 44 ME training (All DPWT) Kickoff Seminar Wrap-up Seminar [Other effects] SIP Seminar
Road bridge maintenance budget developed by RID	[Roads] It became possible to evaluate road conditions objectively by utilizing IRI. RID used this result to improve the ability to create budget proposals. [Bridges] To create a calculation that RID needs on a nationwide level, the applicable DPWT for bridge inspection has been expanded to all DPWTs. MEF approved the budget for bridge maintenance.	[Related achievements] Achievement 1 MOM [Other effects] MEF requests multi-year plan as a basis for budget proposal

To summarize the above: while utilizing the existing methods for road inspection and introducing IRI, an indicator of road flatness, a method for performing efficient and objective evaluations was acquired. In the project, measurements of a total of 2,439.8 km were made on nine single-digit national roads, double-digit and triple-digit national roads. RID uses this method for measurement and evaluation. For bridge inspections, the bridge database (including damage data) of all DPWT (25 stations) was maintained. Using this data, a three-year bridge maintenance plan was drawn up and used to make a budget request to MEF.

Approval of the periodic inspection cost was done, and the base for carrying out the periodic inspection was built.

In terms of road repair and bridge repair, based on the current construction conditions and types of construction, the guidelines, and manuals necessary for the site were developed and distributed as a manual that could be easily used during field work. Based on the above results, the bridge maintenance and management action plan were developed and approved at the director level as the basic framework for RID. It will also be used as a basic resource for future budget requests.

Regarding these activities and guidelines, all 25 DPWT departments have completed lectures and practical training courses under the leadership of RID's master trainers and will gradually establish a system to continuously transfer the work to many DPWT staff.

3.5.3 Manuals Introduced in the Technical Cooperation Project

The following manuals were created for the technical cooperation project. The outline is shown in Table 3.4.

Table 3.4 Introduced manuals

Manual name	Overview
Bridge Inspection Manual	Bridge maintenance general information, bridge inspection general requirements, bridge inspection results recording, non-destructive inspection (Schmidt hammer test, neutralization depth test, ultrasonic velocity method, natural potential method, rebar exploration method, infrared thermography, compression strength test, coating thickness test, steel plate thickness test, magnetic powder inspection test, eddy flow detection test, etc.)
Bridge Repair Manual	Bridge repair general information, safety management, maintenance work, maintenance space, concrete foundation, repair of concrete and steel structure, etc.
Bridge Inspection Handbook	Describe the flow of the iPad system, how to collect bridge inspection data (utilizing the iPad system), ranking of damage and photos of damaged cases, and bridge scoring methods.
Guidelines for repairing road damage	Various road damage types so that the outline, cause, repair method, necessary personnel, and equipment, etc. can be organized into one sheet as a “Job Code.” All 46 types are included.
Guidelines for road maintenance using IRI	Evaluation of inspection results, summary of current condition based on evaluation results, prioritization of maintenance plan, selection of repair method and construction cost estimation, budget request according to road maintenance plan, implementation of road maintenance plan, feedback from road maintenance management and examples of applying guidelines are described.
ME Training Book	Organize training plans and teaching materials for ME training.

3.5.4 Technical Level of Various Manuals

The manual developed in the technical cooperation project contains five items: inspection, repair, DB input, soft operation, and soft management.

As for the inspection manual, the damage classification is unified and consolidated into 17 types, and it is assumed that it is not limited to periodic inspections and is applicable to daily inspections and special inspections.

As for the repair manual, the repair method focuses on concrete. In addition, the method accompanied by the repair design is only the method introduction.

For DB input and soft operation and management, although the necessary matters in using the bridge inspection database are summarized, in order to continuously improve and utilize the software, human resources cultivated in the technical cooperation project must become the master trainers. It is necessary to

confirm whether the technology has transferred to the persons in charge of each maintenance and management office.

3.5.5 Level Reached in Technical Cooperation Projects

Table 3.5 shows the implementation status of the technical cooperation project described in the previous section and the level of the technology attained.

Table 3.5 About the level of technology reached

Item	Technical Cooperation Project Previous level	Level reached to date
Check	1) No regular or standard bridge inspection framework and implementation. 2) Regular visual inspections of the roads were carried out.	1) All bridges (2,389 bridges) under DPWT control nationwide have been inspected. 2) The inspection results were divided into four ranks: SD, D, O and N. 3) The bridge inspection system assisted the implementation of the inspection by making automatic judgments at the time of the ranking. 4) Similarly, the bridge inspection system was able to minimize the process of data integration, etc. and build a database by synchronizing data. 5) A program for regular bridge inspections has been developed. 6) Daily inspection: regular inspection at the same time as road inspections (visual inspection): Inspection training was conducted for 500 bridges each year (plan to visit all bridges and do inspections in five years) (inspection by bridge inspection system) model district (36 bridges, 4 culverts).
Record	1) Road: the annual budget plan was based on the results of visual inspections. 2) Bridge: database not maintained.	1) Roads: hard disk prepared to store the following data ➢ IRI measurement data ➢ IRI map ➢ Inspection and evaluation sheet (visual inspection and IRI) →These inspection results are used to develop budget plans. 2) Bridges: ➢ Install database in RID ➢ Managed by RID ➢ Conduct periodic inspections and update data every year
Repair Planning	1) Bridge maintenance was carried out as part of road maintenance. 2) There was no standard and basic data on bridge maintenance. 3) Regular inspection of the state of the bridge was not carried out.	1) It was proposed to conduct an MMO in April and December (interim August if necessary) to examine the action plan as a basis for the next year's budget. 2) Action plan approved by RID Director 3) Achieve the following four items to implement the action plan ➢ Development of bridge inspection systems and tools ➢ All DPWT bridges are inspected and stored in the database ➢ Divided into 4 ranks depending on the state of the damage

Item	Technical Cooperation Project Previous level	Level reached to date
		➢ RID uses inspection results to develop a three-year maintenance plan →This plan will be used to develop a budget proposal
Repair design	1) Roads: The following manuals exist 2) Bridges: The bridge repair manual was not in place.	1) Roads: The following manuals are maintained. ➢ Road Repair Manual (Revised Edition) (46 Types) [English and Khmer] ➢ Handbook above [English and Khmer] 2) Bridges: The following manuals are maintained. ➢ Bridge Repair Manual [English and Khmer] ➢ Handbook above [English and Khmer]
Repair Construction	1) Roads: Regular repairs are carried out in accordance with the results of visual inspections. 2) Bridges: Regular inspections of bridges have not been carried out. Most bridge repairs are post-mort repairs.	1) Roads: Small-scale pothole repairs using room temperature combination material are carried out as part of the introduction of preventive maintenance repair method in the project. →An Excel Patch demonstration project was carried out on the roads of Kandal DPWT and Takeo DPWT. 2) Bridges: The following two methods were introduced ➢ Crack sealing method ➢ Carbon fiber sheet method Crack sealing method for 4 bridges (Canal DPWT) and 2 bridges (Phnom Penh DPWT) in the first pilot project Carbon fiber sheet method for 2 bridges (Preah Sihanouk DPWT) in the 2nd pilot project In addition, the crack sealing method is applied to damage repair work of Kizuna Bridge in Compong Cham province.

3.5.6 Lessons and suggestions from the project

3.5.6.1 Target DPWT changes to Build Bridge Maintenance Cycles

To build a bridge maintenance cycle, it is necessary to obtain basic data early in the project. While RID, the project's counterpart, is an organization that has a role in planning and budgeting at the national level, PDM has three DPWT sites for bridge inspections. However, to achieve the greatest results as a project, we changed the target DPWT to all DPWTs and carried out activities to build a foundation to examine the bridge maintenance cycle. When RID is the counterpart, it is important to have nationally based information, so it is desirable to specify it in the original PDM.

3.5.6.2 The Importance of Procurement Potential in Target Country

In the pilot project, we proposed and implemented a method to promote preventive maintenance. These materials were procured through imports from Japan during the pilot project implementation phase, but it took time for customs procedures and the possibility of reliable material procurement was a new worry. Therefore, we have secured a local sales agent that can carry out procedures related to imports smoothly and it became possible to ensure local procurement.

3.5.6.3 Overload Management on the Tsubasa Bridge

To reduce the maintenance cost, it is necessary to appropriately eliminate external factors such as overloading. In the Tsubasa Bridge, which was built through grant-providing cooperation, damage to the bridge due to overloaded vehicles has become apparent. In the technical cooperation project, the number of vehicles with significant overloading was reduced by installing two simple shaft gauges and carrying out

overload measurements and enforcement measures. It was also revealed that certain vehicles were repeat violators.

The implementation system for the operation of this overload management has been budgeted to continue even after the end of this project, ensuring sustainability. As a result, the system for continuously carrying out overload management in the future was verified.

3.5.6.4 Maintenance of Bridge Inspection Data and Involvement of IT Engineers

In the technical cooperation project, a system was constructed that utilizes IT technology to improve RID's operations. Although it is not very difficult to manage these systems, it has been proposed that engineers who specialize in IT technology continue to participate in the operation of each maintenance and management-related system and further improve it, taking into account the development of IT technology in the future.

3.5.6.5 Working with Educational Institutions

In the technical cooperation project, we have been working well with the Institute of Technology of Cambodia (hereinafter ITC).

For ITC, students are more exposed to on-site challenges and want to be provided with technology from MPWT and as a result MPWT needs to get advice from Cambodian experts such as the ITC and enhance the education of their staff. Especially regarding bridges, there are few staff members who have basic knowledge within MPWT, and the expertise of ITC is effective for teaching them the basic knowledge that they can use to analyze the damage situation in the field.

Moreover, because it is field education by a local university rather than a Japanese expert, it contributes to the sustainability of the technology transfer.

Therefore, it has been proposed to cooperate with educational institutions such as ITC in the future.

3.6 Construction and Maintenance Capabilities and Technical Levels

3.6.1 Status of Construction Companies and Consultants in Charge of Maintenance

We interviewed Tekken Construction Co., Ltd. and IKEE, which is currently conducting local JICA projects, about the construction, maintenance capabilities, technical levels, etc. of local companies and found the following current situations and issues.

Tekken Construction Co., Ltd. has received two contracts for the renovation of National Highway 5.The first one is a renovation of a constructed section length of 47 km (of which 23 km is a new bypass) and has been underway since November 2017. The second one is the road widening (2 lanes to 4 lanes) of constructed section length of 44 km, which has been underway since April 2019.

These contracts include the current road repair. The contract unit price was 15 dollars per square meter in the first case, but the repair cost increased due to the frequent potholes that occur during the rainy season. The second contract unit price was 70 dollars per square meter. In fact, it took 50 to 60 dollars per square meter for materials and labor.

【Technical level of the maintenance company】

In the above construction, the maintenance and management of the current roads is carried out entrusted to DPWT. DPWT is an organization that conducts road maintenance and management, and because it has workers and work machinery, it was selected as a contract partner. It is unclear whether there are private companies that can maintain roads. In large-scale projects, contractors are determined using an international bid system. In Cambodia, Chinese companies have strong influence, and these Chinese companies are not trying to train local companies but rather bring engineers and workers from home to implement the projects themselves.

In the case of this Joint Venture, they started by finding and nurturing local companies.

It is impossible for local companies to do tasks that are difficult, such as a launching method, and it is necessary for Japanese companies to provide guidance. As a result, erection work for bridges has been achieved.

Workers work obediently and listen to local companies who pay them directly, but they do not listen to Japanese engineers very often. In addition, improvement works planned by MPWT are carried out by DPWT, so there is no chance that local companies implement advice or plans from Japanese engineers.

The level of paving repair technology here is low. Even though large pothole (dragon holes) repair requires cold mix[13] and granular crushing stone and sand, it will soon be ruined because if it is repaired only with cold mix. Technical guidance is necessary for local workers.

In the actual repair work, the first project was managed by Tekken Construction Co., Ltd. and the second project was contracted to DPWT. There are several strong local subcontractors. For example, TCM was the main subcontractor of Obayashi-Corp. for the new construction.

Private building businesses are active, making it difficult to secure subcontracting. The technology is low for local subcontracting, and special construction is difficult to carry out. Simple erection jobs, such as precast PC girder erection, are possible.

The renovation project of National Highway No. 3 is a Korean-supported project by the EDCF (Economic Development Cooperation Fund of the Korea Export-Import Bank).

IKEE, a Japanese company, has established a local subsidiary in Cambodia and owns asphalt paving machinery and plants and sells paving construction and pavement repair materials (Product name: Excel). In the future, they are also considering expanding to Bangladesh and India.

Although repair materials were adopted in the JICA Technical Cooperation Program, Cambodia's domestic results are only in some areas and the company is currently expanding sales activities.

There was a remark of the prohibition of the use of "Excel" from the upper management of MPWT because the wrong construction was done in a large-scale damaged place such as Dragon Hall. However, there are no problems with "Excel" as a material, so they would like to proceed with careful explanations to solve misunderstandings.

In addition, since DPWT engineers perform repair design for maintenance, consultants carrying out repair design could not be confirmed.

3.7 Achievement of Road AM

3.7.1 Road AM Indicator Structural Diagram

The structural diagram of the Road AM evaluation index is shown in Figure3.5 This table describes the detailed numbers through interviews and field confirmations. In the table, the numerical values of the small items are the average value of details; the numerical values of the middle items are the average value of the small items; the numerical values of the large items are the average value of the middle items. In addition, "expansion to other regions and regions" is described as independent items.

[13] Asphalt mixture for room temperature repair

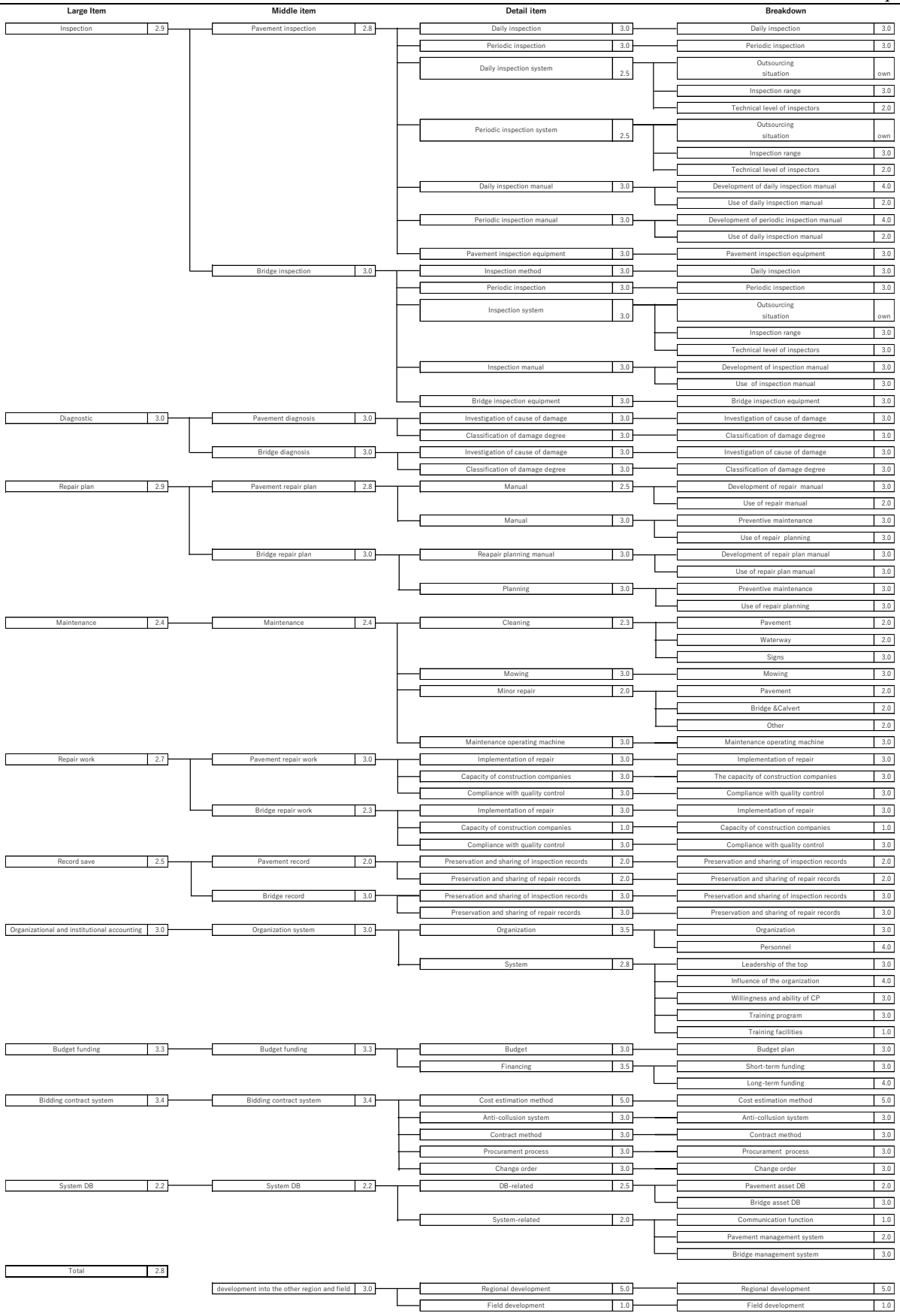


Figure3.5 Road AM evaluation indicator structural diagram of Cambodia

3.7.2 Road AM Indicators (Details)

3.7.2.1 Pavement Inspections

The pavement daily inspections are carried out regularly by NHA staff of RID and they do not outsource. The results of daily inspections are stored in a paper-based record. The inspection range is about 9,000km out of about 16,000km of the total control area. Therefore, for 7,000 km, maintenance and management cannot be carried out. The system is designed to respond only after the damage occurs. In the case of Pursat state, 55 staff members, 40 short-term contract employees and 30 workers are employed.

There are five engineers within the NHA staff, one of whom oversees daily inspections. The technical cooperation project established a maintenance professional program (DRIMS calibration, measurement, analysis, and method of evaluating road conditions using IRI) for training, and five RID engineers were certified as master trainers under road inspection education.

In addition, the technical level of the inspectors was set to be 3.0 points. If the project's efforts continue and progress, in five years the pavement inspection education would be extended to DPWT.

Middle Item	Small Item	Breakdown	Scores
Pavement Inspection	Daily Inspection	-	3.0
	Daily Inspection System	Outsourcing Status	In-house
		Inspection Range	3.0
		Technical level of inspectors	2.0 (3.0)

() the value that is expected to be achieved in about five years after the end of the technical project

Regular paving inspections are carried out by RID. Inspections are carried out according to the manual using DRIMS introduced in the technical cooperation project. RID is now able to evaluate road conditions in a standardized and objective manner.

The technical level of the inspectors was set at 3.0 points. If the project's efforts continue and progress, in five years the pavement inspection education would be extended to DPWT.

Middle Item	Small Item	Breakdown	Scores
Pavement Inspection	Periodic Inspection	-	3.0
	Periodic Inspection System	Outsourcing Status	In-house
		Inspection Range	3.0
		Technical level of inspectors	2.0 (3.0)

() the value that is expected to be achieved in about five years after the end of the technical project

The existing daily inspection manual and the existing periodic inspection manual were reviewed by the technical cooperation project. For paving inspection equipment, four DRIMS units for measuring IRI were introduced. In addition, road maintenance guideline using IRI (English version) and DRIMS guideline (English version) have been introduced and implemented.

The operation of the inspection manual has been scored as 3.0 points. If the project's efforts continue and progress, the inspection manual will be operated on all routes in five years.

Middle Item	Small Item	Breakdown	Scores
Pavement Inspection	Daily Inspection Content	Inspection Manual Maintenance	4.0
		Inspection Manual Operation	2.0 (3.0)
	Periodic Inspection Content	Inspection Manual Maintenance	4.0

Middle Item	Small Item	Breakdown	Scores
		Inspection Manual Operation	2.0 (3.0)
	Pavement Inspection Equipment	-	3.0

() the value that is expected to be achieved in about five years after the end of the technical project

3.7.2.2 Bridge Inspections

The daily inspection of bridges is done at the same time as the pavement daily inspections, and it stays within the visual inspection carried out by DPWT staff. A detailed inspection is carried out by MPWT officials. Based on the ME program to train bridge maintenance managers formulated in the Technical Cooperation Project, 17 educated MPWT became master trainers, and they educated the DPWT staff throughout all 25 states. As a result, there are 112 MEs. An action program has been set up to allow periodic inspections to be carried out once every five years.

Middle Item	Small Item	Breakdown	Scores
Bridge Inspection	Daily Inspection	-	3.0
	Periodic Inspection	-	3.0
	Inspection System	Outsourcing Status	In-house
		Inspection Range	3.0
		Technical level of inspectors	3.0

In the technical cooperation project, the bridge inspection manual (English and Khmer version), the bridge inspection handbook (English version and Khmer version), and the bridge list (English version) were formulated and operated. 10 digital binoculars, 10 hammers, 10 iPads, and 1 robot camera were introduced as inspection equipment. In the inspection support system using iPads, a system that can be automatically process diagnoses by filling in a checklist has been established.

Middle Item	Small Item	Breakdown	Scores
Bridge Inspection	Contents of Inspection	Manual Maintenance	3.0
		Manual Operation	3.0
	Bridge Inspection Equipment	-	3.0

3.7.2.3 Diagnosis

Diagnosis has been carried out for important parts of the inspection. DPWT in Pursat state, which conducted the classification of damage, has set an organizational goal to prevent potholes from happening again at the same location. The investigation into the cause of bridge damage is being carried out on important places. The division of damage is defined in the Bridge Inspection Handbook formulated in the Technical Cooperation Project.

Middle Item	Small Item	Breakdown	Scores
Pavement Diagnosis	Investigation of the Cause of Damage	-	3.0
	Classification of Damage Level	-	3.0
Bridge Diagnosis	Investigation of the Cause of Damage	-	3.0

Middle Item	Small Item	Breakdown	Scores
	Classification of Damage Level	-	3.0

3.7.2.4 Repair Plan

The road repair manual and the road repair handbook were formulated in the technical cooperation project. The paving repair plan was developed by PMS (Pavement management systems), which was introduced in the technical cooperation project. PMS is intended to be used to formulate a repair plan by determining the damage degree of the pavement by a combination of IRI, measurements by DRIMS and visual inspection results. Simple PMS is a stand-alone system operated by RID and is not linked to HDM-4.At the end of the technical cooperation project, the short and medium-term plan was managed by simple PMS, and the long-term plan was managed by HDM-4. This policy was approved by MPWT. During the field survey, however, the department that manages HDM-4 was unable to be identified and could not be interviewed. This point needs to be confirmed in the future.

The operation of the road repair manual has been scored 3.0 points. If the project's efforts continue and progress, the road manual will be operated on all routes in five years.

Middle Item	Small Item	Breakdown	Scores
Pavement Repair Plan	Manual	Maintenance	3.0
		Operation	2.0 (3.0)
	Planning	Maintenance	3.0
		Plan Development	3.0

() the value that is expected to be achieved in about five years after the end of the technical project

The bridge repair manual and the bridge repair handbook were formulated during the technical cooperation project. The bridge repair plan was been developed by BMS (Bridge management system), which was introduced by the Technical Cooperation Project. The technical cooperation project completed the inspection of all DPWT-managed bridges and provided a bridge inventory and inspection database (2,389 bridges). MPWT has a framework that allows DPWT inspection results to be reviewed and reflected in the maintenance plan.

Middle Item	Small Item	Breakdown	Scores
Bridge Repair Plan	Manual	Maintenance	3.0
		Operation	3.0
	Planning	Maintenance	3.0
		Development of Repair Plan	3.0

3.7.2.5 Maintenance

The cleaning of road surfaces is carried out as necessary rather than regularly. It was said that the maintenance of waterways, signs, and planting was carried out regularly. However, after a field inspection of Phnom Penh city and National Highway 3, 6, and 8, it was found that maintenance was insufficient, as the waterway was blocked by sediment and dumped garbage.

Middle Item	Small Item	Breakdown	Scores
Maintenance Management	Cleaning	Pavement	2.0
		Waterway	2.0
		Signs	3.0
	Mowing	-	3.0

It was said that small repairs such as pavement, bridges and culverts were carried out as appropriate, but as a result of field visits to Phnom Penh city and National Highway 3, 6, and 8, potholes and cracks were found on the road surface. In addition, damage including drainage issues were found and it was judged that only small repairs are carried out at a minimum. For this reason, the score was 2.0 points. General construction machinery had been maintained.

Middle Item	Small Item	Breakdown	Scores
Maintenance Management	Minor Repair	Pavement	2.0
		Bridges/Culverts	2.0
		Other	2.0
	Maintenance Work Machine	-	3.0

3.7.2.6 Repair Work

Pavement repair has been carried out by DPWT directly, and their construction capability is of a general level.

It is managed in accordance with quality control standards, and the test pieces are sent to the MPWT laboratory (concrete test pieces, etc.). In some cases, MPWT inspectors are randomly performing quality control checks. In the technical cooperation project, as part of the preventive maintenance repair method, small-scale pothole repairs using cold mix asphalt were carried out.

Middle Item	Small Item	Breakdown	Scores
Pavement Repair Work	Implementation of Repairs	-	3.0
	Capacity of the Construction Company	-	3.0
	Quality	-	3.0

Bridge repair is carried out directly by DPWT, but their construction capability is poor.

It is managed in accordance with quality control standards, and the test pieces are sent to the MPWT laboratory (concrete test pieces, etc.).

In some cases, MPWT inspectors are randomly performing quality control checks.

In the technical cooperation project, bridge repair methods such as the crack sealing method (6 bridges) and carbon fiber sheet method (2 bridges) were introduced.

Middle Item	Small Item	Breakdown	Scores
Bridge Repair Work	Execution of Repairs	-	3.0
	Capacity of the Construction Company	-	1.0
	Quality	-	3.0

3.7.2.7 Record

Inspection record data of the pavement is basically recorded and stored on paper.

IRI measured by DRIMS is recorded in PMS.

Repair history is recorded and stored on a paper basis but not managed by PMS.

Middle Item	Small Item	Breakdown	Scores
Pavement Record	Save/share Inspection Records	-	2.0

Middle Item	Small Item	Breakdown	Scores
	Preservation and Sharing of Repair Records	-	2.0
Bridge Record	Save/share Inspection Records	-	3.0
	Preservation and Sharing of Repair Records	-	3.0

Bridge inspection records and repair history are recorded and stored as electronic data, which is managed by BMS. Inspection results and repair results are shared between MPWT and DPWT.

3.7.2.8 Organization System

The goals of the organization responsible for Road AM are clear.
In addition, the role allotment of the organization and the individuals in charge of Road AM are evaluated as appropriate or not. There is a top commitment to Road AM. The Road AM department has considerable influence on other departments. A training system has been introduced through the technical cooperation project, and training is planned to be conducted in the event of a new hire due to the replacement of people. There are no training facilities.

Middle Item	Small Item	Breakdown	Scores
Organization	Organization	Organization	3.0
		Personnel	4.0
Organization	System	Top leadership	3.0
		Influence of the Organization	4.0
		C/P Willingness and Ability	3.0
		Training System	3.0
		Training Facilities	1.0

3.7.2.9 Budget Financing

The establishment of a framework for the bridge maintenance cycle and the clarification of cost usage and the amount of money needed have led MEF to recognize the budget for bridge maintenance. The budget plan is three years. There is no delay in paying for construction. The difference between the required amount and the amount raised has been shared with MEF.

Middle Item	Small Item	Breakdown	Scores
Budget Financing	Budget	Budget planning	3.0
	Financing	Short-term funding	3.0
		Long-term funding	4.0

3.7.2.10 Bidding Contract System

There are estimation standards and bidding systems for maintenance and management.
It is said that there is an anti-collusion system and it is applied, but it is not clear whether it is functioning.
The estimation method, contract method and contract process are clear. There is no contract change for normal maintenance.

Middle Item	Small Item	Breakdown	Scores
Bidding Contract System	Accumulation Criteria	-	5.0
	Prevention of rigging	-	3.0

Middle Item	Small Item	Breakdown	Scores
	Contract method	-	3.0
	Procurement process	-	3.0
	Contract change	-	3.0

3.7.2.11 System DB

Some of the pavement ledgers are summarized on a paper basis. The bridge ledgers are maintained by the technical cooperation project and are managed by BMS. The communication system development plan between the headquarter sand the offices has not yet materialized. The PMS, with limited functions, is operated by RID. BMS is operated by RID as a stand-alone system.

Middle Item	Small Item	Breakdown	Scores
System DB	Related to DB	Pavement Asset Ledger	2.0
		Bridge Asset Ledger	3.0
	Related to System	Communication Function	1.0
		Bridge Management System	2.0
		Pavement Management System	3.0

3.7.2.12 Expansion into the Other Regions/Fields

The expansion of Road AM to other regions/fields is also underway outside the region targeted in the technical cooperation project for paving. Regarding bridges, it is expanding nationwide.

Middle Item	Small Item	Breakdown	Scores
Expansion to Other Regions and Territories	Regional Development	-	5.0
	Territory Development	-	1.0

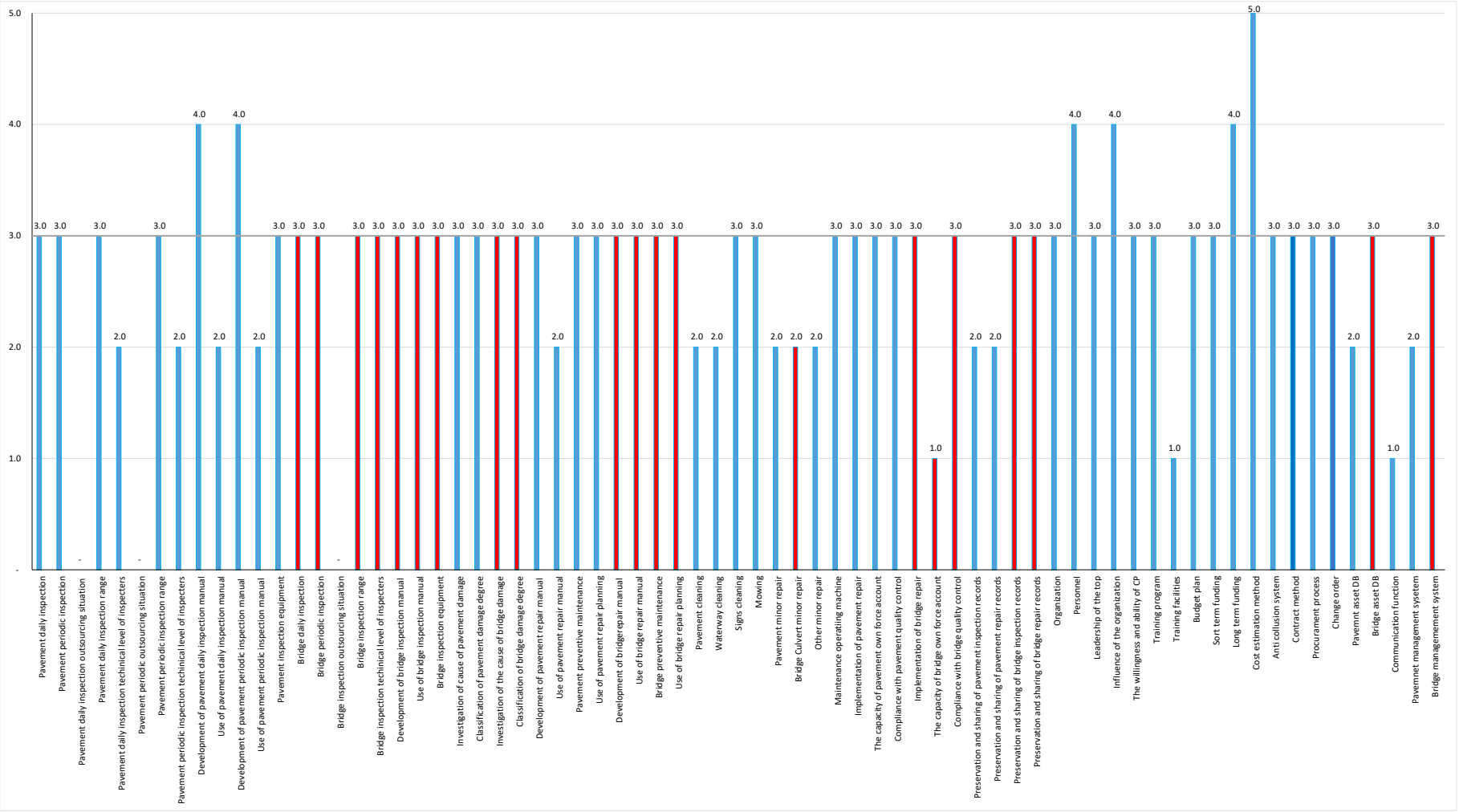


Figure3.6 Road AM indicators in Cambodia (Specifics)

Table 3.6 Cambodia Road AM evaluation sheet (Part 1)

Middle item	Small item	Detail item	Scores	Evaluation items	Score Current	Scale	Achieve %	Score 5years later
Pavement inspection	Daily inspection		1	Inspection is not conducted.	3.0	3.0	100%	3.0
			2	Inspection is carried out at random times.				
			3	Inspection is conducted on a regular basis.				
			4					
			5					
	Periodic inspection		1	Inspection is not conducted.	3.0	3.0	100%	3.0
			2	Inspection is carried out at random times.				
			3	Inspection is conducted on a regular basis.				
			4					
			5					
	Daily inspection system	Outsourcing situation	1	Person in charge within an organization is absent and daily inspection is outsourced without evaluating an outsourcing contractor.	own	5.0	—	3.0
			2	The evaluation method of the contractor is established, and the responsibility, authority, and work contents are defined by the contract document.				
			3	Outsourcing is conducted according to the above.				
			4	Evaluation of the outsourcing methods is conducted.				
			5	In addition to the above, continuous improvements of outsourcing methods are made.				
		Inspection range	1	Inspection is not conducted.	3.0	5.0	60%	3.0
			2	Inspections have been carried out in less than 50% of the road extension of the operating route.				
			3	Inspections have been carried out in 50% or more of the road extension of the operating route.				
			4	Inspections have been carried out in 75% or more of the road extension of the operating route.				
			5	Inspections have been carried out in 100% of the road extension of the operating route.				
		Technical level of inspectors	1	Inspectors have no knowledge of civil engineering and have not received an inspection education.	2.0	5.0	40%	3.0
			2	Inspectors have knowledge of civil engineering, but they have not received an inspection education.				
			3	Inspectors have no knowledge of civil engineering, but they have received an inspection education.				
			4	Inspectors have knowledge of civil engineering, and have received an inspection education.				
			5	In addition to the above, inspectors continuously receive inspection education				
	Periodic Inspection system	Outsourcing situation	1	Person in charge within an organization is absent and daily inspection is outsourced without evaluating an outsourcing contractor.	own	5.0	—	3.0
			2	The evaluation method of the contractor is established, and the responsibility, authority, and work contents are defined by the contract document.				
			3	Outsourcing is conducted in accordance with the above contents.				
			4	Evaluation of the outsourcing methods is conducted.				
			5	In addition to the above, continuous improvements of outsourcing methods are made.				
		Inspection range	1	Inspection is not conducted.	3.0	5.0	60%	3.0
			2	Inspections have been carried out in less than 50% of the road extension of the operating route.				
			3	Inspections have been carried out in 50% or more of the road extension of the operating route.				
			4	Inspections have been carried out in 75% or more of the road extension of the operating route.				
			5	Inspections have been carried out in 100% of the road extension of the operating route.				
		Technical level of inspectors	1	Inspectors have no knowledge of civil engineering and have not received an inspection education.	2.0	5.0	40%	3.0
			2	Inspectors have knowledge of civil engineering, but they have not received an inspection education.				
			3	Inspectors have no knowledge of civil engineering, but they have received an inspection education.				
			4	Inspectors have knowledge of civil engineering, and have received an inspection education.				
			5	In addition to the above, inspectors continuously receive inspection education				
	Daily inspection manual	Development of daily inspection manual	1	Inspection manuals are not developed.	4.0	5.0	80%	4.0
			2	Inspection manuals are partially developed.				
			3	Inspection manuals are developed.				
			4	Inspection manuals are evaluated based on the use of the manuals.				
			5	Inspection manuals are continuously revised based on the evaluations above.				
		Use of daily inspection manual	1	The inspection manuals are not used	2.0	3.0	67%	3.0
			2	The inspection manuals are used in some routes.				
			3	Inspection manuals are used in all routes.				
			4					
			5					
	Periodic Inspection Manual	Development of periodic inspection manual	1	Inspection manuals are not developed.	4.0	5.0	80%	4.0
			2	Inspection manuals are partially developed.				
			3	Inspection manuals are developed.				
			4	Inspection manuals are evaluated based on the use of the manuals.				
			5	Inspection manuals are continuously revised based on the evaluations above.				
		Use of periodic inspection manual	1	The inspection manuals are not used	2.0	3.0	67%	3.0
			2	The inspection manuals are used in some routes.				
			3	Inspection manuals are used in all routes.				
			4					
			5					
	Pavement inspection equipment		1	Inspection equipment is not in place.	3.0	5.0	60%	3.0
			2	Basic inspection equipment is in place, but not in use.				
			3	Basic inspection equipment is used.				
			4	In addition to above, the latest inspection equipment is in place, but not in use.				
			5	In addition to above, the latest inspection equipment is used.				

Table 3.7 Cambodia Road AM evaluation sheet (Part 2)

Bridge inspection	Inspection method	Daily inspection	1	Inspection is not conducted.	3.0	3.0	100%	3.0
			2	Inspection is carried out at random times.				
			3	Inspection is conducted on a regular basis.				
			4					
			5					
		Periodic inspection	1	Inspection is not conducted.	3.0	3.0	100%	3.0
			2	Inspection is carried out at random times.				
			3	Inspection is conducted on a regular basis.				
			4					
			5					
	Inspection system	Outsourcing situation	1	Person in charge within an organization is absent and daily inspection is outsourced without evaluating an outsourcing contractor.	own	5.0	–	3.0
			2	The evaluation method of the contractor is established, and the responsibility, authority, and work contents are defined by the contract document.				
			3	Outsourcing is conducted in accordance with the above contents.				
			4	Evaluation of the outsourcing methods is conducted.				
			5	In addition to the above, continuous improvements of outsourcing methods are made.				
		Inspection range	1	Inspection is not conducted.	3.0	5.0	60%	3.0
			2	Inspections have been carried out in less than 50% of the road extension of the operating route.				
			3	Inspections have been carried out in 50% or more of the road extension of the operating route.				
			4	Inspections have been carried out in 75% or more of the road extension of the operating route.				
			5	Inspections have been carried out in 100% of the road extension of the operating route.				
		Technical level of inspectors	1	Inspectors have no knowledge of civil engineering and have not received an inspection education.	3.0	5.0	60%	3.0
			2	Inspectors have knowledge of civil engineering, but they have not received an inspection education.				
			3	Inspectors have no knowledge of civil engineering, but they have received an inspection education.				
			4	Inspectors have knowledge of civil engineering, and have received an inspection education.				
			5	In addition to the above, inspectors continuously receive inspection education				
	Inspection manual	Development of inspection manual	1	Inspection manuals are not developed.	3.0	5.0	60%	3.0
			2	Inspection manuals are partially developed.				
			3	Inspection manuals are developed.				
			4	Inspection manuals are evaluated based on the use of the manuals.				
			5	Inspection manuals are continuously revised based on the evaluations above.				
		Use of inspection manual	1	The inspection manuals are not used	3.0	3.0	100%	3.0
			2	The inspection manuals are used in some routes.				
			3	Inspection manuals are used in all routes.				
			4					
			5					
	Bridge inspection equipment☒		1	Inspection equipment is not in place.	3.0	5.0	60%	3.0
			2	Basic inspection equipment is in place, but not in use.				
			3	Basic inspection equipment is used.				
			4	In addition to above, the latest inspection equipment is in place, but not in use.				
			5	In addition to above, the latest inspection equipment is used.				
Large Item: Inspection					2.9	4.3	71.9%	3.1
Pavement diagnosis	Investigation of cause of damage		1	The investigation of cause of the damage is not conducted.	3.0	5.0	60%	3.0
			2	The investigation of cause of damage is conducted partially.				
			3	The investigation of cause is conducted for important parts.				
			4	The cause of the damage is systematically investigated.				
			5	The investigation of the cause of damage has been used to improve the overall maintenance.				
	Classification of damage degree		1	There has been no classification of damage	3.0	5.0	60%	3.0
			2	Damage is classified, but the definition of the classification is unclear.				
			3	Damage is classified and the definition of classification is clear.				
			4	The damage classification is evaluated based on the cause of damage.				
			5	The damage classification is continuously reviewed based on the evaluation above.				
Bridge diagnosis	Investigation of cause of damage		1	The investigation of cause of the damage is not conducted.	3.0	5.0	60%	3.0
			2	The investigation of cause of damage is conducted partially.				
			3	The investigation of cause is conducted for important parts.				
			4	The cause of the damage is systematically investigated.				
			5	The investigation of the cause of damage has been used to improve the overall maintenance.				
	Classification of damage degree☒		1	There has been no classification of damage	3.0	5.0	60%	3.0
			2	Damage is classified, but the definition of the classification is unclear.				
			3	Damage is classified and the definition of classification is clear.				
			4	The damage classification is evaluated based on the cause of damage.				
			5	The damage classification is continuously reviewed based on the evaluation above.				
Large Item: Diagnostic					3.0	5.0	60.0%	3.0
Pavement repair plan	Manual	development of repair manual	1	Repair manuals are not developed.	3.0	5.0	60%	3.0
			2	Repair manuals are partially developed.				
			3	Repair manuals are developed.				
			4	Repair manuals are evaluated based on the use of the manuals.				
			5	Repair manuals are continuously revised based on the evaluations above.				
		Use of repair manual	1	Repair manuals are not used.	2.0	3.0	67%	3.0
			2	Repair manuals are used in some routes.				
			3	Repair manuals are used in all routes.				
			4					
			5					
	Planning	Preventive maintenance	1	Not aware of the need to introduce preventive maintenance	3.0	5.0	60%	3.0
			2	The need to implement preventive maintenance is assessed.				
			3	Preventive maintenance is conducted in areas where its is necessary.				
			4	The effect is continuously evaluated based on the results of preventive maintenance,				
			5	Necessary areas and methods of preventive maintenance are continuously reviewed based on the above evaluation.				
		Use of repair planning	1	Repair plan is not drafted.	3.0	5.0	60%	3.0
			2	Only repair plan for the next year is drawn up.				
			3	Repair plan of short-term (about two to three years) is drawn up from the inspection and diagnostic result.				
			4	Repair plan of middle-term (about five years) has been drawn up from the inspection and diagnostic result.				
			5	Repair plan of long-term (over ten years) has been drawn up from the inspection and diagnostic result.				

Table 3.8 Cambodia Road AM evaluation sheet (Part 3)

Bridge repair plan	Manual	Development of repair plan manual	1	Repair manuals are not developed.	3.0	5.0	60%	3.0
			2	Repair manuals are partially developed.				
			3	Repair manuals are developed.				
			4	Repair manuals are evaluated based on the use of the manuals.				
			5	Repair manuals are continuously revised based on the evaluations above.				
		Use of repair plan manual	1	Repair manuals are not used.	3.0	3.0	100%	3.0
			2	Repair manuals are used in some routes.				
			3	Repair manuals are used in all routes.				
			4					
			5					
	Planning	Preventive maintenance	1	Not aware of the need to introduce preventive maintenance	3.0	5.0	60%	3.0
			2	The need to implement preventive maintenance is assessed.				
			3	Preventive maintenance is conducted in areas where its introduction is necessary.				
			4	The effect is continuously evaluated based on the results of preventive maintenance,				
			5	Necessary areas and methods of preventive maintenance are continuously reviewed based on the above evaluation.				
		Use of repair planning	1	Repair plan is not drafted.	3.0	5.0	60%	3.0
			2	Only repair plan for the next year is drawn up.				
			3	Repair plan of short-term (about two to three years) is drawn up from the inspection and diagnostic result.				
			4	Repair plan of middle-term (about five years) has been drawn up from the inspection and diagnostic result.				
			5	Repair plan of long-term (over ten years) has been drawn up from the inspection and diagnostic result.				
Large Item: Repair Plan					2.9	4.5	65.8%	3.0
Maintenance	Cleaning	Pavement	1	Cleaning has not yet been carried out.	2.0	5.0	40%	2.0
			2	Cleaning is being carried out but not regularly.				
			3	Cleaning is performed regularly.				
			4	Evaluation of cleaning methods is done.				
			5	Cleaning frequency is regularly reviewed and optimized.				
		Waterway	1	Cleaning has not yet been carried out.	2.0	5.0	40%	2.0
			2	Cleaning is being carried out but not regularly.				
			3	Cleaning is performed regularly.				
			4	Evaluation of cleaning methods is done.				
			5	Cleaning frequency is regularly reviewed and optimized.				
		Signs	1	Cleaning has not yet been carried out.	3.0	5.0	60%	3.0
			2	Cleaning is being carried out but not regularly.				
			3	Cleaning is performed regularly.				
			4	Evaluation of cleaning methods is done.				
			5	Cleaning frequency is regularly reviewed and optimized.				
	Mowing		1	Mowing has not yet been carried out.	3.0	5.0	60%	3.0
			2	Mowing is being carried out, but not regularly.				
			3	Mowing is performed regularly.				
			4	Evaluation of mowing methods is done.				
			5	Mowing frequency is regularly reviewed and optimized.				
	Minor repair	Pavement	1	Repair has been hardly performed.	2.0	3.0	67%	2.0
			2	The minimum repair works has been done				
			3	The repair works are performed appropriately.				
			4					
			5					
		Bridge & Culvert	1	Repair has been hardly performed.	2.0	3.0	67%	2.0
			2	The minimum repair works has been done				
			3	The repair works are performed appropriately.				
			4					
			5					
		Other	1	Repair has been hardly performed.	2.0	3.0	67%	2.0
			2	The minimum repair works has been done				
			3	The repair works are performed appropriately.				
			4					
			5					
	Maintenance operating machine		1	Maintenance operating machine is not in place.	3.0	5.0	60%	3.0
			2	Maintenance operating machines are in place, but not enough				
			3	Maintenance operating machines are generally in place.				
			4	Maintenance operating machines are well-in place				
			5	In addition to the above, the latest maintenance operating machines are in place				
Large Item: Maintenance					2.4	4.3	58%	2.4
Pavement repair work	Implementation of repair		1	Repair has not been carried out.	3.0	3.0	100%	3.0
			2	Repair has been partially carried out.				
			3	Repairs have been conducted in many sites.				
			4					
			5					
	Capacity of construction companies		1	Lack of ability to perform repair work	3.0	5.0	60%	3.0
			2	General repairs have been carried out, but ability to perform repair works is poor.				
			3	General repairs have been generally carried out, and ability to perform repair works is average.				
			4	General repair have been generally carried out, and ability to perform repair works is high.				
			5	Many advanced repair works have been carried out, and the ability to perform repair works is high.				
	Compliance with quality control		1	Quality Control of repair work has not been carried out.	3.0	5.0	60%	3.0
			2	Quality control regulations are patrilaterally developed.				
			3	Quality control regulations are developed and in compliance.				
			4	Quality control is evaluated and revised.				
			5	In addition to above, quality control in accordance with ISO are carried out.				

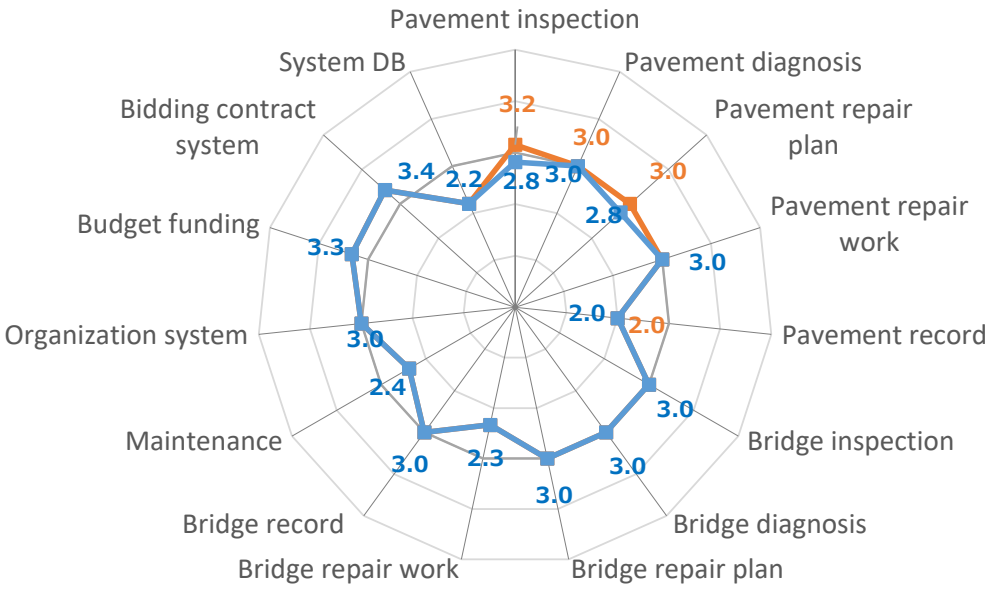
Table 3.9 Cambodia Road AM evaluation sheet (Part 4)

Bridge repair work	Implementation of repair		1	Repair has not been carried out.	3.0	3.0	100%	3.0
			2	Repair has been partially carried out.				
			3	Repairs have been conducted in many sites.				
			4					
			5					
	Capacity of construction companies		1	Lack of ability to perform repair work	1.0	5.0	20%	1.0
			2	General repairs have been carried out, but ability to perform repair works is poor.				
			3	General repairs have been generally carried out, and ability to perform repair works is average.				
			4	General repair have been generally carried out, and ability to perform repair works is high.				
			5	Many advanced repair works have been carried out, and the ability to perform repair works is high.				
	Compliance with quality control		1	Quality Control of repair work has not been carried out.	3.0	5.0	60%	3.0
			2	Quality control regulations are patrilaterally developed.				
			3	Quality control regulations are developed and in compliance.				
			4	Quality control is evaluated and revised.				
			5	In addition to above, quality control in accordance with ISO are carried out.				
Large Item: Repair work					2.7	4.3	67%	2.7
Pavement record	Preservation and sharing of inspection records		1	Inspection results have neither been recorded nor preserved.	2.0	5.0	40%	2.0
			2	Inspection results have been partially recorded and preserved.				
			3	Inspection results have been recorded and preserved.				
			4	Inspection results have been recorded, preserved, and shared.				
			5	Inspection results have been recorded, preserved, shared, and updated.				
	Preservation and sharing of repair records		1	Inspection results have neither been recorded nor preserved.	2.0	5.0	40%	2.0
			2	Inspection results have been partially recorded and preserved.				
			3	Inspection results have been recorded and preserved.				
			4	Inspection results have been recorded, preserved, and shared.				
			5	Inspection results have been recorded, preserved, shared, and updated.				
Bridge record	Preservation and sharing of inspection records		1	Inspection results have neither been recorded nor preserved.	3.0	5.0	60%	3.0
			2	Inspection results have been partially recorded and preserved.				
			3	Inspection results have been recorded and preserved.				
			4	Inspection results have been recorded, preserved, and shared.				
			5	Inspection results have been recorded, preserved, shared, and updated.				
	Preservation and sharing of repair records		1	Inspection results have neither been recorded nor preserved.	3.0	5.0	60%	3.0
			2	Inspection results have been partially recorded and preserved.				
			3	Inspection results have been recorded and preserved.				
			4	Inspection results have been recorded, preserved, and shared.				
			5	Inspection results have been recorded, preserved, shared, and updated.				
Large Item: Record Save					2.5	5.0	50%	2.5
Organization system	Organization	Organization	1	The goal of organizations for Road AM is not established	3.0	5.0	60%	3.0
			2	The goal of organizations for Road AM is unclear.				
			3	The goal of organizations for Road AM is clear.				
			4	Achievement of the organizational goal is evaluated.				
			5	Based on the above evaluation, the goal is continuously reviewed.				
		Personnel	1	Roles of organizations and individuals in charge of Road AM have not been defined.	4.0	5.0	80%	4.0
			2	Roles of organizations and individuals in charge of Road AM are unclear.				
			3	Roles of organizations and individuals in charge of Road AM are clear.				
			4	Roles of organizations and individuals in charge of Road AM are evaluated.				
			5	Roles of organizations and individuals in charge of Road AM are continuously reviewed.				
	System	Leadership of the top	1	The head of the organization is indifferent to the Road AM	3.0	5.0	60%	3.0
			2	The head of the organization is interested in Road AM, but less commitment.				
			3	The head of the organization makes commitments.				
			4	The head of the organization relatively often makes commitments.				
			5	The head of the organization frequently makes commitments.				
		Influence of this organization	1	Road AM department has a weak influence on other organizations	4.0	5.0	80%	4.0
			2	Road AM department has a certain level of influence on other departments				
			3	Road AM department has influence on other departments				
			4	Road AM department is considerable influence on other departments				
			5	Road AM department has strong influence on other organizations				
		Willingness and ability of CP	1	Awareness is low and ability is inadequate.	3.0	5.0	60%	3.0
			2	High awareness, but ability is inadequate.				
			3	Awareness and ability are both moderate.				
			4	Ability is high, but awareness is low.				
			5	Both ability and awareness are high.				
		Training program	1	No training program for human resource development	3.0	3.0	100%	3.0
			2	Training program for human resource is available, but insufficient.				
			3	Training system for human resources development is developed.				
			4					
			5					
		Training facilities	1	No training facility for human resource development	1.0	3.0	33%	1.0
			2	Training facility for human resource is available, but insufficient.				
			3	Training system for human resources development is developed.				
			4					
			5					

Table 3.10 Cambodia Road AM evaluation sheet (Part 5)

Budget funding	Budget	Budget plan	1	Budget plan has not been drawn up.	3.0	5.0	60%	3.0
			2	Budget plan for the next year only has been drawn up.				
			3	Budget plan of short-term (about two to three years) has been drawn up.				
			4	Budget plan of middle-term (about five years) has been drawn up.				
			5	Budget plan of long-term (over ten years) has been drawn up.				
	Financing	Short-term funding	1	Payment for procurement of materials, machinery and labors are often delayed.	3.0	3.0	100%	3.0
			2	Payment for procurement of materials, machinery and labors are sometimes delayed.				
			3	Payment for procurement of materials, machinery and labors are not delayed.				
			4					
			5					
		Long-term funding	1	The gap between the amount of funds required and funds available is not grasped.	4.0	5.0	80%	4.0
			2	Simple financial forecasting keeps track of the gaps in some areas.				
			3	Conduct financial forecasts to analyze and understand the gaps.				
			4	Approaching stakeholders to eliminate the gaps.				
			5	Explanation to stakeholders about minimizing the gaps, and reached to the resolution.				
Large Item: Budget funding					3.3	4.3	80%	3.3
Bidding contract system	Cost estimation methods		1	Cost estimation standard of procurement of materials, machinery and labors are not developed	5.0	5.0	100%	5.0
			2	Cost estimation standard of procurement of materials, machinery and labors are developed but not used.				
			3	Cost estimation standard of procurement of materials, machinery and labors are developed and used.				
			4	Cost estimation standard of procurement of materials, machinery and labors are evaluated.				
			5	Cost estimation standard of procurement of materials, machinery and labors are continuously revised.				
	Anti-collusion system		1	No anti-collusion system.	3.0	5.0	60%	3.0
			2	There is an anti- collusion prevention system, but it is not in operation.				
			3	There is anti-collusion prevention system and it is in operation.				
			4	Anti-collusion system is evaluated.				
			5	Anti-collusion system is continuously reviewed.				
	Contract method☒		1	Contract method is not categorized.	3.0	5.0	60%	3.0
			2	Contract method is partially categorized.				
			3	Contract method is categorized.				
			4	Categorization of contract method is evaluated based on the results of using these method.				
			5	Categorization of contract method is continuously reviewed based on the evaluations above.				
	Procurement process☒		1	Procurement process is not clear.	3.0	5.0	60%	3.0
			2	Procurement process is partially clear.				
			3	Procurement process is clear.				
			4	Procurement process is evaluated based on its operation.				
			5	Procurement process is continuously reviewed based on the evaluations above.				
	Change order		1	Change order procedure is unclear.	3.0	5.0	60%	3.0
			2	Change order procedure is partially clear.				
			3	Change order procedure is clear.				
			4	Change order procedure is evaluated based on its operation				
			5	Change order procedure is continuously revised based on the evaluations above.				
Large Item: Bidding contract System					3.4	5.0	68%	3.4
System DB	DB-related	Pavement assets DB	1	No asset DB	2.0	5.0	40%	2.0
			2	Some of the asset DB are developed as paper base.				
			3	Asset DB are developed as electronic data.				
			4	In addition to the above, the asset DB is partially shared among relevant parties				
			5	In addition to the above, the asset DB is fully shared among relevant parties				
		Bridge assets DB	1	No asset DB	3.0	5.0	60%	3.0
			2	Some of the asset DB are developed as paper base.				
			3	Asset DB are developed as electronic data.				
			4	In addition to the above, the asset DB is partially shared among relevant parties				
			5	In addition to the above, the asset DB is fully shared among relevant parties				
	System-related	Communication function	1	There is no plan of communications facility development between headquarters and local offices	1.0	5.0	20%	1.0
			2	There is a plan of communications facility development between headquarters and local offices				
			3	Development of communication facilities between headquarters and office are now ongoing.				
			4	Communications facility development is well-maintained with no data sharing.				
			5	Communications facility development is well-maintained and data sharing is available.				
		Pavement management system	1	No system has been introduced.	2.0	5.0	40%	2.0
			2	The system has been introduced and partially operational				
			3	The system has been introduced and in operation.				
			4	The effectiveness of the system is evaluated based on the operational results of the system.				
			5	Based on the above evaluation, the system has been continuously improved and updated.				
		Bridge management system	1	No system has been introduced.	3.0	5.0	60%	3.0
			2	The system has been introduced and partially operational				
			3	The system has been introduced and in operation.				
			4	The effectiveness of the system is evaluated based on the operational results of the system.				
			5	Based on the above evaluation, the system has been continuously improved and updated.				
Large Item: System DB					2.2	5.0	44%	2.2
Total					**2.8**	**4.5**	**64%**	**2.9**
Development into the other region and field	Regional development		1	Road AM development has been remaining in its development in a specific area.	5.0	5.0	100%	5.0
			2	Road AM development has begun to develop to the surrounding area of the specific area.				
			3	Road AM development is being developed outside of a specific area.				
			4	Road AM development has been developed more than half of the regions.				
			5	Road AM development has been developed to all regions				
	Field development		1	Road AM development remains in areas where the technical cooperation project was conducted.	1.0	3.0	33%	1.0
			2	Road AM development has begun to extend to the surrounding area where technical cooperation project was conducted.				
			3	Road AM development is progressing to other areas.				
			4					
			5					

3.7.3 Road AM Indicator (Medium Item)



Note: The blue line in the figure is status, and the orange line is expected achievement five years after the end of the technical project.

Figure3.7 Road AM indicators in Cambodia (Medium)

【Overall Overview】

We are generally satisfied with the level 3 that we are aiming for in the JICA Technical Cooperation Project, as well as for bridges and pavement. However, the pavement management systems (hereinafter PMS) that support the maintenance and management of the pavement have not been introduced, and it is necessary to introduce these systems. In addition, the limited repair capability of the Department of Public Works and Transport (hereinafter DPWT), which directly carries out management maintenance / repair of pavement and bridges, needs to be improved.

Although urban roads were well managed, on the suburban national highway (National Highway No. 3), drains and road markings were not sufficiently managed and the division of the driving lane and the oncoming lane was ambiguous and dangerous because there was no clearly displayed center line.

In addition, in the widening construction section, a project was underway to increase from two to four lanes by widening both sides of the existing two-lane road, but the widening portion was undergoing construction while passing through traffic in an area with a lot of dirt. There were no construction signs, guidance markings, traffic arrangements and, in addition, there were waves and potholes on the existing pavement. Overall, it was a dangerous situation. Although it is a section under construction, it was necessary to review the construction method and traffic operation to ensure safety. Generally, it seemed that safety was not considered much.

The bridges crossing the small and medium-sized rivers are unified with PC bridges based on standard design, and as far as the main road around Phnom Penh was inspected, the construction situation was good and the damage could not be found (National Highway No. 6). However, garbage was illegally dumped under the bridge to the point where the river cross section was inhibited. The Chroy Changvar Bridge (China-made bridge opened in 2014) and the Prek Tamak Bridge on National Highway No. 8 (opened in

2010) were PC box-girder format, and there was no noticeable damage, perhaps because it had not been so many years since the construction were completed.

【Paving inspection, diagnosis and repair plan】

The technical cooperation project updated the documentation and guidelines for paving inspection, paving diagnosis, and repair planning, which are owned by RID, to improve the maintenance capability of pavement. Inspection, diagnosis, and repair plans are planned based on these manuals and guidelines. In addition, IRI measurement by DRIMS and simple pavement management systems (PMS) that can formulate repair plans were introduced.

This PMS identifies the necessary parts of pavement repair based on the IRI measured by DRIMS, and is intended to formulate the repair plan, but it is not intended to manage the pavement ledger, inspection results, and records of the repair locations. Currently these records remain recorded on a paper basis. RID hopes to introduce some PMS that can manage these records in an integrated way.

【Bridge inspection, diagnosis and repair plan】

The technical cooperation project introduced new manuals and guidelines for bridge inspections, bridge diagnostics, and repair planning to improve MPWT's bridge maintenance capabilities. Based on these manuals and guidelines, inspection, diagnosis, and repair planning are formulated, and the PDCA cycle of bridge maintenance and management is rotating smoothly. The technical cooperation project provided holistic education not only for RID but also to all DPWT employees, and this initiative continues.

The bridge management system (BMS) was introduced to manage these records integrally. In addition, the system so that the road maintenance budget could be approved after RID and MEF were negotiated, and this initiative also continues. To ensure the continuous operation of the BMS, it is important to involve IT engineers in system maintenance and to guarantee continuous system operation.

【Maintenance and repair of pavements and bridges】

Pavement and bridge repairs are carried out directly by DPWT. The DPWT in Pursat state oversees road and bridge maintenance and receives regular maintenance and improvement work from MPWT every year. 55 staff, 40 short-term contract workers and 30 workers routinely carry out road repairs and drainage maintenance.

The DPWT in Pursat state maintains 350km out of 800km of roads they control, and they manage highways, but the local roads are not well managed. The main roads are paved, but the local roads are not.

The DPWT mainly carries out small repair work according to daily inspection results. The pavement improvements carried out by the DPWT are about 5 to 6 km a year, and they have the construction machinery necessary for the paving improvements (shovel truck, dump truck, etc.). There are five technical staff members who are responsible for construction supervision from the design stage. In addition, the DPWT oversees issuing driver's licenses at the transportation office in addition to the general affairs department, road maintenance and sewage business.

DPWT’s paving repair capabilities are at a level without problems to do general repair work. On the other hand, the bridge repair capabilities are limited to small repair work such as crack sealing. It is necessary to work for improving the construction capability. In the pilot project of the technical cooperation project, crack sealing and carbon fiber sheet method, etc. seem to have been implemented, but it is required to improve the construction capability by practicing other repair methods as well.

【Working with Educational Institutions】

The ITC is currently trying to establish their Department of Logistics. It is said that the research of the Road AM will be done in that department. In addition, if information can be obtained on Road AM-related themes that are being studied at Japanese universities, the ITC will involve themselves in the research topic

that they are interested in. Going forward, there is a need to provide information to the ITC on JICA trainee acceptance process for Road AM.

【Organizational structure】

DPWT hires workers and owns construction machinery because it directly conducts road maintenance and management.

In the future, management extensions will increase as road development progresses, but due to the limitations of DPWT's resources, it is time to consider policies such as how much they should directly implement road maintenance and management, and whether they should outsource to private companies. In many developed countries, including Japan, the government has outsourced road maintenance and management, significantly reducing the burden on the government. In the case of Japanese highway companies, the actual road maintenance is outsourced to group companies. After deciding on a policy, it is necessary to advance technical cooperation targeting organizations that improves bridge repair capabilities, safety management and construction management technology.

【Others】

Since development by the ADB and WB are outside the jurisdiction of RID, they select construction companies by international bid for improvements and renewal projects, and the construction companies (mainly overseas construction companies, etc.) make contracts with consultants or local construction companies to carry out the project.

Although there are contractors in the construction stage, after handing over the maintenance and management to the department in charge after completion of construction, major problems do not occur in the initial stage of maintenance, but it is difficult to respond when a large problem occurs after some time has passed. Particularly for the structures constructed by Chinese companies, there are many problems such as design drawings not being taken over, etc.

The construction of the highway is being carried out as a toll road business by BOOT. The length currently under construction is 190Km, and about 7% of the work volume is completed. The contractor is CWC, a Chinese company, and they borrow from the Bank of China. Design and construction standards are all based on Chinese standards (JTG).

The cost of acquiring land is borne by CWC up to a certain base amount, and any more than that will be borne by the Government of Cambodia. In addition, the toll collection is real-toll method, and the risk of toll revenue is to be taken by CWC.

【Five years from now】

Evaluation points expected five years after the end of the technical cooperation project were described by orange lines. By implementing this technical cooperation project, bridge inspections, bridge diagnoses, bridge repair plans, and bridge records were improved and reached 3.0 points. In addition, the system DB is expected to improve through the maintenance of bridge asset registers and the operation of BMS. On the other hand, it is unknown for other items, including repair work of bridges.

3.8 Organizing Issues for Road AM Fixation

3.8.1 Issues in Pavement Maintenance

The technical cooperation project implemented in the past year has updated the manuals and guidelines for pavement inspection, pavement diagnosis, and repair planning for roads managed by RID and DPWT, and pavement inspections, pavement diagnosis, and repair plans have been planned based on these. In addition, the pavement damage cases confirmed through the daily inspection performed by DPWT and the report from the general road users have been reported to RID sequentially. However, this maintenance

information is only shared on a paper basis, and there is no situation in place for continuous accumulation of information and information sharing among related departments. In addition, although we have formulated a pavement repair plan by PMS that has been introduced for assistance in the technical cooperation project, management of the pavement ledger, records of the inspection results and pavement repair have not been made.

From these situations, it is necessary to introduce a DB system that can manage the road maintenance information that can be continuously utilized by RID.

3.8.2 Problems in Bridge Maintenance

The technical cooperation project implemented in the past year has introduced the manuals and guidelines for bridge inspection, bridge diagnosis, repair planning for road bridges managed by RID and DPWT, and based on these bridge inspections, bridge diagnoses, and repair plans are being made and PDCA cycles of bridge maintenance are rotating smoothly. In addition, during the technical cooperation project human resource development education was also conducted on maintenance and management, including not only RID but also all DPWT organizations, and the inspection and diagnoses were carried out for all bridges. To continue this situation, it is necessary for efforts to develop human resources within the organization continuously. The next bridge inspection will be carried out voluntarily, and rotating the PDCA cycle on its own will lead to the establishment of true Road AM.

In addition, for bridge damage that will be diagnosed through future inspection activities, appropriate repairs and renovations are required and the introduction of optimal repair technology is desired. On the other hand, BMS has been introduced through the technical cooperation project, and it is used for discussions with the budgeting department for the road and maintenance budget. It is important to continue the operation system of BMS.

3.8.3 Issues in Road Maintenance DB

This survey confirmed the necessity of information sharing by database for road maintenance information and the importance of the continued operation of PMS. On the other hand, it has been confirmed that HDM-4 that was already introduced by the WB is being utilized for the WB and ADB project formation, but data cooperation between the systems with PMS supported by the technical cooperation project has not been made. From the viewpoint of efficiency of road maintenance, it is desirable to examine the ideal way to have data cooperation between those systems.

3.8.4 Issues in Road Repair Technology

In the technical cooperation project implemented in the past year, bridge repair technology such as pothole emergency repair using cold mix asphalt and the crack sealing method were introduced through the pilot project.

However, through a field interview with a Japanese company, it was found that the improper application of repairs with cold mix asphalt had been confirmed, and that there was no understanding of the material application policy or the thoroughness of appropriate construction methods.

3.8.5 Safety Management Issues in Maintenance and Management

Large-scale projects, such as the National Highway Widening Project, ~~which is a highway,~~ are being implemented by multinational companies, who are international bidders from other countries. In the National Highway No. 3 widening project, there were insufficient construction regulations and traffic operation methods, causing traffic safety problems and traffic jams. It is necessary to appropriately implement the construction regulation method on the main road according to the traffic characteristics. In addition, since the awareness of the safety of construction workers as well as general travel vehicles is insufficient, it is necessary to increase the interest in traffic safety and construction safety.

3.8.6 Quality Control Issues in Maintenance and Management

Small-scale pavement repair work is carried out by DPWT itself; it has the necessary workers and work machinery vehicles. In terms of bridge repair, DPWT is directly implementing minor repairs.

On the other hand, large-scale road widening, and bridge replacement projects are being carried out by multinational companies that have internationally bid from other countries. In order to cope with road and bridge damage caused by aging, it is expected that the DPWT direct management system and the ability to improve the repair technology of local companies while also ensuring quality will be necessary as to reduce the reliance on multinational companies.

3.8.7 Issues of the Maintenance and Management Organization System

At present, the DPWT is implementing road maintenance on its own, but since the management expansion will increase with the progress of road development in the future, it can be assumed that it will be difficult to respond with the limited resources of the DPWT. For the future, it is necessary to discuss with relevant agencies whether to continue to expand the organization size of the DPWT task force or to develop and outsource to domestic local companies and to establish this as a national policy.

In addition, 11 RID employees have been trained as maintenance master trainers in the technical cooperation projects that were implemented over the past year, and a system that can be maintained continuously has been established, such as training 35 other DPWT staff. To maintain this system and to conduct technical studies in the future, it is desirable to establish voluntary training organizations and programs.

3.8.8 Issues of Maintenance and Management System of Expressways and Long-span bridges

In Cambodia, 50 long-span bridges (of which 3 bridges are supported by Japan) have been developed with support from each donor country, and the inspection and minor repairs are also carried out directly by EXMID, which is an organization within MPWT. In addition, Expressway No. 4, which is currently under construction with Chinese support, will be transferred to EXMID in the future.

In the present situation, EXMID does not have the maintenance inspection technology of the cable-stayed bridge such as the Tsubasa Bridge, and future difficulty in their ability to cope with large-scale repair of steel and PC bridges can be assumed.

3.9 Development of Support Measures for Road AM Fixation

3.9.1 Support Measures for Pavement Maintenance

Dispatching short-term experts and consultants to develop and operate the pavement inspection, repair, and repair planning manuals. In addition, it is effective to invite trainees to highway management companies in Japan to conduct OJT education, group, and country-specific training to improve the maintenance and management capabilities for pavement.

3.9.2 Support Measures for the Maintenance of Bridges

While maintaining the current BMS operational management system, short-term experts and consultants should be deployed to assist in the introduction of appropriate repair and renovation technologies for bridge damage diagnosed through inspection activities.

In addition, continuously monitoring the operational BMS system to ensure that the BMS introduced through the technical cooperation project is being used for discussions with the budgeting department regarding the road and maintenance budget.

3.9.3 Support Measures in the Road Maintenance DB

For the purpose of sharing construction and maintenance data for pavement, bridges, and road accessories, short-term experts and consultants should be deployed to develop and manage DB systems that enable integrated management of road maintenance information that can be continuously utilized in RID

organizations. Since HDM-4 seems to be operating as a project cost estimating application, taking into account the data linkage with PMS, the introduction of a model that can be customized locally, such as the Japanese pavement management system (e.g., Kyoto model), may also be effective in establishing an effective management system.

3.9.4 Support Measures for Quality Control and Safety Management

Effort needs to be made to strengthen efforts to improve quality control, traffic operation, including traffic restrictions during construction, and health and safety management capabilities (improvement of guidelines, awareness reform by holding seminars and application of penalties for violations). In addition, it is effective to invite trainees to highway management companies in Japan to improve quality control and safety management capabilities through OJT education, group, and country-specific training.

3.9.5 Support Measures for Future Maintenance and Management Organizations

In response to the increase in management extensions as road development progresses, short-term experts and consultants should be deployed to promote discussions on system designing, organizational planning, and contracting methods with relevant organizations in order to determine whether to continue to expand the organization size of the DPWT or to foster and outsource to domestic local companies. In addition, it is effective to invite maintenance master trainers and candidates among RID staff as trainees to road management companies in Japan, research institutes and construction companies to improve Road AM capabilities through OJT education, group and country-specific training.

3.9.6 Support Measures for the Maintenance and Management Organization System of Expressways and Long-Span Bridges

For EXMID, short-term specialists and consultants should be deployed for the purpose of maintaining and inspecting long-span bridges and improving repair technology capabilities. In addition, it is effective to improve the maintenance ability of expressways and long-span bridges through OJT education, group, and country-specific training by inviting EXMID staff to highway management companies in Japan, research institutes and construction companies.

3.9.7 Examination of Research Content at Japanese Universities

In Cambodia, due to budget constraints and a lack of human resources with knowledge, experience, and skills, the improvement of pavement quality, bridge maintenance, repair technology and Road AM capability are major issues. For this reason, it is considered necessary for Japanese universities to work on the content of the research shown in Table 3.11 regarding the maintenance and management technology of pavement, bridge engineering and bridge maintenance technology.

Table 3.11 Cambodia focused research topics at Japanese universities (draft)

Challenges	Research Program
Pavement Maintenance and Quality Improvement	Study of effective pavement repair design methods considering existing pavement structure and strength
	Study of construction methods for pavement repair considering long-term durability
	Study of long-term durability of pavement materials
	Study of efficient and effective methods of recycling pavement materials
	Study of pavement and embankment structures, development of diagnostic automation technology
Improvement of Bridge Maintenance and Repair	Study of deterioration diagnosis technology for steel bridges and concrete structures
	Study of utilization and analysis of bridge damage data

Challenges	Research Program
Technology	Study of health evaluations for bridges
	Study of preventive maintenance methods for bridges considering reliability and risk
	Study of the setting and the standards of the performance level which should be given to bridges
Road AM capability improvement	Bridge Maintenance Integrated Database System
	Development of the road infrastructure management cycle and general research aimed at domestic and overseas implementation
	Implementation by the ME Network of SIP maintenance management that is being considered
	Research and development for the social implementation of innovative advanced technology for infrastructure maintenance management

Chap. 4 Initiatives on Road AM in Japan

4.1 Target of the Chapter

This chapter marshals the efforts for the establishment of Road AM by conducting interviews with two or more organizations for road administrators such as the Ministry of Land, Infrastructure, Transport and Tourism (hereinafter MLIT), domestic local governments, and expressway companies. In addition, it marshals the current condition of research and development technologies at universities, research institutions and private companies as well as the status of development technologies expected to be used in developing countries through possessed technologies and the like.

4.2 Overview

The outline of the results on the survey policy, 2018 survey outline, 2019 survey outline, and recommendations for the following years regarding the initiatives on road asset management in Japan are as listed below.

Survey policy	Various efforts related to the maintenance cycle in Japan are being implemented, and useful approaches and technologies to solve issues from three viewpoints (budget, technology, human resource shortage) in developing countries and regions are summarized. The survey method is basically an analysis of documents and publicly available materials. Exchange of opinions and hearings are conducted on particularly useful methods and technologies.
2018 Survey outline	Regarding the organization of documents and published materials, we conducted a questionnaire to local governments who are connected to university professors based on information gathering results obtained at various seminars and technical exhibitions. We exchanged opinions with four universities (The University of Tokyo, Tohoku University, Gifu University, Nagasaki University) that are conducting research on SIP area implementation, Yokohama National Road Office, and toll road management companies.
2019 Survey outline	Regarding the organization of documents and publications, the first round of inspections, infrastructure maintenance, and a national conference on inspection support technology (image measurement, nondestructive inspection) were conducted by the MLIT. These are summarized in this outline. Exchange of opinions with organizations such as NEXCO West Japan, Honshu-Shikoku Bridge Expressway, Hokuriku SIP Team (Kanazawa Institute of Technology, Kanazawa University, University of Fukui), University of the Ryukyus, Kanto Maintenance Center, Omiya National Highway Office, Civil Engineering Research Institute, Toyama City were conducted.
Recommendations for the following years	Regarding the organization of documents and published materials, it is necessary to organize and analyze the issues faced by local governments based on the results of the first round of inspections. Regarding hearings, based on the results of the 2019 survey, it is conceivable that the opinions will be deepened and exchanged with related organizations. Specifically, the Bridge Maintenance Study Group of Saitama University in collaboration with the Omiya National Highway Office, local governments in collaboration with Hokuriku SIP team, local companies in collaboration with University of Ryukyus, and such. If possible, we also propose to participate with observers at road maintenance meetings and additional hearings with participating municipalities.

4.2.1 List of Survey Results

An outline of initiatives with the organizations that conducted literature surveys and exchanged opinions in 2018-2019 is shown in Table 4.1 and Table 4.2.
In addition, the status of efforts and technologies used for exchanging opinions, hearings, and literature surveys are organized in individual survey sheets as reference materials.

Table 4.1 List of survey/hearing results (2018)

No.	Institution / Company	Title of Research / Outline of Initiatives	Applicability and Effective Technology	Technology Field(s)	Field(s) Applied
■Cutting-edge initiatives by Expressway companies					
1.	E-NEXCO	Advancement of expressway asset management through ICT utilization and mechanization	Recording efficiency improvement	Survey Inspection	Pavements
2.	Metropolitan Expressway Co Ltd	Infrastructure maintenance management and society implementation of disaster prevention system using advanced technology（i-DREAMs）	Recording efficiency improvement	Survey Inspection	Pavements
3.	Metropolitan Expressway Co Ltd	Maintenance management support system using GIS and 3D point cloud data (Infra Doctor)	Recording efficiency improvement	Survey Inspection	Pavements
4.	Metropolitan Expressway Co Ltd	Patrol inspection system using high-performance drive recorder (infrastructure Patrol)	Inspection efficiency improvement	Survey Inspection	Pavements
5.	West Nippon Expressway Engineering Shikoku Co Ltd	Road surface survey with a small vehicle adopting a simple system (Smart Eagle)	Inspection efficiency improvement	Survey Inspection	Pavements
6.	Shutoko Engineering Co Ltd	Structural inspection equipment in high places and/or narrow areas	Inspection efficiency improvement	Survey Inspection	Structures
7.	Shutoko Engineering Co Ltd	Lateral-tightening PC grout filling investigation with elastic wave method	Inspection efficiency improvement	Survey Inspection	Structures
■Initiatives on National Roads, Prefectures and Municipalities					
8.	Yokohama National Road Office / Kanto Regional Development Bureau/ MLIT	Approach to Road Maintenance Meeting, etc.	Technical Support	Road AM	Others
■Trends in research and development of technologies and systems at universities and research institutes					
9.	National institute for Infrastructure Management / MLIT	Maintenance and Utilization of road space data	Road Management	Road AM	Others

No.	Institution / Company	Title of Research / Outline of Initiatives	Applicability and Effective Technology	Technology Field(s)	Field(s) Applied
10.	The University of Tokyo /Associate Prof. Nagai	Approach of Niigata City Bridge Asset Management Review Committee	Technical Support	Road AM	Others
11.	Gifu University /Prof. Kunieda, et al	Infra-Museum as Technical Educator	Training facilities	Road AM	Structures
12.	Gifu University /Prof. Rokugo, et al	Efficiency and advancement of regular bridge inspection by robot technology and greatly shortening traffic regulation	Inspection efficiency improvement	Robots	Structures
13.	Tohoku University /Prof. Hisada	Construction and Bridge maintenance integrated database system and introduction support to local governments by industry-academia-government collaboration	Recording efficiency improvement	Road AM	Structures
■Development trends of inspection and maintenance technology etc. which are implementable overseas by private companies					
14.	TRION Corporation	All-road surrounding view information – "All Road Around View Information" (CV-RAVI)	Recording efficiency improvement	Information Communication	Others
15.	TSUTAI	Hammering inspection system (T.T. Car)	Inspection efficiency improvement	Survey Inspection	Pavements
16.	Institute of System Planning Co Ltd /ISP	Crack detection engine with AI/Deep Learning	Inspection efficiency improvement	Survey Inspection	Structures
17.	Nippon Engineering Consultants Co Ltd	Multicopter for bridge inspection (MARCO)	Inspection efficiency improvement	Survey Inspection	Structures
18.	Toshiba Infrastructure Systems and Solutions Co Ltd	Road pavement crack analysis service	Inspection efficiency improvement	Survey Inspection	Pavements
19.	Kurabo Industries Ltd	Road surface inspection compact-unit-PG-4	Inspection efficiency improvement	Survey Inspection	Pavements
20.	Nichireki Co Ltd	Romencatcher VPW	Inspection efficiency improvement	Survey Inspection	Pavements
21.	Asia Air Survey Co Ltd	Road surface profile measurement system (Road Profiling System)	Inspection efficiency improvement	Survey Inspection	Pavements
22.	FUJIFILM Holdings Corporation	Social infrastructure imaging diagnosis service (HIBIMIKKE)	Inspection efficiency improvement	Survey Inspection	Structures
23.	JIP Techno Science Corporation	Road surface inspection system using Smartphone (DRIMS)	Inspection efficiency improvement	Survey Inspection	Pavements

No.	Institution / Company	Title of Research / Outline of Initiatives	Applicability and Effective Technology	Technology Field(s)	Field(s) Applied
24.	Sumitomo Mitsui Construction Co Ltd	Bridge-inspection robot camera	Inspection efficiency improvement	Survey Inspection	Structures
25.	IKEE Co Ltd	Spread and Verification regarding Manufacturing of Cold Patch (Excel) and Daily Road Maintenance Management Operation	Example of overseas development	Road AM	Pavements
26.	Shiraito Highland Way / GAEART Corporation	Maintenance and Operation of Toll roads and acquisition of ISO 55001 by road pavement companies	Road AM	Road AM	Pavements
27.	Hakone Turnpike / C-NEXCO	Maintenance and operation of toll roads by expressway related companies	Road AM	Road AM	Pavements
■Initiatives on establishment of Road AM by Local Government and Universities					
28.	Gifu University	Maintenance Expert System	Human Resource Development	Road AM	Others
29.	Nagasaki University	Michimori System	Human Resource Development	Road AM	Others
30.	Tohoku University	Approach to Tohoku Infrastructures Management Platform	Technology Sharing	Road AM	Others
31.	Nihon University	Establishment and Practice of “Bridge self-maintenance; Fukushima Model”	Inspection efficiency improvement	Survey Inspection	Structures

Table 4.2 List of survey/hearing results(2019)

No.	Institution / Company	Title of Research / Outline of Initiatives	Applicability and Effective Technology	Technology Field(s)	Field(s) Applied
■Cutting-edge initiatives by Expressway companies					
1.	W-NEXCO	Improvement in asset management by building internal system and external collaboration systems	Road AM	Road AM	Others
2.	Honshu-Shikoku Bridge Expressway Co Ltd	Maintenance technology for long bridge (Corrosion prevention technology)	Longer life	Materials Repairs	Structures
3.	Honshu-Shikoku Bridge Expressway Co Ltd	Maintenance technology for Long bridge (Inspection efficiency improvement)	Inspection efficiency improvement	Robots	Structures
4.	West Nippon Expressway Engineering Shikoku Co Ltd	Total support system for infrared survey (J-SYSTEM)	Inspection efficiency improvement	Survey Inspection	Structures
■Initiatives on national roads, prefectures, and municipalities					
5.	Kanto Regional Maintenance Center / Kanto Regional Development Bureau / MLIT	Technical support for local governments, technical training for inspections	Local Government Support	Road AM	Others
6.	Omiya National Road Office / Kanto Regional Development Bureau / MLIT	Saitama Prefecture Road Maintenance Meeting Collaboration with Saitama University	Collaboration with universities	Road AM	Others
7.	Toyama City	Evaluation system for human resource development and repair technology	Human resource development Evaluation system	Road AM	Others
8.	Kimitsu City	Drone inspection by city staff	Inspection efficiency improvement	Robots	Structures
■Initiatives on research institute					
9.	Public Works Research Institute	Technical evaluation, standard revision	Evaluation system	Road AM	Others
■Development trend of inspection and maintenance technology etc. which are implementable overseas by private companies					
10.	Luce Search Co Ltd CTI Engineering Co Ltd	Structure inspection robot system “SPIDER”	Inspection efficiency improvement	Survey Inspection	Structures
11.	Sanshin Construction Materials Co Ltd Autonomous Control System Laboratory Ltd	Close-up visual inspection support technology using non-GPS environment-friendly drone	Inspection efficiency improvement	Survey Inspection	Structures

No.	Institution / Company	Title of Research / Outline of Initiatives	Applicability and Effective Technology	Technology Field(s)	Field(s) Applied
12.	Musokagaku Ltd.	Close-up photography by multi-copter and two-dimensional measurement of abnormal places	Inspection efficiency improvement	Survey Inspection	Structures
13.	Kawada Technologies, Inc. Nippon Engineering Consultants Co Ltd	Bridge inspection system using multi-copter	Inspection efficiency improvement	Survey Inspection	Structures
14.	Zivil investigation design Ltd. INTES University of Fukui	Assistance/complementary technology for close-range visual inspection and tapping sound survey by "looking and examining bridge inspection camera systems"	Inspection efficiency improvement	Survey Inspection	Structures
15.	Sumitomo Mitsui Construction Co Ltd Hitachi Industry & Control Solutions Ltd	Inspection robot camera for bridge structures	Inspection efficiency improvement	Survey Inspection	Structures
16.	Tohoku Institute of Technology O・T・Techno Research Co Ltd	A simple device for supporting visual proximity of the underside of a bridge	Inspection efficiency improvement	Survey Inspection	Structures
17.	NEC Corporation Highway Technology Research Center	Pole hammering inspection machine	Inspection efficiency improvement	Survey Inspection	Structures
18.	Zivil investigation design Ltd INTES University of Fukui	Bridge inspection support robot	Inspection efficiency improvement	Survey Inspection	Structures
19.	Shin-Nippon Nondestructive Inspection Co Ltd Nagoya University Kyushu Institute of Technology National Institute of Technology, Kitakyushu College Fukuoka Industrial Technology Center	Flight robot inspection system using close-up visual inspection, tapping inspection, etc.	Inspection efficiency improvement	Survey Inspection	Structures
20.	ONGA Engineering Co Ltd	Concrete structure deformation part detection system "BLUE DOCTOR"	Inspection efficiency improvement	Survey Inspection	Structures
■Initiatives on establishment of Road AM by local government and universities					
21.	Hokuriku SIP Team Kanazawa University, Kanazawa institute of Technology, University of Fukui	Preparation of Hokuriku edition manuals and guidelines	Local government support	Road AM	Others

No.	Institution / Company	Title of Research / Outline of Initiatives	Applicability and Effective Technology	Technology Field(s)	Field(s) Applied
22.	University of the Ryukyus	Technology transfer to local government	Local government support	Road AM	Others

4.2.2 Outline of Previous year's Interviews (2018)

The organizations that conducted the hearings and an outline of the surveys in 2018 are as follows:

Tohoku University	School of Engineering: Professor Hisada, Associate Professor Minagawa Tohoku University is establishing and supporting the "Tohoku Infrastructure Management Platform" in collaboration with relevant government agencies, private companies, and universities in the six prefectures of Tohoku. The outline of initiatives includes "establishment of the platform," "development of information infrastructure, social implementation," "support for social implementation of results," "framework construction for human resource development," among others.
The University of Tokyo	Institute of Industrial Science: Associate Professor Nagai The Niigata City Bridge Asset Management Review Committee has launched the "Contract Study Group" and "Bridge Maintenance Management Study Group."
Gifu University	Faculty of Engineering: Professor Emeritus Rokugo, Visiting Professor Hatano, Associate Professor Kinoshita Gifu University has established a system to train maintenance experts who are engineers that can perform appropriate diagnosis and treatment for existing infrastructure facilities. Specifically, a four-week training course is held for members of society who are involved in the maintenance and management of social infrastructures, and certifications have been issued since 2008.
Nagasaki University	Graduate School of Engineering: Professor Matsuda, Professor Nakamura, Associate Professor Nishikawa Nagasaki University established a system to maintain, manage, and develop human resources in collaboration with Nagasaki Prefecture, local companies, local governments, OB retirees, and the citizenry. The outline is divided into four courses and which include: (1) Training personnel who can maintain and manage entire roads, (2) Developing advanced technology, (3) Developing personnel who can perform inspection planning and diagnosis, (4) Developing personnel who can perform inspection work, and assistants.
Yokohama National Road Office / Kanto Regional Development Bureau/ MLIT	Opinion exchange meeting with Road Management Division 2 which is the maintenance department Exchange opinions on the current state and issues of road maintenance based on a maintenance questionnaire
Shiraito Highland Way/ GAEART Corporation	Exchanged opinions on operation and maintenance of toll roads by a road paving company and cases of ISO 55001 acquisition
Hakone Turnpike / C-NEXCO	Exchanged opinions on maintenance and management of toll roads by expressway affiliates

4.2.3 2019 Hearing

The organizations that conducted hearings and an outline of the survey of their work this year are as follows:

Organization	Outline of the survey
W-NEXCO	Interview on the status of efforts related to advanced asset management The main efforts are: (1) Asset management system, (2) Large-scale renewal and repair project of aging structures, (3) Strengthening disaster response capabilities, (4) Engineer training center.
Honshu-Shikoku Bridge Expressway Co Ltd	Interview on improving service life of long span bridges and development of inspection technology These approaches are useful technologies for developing countries with many long span bridges that do not consider maintenance work such as inspections and repairs.
West Nippon Expressway Engineering Shikoku Co Ltd	Interview on inspection technology development and system development related to bridge inspection A particularly useful technology is the total support system for infrared survey (J system).
Public Works Research Institute	Center for Advance Engineering Structural Assessment and Research (CAESAR): Chief Researcher Oshima Since it is a national research institute, the core principle is doing research in fields and areas that do not put pressure on the private sector. Therefore, the main activity is to perform technical evaluation. If so, it may be possible to build a scheme that takes the form of technical consultation and conveys the sophistication and know-how of AI inspection and diagnosis. A recent topic suggest is the possibility to introduce techniques using neutrons and techniques for exploring the sedimentation of floor plates using electromagnetic radars. If we can support the research fund by collaborating with JICA, the range of activities can be expanded further.
Local government Toyama City	Interview with Ueno Construction Engineering Supervisor The supervisor is implementing a training program for technology transfer and human resource development called “Ueno Juku” for Toyama City staff. Toyama City's unique activity to evaluate repair technology, the “Repair Olympic Games,” provides a trial site for repair technology and has a system in place for evaluation by university researchers.
Kanazawa University, Kanazawa Institute of Technology, University of Fukui	Kanazawa University: Associate Professor Kubo Kanazawa Institute of Technology: Vice President Shikata, Professor Miyazato University of Fukui: Associate Professor Suzuki The Hokuriku SIP team is working on manuals and human resource development in collaboration with Kanazawa University, Kanazawa Institute of Technology, University of Fukui, etc., and shares issues and solutions unique to the Hokuriku region.
University of the Ryukyus	Professor Shimozato, Associate Professor Toyama, Assistant Professor Suda, Assistant Professor Tai The University of the Ryukyus has established a scheme to collaborate with local companies on areas of investigation such as photoimaging, as well as the combination of efforts in university and major general contractors for UAV and crack image diagnosis. A steel structure anticorrosion manual specific to the Okinawa area was developed in cooperation with the national and prefectural governments.

4.3 Cutting-Edge Efforts at Expressway Companies

4.3.1 West Nippon Expressway Company Limited

West Nippon Expressway Company Limited (W-NEXCO) manages a vast amount of expressway assets including a total road length of approx. 3,000 km, a bridge length of 600 km, and a tunnel length of 450 km. Most of these assets were constructed in the era from the 1960s to the 1990s, and the length of time after their services is around 30 years (average weight over distance), deteriorating with age. Assets of W-NEXCO and trends in length of time after their services are shown in Figure4.1 and Figure4.2.

■ Extension of Management (As of 03/31/2018)

dch Name	Extension of Management			Extension by road structures			Average passed years after services
	Expressway	Ordinary toll roads	Total	Earthwork	Bridge	Tunnel	
Kansai	711 km	176 km	887 km (25%)	545 km	223km	119 km	30 年
Chugoku	968 km	66 km	1,034 km (30%)	759 km	138km	137 km	30 年
Shikoku	447 km	29 km	476 km (13%)	295 km	97 km	84 km	22 年
Kyusyu	972 km	135 km	1,107 km (32%)	855 km	148 km	104 km	29 年
Total	3,098 km	406 km	3,504 km (100%)	2,454km (70%)	606 km (17%)	444 km (13%)	29 年

Figure4.1 Assets of W-NEXCO[14]

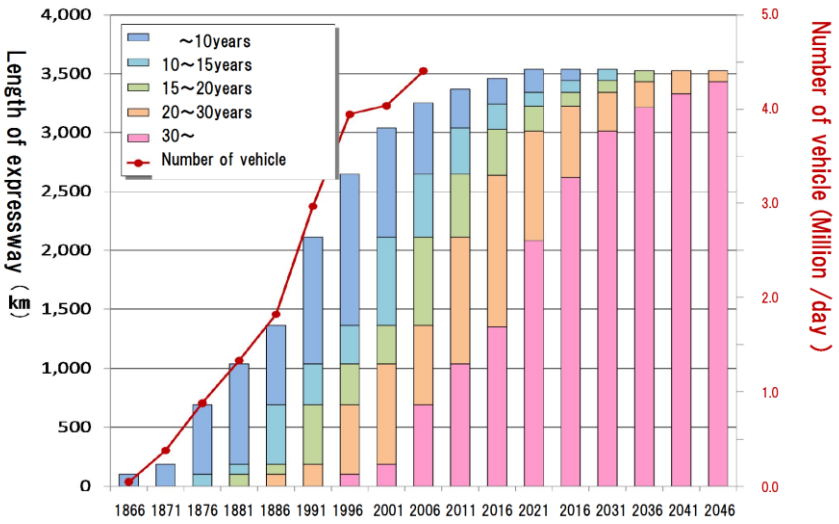


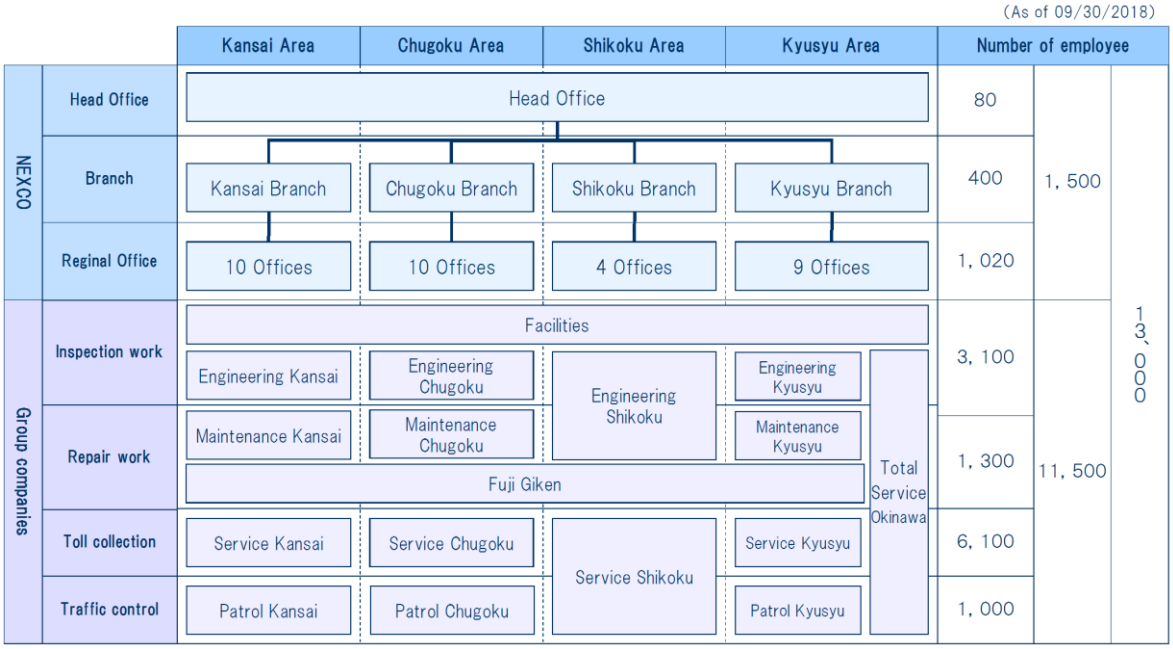
Figure4.2 Trends in average passed year after services of expressway assets[14]

As for the maintenance management of the existing expressway assets, in addition to ordinary repairs, other problem areas have been identified, such as large-scale updates and repairs of deteriorated structures, appropriate preventive maintenance, and responses to intense large-scale disasters. Considering these issues, the following system of expressway companies and their efforts are being highlighted for efficient asset management of existing expressway assets.

4.3.1.1 Maintenance Management System Integrated with Group Companies

W-NEXCO entrusts core business operations related to maintenance managements of expressways to their group companies. The division of labor of W-NEXCO is shown in Figure 6.3. They oversee the following works below. ①W-NEXCO, a parent company, wholly carries out management. ②Engineering companies carry out inspection operations. ③Maintenance companies carry out maintenance and repairs. ④Service companies perform toll collection work. ⑤Patrol companies are in charge of traffic control and regulation.

[14] Source: West Japan Expressway Co., Ltd.



※Facilities oversee maintenance inspection of the structures and communication facilities, and Fuji Giken oversees design construction concerning reinforcement and repair of bridges

Figure 4.3 Division system in W-NEXCO group[15]

The following companies are shown as maintenance management companies for expressways; ①W-NEXCO, a parent company ②Engineering company ③Maintenance company ⑤Patrol company ― Cooperating with each other, these companies continue to establish efficient and multifaceted maintenance management systems. More concretely, ①NEXCO, the parent company, has a comprehensive perspective that includes various management perspectives such as budget control, process control, and human resource management at each stage, as well as external perspectives such as user benefits and prevention of damage to/from third parties. ②Making use of unitary management of data on inspection and repair, engineering companies develop efficient inspection planning and repair plans utilizing progress estimation of damages. Furthermore, ③Taking advantage of on-site repairs and actual performance of monitoring at sites after repairing, maintenance companies develop a construction plan that includes repair methods and traffic regulations corresponding to the site condition and state of damage. As a supplement, ⑤Making the most of periodical performance of daily inspection, patrol companies provide timely progress status reports of damages. Holistically, each company has a different viewpoint at each stage of inspection: sound evaluation, survey, repair, and record of repair history. All these contribute to the establishment of an efficient maintenance management cycle. This cycle is diagramed in Figure 4.4 and Figure 4.5.

[15] Source: West Japan Expressway Co., Ltd.

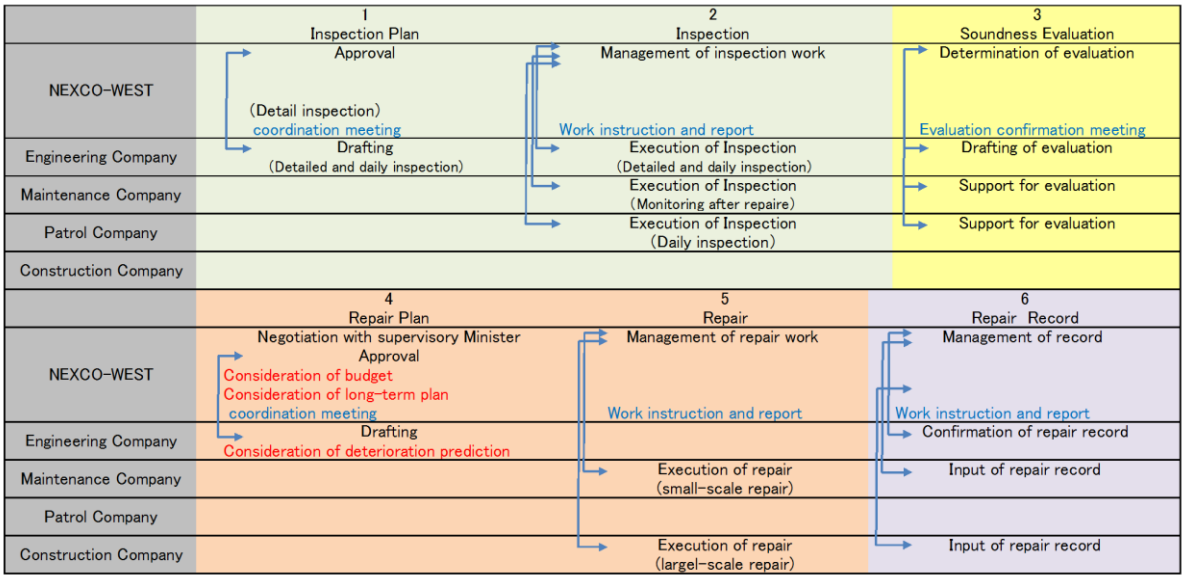


Figure 4.4 Implementation of maintenance management by the cooperation of group company[16]

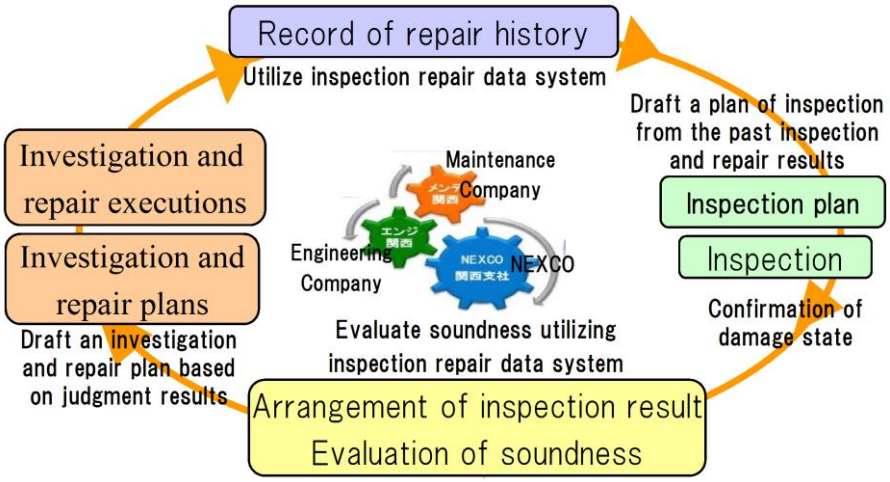


Figure 4.5 Operation of maintenance management cycle in cooperation with group companies[16]

4.3.1.2 Large-Scale Renewal and Repair Projects of Aging Structures

Particularly remarkable deformations observed in aging structures, are shown in Figure 4.6. Deformations of bridges are observed in floor slabs and girders, and the main causes are the fatigue due to overloading vehicles and a residual salinity of anti-freezing agents, in addition to aging degradation. Also, deformations of soil structures and tunnels can be seen on ground anchors and road surface sections, and the causes are considered to be rusting on ground anchors and a change in the stress state of structures due to displacements of natural ground.

[16] Source: West Japan Expressway Co., Ltd.

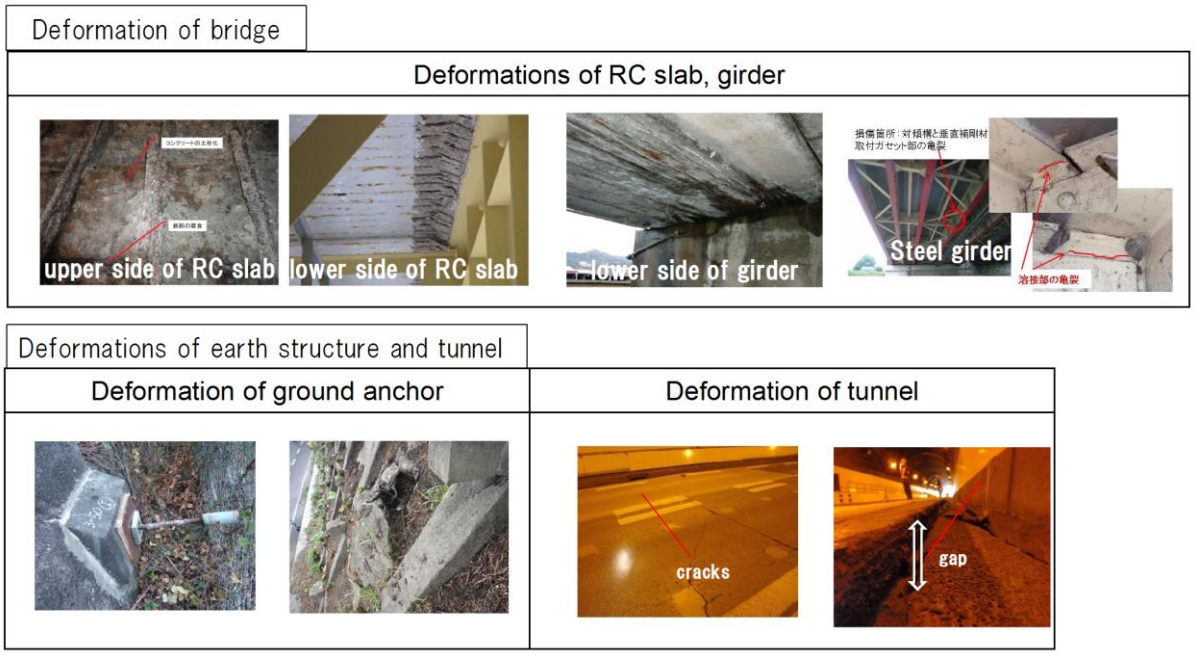


Figure 4.6 Deformation state of structures[17]

Large-scale update and repair projects have been continuing for 15 years since 2015 regarding these deformations. Concrete measures and the size of the budget are shown in Figure4.7. Regarding bridges, relatively sound girders are reinforced, along with the replacements of remarkably deformed floor slabs and girders, and as preventive maintenance, water-proofing work is conducted. As for soil structures, the replacement work of ground anchors that show high corrosion (preventing proper performance) have been carried out. And inverts, with the objective of improving the bearing power of the soil, have been installed.

As the efforts are still in progress, efficient maintenance management cycles, dedicated to large-scale update and repair projects, are being established. For example, the smart handling of tasks have been progressing, such as preparation check lists for inspection, a scoring of damages for determining carry-out orders by level of priority, a preparation of a standard flow chart, and a preparation of a standard construction procedure.

	Structure	Portion	Main measures	length (km)	Estimated project cost (Billion JPY)
Large-scale update	Bridge	Slab	Slab replacement	230	1650
		Girder	Girder replacement	10	100
	Sub-total			240	1760
Large-scale repair	Bridge	Slab	High-performance slab waterproof	360	160
		Girder	Girder reinforcement	150	260
	Earth structure	Embankment, Slope	Ground Anchor, Drainage boring	1230	480
	Tunnel	Tunnel	Invert arch construction	130	360
	Sub-total			1870	1260
Total				2110	3020

Figure4.7 Menu of large-scale update and repair projects (3 NEXCOs)[17]

[17] Source: West Japan Expressway Co., Ltd.

4.3.1.3 Strengthening of Capacity to Respond to Disasters

After large-scale disasters including the 2016 Kumamoto earthquake and the 2018 West Japan downpours, the importance of functions of expressways during times of disaster has been widely recognized. Also, disasters tend to be relatively more intense than ever before because of climate change, and as a result the severity of damage also continues to increase. Under the current circumstances, W-NEXCO has taken measures with a goal of strengthening the capacity to respond to disasters on expressways from both hardware and software perspectives, which is shown inFigure 4.8. Measures taken from the hardware perspective include improvement and reconstruction at existing facilities in such a way that at a time of disaster expressways will not fall into malfunction and that the assets of the expressways will be used effectively. More concretely, this includes seismic retrofitting of bridges, installation of back-up facilities at the time of disasters, the setting up communication cables and servers, establishing disaster prevention bases of the existing SAPA, and stockpiling supplies for disaster response at SAPA. Measures taken from a software perspective include the establishment of disaster prevention systems within the company, establishing cooperative disaster prevention system with related parties, development of BCP providing relief from the disaster, and disaster drills with residents and related agencies. Moreover, coordination with other road administrators has been promoted for smooth transitions to alternative transportation on expressways and general roads when a road closure occurs at a time of disaster.

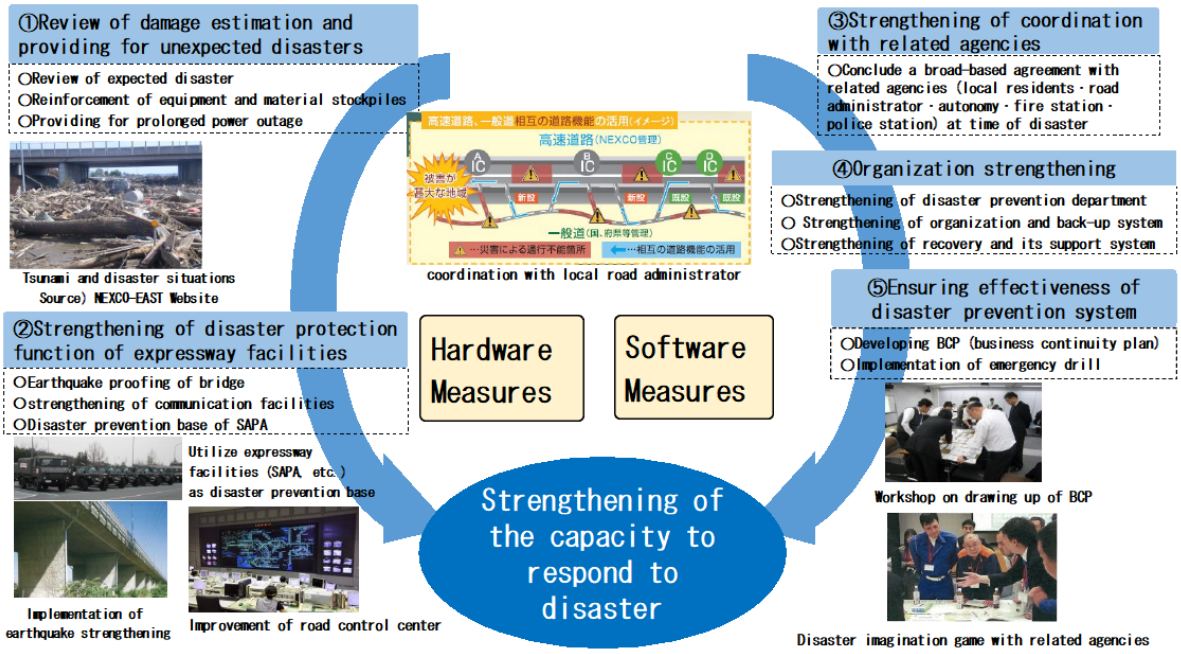


Figure 4.8 Measures taken for the strengthening of capacity to respond to disaster[18]

4.3.1.4 Training Center for Engineers

W-NEXCO has a training center for their employees and other company groups that focuses on the improvement of technology concerning expressways. Outside the building of the training center are allocated sample structures that were replaced due to aging, which are then utilized for the better understanding of deterioration processes and proper inspection practices. Inside the building of the training

[18] Source: West Japan Expressway Co., Ltd.

center are exhibited test-pieces and models related to expressway technologies, which are utilized for the understanding of the technology through direct observation from trainees during training sessions. At this training center, they can acquire a more reliable understanding of the technology compared to training with just mere lectures. Hammering inspection practices using actual structures, inspection practices using high resolution cameras (which is a new technology) and infrared cameras all can be conducted at this center. This contributes to the improvement of asset management techniques for roadways. External and internal conditions of the building, training status, and actual performance of training in the field of civil engineering in 2019, are shown in Figure 4.9, Figure 4.10, Figure4.11, Figure4.12and Table 4.3, respectively.

Figure 4.9 Status outside the building (Replaced bridge slab, etc.)[19]

Figure 4.10 Status outside the building (Replaced bridge members)[19]

[19] Source: West Japan Expressway Co., Ltd.

Figure4.11 Inside situation of building(Test piece and model)[20]

Figure4.12 Training Status[20]

[20] Source: West Japan Expressway Co., Ltd.

Table 4.3 List of training courses (Civil engineering only)[21]

employees	Classification	Name of training course	Number of days	Number of persons	total
Young employee (20s)	General studies	Maintenance planning training	2.5	36	90
		Construction project training	5.0	21	105
		Maintenance operation training	5.0	26	130
		Maintenance operation training	5.0	22	110
		Maintenance and inspection training	2.5	24	60
	specialized studies	Basic training Ⅰ (Bridge)	1.5	143	214.5
		Basic training Ⅰ (Earthwork・Pavement)	1.5	104	156
		Basic training Ⅰ (Tunnel・Greening)	1.5	86	129
		Basic training (Quality)	1.5	131	196.5
		Basic training Ⅱ (Bridge・Pavement)	1.5	28	42
		Basic training Ⅱ (Earthwork・TN・Environment・Landscaping)	1.5	26	39
Mid level employees (30s)	General studies	Project investigation training	2.5	21	52.5
		Technology Management technique training	2.0	14	28
		Green space-managing practical training	1.5	10	15
		Training for specific renewal project	1.5	19	28.5
	specialized studies	Specialty training (Bridge)	2.5	24	60
		Specialty training (Pavement)	2.5	20	50
		Specialty training(Earthwork)	2.5	24	60
		Specialty training (Tunnel)	2.5	17	42.5
		Specialty training (Landscaping)	2.5	10	25
Manager (40s～)	General studies	Inspection diagnostic training for the experienced	1.5	13	19.5
		Training for safety management (Intermediate level)	2.0	51	102
		Training for safety management (Upper level)	1.0	15	15
				885	1770

4.3.2 Honshu-Shikoku Bridge Expressway Company Limited.

Making the most of construction technology including suspension bridges and cable-stayed bridges, as characterized by the construction of Honshu-Shikoku Bridge, the Honshu-Shikoku Expressway Company Ltd. has provided technical assistance to the construction of many long-span bridges outside Japan. Also, with over 30 years of positive results in maintenance management of long-span bridges, the company also has advantageous and acute experience in the long-life inspection of long-span bridges.

There is little to no consideration for the maintenance management works of long-span bridges, including inspection and repair, in some developing countries. Because of this, the provided maintenance practices and techniques of long-span bridges is highly helpful. The cause of the collapse of the Myaung Mya Bridge in Myanmar was the corrosion of main suspension cables of the bridge (For your information, the new bridge replacement won the Tanaka Award from the Japan Society of Civil Engineers in 2019.). In particular, aspects that are considered to be especially useful are the anti-corrosion technologies for important parts of the long-span bridge and the development of both mobile inspection work vehicles and a main tower inspection robot that contribute to improvements in inspection efficiency and reliability.

4.3.3 West Nippon Expressway Engineering Shikoku Company Limited

West Nippon Expressway Engineering Shikoku Company Limited develops new techniques intended for the optimization of maintenance management of existing expressway facilities. Among them, the techniques considered to be especially helpful are shown in Figure4.13. Technical developments such as the use of high-resolution cameras and hi-vision cameras for the purpose of detecting cracks in concrete structures, and the use of infrared camera to detect floats and stripping of concrete structures by differences in temperature, have advanced with a goal to increase the efficiency of bridge inspections. These inspection techniques are utilized in actual inspection operations, which allows the inspection time to be reduced when compared to check just with unaided eyes, contributing to the inspection efficiency. Also, an inspection repair management system, which integrates with the conventional individual system, is currently under development. A unified centralization of data, such as basic information on road locations and bridge specifications, and information about quality, inspection and repair, will allow new inspections, the repair record, and past records to be referred with ease, contributing to operation efficiency.

Furthermore, a development of BMS (Bridge Management System) enables more accurate prediction of bridge deterioration using the analysis of past extensive, quantitative data on bridge inspections, making it

[21] Source: West Japan Expressway Co., Ltd.

possible for the planning of repair works to be drafted at an appropriate time when considering bridge life-cycle costs.

Among them, the infrared investigation total support system (J system) has the utilization results inside and outside Japan and is expected to contribute to the inspection efficiency of future concrete structures.

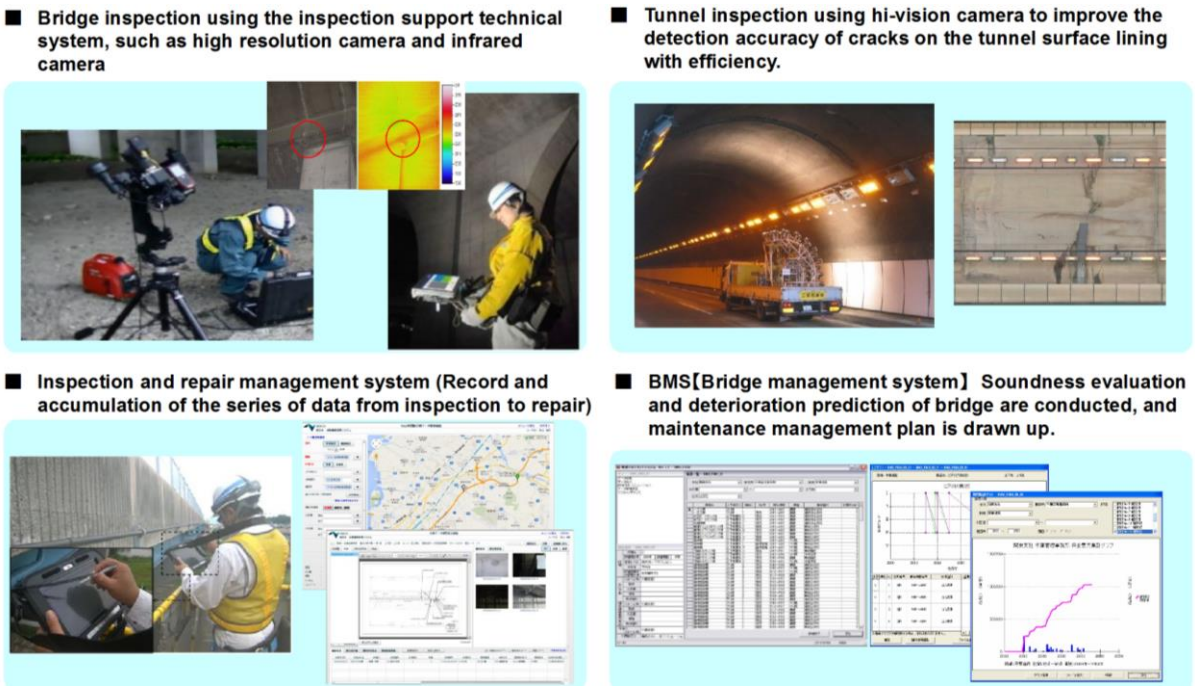


Figure4.13 Technical development for the efficiency of maintenance management[22]

4.4 Initiatives of National, Prefectural and Municipal Roads

4.4.1 MLIT

The MLIT positions 2013 as the first year of social capital maintenance, and the facility managers of various infrastructures including the national government will work together to strategically perform maintenance and renewal.

Specifically, outlines show current efforts in the following: (1) legislation of inspection standards for national roads, prefectural roads, and municipal roads, (2) formulation of "the initiative for improving service life of infrastructure," (3) human support such as financial support and training through disaster prevention and safety grants, (4) improvement of bidding contract system and individual facilities. The standards and manuals of these are being reviewed.

In the future, it will be important to establish management that continuously carries out infrastructure maintenance. Including mid- to long-term budgeting based on preventive maintenance, utilization of new technologies that will lead to labor-saving efficiency, updates to databases, continued human resource development and information sharing with infrastructure beneficiaries.

4.4.1.1 Status of the First Round of Inspections

In response to the "Bridge Regular Inspection Procedures" and "Road Tunnel Regular Inspection Procedures" formulated in 2014, an inspection cycle will be implemented once every five years, and the second cycle will be implemented from 2019.

[22] Source: West Japan Expressway Co., Ltd.

In the annual Road Maintenance Report published since 2015, the results of the first inspection from 2014 to 2018 of bridges, tunnels, road attachments are compiled. Pavements, small-scale attachments, and earthwork structures inspections are compiled in the results for inspections from 2017 to 2018.There are about 730,000 bridges in Japan, but about 70% are bridges managed by local governments, many of which are post-maintenance type repairs, so preventive maintenance type repairs have not been progressing.

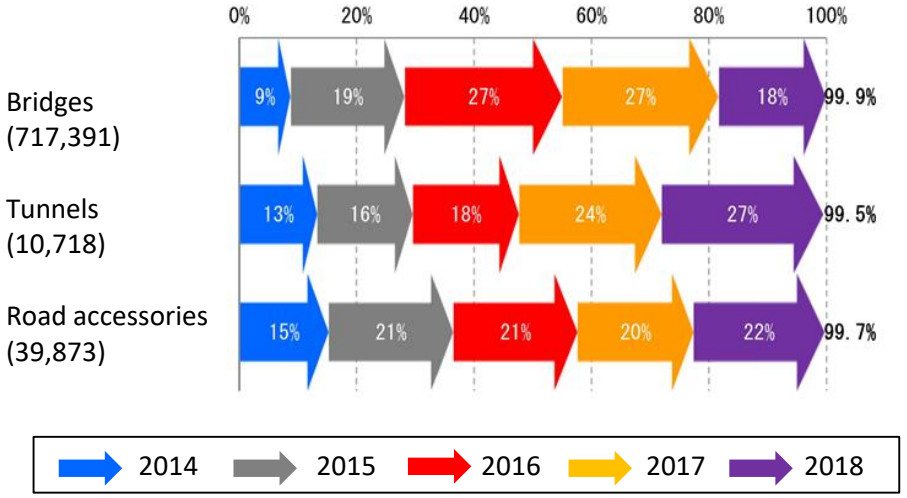
Figure4.14 shows the inspection status of bridges, tunnels, road accessories, etc., Figure4.15 shows the status of repairs and measures for bridges, tunnels, road accessories, etc., and Figure4.16 shows the inspection status of pavements.

2. Implementation staus of the first round inspection from 2014 to 2018

(1) Bridges, Tunnnels, Road accessories
1) All Road administrators

○ 5-year inspection since 2014 (the first round) has been almost compleated (for 99.9% of bridges, 99.5% of tunnnels and 99.7% of road accesspries).
○ Ratio of soundness levels Bridges: I-41%, II -49%, III-10%, IV-0.1%, Tunnels: I-2%, II-56%, III-41%, IV-1%, Road Accessories: I-32%, II-53%, III-15%, IV-0.1%

○Impementation status of the first round inspecton from 2014 to 2018



	Number of Facilities	Number of inspection targets	Number of inspections	Inspection rate
Bridges	722,942	717,391	716,557	99.9%
Tunnels	11,215	10,718	10,662	99.5%
Road accessories	41,149	39,873	39,750	99.7%

Figure4.14 Inspection status of bridges, tunnels, road accessories, etc.[23]

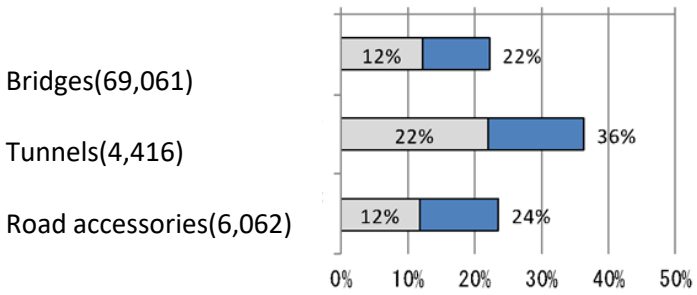
[23] National Highway Bureau for Land, Infrastructure, Transport and Tourism: Annual Report of Road Maintenance, August 2019

3. Status of repair measures

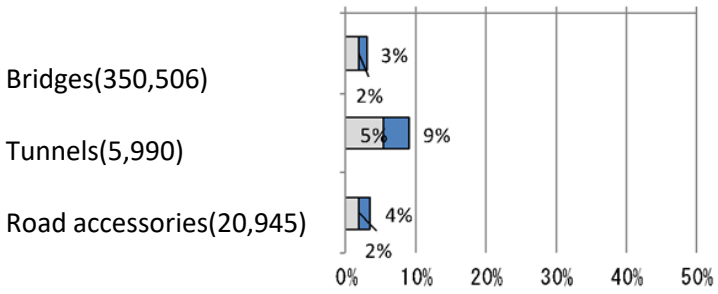
(1) Status of facilities for which repair measures have been commenced to the facilities rated soundness levels II, III, IV

○ For the steady implementation of the second stage of maintenance, the status of implementation of Corrective maintenance type repairs (soundness levels III and IV) and preventive maintenance type repairs (soundness levels II) was organized.
⇒Compared to post-conservation type repairs, preventive maintenance type repairs have not progressed yet.

Corrective maintenace (repair measures for bridges with soundness levels III and IV)
(2014 to 2018)



Preventive maintenance (repair measures for bridges with soundness levels II)
(2014 to 2018)



Ratio for repair measures have been commenced
Ratio for repair measures have been completed

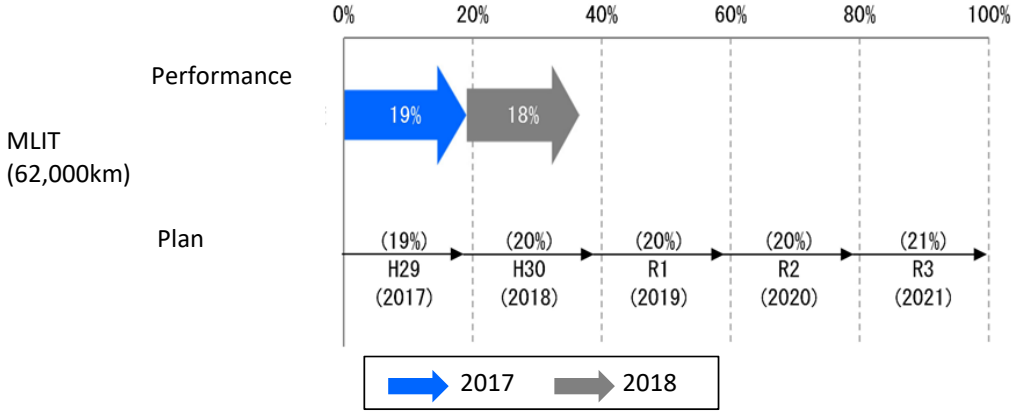
Figure4.15 Status of repairs and measures for bridges, tunnels, road accessories, etc.[24]

[24] National Highway Bureau for Land, Infrastructure, Transport and Tourism: Annual Report of Road Maintenance, August 2019

2） Inspection Results

○ The rate of regular pavement inspections on roads managed by the MLIT is steadily progressing to 37% as planned.
○ Ratio of soundness levels AS pavements: I-48%, II -38%, III-1-13%,III-2-2%, CO pavements: I-60%, II-32%, III-8%

○Five-year inspection plan and inspection implementation rate



○Ratio of soundness levels

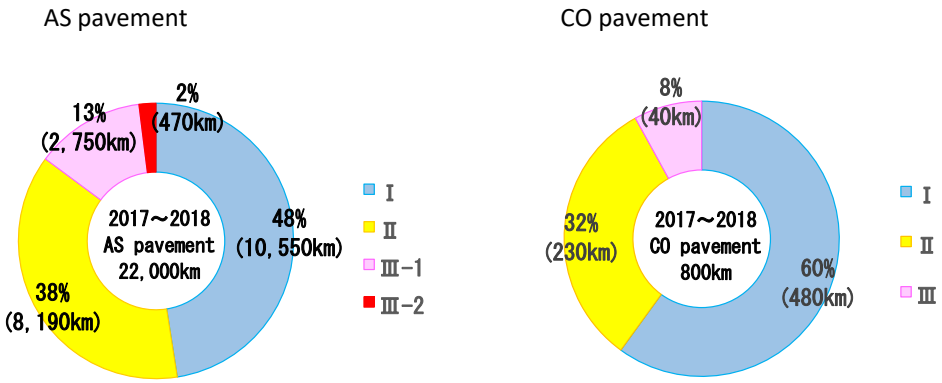


Figure4.16 Inspection status of pavement[25]

[25] National Highway Bureau for Land, Infrastructure, Transport and Tourism: Annual Report of Road Maintenance, August 2019

4.4.1.2 Road Maintenance Meeting

In response to the proposal of the Road Subcommittee of the Social Infrastructure Development Council in 2014, "Proposals for full-scale implementation of measures against aging roads," each prefecture has a "road maintenance meeting" with national, prefectural, municipal, and highway companies as participating members.

4.4.1.3 Activities of the National Council for Infrastructure Maintenance

In 2016, the "Infrastructure Maintenance National Conference" was established as a platform for industry-academia-government-private collaboration to improve the efficiency and sophistication of maintenance. Discussions are deepened by exchanging information about each concern and issue through various official forums.
The role and vision of the National Council is shown in Figure 4.17.

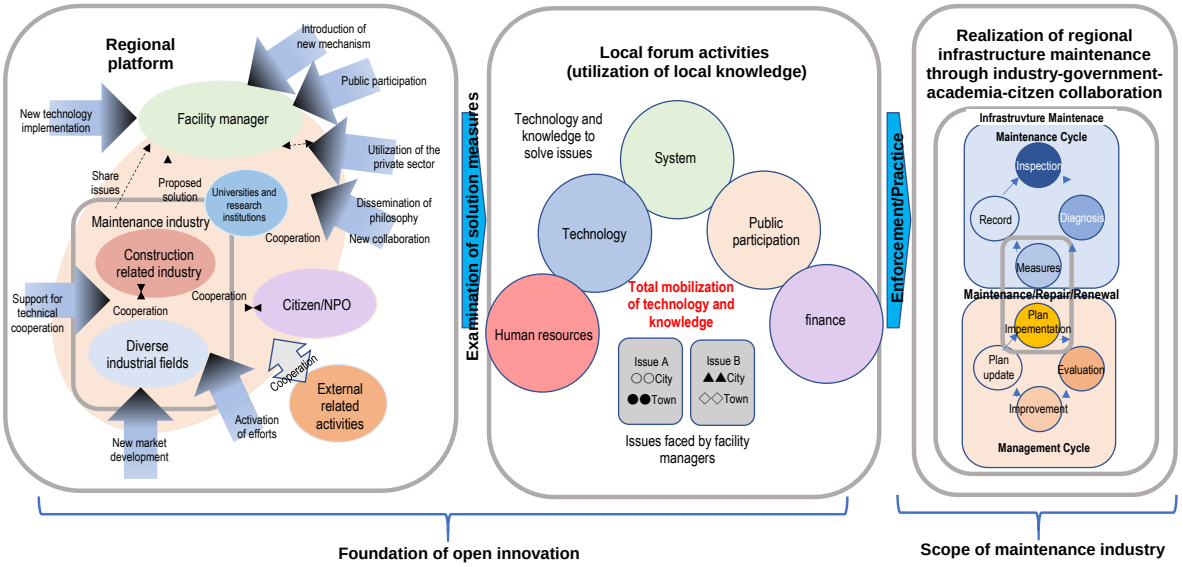


Figure 4.17 Role and vision of the National Assembly[26]

4.4.1.4 Kanto Regional Maintenance Center/Kanto Regional Development Bureau/MLIT

This office has been newly established this year as the 52nd office of the Kanto Regional Development Bureau. Major activities include (1) promotion of strategic and efficient maintenance, (2) sophistication of road maintenance, and (3) implementation of various consultation services and training.

As a result of this year's consultation, there are 6 cases from the National Road Office and 8 cases from the local government. It is the actual situation that maintenance staff are flagged by the chief of the national road office. However, the follow-up is limited to bridges with a special structure.

Other activities include technical support for local governments and technical training for inspections. The maintenance center is also planning to introduce new technologies such as drones and AI technology.

The reason why inspections have progressed over the past five years is through road maintenance meetings in each prefecture. The number of facility inspections has increased rapidly because of activities such as supporting local governments by ordering inspections collectively and coordinating with railway companies for overpass inspections.

[26] National Council for Infrastructure Maintenance: Business Plan. August 2019

4.4.1.5 Omiya National Road Office/ Kanto Regional Development Bureau/ MLIT

Although the road maintenance meeting itself has not been able to pick up detailed needs, it is characterized by the establishment of a working group of local governments who are active in maintenance activity. The meeting itself is not a place to decide the priority of repair and reinforcement, but a place to share technical information and training information.

The purpose of the Working Group, which forms part of the activities, is to share good practices through the activities with other local governments. With the revision of the bridge inspection procedure, it is important to establish a system that can immediately incorporate new technologies such as drones.

Regarding collaboration with academic knowledge, there is a study group called Saitama Prefecture Bridge Maintenance Study Group at Saitama University, and they are collaborating and requesting lecturers.

As a characteristic of Saitama prefecture, there are 63 local governments, and the number of local governments is large compared to other prefectures in Kanto. Five years have passed since bridge inspection guidelines were issued, and after further revision, the local government is aware of the issues of budget shortage, engineer shortage, and how to improve efficiency.

Initiatives that can be expanded to developing countries include holding seminars and study sessions on basic knowledge and new technologies related to bridges.

In addition, the National Highway Office serves as the consultation point for maintenance and management, while the Conservation Measures Officer serves as another consultation point, but there are few direct consultations with the National Highway Office. Basically, it is assumed that municipalities are consulting with the prefectural soil maintenance office instead.

Depending on the degree of urgency and priority, a system has also been implemented in which alternative diagnosis is made by national institutions and the state acts on behalf of the municipalities.

4.4.2 Local Governments

4.4.2.1 Toyama City

Toyama City has appointed a person who has practical experience as a bridge maker and a design consultant acts as technical supervisor and carries out unique efforts such as human resource development and an evaluation system for repair technology.

A training called “Ueno Juku” is conducted for Toyama City staff to pass on technology and develop human resources. Currently, in the 6th year, it has been held over 50 times with a frequency of about once a month. In the early stages, the curriculum was specialized in the maintenance of structures, but recently, it has been reviewed as a lecture on the knowledge of engineers, contract systems including rigging prevention, and new technology utilization from the viewpoint of training in-house engineers. In addition, the curriculum is positively incorporated into site and factory tours for young employees.

4.4.2.2 Kimitsu City

Kimitsu City, Chiba Prefecture, is conducting a trial in collaboration with private companies called “the Kimitsu Model” to introduce inspection technology using a drone operated by the city officers themselves. Kimitsu City aims to not overlook the Soundness III of bridge structuring by introducing “drone inspection and AI technology” and inspections have been completed on 4 of the 20 bridges tested. In addition, when a typhoon disaster occurred this year, because of an emergency inspection by drones of concrete-sprayed surfaces, the effectiveness of the inspection was verified by being able to confirm fallen trees and damage in the hinterland.

4.5 Trends in R&D Related to Technology and Systems at Research Institutions

4.5.1 Public Works Research Institute

The Center for Advance Engineering Structural Assessment and Research (CAESAR) is a research institute under the MLIT Road Bureau.

The main activities of the institute are consultation from the regional development bureau, clinical research using actual bridges, and research related to revision of design standards.
There are about 30 researchers, and they are in charge in the bridge field related to earthquakes and maintenance.

Since it is a national research institute, the principle of research is in fields and areas that do not put pressure on the private sector, so its main activity is to perform technology evaluation.
As a possibility for the future, a scheme for advancing AI inspection/diagnosis and transmitting know-how can be considered as a position for technical consultation.

Recent topics include technology using neutrons and technology for exploring sedimentation of floorboards with electromagnetic radars. If we can support the research fund in collaboration with JICA, it is considered that the range of activities will be further expanded.

4.6 Trends in Development of Repair Technology and Life Extension Technology that can be Implemented Overseas by Private Companies

From the new technology described in the "Inspection support technology performance catalog (draft) as of February 2019" published by the MLIT, 1) Image measurement technology and 2) Non-destructive inspection technology will be summarized in a technical overview.

The inspection support technology list is shown in Table 4.4, and details are shown in the individual survey table of the reference material.

Table 4.4 Inspection support technology list[27]

Technology Classification	Technology Name	Developer
Bridges Image measurement 1	Structure inspection robot system "SPIDER"	Luce Search Co Ltd CTI Engineering Co Ltd
Bridges Image measurement 2	Close-up visual inspection support technology using non-GPS environment-friendly drone	Sanshin Construction Materials Co Ltd Autonomous Control System Laboratory Ltd
Bridges Image measurement 3	Close-up photography by multi-copter and two-dimensional measurement of abnormal places	Musokagaku Ltd
Bridges Image measurement 4	Bridge inspection system using multi-copter	Kawada Technologies Inc Nippon Engineering Consultants Co Ltd
Bridges Image measurement 5	Assistance/complementary technology for close-range visual inspection and tapping sound survey by "Looking and examining bridge inspection camera system"	Zivil investigation design Ltd INTES University of Fukui
Bridges Image measurement 6	Robot inspection camera for bridge structures	Sumitomo Mitsui Construction Co Ltd Hitachi Industry & Control Solutions Ltd
Bridges Image measurement 7	A simple device for supporting visual proximity of the underside of a bridge	Tohoku Institute of Technology O・T・Techno Research Co Ltd
Bridges Non-destructive inspection 1	Pole hammering inspection machine	NEC Corporation Highway Technology Research Center

[27] Inspection support technology Performance catalog (draft). February 2019

Technology Classification	Technology Name	Developer
Bridges Non-destructive inspection 2	Bridge inspection support robot	Zivil investigation design Ltd. INTES University of Fukui
Bridges Non-destructive inspection 3	Flight robot inspection system using close-up visual inspection, tapping inspection, etc.	Shin-Nippon Nondestructive Inspection Co Ltd Nagoya University Kyushu Institute of Technology National Institute of Technology, Kitakyushu College Fukuoka Industrial Technology Center
Bridges Non-destructive inspection 4	System for the detection of deformation in concrete structure parts "BLUE DOCTOR"	ONGA Engineering Co Ltd

4.7 Initiatives on Establishment of Road AM in Local Governments and Universities

4.7.1 Hokuriku SIP Team "Kanazawa University, Kanazawa Institute of Technology, University of Fukui"

The Hokuriku SIP team shares problems unique to the Hokuriku region (salt scattering, alkali silica problems) and their solutions in collaboration with Kanazawa University, the Kanazawa Institute of Technology, and the University of Fukui.

The team is working on the following manuals and human resource development.

1) Creation of Hokuriku edition manuals and guidelines.

2) Elucidation of complex deterioration mechanism of RC structure and its countermeasures.

3) Interview surveys with local governments.

4) Accumulation of repair methods data suitable for municipalities.

5) Technology exhibition for municipal staff and local consultants.

6) Effective use of maintenance guidance for municipalities.

4.7.2 University of the Ryukyus

The University of the Ryukyus has established a scheme to collaborate with local companies on the investigation part such as photoimaging, as well as the combination of university and major general contractors for UAV and crack image diagnosis. Currently, local companies are aiming to transfer technology to the Okinawa area as a prime contractor or consulting subcontractor. In addition, a steel structure anticorrosion manual, which is a unique issue for this region, is being developed in cooperation with the national government and prefectures.

A characteristic of Okinawa, which is surrounded by the sea, is the corrosion of bolts and edges of steel structures. Therefore, for bolts, we are developing a transparent bolt cap (with less adhesive and easy maintenance), and we are developing a technology called cold spray method for spraying metal powder at ultra-high pressure. The university does not participate in road maintenance conferences in Okinawa Prefecture, but the National Council for Infrastructure Maintenance, Bridge Conservation Meister, and Bridge Inspector System cooperate with MLIT.

Chap. 5 Introducing Road AM in Developing Countries by Foreign Donors

5.1 Target of the Chapter

As for Road AM, donors including WB and ADB are offering various types of support. Unlike road construction, the achievements of Road AM are hard to recognize due to the invisibility of its progress. Results do not take root immediately, so a long-time duration and considerable effort are required for before results can be seen. Areas to be covered by the Road AM have are broad, and one country can support only a small part of the whole.

Because of that, when Japan supports Road AM in developing countries, it is desirable to make a support plan after collecting information about other donors' efforts. In this report, activities of WB, which has been taking a lead role in supporting Road AM, were studied. Regarding the other donor, ADB's activities were also summarized in the report. ADB has continued to offer support in Asian countries in cooperation with WB.

Though we consulted written documents by WB and ADB, which are publicly available on the web, we could not find any literature that describes the support activities of introducing Road AM to developing countries in a comprehensive manner. Therefore, we extracted the essential information from various reports and cases and decided to ascertain an overview of the support policy for the efforts as well as the way of thinking of WB and ADB.

We not only studied the reports which were made by the head offices of donors but also, we studied the actual support activities in the several developing countries to confirm the recent policies of WB and ADB. Considering that this report is a web-based document, it is necessary to separately pay attention in hearing sessions to confirm the latest policies of WB and ADB.

5.2 Overview

WB and ADB have shifted support from new road construction into existing road maintenance and improvement. They put emphasis on the following three areas for Road AM, (1) Optimization of Road maintenance and improvement plan by introducing maintenance management system, (2) Securing financing by establishing road funds, and (3) Outsourcing of maintenance activities by performance-based contracts (hereinafter PBC). Recently, disaster prevention and recovery methods also have started being taken into consideration in the road AM.

Concerning (1) mentioned above, HDM-4 which is a road maintenance management system developed by WB assistance, has been introduced in many countries and has been utilized for the optimization of road maintenance plans. However, since the system is too complicated for developing countries to fully utilize, simple and easy systems are expected to be introduced. As for (2), many road funds were created in a lot of countries especially African nations with the support of WB, that made it possible for them to secure financial resources. Regarding (3), routine maintenance by PBC has been introduced in many nations and its coverage has been expanding.

Areas to be covered by the Road AM are broad in range and require long time duration support. Therefore, when Japan supports Road AM, understanding the activities of WB and ADB and cooperating with them is necessary.

5.3 Introducing Road AM in the Developing Countries by WB

5.3.1 Background of Road AM

"Road Deterioration in Developing Countries- Cause and Remedies"[28] (hereinafter RDDC), the report of WB published in 1988, changed the strategy of WB road sectors. Strategy of WB shifted from the conventional new road construction to road maintenance and improvement works.

According to RDDC, the loss of asset values caused by road damage amounted to over several billion dollars, and they said that a further loss of assets equating to several billion dollars would be seen unless they immediately took steps to counteract this. It is reported that restoring a road that is already damaged

[28] WB: Road Deterioration in Developing Countries – Cause and Remedies. 1988

costs 3 to 5 times more than if it were properly maintained. Also, the cost of fuel of vehicles as well as the cost of maintenance for vehicles will also increase, which would become an obstacle for economic growth. Because of these reasons, the following principles were proposed in the RDDC report to efficiently proceed with road maintenance management of developing countries.

1) Develop a plan for new road construction and existing road maintenance with consideration to life cycle costs and costs to road users.

2) Create a new mechanism in such a way that financial resources will be appropriately secured to do necessary road maintenance activities.

3) Separate the implementing organization of road maintenance and road planning. Road maintenance works should be outsourced to the private contractors.

4) Provide standards for evaluating road quality to fulfill and maintain accountability; government should regularly monitor them.

It was necessary to stop the increasing damage of existing roads by taking the steps mentioned above. How issues in the RDDC report had been addressed in the subsequent 20 years were summarized in "Maintaining Road Assets"[29] (hereinafter MRA) report in 2011. The following points were raised in MRA. Concerning the problems mentioned in RDDC report, they had been dealt with. Furthermore, the problems pointed out in RDDC had not yet been resolved and there seemed to be no modifications to the strategies in Road AM.

1) The cost to road users as well as lifecycle costs of roads came to be considered by the HDM4 model that was developed by WB support. However, proper monitoring of road conditions is necessary.

2) Concerning financial resources, road maintenance funds were created in many nations, and it became possible to secure the budget independently from the general finances.

3) Outsourcing of routine maintenance has been implemented in many nations, and road maintenance by force accounts has decreased. In addition, PBC which incorporates indicators of performance evaluation for fulfilling accountability, were introduced widely

Considering the 1998 RDDC report, and the 2011 MRA report, the response to climate change is mentioned below, and in regards to the assistance rendered to Laos and Cambodia by WB, the following were the support policies of WB and these were not changed from the proposal of RDDC, but (D) Climate change had been added due to recent world trends.

(A) Development of maintenance plans optimized by the road maintenance management system

(B) Securing stable finance resources for road maintenance

(C) Promotion of outsourcing of routine maintenance by introducing performance-based maintenance contracts

(D) Response to climate change into the Road AM

5.3.2 Optimization of Road Maintenance Plan by Introducing Road Maintenance Management System

The following sections are from reports of WB regarding each of the above-mentioned items (a) thru (d).

5.3.2.1 About HDM4[30]

Modeling of expenses for road maintenance dates in Highway Cost Model (hereinafter HCM) prepared by MIT with funds from WB in 1968. After that, an improvement was made based on research in each field;

[29] WB: Maintaining Road Assets. 2011
[30] PIARC: HDM-4 Volumes 1 – Overview of HDM-4

HDM-2 was developed in 1979 and HDM-3 was developed in 1987, respectively.

Considering the use of this system in developed nations , HDM-4 was developed in 2000, using the funds provided from WB, ADB, Department for International Development of Britain (hereinafter DFID), and SNRA (Swedish National Road Administration) , along with the technical support from the Bureau of Finland, an American federation cement manufacturer, the University of Birmingham, the Research road institute in Malaysia, and the British Transportation Research Institute. HDM-4 has been used in over 100 nations including developed countries, and the improved version of HDM-4 Version 2.0 was also developed in 2005. Equipped with the function to predict road damage, HDM-4 can carry out analytical works in consideration of life cycle cost and road user cost. It has three functions: Project Analysis, Program Analysis and Strategic Analysis.

1） Project analysis

This function carries out economic analysis, evaluating various alternative proposals in new road construction, expansion, and maintenance activities for certain sections by calculating life cycle costs and the effects of repair work and costs to road users. The benefits of a long-term project period of about 40 years can be calculated in a form that includes user costs, this way it becomes clear when, where, and what kind of maintenance and repair should be performed.

2） Program analysis

Program Analysis analyzes which repair work should be implemented for obtaining effective results on road networks. If a certain budget is allocated within a certain fiscal year, it becomes clear which project should be prioritized. The project analysis section mentioned above focuses on certain road sections. However, program analysis can calculate what part of a network should carry out the most suitable project for organizations to maximize the benefit of said project.

3） Strategic analysis

Strategic Analysis is used for developing the medium and long-term planning of the whole network. This analysis can be used for the calculating the budget necessary for maintaining a certain service level road network. Road authorities can understand to what extent the service level of a whole road network should be when considering budget constraints. This is used for road institutions to develop future for whole networks.

5.3.2.2 Prediction of Pavement Deterioration by HDM-4

One of the characteristics of HDM-4 is that it is incorporated into the prediction system of pavement deterioration. Damage items such as 1) Cracks, 2) Roughness, 3) Potholes, 4) Rutting, 5) Rebelling, 6) Damage of pavement edges, are incorporated into this model. The mechanisms of each damage type ultimately lead to roughness as shown in

Figure 5.1. Roughness is considered a representative indicator of road damage.

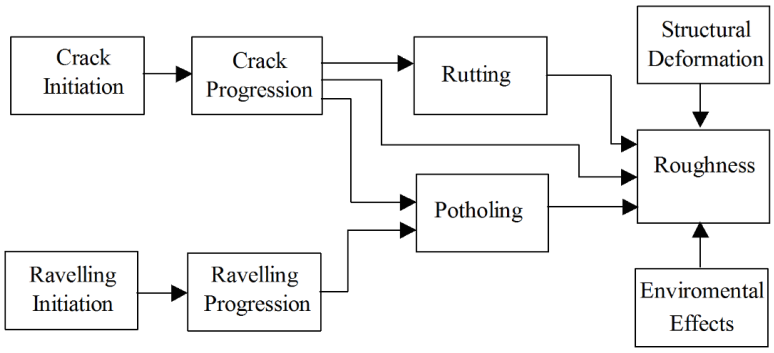


Figure 5.1 Association of various indicators of asphalt pavement[31]

[31] Washington State Transportation Center: Application of HDM-4 in the WSDOT highway system.2003

To estimate repair plans by damage prediction, it becomes necessary to set parameters in the pavement deterioration model. Various data points including the current damage status, costs of repair work, traffic volume, road structures, meteorological data, costs of vehicles and so on, should be gathered and input into the HDM-4 model. Therefore, it can be said that using all the functions of HDM-4 is very labor-intensive.

5.3.2.3 Gathering Road Condition Data for the System[32]

It is necessary to monitor road conditions regularly to confirm if predefined service level is being maintained or not. Accurate data gathering at a suitable frequency is a key factor to the success of operating a road maintenance management system. It is important to consider what the necessary data is, and what specific level of data is appropriate for use. Because the work of data gathering is time-consuming and labor-intensive, only minimal data should be gathered for the analysis.[33]

Even in the past cases that were supported by the WB, all countries that successfully operated the road maintenance system had clear data collection policies and procedures and established an organization to carry them out. In the case of a failure to gather data, the gathering itself was not the issue, but rather the organization of the said gathered data.

Data classification of road conditions summarized by the WB, is shown in Figure 5.2. Lower level data (IQL-1, 2) often refers to raw data used for design and calculation, and when it comes to pavement, the actual measurement value of a laser profile meter is imaged. Mid-level data (IQL-3) is a ride quality index that is shown in IRI, for example. Upper level data (IQL-4, 5) is an index of Good/Poor/Bad and so on, to be used for the planning of road maintenance projects and to provide explanation to the public about the road conditions.

Upper level data (IQL-4, 5) is made by converting data from the medium and lower levels (IQL-1, 2, 3).

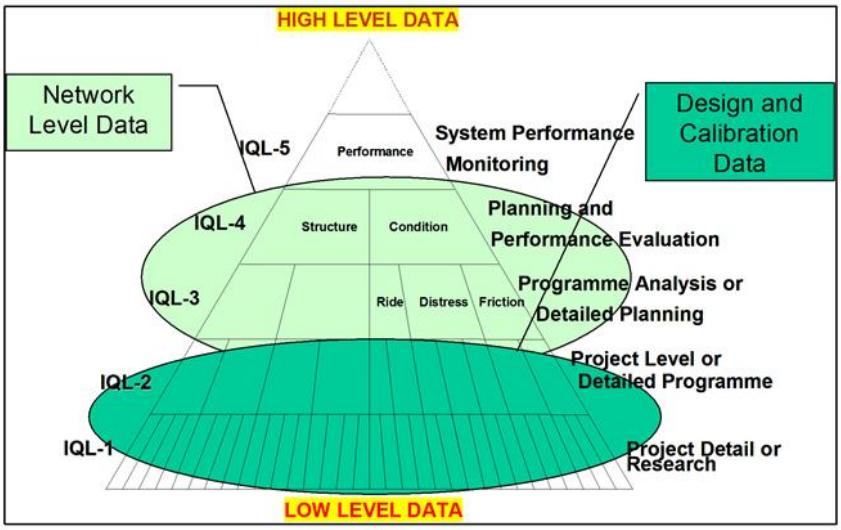


Figure 5.2 Level of road condition data[34]

The possibility of continuous data gathering is largely affected by the data collection frequencies. Since the collection of data is expensive, time-consuming, and labor-intensive, it is important to gather minimal amounts data at a reasonable frequency.

[32] WB: Data collection technologies for pavement management system. 2008
[33] WB: Success factors for road management systems. 2005
[34] WB: Data collection technologies for pavement management systems. 2008

5.3.3 Securing Financial Resources[35]

Heggie and Vickers proposed a concept of road funding in the 1998 WB report [64] to secure financial resources to be allocated for the road maintenance. Instead of entrusting financing and operation of roads to government organizations, they insisted that a market mechanism should be introduced so that the opinions of road users could be reflected. Considering road maintenance as a business, they believe that those who receive services should bear the expenses, as can be seen in utilities business such as electric power and water service.

Board members elected from both the government and the private sector will decide the future maintenance management levels as well as necessary budget plans for ensuring those maintenance management levels. If there is a lack of funding, they will address the situation by adjusting the tax rate of gasoline and vehicle registration fees, but these will be separated from the general finance resources. Necessary funds are to be borne by road users without diversion from general finances. The management of procured funds are to be conducted by the road fund. In principle, road fund budgets are allocated to maintenance work only. For diverting funds to construction, it is to be implemented only when the maintenance work budget has been satisfied or if an upper limit of fund diversion into the construction budget was set in advance.

Road maintenance funds were created in many nations. Especially in Sub -Saharan region of Africa. Road funds were created in 26 countries and 60% of the whole Sub -Saharan region as of 2006. The funding sources for these funds are still vulnerable, but it is considered that the existence of road funds is suppressing the budget fluctuation. Although there are many nations whose funds are highly shifted to road construction in developing countries, there are some nations where maintenance budgets are secured at the same level as construction. Among the nations with established road funds, those having a high percentage of fuel tax have been able to cover the necessary maintenance budgets.

5.3.4 Outsourcing of Maintenance Works by Performance-based Contracts

5.3.4.1 Introduction of Performance-based Contracts[36]

Based on the idea that "Better asset management is an indispensable goal of road networks that WB invests in," WB has been introducing PBC considering the effect to be obvious (but not the only method). PBC improves transparency and work efficiency and is expected to reduce the long-term operating costs of projects.

The Argentine Concession of rehabilitation and maintenance (hereinafter CREMA) method, which was introduced in 1997 with the support of WB, packaged road improvement and daily maintenance for 5 years. After initial improvement work was completed, they conducted routine maintenance for five years. Routine maintenance contracts had mainly been issued on a yearly basis before, and often budgets cuts were made depending on the financial conditions for the year. After introducing CREMA, the budget for routine maintenance became stable and the unit cost of improvement work and routine maintenance from 2004 to 2006 decreased by 5% from the 1997's baseline. CREMA contracts accounted for 90% of the 19,000 km of national roads in Argentina for the 2011 year.

The introduction of the performance regulation system was also effective in reducing the burden on government organizations. Since the private sector would carry out the work from improvement to maintenance, the number of employees in the Argentine National Highway would be reduced to one-third as compared to before the implementation of CREMA. This made it possible for the government to focus on strategic planning, budget management, and supervising contracts. For strategic planning, tools such as HDM-4 were adopted for optimization and efficiency.

5.3.4.2 Overview of Performance-based Method

Contracts for road maintenance consist of mainly three types as shown below. The Hybrid type (3) which includes both of specification contracts and performance-based contracts has been widely used in many

[35] WB: Maintaining Road Assets. 2011
[36] WB: Maintaining Road Assets. 2011

nations[37].

1) Conventional specification method contract (Client specifies the work method and pay is calculated by unit price times implemented quantities.)

2) Performance based contract (Client specifies service levels, and rewards are paid by the degree and satisfaction of service)

3) Hybrid of specification and performance-based contracts (combines the above items 1. and 2)

The hybrid type incorporates improvement work and emergency work as specifications, and routine maintenance as performance specifications into a project. The above-mentioned CREMA method is a typical example. Routine maintenance begins only after roads are made maintenance-ready by improvement work. The maintenance period is typically 3 to 5 years, the longest being about 10 years.

Unlike the conventional specification methods, PBC specifies what level the roads need to be maintained, instead of what maintenance activities should be implemented.

In the case of specification methods, clients designate maintenance methods and work frequencies. On the other hand, regarding PBC, contractors determine work methods and frequencies by themselves. The amount of effort required to ensure the prescribed quality can be determined at the discretion of the contractor. In turn, overall economic efficiency can be pursued in a PBC.

To popularize and operate PBC appropriately, WB has been developing samples of tender documents including the Performance-based Management and Maintenance of Roads (2002), and the Output- and Performance-based Road Contracts (2006). WB pointed out that the merits of PBC are as follow.

1) Government and road agency staff are freed from daily road maintenance work and can concentrate on network-wide management and strategic planning.

2) Maintaining the service levels of road networks can be done so in a unified manner.

3) Long-term maintenance costs can be reduced.

In PBC, the client assesses whether the work of the contractor satisfies the prescribed performance. For this, a bucket method mentioned below is an effective way to evaluate unachieved performance. It is not realistic for there to be constant performance satisfaction for the whole period of a contract. And even if there are deficiencies in performance, it would be impossible to achieve the repair work all at once. Therefore, penalties are given to contractors when they exceed a certain level of non-compliance in performance.

Performance evaluation items are specified in the contract and include the conditions of pavement, traffic markings, road shoulders, traffic signs, guard rails, road safety facilities and so on. Items not satisfying performance levels should be regarded as Non-Conformance (hereinafter NC). Items which are important to road users or long periods of continuous NC should be weighted heavily in evaluations.

A penalty concept is shown in Figure 5.3 A large NC indicates an item of high importance or an item with a long period of non-compliance. The water in the bucket is the compensation paid to the contractor, and the more NC items are accumulated, the less compensation is paid as demonstrated by the overflowing water at certain stages. However, the unachieved amount in the bucket can be cleared after a certain period (monthly or quarterly).

[37] Guide to performance-based road maintenance contracts. 2018

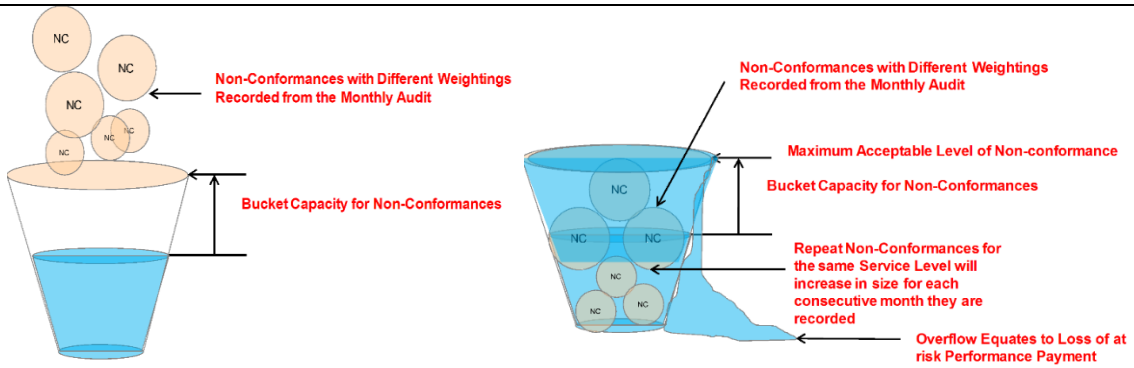


Figure 5.3 Relationship between amount of non- conformances and decrease of compensation[38]

5.3.5 Response to Climate Change

With the recent increase in global warming and disasters that bring about climate change, WB and ADB have come to incorporate measures to cope with these issues. In this section, WB's report of "Integrating Climate Change into Road AM", shall be summarized. ADB also published a "Guideline for Climate Proofing Investment in the Transport Sector" in 2011 which describes how climate change should be considered in project planning.

5.3.5.1 Impacts of Climate Change

Although the exact cause of climate change has not been identified, the rise in temperature and the occurrence of floods are increasing year by year. Developing countries located in areas such as Africa, Asia, and South America are the most affected by climate change, and WB and ADB are making efforts to tackle climate change in these developing countries.

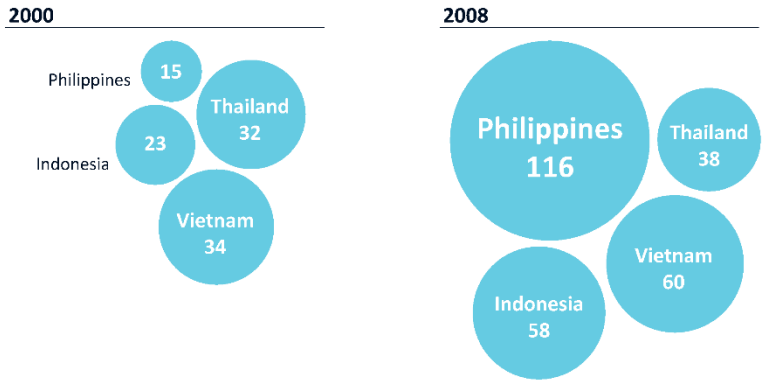


Figure 5.4 Comparison of the number of flood occurrences in 2000 and 2008[39]

As shown in Figure 5.4, the number of occurrences of flood in developing countries has been increasing. Also, in addition to floods, tropical cyclones and drought have also been increasing as is shown in Figure 5.5.

[38] WB: A guide to delivering good asset management in road sector through performance-based contracting. 2014

[39] Integrating climate change into road asset management. 2017

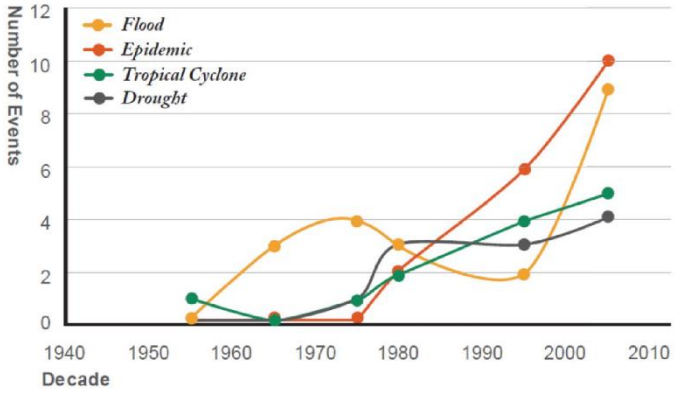


Figure 5.5 Change occurrence of disasters in Mozambique[40]

Considering the impact on roads, climate change has been roughly classified into the following two types:

1) Long-term climate change

Things that fluctuate over a relatively long period of time, such as rising temperatures and increased rainfall. As these fluctuations have a long-term impact on the road, it is necessary to consider how to deal with them.

2) Short-term climate change

Things that occur in a short period of time, such as floods and typhoons. Since these destroy roads, it is necessary to consider countermeasures in the event of a disaster and recovery methods from disasters, along with precautionary measures.

5.3.5.2 Impact on Roads from Climate Change and Response by Road AM

When considering climate change, it is necessary to revise conventional ways of thinking, such as setting the appropriate service levels. Also, it is necessary to revise road structure design and maintenance methods when considering abnormal rainfall and the deterioration of strength of the natural ground.

Although few institutions are largely adopting climate change response, if the response to climate change is not taken into consideration, the likely damage in the event of a disaster will be extensive. This will be most evident in developing countries where foreign assistance is still needed. Therefore, it is necessary to prepare and study the above countermeasures in advance to mitigate its impact at the time of a disaster, and to carry out the disaster recovery process efficiently.

5.4 Introducing Road AM in Developing Countries by ADB

5.4.1 Introducing Road AM in Asian Countries by ADB

According to the report" Road Funds and Road Maintenance (RFRM)" published by ADB in 2003, the conditions of roads in developing countries are poor, and the main cause of these poor conditions is said to be insufficient maintenance budget allocation. The report explains the importance of securing funds by establishing road funds for road maintenance and repairing damaged parts in a planned manner so as not to pass the bill on to future generations.

As for Road Management System (RMS), it was pointed out that there were many cases where data was not updated with enough frequency, and persons in charge of RMS often moved to other departments. This caused the RMS to be no longer in use. They proposed to temporally give up using such a complicated system for making maintenance plans and rather use a simple model like an Excel spreadsheet. The

[40] WB: Integrating climate change into road asset management. 2017

introduction of RMS should be done carefully while making sure to consider the levels of understanding of Road AM by the road authorities of each nation. User satisfaction is the most important factor when introducing RMS to organizations. In developing countries, they sometimes did not have a culture of road maintenance. Occasionally, politics was given priority over decision making, so they would point out that HDM-4 seemed too difficult to be used as a decision-making tool.

In the road maintenance reports from 22 countries of ADB member nations, several issues were presented. The largest issue being the shortage of funds. The second one being improper maintenance procedures. RMS is often cited as a large issue in many nations, which shows that there are many nations struggling in the operation of this system. Furthermore, measures against overloading are often cited as an issue, showing that the scope to be covered by Road AM is very broad.

5.4.2 Best Practice of Each Country

ADB compiles the efforts of Road AM in each country and is holding workshops and releasing reports to promote the horizontal expansion of successful cases and lessons that have been learned. In 2013, a workshop of Road AM was held by the ADB headquarters. In 2018, a report about Road AM by the central Asia member nations of ADB was presented.

Of the common items in the workshop and the report mentioned above, the followings items were emphasized: 1) Introduce Road AM across an entire organization under strong leadership from top management, 2) At the initial introduction of RMS, make the system simple and add functions gradually, corresponding to organizational level, 3) Recognize the fact that it takes five to ten years for Road AM in developing countries to be understood and fully utilized, and 4) Secure stable funding for road maintenance. These items are the points to be considered for the successful introduction of Road AM.

5.5 Situation of WB/ADB for Road AM at Country Levels (Laos, Cambodia)

5.5.1 Situation in Laos for Road AM

5.5.1.1 Situation of WB Assistance

Supports by WB have continued without interruption since 2001. Improvement of national roads and local roads, regular maintenance, and daily maintenance are implemented as hardware measures. Technical software measures included the introduction of Road Management System (RMS) on national roads in "Road Maintenance Project Phase 1", started in 2001, and the introduction of the Provincial Maintenance Management System (ProMMS) on rural roads in "Road Maintenance Project Phase 2". Road Sector Projects I and II continue to provide support, aiming to incorporate climate change factors into the road maintenance system, as well as providing support for the introduction of PBC.

The characteristic of support by WB is to package road improvement/maintenance projects and capacity building projects for government agencies.

In Laos, a road maintenance management fund (hereinafter RMF) was created with support from the WB. There are few cases of RMF establishment in Asian countries, and Laos is a model case.

5.5.1.2 Situation of ADB Assistance

As stated above, they cooperate with WB in "Road Maintenance Project Phase 2" from 2004 to 2010. Then, they started "Road Sector Governance Project" in 2016 and continue to support the introduction of PBC, overload management, Road AM system, and revisions to various technical manuals.

5.5.2 Situation in Cambodia for Road AM

5.5.2.1 Situation of WB Assistance

WB started the introduction of a road maintenance management system based on HDM-4 in the 2004 "Provincial and Rural Infrastructure Project" and completed it as a system in the subsequent "Road Asset Management Project". However, the government employees were still not able to master the system and WB concluded that a simpler system should be created in the subsequent "Road Asset Management Project Ⅱ." Currently, the government is carrying out routine maintenance work, but plans to outsource this to private contractors by using PBC in the "Road Asset Management Project II" assisted by WB.

5.5.2.2 Situation of ADB Assistance

ADB has aided on various projects since the jointly supported "Road Asset Management Project" by WB and ADB in 2008. Areas of assistance by ADB include overload countermeasures and outsourcing of routine maintenance through PBC. Daily maintenance is carried out by MPWT's directly managed units, but they are trying to adopt a performance regulation system in line with opening this work to the private sector. Also, measures against overloading have been implemented continuously in cooperation with the projects assisted by the WB.

5.6 Summary of WB/ADB Assistance Measures

5.6.1 Direction of Assistance

1) WB takes the lead in assisting developing with Road AM. ADB assists in coordination with WB.

2) WB shifted the emphasis of assistance from new road construction to the improvement and maintenance of existing roads

3) Strategy of WB is focusing on,

(A) Optimization of maintenance planning by introducing a maintenance management system

(B) Securing a maintenance budget with an establishment of road funds

(C) Outsourcing of maintenance works utilizing PBC

- Furthermore, the response to climate change has been employed in Road AM in recent years. Perspectives in disaster recovery and disaster prevention have also been added to the Road AM.

5.6.2 The Effects of Support

1) Road funds have been established in many countries, particularly in Sub-Saharan Africa, and they have come to be utilized as a method to secure financial resources.

2) Applications of PBC have been gradually expanded and outsourcing of maintenance work has also been progressing. PBC, from examples like the introduction of CREMA in Argentina, reduces maintenance work costs and reduces the number of government employees needed.

3) HDM-4 has been introduced in many nations including many developed countries. But many developing nations have failed to master it because of the complexity of the system and the requirement to input so much data. Such as in the case of Cambodia, in which a simpler version of HDM-4 shall be tried, a system which is easier to use and matches the local level of users' understanding.

5.6.3 References for the Assistance by Japanese Government to Developing Nations

1) The support of Road AM covers a broad range of fields and is time-consuming. When Japan supports Road AM, it is important to cooperate with other donors, especially WB and ADB. And, when evaluating the effectiveness of the support by the Japanese government, knowing the content of assistance by the other donors is necessary

2) Regarding pavement, WB and ADB support the development of maintenance management systems using HDM-4. There are few reports on bridge maintenance, so this gives Japan an opportunity to provide specialized assistance in this regard, to maximize the potential of these assets. Also, with support from the Japanese government it is important to establish a maintenance system to support the construction of new bridges.

3) When introducing road maintenance management systems to developing countries, it is more appropriate that a simple system be introduced first, and then gradually it can be expanded to include more functions later.

Chap. 6 Data Analysis of Technical Manuals Developed in Technical Cooperation Projects

6.1 Target of the Chapter

This chapter targets the streamlining of the formation for new Technical Cooperation Projects on Road Maintenance. Through extracting and synthesizing the existing manuals which were developed in past JICA's Technical Cooperation Projects, "the overall picture of technical manuals" is formed as a basic material, which is customizable to suit many countries. The original existing manuals, which are provided by JICA as sources to this overall picture, include the following: Technical Standards, Guidelines and Handbook for Design, Cost Estimation, Inspection, Repair works, Rehabilitation works, Road Maintenance and such.

In addition, using the above materials, we summarize an outline of the existing Technical Projects, the Technical Manuals, and their scope and contents are roughly compared on various technical level perspectives.

6.2 Overview

JICA has been implementing these Technical Cooperation Projects in many countries including Asia, Oceania, Africa, and Southern America, hence, the provided technical manuals are varied and extensive in volume. 115 documents of manuals for 10 countries were collected for this data analysis and were organized and classified with the structure of a Road AM Evaluation Index. As a result of this analysis, the following facts were revealed; JICA's technical manuals are created in cooperation with their own standards or other donor support, and their scope and technical levels are varied to suit the situation of recipient countries. And through the mutual completion of these manuals, the "overall picture of technical standards" was formed.

6.3 Information and Summarization of the Technical Manuals

Table 6.1 shows the list of JICA's Technical Cooperation Projects on Road Maintenance (including Bridge Maintenance) implemented in recent years, and the Technical Manuals collected are from projects marked with "■". These technical manuals were developed jointly between C/P and JICA experts and obtained through JICA officials or experts. Moreover, the countries participating in these projects are shown in Figure 6.1; the 38 countries marked with "■" are recipient countries, and the 10 countries marked with "■" are the source countries for the manuals. JICA's technical cooperation projects are widely implemented all over the world, and that the manuals are collected without bias to any region.

Table 6.1 List of JICA's technical cooperation projects on road maintenance

Recipient	Name of Projects	Period	Manuals Obtained	Rough Classification		
				Pavement	Bridge	Others
Asia						
Afghanistan	The Project for Capacity Development and Establishment of Road Maintenance Management System	2008-2012		■		
	Project for Capacity Development for Management of Kabul City Road Improvement	2016-2020		■		
Bangladesh	Bridge Management Capacity Development Project	2015-2018	■		■	
Bhutan	Technical Cooperation Project for Capacity Development in Construction and Maintenance of Bridges	2016-2020			■	
Cambodia	The Project for Strengthening Capacity for Maintenance of Roads and Bridges	2015-2018	■	■	■	
Indonesia	Project on Capacity Building for Asset Management of Road and Bridges	2010-2012		■	■	

Recipient	Name of Projects	Period	Manuals Obtained	Rough Classification		
				Pavement	Bridge	Others
India	the Capacity Development Project on Highways in Mountainous Regions	2016-2021		■		
Kyrgyz	The Project for the Capacity Building of Road Maintenance	2008-2011		■		
	The Project for Capacity Development for Maintenance Management of Bridges and Tunnels	2013-2016			■	■
	The Project for Capacity Development for Road Disaster Prevention Management	2016-2019	■			■
Lao	The Project for Improvement of the Road Management Capability	2011-2017		■		
Mongol	The Project for Capacity Development on Bridge Maintenance and Management	2013-2015			■	
Myanmar	The project for capacity development of road and bridge technology	2016-2019			■	
Nepal	The Project for the Operation and Maintenance of Sindhuli Road Phase 1 Phase 2	2011-2016 2019-2022		■		
Pakistan	The project for technical assistance on implementation of bridge management system in NHA	2016-2019			■	
Philippines	Improvement of Quality Management for Highway and Bridge Construction & Maintenance Phase 1 Phase 2 Phase 3	2007-2010 2011-2014 2016-2019	■	■	■	
Sri Lanka	The Project for Capacity Development on Bridge Management	2015-2018	■		■	
Tajikistan	The Project for Improvement of Road Maintenance	2013-2016		■		
	The Project for Capacity Development for Road Disaster Management	2017-2020				■
Thailand	The Project for Bridge Master Plan and Bridge Maintenance Ability in Rural Area	2011-2013	■		■	
Timor-Leste	The Project for Capacity Building of Periodic Road Maintenance	2005-2008		■		
	The Project for the Capacity Development of Road Services	2016-2019	■	■		
	The Project for the Capacity Development of Road Works	2010-2014	■	■		■
Vietnam	The Project for Capacity Enhancement in Road Maintenance Phase 1 Phase 2	2011-2014 2015-2018	■	■		
Latin America						
El Salvador	The Project for Capacity Development of the Department of Climate Change Adaptation and Strategic Risk Management for Strengthening of Public Infrastructure Phase 1 Phase 2	2012-2015 2016-2021	■			■
Bolivia	The Project for Capacity Development of Road Disaster Prevention and Bridge Management and Maintenance	2009-2012		■	■	
Oceania						
Papua New Guinea	The Project for Capacity Development on Road Maintenance	2013-2017		■		
Africa						
Democratic Republic of the Congo	The Project for Capacity Development of Road Maintenance Management	2016-2019	■	■		

Recipient	Name of Projects	Period	Manuals Obtained	Rough Classification		
				Pavement	Bridge	Others
Egypt	The Project for Improvement of the Bridge Management Capacity	2012-2015			■	
Ethiopia	Capacity Development Project on Bridge Management	2007-2012			■	
	The Project for Development of Road Maintenance Capacity of Addis Ababa City	2015-2019		■		
Ghana	The Project on Capacity Building for Road and Bridge Management	2019-2023		■	■	
Kenya	The Project for Strengthening of Capacity on Road Maintenance Management Through Contracting Phase 1 Phase 2 Phase 3	 2010-2013 2013-2016 2016-2019	■			■
Mozambique	The Project for the Capacity Development of road maintenance	2011-2014		■		
South Sudan	Technical Cooperation Project for Capacity Development on Sustainable Road Maintenance and Management in Juba	2011-2014		■		
Tanzania	Rural Road Maintenance System Development Project	2012-2016		■		
Uganda	District and Urban Roads (DUR) Mapping and Roads Database Project	2012-2015		■		
Zambia	The Bridge Maintenance Capacity Building Project	2015-2017			■	

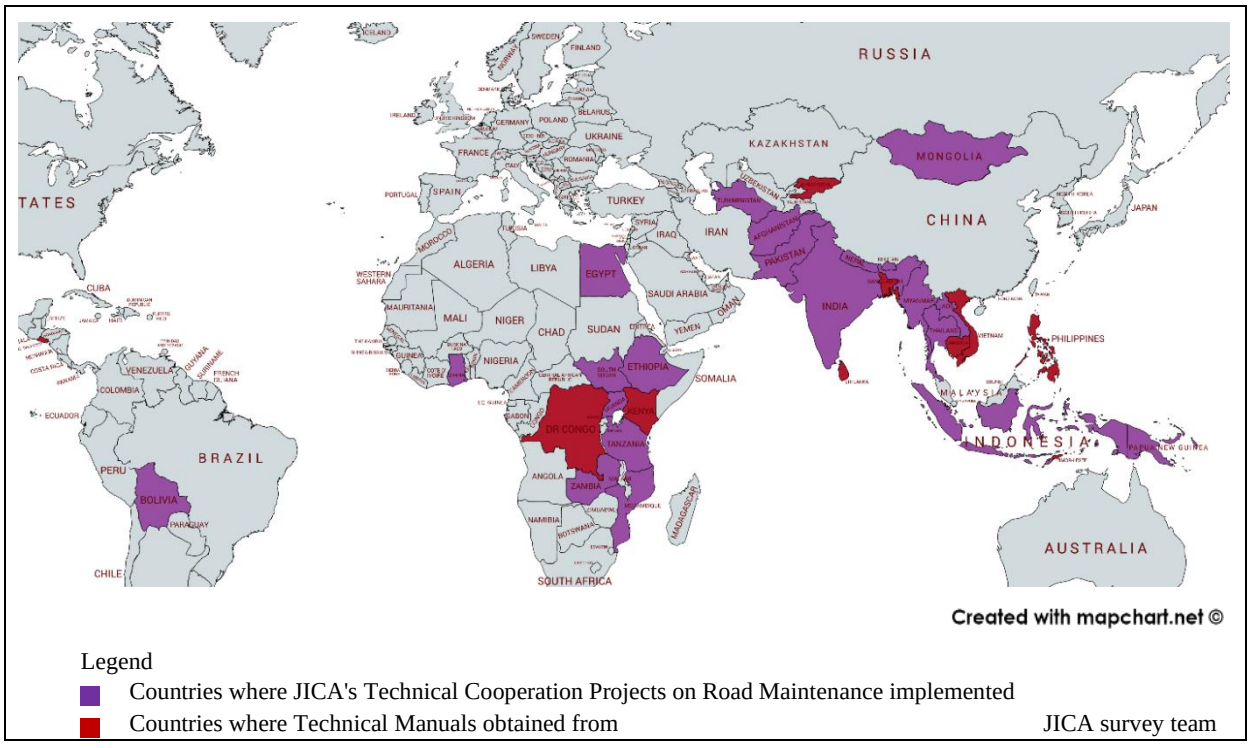


Figure 6.1 Location map of JICA's Technical Cooperation Projects on Road Maintenance

On the following pages, the Technical Manuals have been summarized in a rough document structure.

Country	Bangladesh
Project name	Bridge Management Capacity Development Project
Period	Jul 2015 – Sep 2018
Background	Construction of bridges in Bangladesh has been accelerated drastically after its independence in 1971, and the number of bridges and culverts increased from 1,112 to 18,356 in 2013. Meanwhile, the rapid increase of bridges has caused frequent falls of bailey bridges (emergency bridges) and road condition has seriously deteriorated due to inadequate maintenance. Though GOB is aware of the necessity of the capacity development on bridge management, it is yet to be implemented. This results in bridges fall before the arrival of the end of their durable years.
Project Purpose	Bridge maintenance capacity of RHD is improved.
Outputs	1. Bridge maintenance framework is developed 2. Bridge inspection / evaluation manual and Bridge rehabilitation / strengthening manual are developed 3. Bridge management system is developed 4. Necessary knowledge of bridge management is enhanced by RHD staff

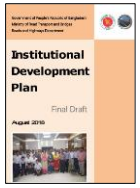
The manuals are written in English

Organization

Training Program and Material

Institutional Development Plan

1.Outline
2.BMS
3.Procedures and Staff Deployment regarding Bridge Maintenance Works
4.Recommendations
84 pages



Bridge

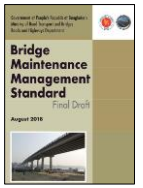
Cycle of Inspection & Maintenance

Bridge Maintenance Management Standard

1.General
Background, Purpose, Scope, Related manuals
2.Current situation of Bridges and Culverts
3.Establishment of Bridge Mainte. Manage. Cycle
Basic concept, Inspection, Evaluation,
Short/Mid/Long-term Mainte. Plan
4.Improvement of Mainte. Institutional Framework

Appendix
A : Zonal organization of RHD B : Items to be considered in Planning & design stage
C : Number of Bridges & Culverts

82 pages



Inspection and Diagnosis

Bridge Inspection and Evaluation Manual

1.Background
2.Introduction
3.Bridge inspection program
Type, Frequency, Team, Requirement
Tool, Equipment
4.Inspection procedure
Planning, Preparation, Perform, Report, Safety
5.Type and condition of defects
6.Evaluation and countermeasure
Evaluation of element/whole bridge
Detailed investigation, Appraisal committee
7.Records of inventory and inspection results

Appendices
1 : Points to find defects
2 : Guideline for bridge type & config
3 : Inspection tool & instrument
4 : Numbering system of bridge element
5 : Viewpoints durling inspection
6 : Type of defects and rating
7 : Evaluation criteria
8 : Detailed investigation
9 : Recording report forms

340 pages

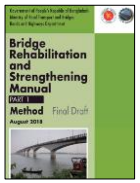
Maintenance and Repair

Bridge Rehabilitation and Strengthening Manual

Part 1: Method
1. Overview
2. Routine mainte. works
3. Minor repair works
4. Selection of Major repair works
5. Repair method for different defects
200 pages

Part 2: Cost estimate
1. Introduction
2. Contents of cost estimation standards
3. System of cost estimation
4. Calculation of pure construction cost

262 pages

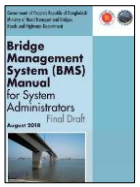


Inspection History and DB

Bridge Management System (BMS) Manual

1.Background
2.Introduction
3.Role based access in BMS
4.Rating, Degree and Category
5.How to use (Periodic)
6.How to use (Routine)
7.How to use (Other inspection)
8.Tech note

for Inspector & Evaluator...158 pages
for Bridge mngmnt wing...236 pages
for Public users...16 pages
for System admin...238 pages



Country	Cambodia
Project name	Th Project for Strengthening Capacity for Maintenance of Roads and Bridges
Period	Mar 2015 –Mar 2018
Background	The main problems facing the maintenance of roads and bridges are, (1) Financial Constraints, (2) Insufficient Skills and Experience and (3) Lack of Equipment for Road Development Maintenance Works. Under these circumstances, to tackle the items above, the Cambodia Government requested Japan to conduct a technical cooperation project to strengthen capacity for maintenance of roads and bridges.
Project Purpose	Capacity of Road Infrastructure Department (RID) under the Ministry of Public Works and Transport (MPWT) to supervise implementing bodies maintaining roads and bridges is enhanced.
Outputs	1. The bridge maintenance cycle is established 2. Road and bridge inspection capacity of RID is enhanced. 3. Road and bridge repair capacity of RID is enhanced. 4. Road and bridge maintenance cycle is introduced to other MPWTs and concerning agencies.

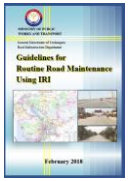
The manuals are written in English and Khmer

Pavement

Cycle of Inspection & Maintenance

Guidelines for Routine Road Maintenance Using IRI

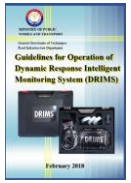
1.Road Maintenance Cycle Using IRI
2.Step.1: IRI Measurement and Visual Inspection
3.Step.2: Evaluation of Inspection Results
4.Preparation of Road Lists with Evaluation Results
5. Selection of Maintenance Methods and Cost Estimate
6.Budget Request for Road Maintenance Plans
& Implementation of Road Maintenance Plans
7. Feedback of Road Maintenance Works
8.An Example of the Guidelines Application
75 pages



Inspection Support System & Datebase

Guidelines for Operation of Dynamic Response Intelligent Monitoring System (DRIMS)

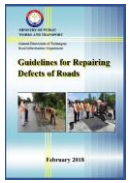
1.Introduction ...Outline of DRIMS
2.PC Software Installation
3.Equipment Installation
4.Basic Operation
5.Calibration
6.IRI Estimation
7.Post Processing of Analysis Results
8.Data Storage in DB
9.Checklist for DRIMS Operation
65 pages



Maintenance and Repair Work

Guidelines for Repairing Defects of Roads

1.Introduction
2.Repair job sheet
Cleaning, Repair of Pavement & Structures
3.Equipment list
4.Guideline road marking
A4 :71 pages + Handbook: 118 pages

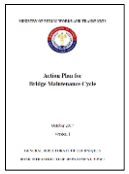


Bridge

Cycle of Inspection & Maintenance

Action Plan for Bridge Maintenance Cycle

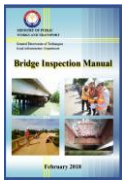
1 Objectives of the Action Plan
2 Bridge Maintenance Cycle
3 Action Plan
4 Implementation of Action Plan
5 List of Appendix
56 pages



Inspection & Diagnostic

Bridge Inspection Manual

1 Introduction ...Purpose, Process
2.Organization ...Schedule, Jurisdiction
3.Requirement for Inspection ...Preparation, Safety, Classification, Method, Viewpoint, Evaluation
4.Recording ...Datebase
5.Non-Destructive-Test ...Hammar, Carbonization, Ultrasonic, Infrared-camera,,
Appendix ...Sample pictures of damage and scores
210 pages



Support system & Datebase

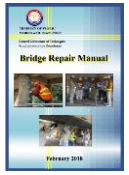
Bridge Inspection Handbook

1.Flow of iPad system
2.How to with iPad system
3.Sample Photos of Damage
4.Scoreing
52 pages

Maintenance and Repair work

Bridge Repair Manual

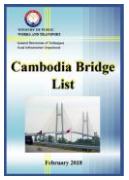
1.Introduction ...Purpose, Process
2.Organization ...Schedule, Jurisdiction
3.Safety and maintenance work
4.Maintenance room and basic knowledge of concrete
5.Repair of concrete structure
6.Repair of steel structure
7.Repair of foundation or other structure
Attachment ... Bridge repair work job sheet
221 pages



Inventory

Cambodia Bridge List

Bridge name, Category, Province, Position, Length, Material, Damage Level
110 pages



Organization

Training Program and Material

Maitenance Expert Training Program

1.Training Program
2.Training Material
Bridge/Road, Inspection/Repair
182 pages

Country	Kyrgyz
Project name	The Project for Capacity Development for Road Disaster Prevention Management
Period	Apr 2016 – May 2019
Background	The Ministry of Transport and Roads (MOTR) has managed the main highway and has carried out the recovery works after the road disaster. But the damages due to aforementioned road disaster has occurred repeatedly at the road disaster prone area since the preventive countermeasures have not been carried out by MOTR. To improve the situation, the Government of the Kyrgyz Republic had requested the Government of Japan for assistance in implementing the "Project for Capacity Development for Road Disaster Prevention Management" to enhance the management capacity of the Government of the Kyrgyz Republic in road disaster prevention and thereby minimize negative impacts.
Project Purpose	The capacity of MOTR's relevant units in the Project (HQ, RMD, target PLUADs/UADs, and DEPs) is enhanced for management of road disaster prevention (including road disaster inspection, preparing of road disaster prevention management plan and planning of budget for road disaster prevention)
Outputs	1. Responsibilities of MOTR on road disaster prevention, including specific duties to be performed by relevant units (HQ, RMD, PLUADs/UADs, DEPs) with necessary staffing in each, become clear. 2. Capacity of target PLUADs/UADs and DEPs for inspection and analysis of road disaster is enhanced.

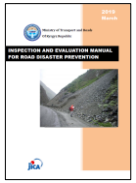
The manuals are written in English and Russian

Slope Protection

Inspection and Diagnosis

Inspection and Evaluation Manual for Road Disaster Prevention

1.Introduction
General, Outline
2.Type of road disasters
Rockfall, Landslide, Collapse, Debris flow, Erosion, Avalanche, Snowdrift
3.Inspection and evaluation
Inspection method, Monitoring, Evaluation
73 pages



Countermeasure

Countermeasures Manual for Road Disaster Prevention

1.Introduction
2.Type of road disasters
3.Rockfall ...selection of counter measures, detailes
4.Landslide ... (ditto)
5.Slope Collapse ... (ditto)
6.Debris flow ... (ditto)
7.Erosion ... (ditto)
8.Avalanche ... (ditto)
9.Snowdrift ... (ditto)
10.Non-structural measure ... (ditto)
155 pages

Management Plan

Short-Term and Medium-Term Road Disaster Prevention Management Plan Manual

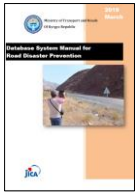
1.General ...Budget request, Process from inspection to construction
2.Risk assessment
3.Priority level assessment
4.Assessment based on costs and effectiveness
5.Request to donors
6.Developing a short-/medium-term management plan
7.Action plan
34 pages

Inspection record and DB

Slope Protection

Database System Manual for Road Disaster Prevention

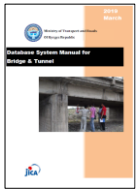
1.General information
DB operation flow, DB structure, Equipment, Installation, Main menu
2.Input method for inspection
3.Analysis method
26 pages



Bridge and Tunnel

Database System Manual for Bridge & Tunnel

1.General information
DB operation flow, DB structure, Equipment, Installation, Main menu
2.Input method for inspection and inventory
3.DB operation
36 pages

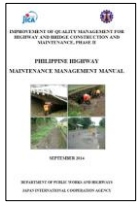


Country	Philippines
Project name	Improvement of Quality Management for Highway and Bridge Construction & Maintenance
Period	Phase 1 : Feb 2007 – Feb 2010 Phase 2 : Oct 2011 – Sep 2014 Phase 3 : Feb 2016 – May 2019
Background	The Philippine Development Plan (2011-2016) sets "development of road and bridge infrastructure" as one of prioritized areas since it will reduce transportation costs and revitalize economic activities. In addition, the Medium-Term Program (2011-2016) prepared by DPWH pledged that remaining unpaved roads shall be paved, all temporary bridges shall be replaced by permanent ones and strengthening of the maintenance management of the roads and bridges as to the highest priority. Under Phase I and Phase II, technology transfer to counterpart engineers of the CO, model 3 ROs (CAR, VII, and XI) and their DEOs was carried out through preparing related manuals/guidelines and conducting seminars/inspection OJTs, and pilot projects on road slope stability and bridge repair were implemented in these 3 ROs. As a result, it was confirmed that capability of these ROs/DEOs on road and bridge maintenance management was highly enhanced. However, the capacity enhancement of the DPWH as a whole remained an issued to be realized. The Government of the Republic of the Philippines requested JICA to assist in implementing the subsequent project to these projects.
Project Purpose	Road and bridge maintenance management works of DPWH are improved.
Outputs	1: Capability of concerned engineers of all ROs/DEOs on road maintenance management is enhanced. 2: Capability of concerned engineers of all ROs/DEOs on bridge maintenance management is enhanced. 3: Capability of concerned engineers of ROs/DEOs in target Regions (II, III, VII, VIII, and XIII) on special bridge maintenance management is enhanced. 4: Database system to be utilized for road and bridge maintenance management is developed.

The manuals are written in English

- General
  - Organization
    Cycle of Inspection & Maintenance
    - Philippine Hightway Maintenance Management Manual

1.Management systems	5. Scheduling
2.Activities	6. Directing
3.Organizations	7. Reporting
Crew/District/Regional Organization,	8. Control
Responsibility	Procedure,
4.Planning	Operational control,
Concepts, Objectives, Planning limitation,	System control,
Annual program, Work program, Budget,	Mngmnt & fiscal control
Routine Mainte, Monthly crewday dstribution	200 pages



  - Project management
    - Road Project Management and Supervision Manual

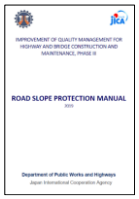
1.Introduction
2.Contract and guidelines
3.Implementing organizations and role of entities
4.Procurement
5.Public Information, Road Safety and Environmental Management
6.Construction Management and Supervision
7.Quality Control

- Pavement and Road accessories
  - Routine maintenans and repair
    - Pocketbook on Routine Maintenance

0.Routine maintenance	5.Drainage
Office/Personnel, Material/Equipment, Safety	Cleaning of ditch/culvert
1.Unpaved road	6.Roadside features
Manual repair/Machine works	Vegetation, Erosion, Repairs
2.Bituminous pavement	7. Traffic services
Patching, Sealing, Replacement	Sign, Marks, Gurardrail, Sight distance
3.Concrete pavement	8. Bridges
Patching, Sealing, Replacement	Cleaning, Patching/Repair of concrete
4. Unpaved shoulder	Paint of Steel bridge ,,,
Manual repair/Machine works	9.Emergency works
	94 pages

- Slope protection
  - Cycle of Inspection & Maintenance
    Survey & Design
    - Road Slope Protection Manual

1.Introduction	6-9.Countermeasure for
2.Soil classification and modulus	Slope collapse, Slip, Rock slope collapse, others
3.Factors of failures	
4.Slope maintenance	215 pages
5.Selection of protection works	

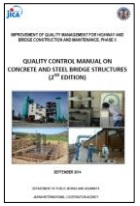


- Construction
  - Survey and design
    - Guidebook for Road Construction and Maintenance Management

1.Introduction	5.Slope protection
2.Soil classification and modulus	6.River/Coastal erosions
3.Road drainage	7.Road safety
4.Pavement	8. Monitoring& Investigation
	138 pages

  - Quolity control
    - Quality Control Manual on Concrete and Steel Bridge Structuers

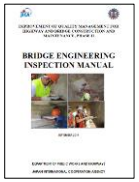
1.Concrete structure ...Material requirement, Supervision,,
2.Steel structure ... (ditto)
3.Miscellaneous items ... (ditto)
454 pages



Bridges

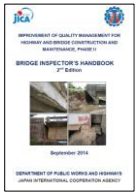
Inspection and Diagnosis

Bridge Engineering Inspection Manual



1. Engineering inspection	NDT for steel...Paint/Metal thickness
Background, Purpose, Process, Scope,	Special NDT...
Procedure, Deliverables,	3. Assesment
Tasks/Activities of Advisory Team	Scope, Cause of damage,
2. Non-destructive testing (NDT)	Identification/prediction of deterioration,
Introduction, Type/Reliability of NDT	Evaluation, Overall assesment
NDT for concrete...Rebound hammer,	
Carbonation depth measurement,	310pages
Ultrasonic pulse velocity, ,,,	

Bridge Inspector's Handbook



1.About bridges	-Superstructure
2.The inspection	-Abutment, Pier
-Preparation, Focuspoints,,,	-River, Bed protection,,
-Road approach, drainage	216 pages

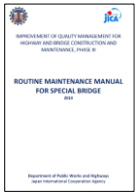
Maintenance and Repair

Bridge Repair Manual

1.Introduction	7.Repair of steel superstructure
2.Routine repair	8.Repair of expansion joint
3.Major repair	9.Repair of bearing
4.Repair of concrete deck	10.Protectoin works
5.Repair of concrete superstructre	
6.Repair of concrete substructure	296 pages

Other

Manual for Load Rating of Bridges

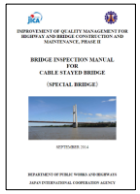


1.Introduction
2.Engineering and in-depth inspection for load rating
3.Load rating
4.Load rating examples
5.Computer based program on load rating

Special bridge

Inspection and Diagnosis

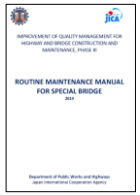
Bridge Inspection Manual for Special Bridge
1. Cable Stayed Bridge, 2. PC Box Girder Bridge, 3. PC Extradosed Bridge,
4.Steel Arch Bridge, 5.Streel Truss Bridge, 6.Suspention Bridge



1.Introducton	6. Emergency inspection
2.General requirement for bridge inspection	7. Inventory inspection
3.Routine inspection	8. Geometrical inspection
4.Condition inspection	
5.Engineering inspection	
(refering the manual for normal bridge)	200-500 pages for each type

Routine Maintenance

Routine Maintenance Manual for Special Bridge



1.Introduction
2.Types of defects and causes
3.Routine maintenance
Activities, Equipment/Repair material, Activity standards
103 pages

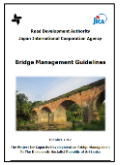
Country	Sri Lanka
Project name	The Project for Capacity Development on Bridge Management
Period	Feb 2015 – Feb 2018
Background	There are 4,800 bridges in A and B Class roads, which are not covered under a comprehensive maintenance strategy due to non-availability of a database that consists of lifespan, durability, and maintenance plan. Although RDA has road maintenance system, currently, it does not have any institutional and technical mechanism for bridge maintenance. Establishment of a bridge maintenance system and & Bridge Assessment Unit in RDA is an essential requirement to maintain bridges effectively to ensure safety of road users and smooth flow of traffic.
Project Purpose	Institutional capacity of RDA on bridge management is improved.
Outputs	1. Bridge management strategy is prepared. 2. Framework for bridge management at both RDA head office and regional offices in sample province(s) (PD, CE, EE) is re-established. 3. Bridge inspection and diagnosis manuals are revised. 4. Bridge Management Data System (BMS) is established. 5. Basic Engineering knowledge for staff working for both RDA head office and regional offices in sample province(s) is enhanced through seminars and OJTs.

The manuals are written in English

- Bridge
  - Cycle of Inspection and Maintenance
    - Bridge Management Guidelines

1. Structure of Bridge Management
2. Target Bridge Management Level
3. Understanding and Evaluation of Present Conditions
4. Development of Bridge Repair and Maintenance Plan
5. Bridge Reconstruction Indicator
6. Development of Bridge Reconstruction Plan
7. Monitoring and Ex.Post Evaluation

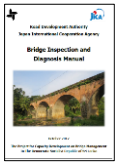
Attachments : Bridge Management Procedure Manual
Main 42 pages+Attachments 48 pages



  - Inspection and Diagnosis
    - Bridge Inspection and Diagnosis Manual

1. General
   Scope, Purpose, Type of Inspection, Safety, Update of Manual
2. Periodic Inspection
   Scope, Work flow, Implementation Structure, Detaile, Evaluation, Records, Cost Estimation, Emergency Actions

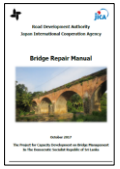
Attachments
1.Guideline for Development of Bridge Inspection Record Sheets (Example)
2 Calculation and Recording of Health Index
3 Example of Record and Outputs of Bridge Inspection Record Sheet by BMS
4 Standard Repair Cost and Standard Unit Rate of Bridge Member Repair
5 Standard Unit Rate for Bridge Reconstruction
6 Description and Examples in need of Emergency Actions
7 Examples of Bridge Diagnosis



  - Maintenance & Repair methods
    - Bridge Repair Manual

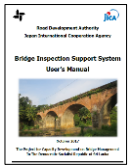
1. General ...Scope, Purpose
2. In-Depth Investigation
3. Bridge Repairs and Strengthening

Attachment
1. Specification for Plastering Method
2. Cleaning the Surface of Steel Members
3. Specification for Zone Painting
4. Machinery and Equipment for Repair Work
5. Outline of Representative In Depth Investigation
54 pages + Attachment 86 pages



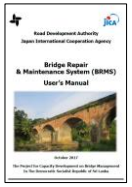
- Support System & Database
  - Inspection Support System
    - Bridge Inspection Support System – User's Manual

1.Outlines of the System
2.Initial Setting
3.Selection of Bridge
4.File ..import/export/management
5.Inventory
6.Inspection record
7.Maintenance record
42 pages



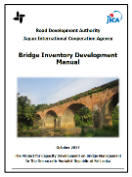
  - Maintennce Plan Support System
    - Bridge Repair & Maintenance (BRMS) System -User's Manual

1.Introduction
2.System Requirements
3.Ins tallation 4Operation Instruction
30 pages



  - Inventory
    - Bridge Inventory Development Manual

1.Purpose
2.Contents of Inventory
3.Forms and Recording
54 pages



  - DB and Inspection Record
    - Bridge Database System

1.User's Manual, 2.Administrator's Manual
3.Server OS Design Documents

- Structure of DB
- How to use
- Registration of Inventory Data, Picutres, Drawings
- Registration of Inspection Result

172 pages

  - Portal System
    - Bridge Management Portal Site User's Manual

- List of Functions
- Portal Home
- Electorical Library of Manuals
- DB

20 pages

Country	Thailand
Project name	The Project for Bridge Master Plan and Bridge Maintenance Ability in Rural Area
Period	Oct 2011 - Jul 2013
Background	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 are 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.
Project Purpose	1. To review the bridge master plan formulated by the Department of Rural Roads (DRR). 2. To improve the bridge maintenance ability of the DRR in the rural area in Thailand.
Outputs	1. Review of the present conditions of the road and bridge sectors in Thailand. 2. Review of the Bridge Master Plan formulated by the DRR 3. Review of current procedures of Feasibility Study implemented by the DRR 4. Assistance in conducting proper bridge maintenance and management by the DRR. 5. Technology Transfer to develop bridge maintenance capacity of DRR staff 6. Introduction of the latest technology to the Project

The manuals are written in English, Thai, and Japanese

Bridge

Inspection and Diagnosis

Bridge Inspection and Evaluation Manual

1.Common
- Application, Purpose, Type of Inspection

2.Periodic Inspection
- Inspection work
- Grasp of damage condition and evaluation of damage
- Inspection Records
- Evaluation on urgency of damage class 5

3.Appendix
- Quick Manual (Sample of Damage Photos and Evaluation)

125 pages

Maintenance Plan, Management System

Long-term Bridge Maintenance and Management Plan Development Manual

1.Examination of the long-term maintenance plan
- Planing flow, Maintenance scenario, Soundness evaluation
- Future prediction of soundness, Maintenance/Repair measure

2.Examination geared to long-term maintenance planning
- Simulation flow, Control level, Simulation of period/single year budget
- Evaluation of results

Appendix

66 pages

Inspection and Repair for Flood damage

Flood Damage Rehabilitation Manual

1.Before Using this Manual
- Objectives, Structure of Manual, Points

2.Method of Actual Site Investig
- Inspection on normal time/ durling flooding

3.Flood Disaster Assessment

4.Flood Disaster Measures and Rehabilitation Plan

5.Estimation of Cost for Flood Disaster Measures

6.Design Examples
- Flow, Post-flood inspection, detailed survey, evaluation, methods/estimation

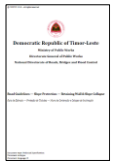
Country	Timor-Leste
Project name	The Project for the Capacity Development of Road Works in Timor
Period	Jun 2010 – Oct 2014
Background	The Project aims to make roots of outcomes of the Project for the Capacity Building of Road Maintenance in Timor-Leste (CBRM) which was carried out from June 2005 to March 2008. Required works to maintain and repair roads and restore roads damaged by disasters should be systematically executed by Directorate of Road, Bridge and Flood Control (DRBFC) and Institute of Equipment Management (IGE) under Ministry of Infrastructure (MOI). Capacity development for a total management of road works is to be one of main purposes of the Project. And capacity development of the management for construction equipment under IGE to be used at construction sites is to be also one of main purposes of the Project.
Project Purpose	Technology and management capacities on road works by the Timorese (DRBFC, IGE) are enhanced.
Outputs	1: Road maintenance is timely and properly managed by DRBFC. 2: Small scale construction works (including maintenance/repairs) are conducted with enough quality by DRBFC in collaboration with IGE through case study. 3: The equipment at IGE is properly managed and maintained.

The manuals are written in English

- Slope protection
  - Investigation and Design
    - Road Guidelines－Slope Protection －Landslide Investigation

1.What is a landslide?	Annex
2.Landslide warning signs	A : Specification & operation of UAV
3.Flow of investigation	B : Specification for Geotechnical Investigation
4.Preliminary investigation	C : Guidelines for Inclinometer
5.Detailed investigation	D : Supplimental guide for Inclinometer
6.Mechanism of the landslide	E : How to use Inclinometer
7.Countermeasures	F : Logger for Inclinometer
8.Conclusion	G : Countermeasure for Mass movement
38 pages	64 pages

    - Road Guidelines—Slope Protection—Retaining Wall &Slope Collapse



1.Scope	10.Stability calculations
2.Normative reference	11.Factors of stability calculations
3.Term and definisions	12.Design of shallow slope collapse
4.Investigation	Annex
5.Design of Gravity retaning wall	A : How to use Total station
6.Drawing of Gravity retaining wall	B : How to use Dokenbo
7.Bearing capacity	C,D : Excel sheet for stability calculation
8.Slope	E: Catch wall
9.Slope disaster	F: Disaster investigation sheet
	90 pages

- Drainages
  - Investigation and design
    - Road Guidelines —Drainage —Culvert Design

1.Scope	6.Rainfall analysis	Annex
2.Normative reference	7.Design flood	A : Case study
3.Term and definisions	8.Open channel hydraulics	B : Training material
4.Planning	9.Protection works	C : Weather station
5.Data collection	46 pages	80 pages

- Bridge (Substructure)
  - Investigation and design
    - Bridge Substructure Protection Guidelines

1.Scope	7.Scour around abutment
2.Normative reference	8.Protection of substructure
3.Term and definisions	Annex
4.Characteristics of rivers	A : Case study
5.Condition of Bridge substructures	B : Training material
6.Hydraulic phenomenon around piers	62 pages

Country	Timor-Leste
Project name	The Project for the Capacity Development of Road Services in Timor-Leste
Period	Feb 2016 – Dec 2019
Background	Timor-Leste is carrying out road rehabilitation across the country with loans and grants from the Asian Development Bank, the World Bank and JICA as well as the national budget. However, roads are frequently damaged because they are mostly located in mountainous terrain and are frequently affected by natural disasters such as heavy rains, landslides and flooding. Road maintenance is crucial to keeping roads in a good condition. JICA provides technical assistance to develop human resources and institutional capacity of road maintenance in both technical aspect and management aspect including budgeting.
Project Purpose	Technology and management capacities on road maintenance by the Timorese are enhanced.
Outputs	1. Appropriate road maintenance is established according to yearly management and budget plan. 2. Construction management capacity of DRBFC's repair/improvement/restoration work (including slope measures) is improved throughout East Timor. 3. Standard drawings for improvement and restoration work is prepared for appropriate construction design tool.

The manuals are written in English

- Pavement and Road accessories
  - Cycle of Inspection and Maintenance
    - Road Maintenance Manual

1.General …Scope, Objectives, Maintenance Category	
2.The nees for road maintenance	
3.Road inspection …Scope, Frequency, Category, Form, Team, Procedure	
4.Maintenance treatment …Routine/Periodical maintenance	
5.Indicative maintenance plan	
82 pages	

  - Database
    - Guideline for the Database of Road Maintenance

1.Introduction	4.How to update
2.How to establish DB	Attachment
3.How to operate DB	130 pages

- Bridge
  - Cycle of Inspection and Maintenance
    - Bridge Maitenance Manual

1.Introduction	
Background, Overall requirement	
2.Bridge anatomy and referencing system	
Bridge type, Component, Reference system	
3.Inspection and Evaluation	
4.Routine maintenance	
5.Programmed maintenance	
6.Rehabilitation	
82 pages	

  - Database
    - Guideline for the Bridge Register Database

1.Introduction	3.How to operate DB
2.Structure of DB	38 pages

Country	Vietnam
Project name	The Project for Capacity Enhancement in Road Maintenance
Period	Phase 1 : Jul 2011 - Jan 2014 Phase 2 : Feb 2015 - Apr 2018
Background	JICA conducted a technical assistance project on capacity enhancement in road maintenance (Phase I Project), from 2011 to 2014 in Directorate for Roads of Vietnam (DRVN) with RMB I as a pilot area, aiming to improve management capacity of Plan-Do-Check-Action (PDCA) cycle for road maintenance including road information management system (i.e. development of road database), pavement maintenance budget planning (i.e. development of PMS and pavement maintenance budget planning), road facility inspection and repair technology, road maintenance administrative procedure and intuition and training programs. In order to upgrade output of Phase I Project to make them applicable to nationwide national road network, support legalization of outputs as DRVN institution, and implement some pilot repair works on new road maintenance technology, JICA and DRVN is now implementing a technical cooperation for "the Project for Capacity Enhancement in Road Maintenance Phase II" (hereinafter referred to as the Project)since February 2015.
Project Purpose	The Project aims to enhance capacity of national road maintenance for DRVN and its subsidiary organizations through applying the JICA Phase I Project outputs, which was implemented under the RMB I jurisdiction as a pilot area, into the rest of the country (RMB II, III and IV jurisdiction),transferring technology at the same time.
Outputs	1.PMS data development technology is improved 2.PMS is upgraded and applied to the planning of trial pavement repair work plans 3.Technical specifications for inspecting road facility and selecting repair work are developed 4.Responsibility assignment and administration procedure are clarified for road maintenance 5. Training implementation and public relations are reinforced

The manuals are written in English and Vietnamese

All assets

- Cycle of Inspection & Maintenance
  - Road Routine Maitenance Manual

    1.Scope
    2.Quoted document
    3.Terms and definitions
    4.General regulations
    5.Road maintenance and rapair technology
    Defects, couses, routine mainte, repair
    of Pavement/Brige/Tunnel/Slope,,
    6.Acceptance of routine maintenance

  - Expressway Maitenance Manual

    1.Scope
    2.Quoted document
    3.Terms and definitions
    4.General regulations
    6.Road maintenance and repair technology
    Defects, couses, routine mainte, repair
    of Pavement/Brige/Tunnel/Slope,,

- Inspection and Diagnosis
  - GUIDELINE FOR ROAD FACILITY INSPECTION

    1.Scope
    2.Quoted document
    3.Terms and definitions
    4.General regulations
    5-13.Inspection
    Classification, Inspection facilities, Typical damages,
    Focus points, inspection method, evaluation,
    data registration, report
    for Pavement/Brige/Tunnel/Slope/Drainage,,

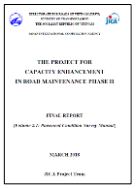
  - Photo Album for Road Facility Defects

    1.Scope
    2-9.Pavement/Brige/Tunnel/Slope/Drainage,,
    Sample Photos and comments of typical damages for each rating

Pavement

- Inspection and Diagnosis
  - Pavement Condition Survey Manual

    1.Overview — Introduction, summary survey, method of mesure/analysis
    2.Management — Plan, Supervision(field work, data analysis, processing),,,
    3.Operation — Plan, field work, data analysis, processing, report,,
    4.Instruction book of survey vehicle
    5.Data preparation
    6.Data validation
    7.Appendix — Specification, drawings of survey vehicle
    576 pages



- Inspection History and DB Management system
  - System User Manual

    1.Pavement mng system data input
    2.Pavement mng system dataset form
    3.Pavement deterioration evaluation model
    4.Strategic budget simulation
    5.Repair work planning module
    6.Pavement condition data display system
    7.Pavement data analysis system
    8.Pavement monitoring system
    9.Road technology information system
    236 pages

Others

- Contract Organization
  - Main Report

    6.5 Technical specification for pavement and bridge repair work
    8.8 Post-project training program
    8.9 Future training program on road asset management

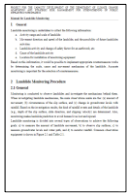
Country	El Salvador
Project name	The Project for Capacity Development of the Department of Climate Change Adaptation and Strategic Risk Management for Strengthening of Public Infrastructure
Period	Phase 1: Jan 2012 – Jan 2015 Phase 2: Aug 2016 – Aug 2021
Background	Due to its geographical conditions, El Salvador has been extremely vulnerable to a variety of natural disasters, such as hurricanes, tropical storms, earthquakes, and volcanic eruptions, which frequently affect its territory and people. The recent trends of increasing natural hazards have posed risks not only on human lives but also on public infrastructures such as roads, bridges, and urban drainage systems. Given this situation, MOPTVDU has established the Department of Climate Change Adaption and Strategic Risk Management (hereinafter referred to as "DACGER"), to integrate and promote the risk prevention and mitigation for public infrastructures. This initiative of reducing the vulnerability of infrastructure from natural disasters is included in the Five-Year Development Plan 2014-2019 and the MOPTVDU's Institutional Strategic Plan 2009-2024. GOJ and JICA have been supporting the disaster risk management sector in El Salvador, as one of the priority areas of cooperation. In 2012-2015, the Project for capacity development of the department of climate change adaptation and strategic risk management for strengthening of public infrastructure, phase I, was implemented for DACGER to improve their capacity of the risk management primarily against rain. Based on the new request from GOES, the GOJ has decided to implement the Project (Phase II) and entrusted it to JICA.
Project Purpose	Capacity of the Department of Climate Change Adaptation and Strategic Risk Management (DACGER) is strengthened to improve disaster risk management of road infrastructure.
Outputs	1. Risk diagnosis ability against earthquake for road infrastructure (bridges, road slopes) is improved. 2. Standard specifications, design guide and cost estimation standards for road disaster risk reduction projects are formulated. 3. DACGER's project management capacity on road disaster risk reduction projects is enhanced. 4. Project outcomes from disaster risk diagnosis and road disaster risk reduction projects are shared with domestic and outside countries.

The manuals are written in English and Spanish

- Slope protection
  - Outline of slope study
    - Geotechnics and Seismic Considerations Manual with a risk management approach for infrastracture in Central America, Topic : Slopes
      - 1.General aspect
      - 2.Preliminary actions for geotechnical study
      - 3.Geotechnical study for slopes
      - 4.Slopes stability analysis and stabilization methods
      - 5.Highway slope countermeasures maintenance and control
      - 6.Risk management
      - 7.Reference sources and bibliografy
      - 8.Annexes
      - 289 pages

  - Survey and Design
    - Design Manual for Countermeasures for Slope Problems
      - 1. Slope protection works
      - 2. Slope drainage
      - 3. Countermeasure against falling rock and rock collapse
      - 51 pages

  - Monitoring
    - Manual for Landslide Monitoring
      - 1.General
      - 2.Landslide monitoring procedure...equipment and explanation
      - 32 pages



- Road accessories
  - Survey and Design
    - Gguideline for Investigation and Design of Drainage Facilities in Urban Area for Risk Reduction Measures on Road Disasters
      - Part 1: Risk reduction measures on undergraoud cave-in of the road
      - 1.Damage investigation
      - 2.Action for potential risk assesment
      - 3.Proposed recovery method
      - Part 2: Risk reduction measures on mitigation of road submergence
      - 4.Rainfall analysis
      - 5.Runoff analysis
      - 72 pages

  - Construction
    - Standard Specifications for Risk Reduction Measures on Road Submergence and Cave-in
      - 1.General requirement
      - 2.Project requirement
      - 3.Standards
      - 4.Materials
      - 5.Construction requirements for Drainage facilities
      - 6.Work in public roadways
      - 7. Public road reinstatement
      - 8.Reinstatement of other surfaces
      - 9.Other reinstatement
      - 16 pages

Country	Democratic Republic of the Congo (DRC)
Project name	The Project for Capacity Development of Road Maintenance Management
Period	Feb 2016 – May 2019
Background	The transport infrastructure in DRC has much space for further development after the end of a long-lasting civil war. Since the insufficient development of transport infrastructure is one of the causes of stagnation in social and economic development, GDRC has decided the transport infrastructure development as a top priority policy in the "Second Growth and Poverty Strategy Document, Oct 2011" and "5 Year Action Plan (2012 - 2016)". Furthermore, GDRC emphasizes the importance of rehabilitation of deteriorated transport infrastructures for smooth traffic and transportation. The condition of existing road network is comparatively had, only 2% of which has pavement. To improve this situation OR established "Road network improvement 5 years plan. whose targets are expansion of road network and repair, rehabilitation, and pavement of existing arterial roads. At the same time. GDRC acknowledges the importance of maintenance of paved roads for securing the minimum traffic and transport in the country.
Project Purpose	Asphalt Paved (AP) road maintenance capacity of OR and OVD in the project sites is developed
Outputs	1. AP road maintenance cycle is established in OR and OVD with clearly defined roles and responsibilities in the project sites 2. Technical guidelines on AP road maintenance are developed 3. AP road maintenance skills and knowledge of OR's and OVD's technical staffs are improved in the project sites

The manuals are written in English and French

Pavement

Inspection - Maintenance - Repair

Manual for Maintenance and Repair of Asphalt Paved Roads

1.Overview of maintenance and repair of asphalted roads
 -Inportance
 -Road use and maintenance cycle
 -Implementation procedure
 -Persons involved in maintenance and repair
2.Work implementation structure
 -Organization
 -System for sharing information
 -Machins and installations
3.Planning and implementation of work
 -Work planning
 -Arrangement before works
 -Construction site log
 -Daily attachment
4.Road safety and environmental measures
5.Patrol
 -Daily/ Night/ Periodic/ Extraordinaly patrol
6.Maintenance method
 -Diagnosis of road surface, rod structure, road sanitation works
 -Classification of deteriorations
 -Observation, investigation or road surface
 -Maintenance and repair procedure
 -Evaluation of deterioration
 -Classification/Evaluation of deterioration of drainage
7.Repair method
 -Patching
 -Filling of cracks,
 -Surface treatment
 -Reconstruction
 -Treatment of flushing
 -Maintenance for drainage
8.Rehabilitation methods
 -Overlay
 -Reconstruction
 -Widening
9.Quality control
 -Quality control before/ during/ after work
10.Database
11.Supervision of works

Country	Kenya
Project name	The Project for Strengthening of Capacity on Road Maintenance Management Through Contracting
Period	Phase 1: May 2010 – May 2013 Phase 2: Nov 2013 – Apr 2016 Phase 3: Dec 2016 – Nov 2019
Background	In Kenya about 90% of all domestic transport relies on road transport. Road construction and maintenance is a key enabler for sustainable development, facilitating cross border and domestic trade as well as providing people with access to market and social services. The Kenyan government actively engages private contractors in road maintenance works. Performance based contract (PBC) is one of such contracts in which a contractor is required to meet road maintenance levels and payment is contingent on their successful achievements. In Kenya, pilot projects using performance-based contracts started in 2010. During the phase 1 of the project JICA assisted in various activities to introduce performance-based contracts for road maintenance works. This includes the tabulation of unit and productivity rates applicable to such contracts, introduction of term contracting, preparation of standard PBC tender document and the introduction of the Vehicle Intelligent Monitoring System (Dynamic Response Intelligent Monitoring System: DRIMS) to conduct an IRI survey. Phase 2 of the project commenced to further the capacity strengthening of road maintenance work with much focus on PBC. While phase 2 has been successfully implemented, there is a strong need for the next phase to streamline PCDA cycle for the road maintenance by using the term contract for outsourced works.
Project Purpose	Road maintenance management methodologies are improved and widely applied in Kenya.
Outputs	(1) Cost estimation capacity of road agencies (RAs) is enhanced. (2) Management capacity of RAs to maintain roads under PBC is improved. (3) Institutional capacity to conduct PBC (term contract) training is improved (for KIHBT, NCA, RAs, etc.) (4) DRIMS is widely used for road conditions assessment by RAs in Kenya and, upon request, in neighboring countries.

* The manuals for DRIMS survey are unacquired

The manuals are written in English

Cost Estimation

for Maintenance works

Cost Estimation Manual for Road Maintenance Works

1.Work items and coding
2.Cost configration
3.Price list and source
4.Haulage cost
5.Unit quantity and productivity
6.Indirect work costs
7.Overheads and Profit
8.Unit rates list

Includs;
- routine maintenance
- small repair
- major repair

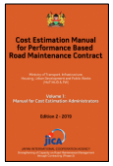
Popular edition: 56 pages
Complete edition: 631 pages

for Performance based contract

Cost Estimation Manual for Performance Based Road Maintenance Contract

1.Introduction
2.Importance of Cost Estimation
3 Role of Cost Estimation Administrator
4 PDCA Cycle for Cost Estimation
5 Cost Estimation of PBC Works
6 Cost and Other Affiliated Surveys
7 Analytical Results Based on Surveys Conducted
8 Manual Revisions

Vol 1: Administrators ..134 pages
Vol 2: Gov cost estimator..124 pages
Vol 3: Contractor ...82 pages



iCostes Manual for Cost Estimation of Performance Based Road Maintenande Contracts

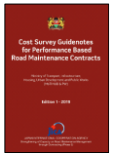
1.General information
2.System summaries
3.Cost estimation
4.Detail system structure
5.System and data administration
67 pages

Cost Survey Guidenotes for Performance Based Road Maintenande Contracts

Part 1: Cost survey guidenote
1.Introduction
2 Unit Price Survey
3 Quantity Survey
4 Productivity Survey

Part 2:Quantification guidenote on selected 6 works
Part 3:Data management and sample data

120 pages



Contract

Performance Based Contract

Performance Based Road Maintenance Contract (PBC Guideline)

Introduction
1.Background
2.Outline of PBC
3.Sample photos from PBC
4.Reference document

Part 1 : Service level setting for PBC
5.Objective
6.Standard service level category
7.Service level setting
8.IRI levels for pavement

Part 2: Work management under PBC
9.Objective
10.PBC work flow
11.Actions by the contractor
12.Sample forms
13.Recommended work flows for PBC

Part 3: Service level inspection under PBC
14.Objective
15.What is "Service Level Inspection"?
16.Inspection Methods
17.Self-Inspection
18.Ad hoc Inspection
19.Formal Inspection
20.Formal Inspection
(Supplementary and Follow-up Site Visit)
21.Monthly Statement and Calculation of Payment Length

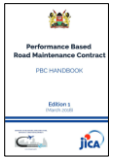
Part 4:Contractor's Evaluation for PBC
22.Objective
23.Evaluation Methods
24.Contract Management using Evaluation Scores

Part 5 :Quality and Environmental Management in PBC
25.Objective
26.Quality management
27.Quality Assurance Procedures Typical to the PBC Works and the Rehabilitation Works
28.Quality Control Procedures Typical to the Improvement Works, the Emergency Works and the Instructed Works
29.Environmental Management
30.Environmental Management Procedures Typical to PBC

198 pages

Performance Based Road Maintenance Contract (PBC Handbook)

1.Concept of PBC Guideline
2.Workflow for PBC Works
3.Establishment of the Self-Control Unit
4.Criteria of Standard Service Level (Paved)
Road Usability, User Comfort, Durability
5.Criteria of Standard Service Level (Unpaved)
Road Usability, User Comfort, Durability
6.Contractor's Evaluation
Appendix: Failure Case
108 pages



Trial/Pilot Phase PBC Contractor's Evaluation Handbook

1.Objectives of Contractor's Evaluation system
2.Evaluation procedure
3.Evaluation criteria
4.Implementation scheme and framework
5.How to evaluate hybrid PBC work?
6. Notification to the contractors
7. How to utilize evaluation results in the future?
21 pages

Standard Tender Document

- Draft Standard Tender Document for Performance Based Contract (Road Maintenance Works)
- Standard Tender Document for Procurement of Road Maintenance Works under Performance Based Term Contract

Form of tender documents
0.Invitation letter
1.Tender procedure
2.Works and service requirement
3.Condition of contract and contract forms
4.Specification (Performance specification, Special specification, etc.)
246 pages + 192 pages

6.4 Classification and Comparison of the Technical Manuals

Based on the above mentioned information and summarization, the Technical Manuals are classified using the indicator shown in Figure 6.2, which is extracted from Figure2.1 (Road AM indicator structural diagram of Chapter 2).

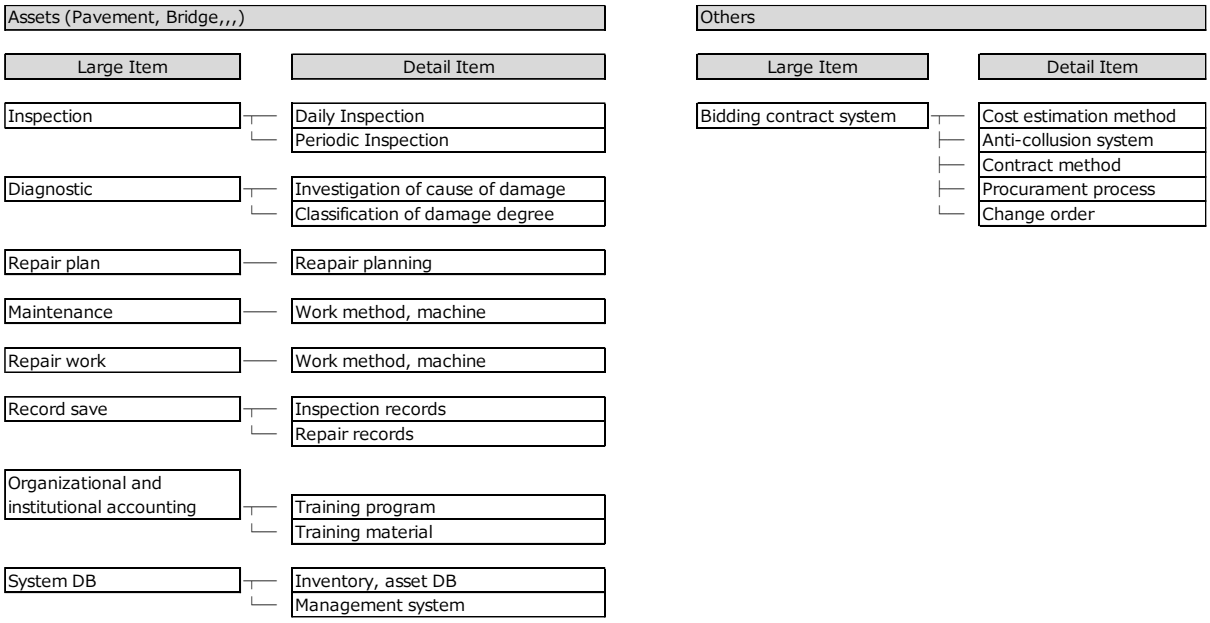


Figure 6.2 Classification indicator for the technical manuals

Table 6.2 shows the result of the classification and comparison. In this table, "●" denotes an item that is fully covered in the Manuals, "○" denotes an item that is only partially covered or imperfectly mentioned.

NOTE: These marks mean the coverage found only in the Manuals supported by JICA's cooperation projects, and not those including from other donors, international cooperation organizations, or country-specific manuals developed by themselves.

Table 6.2 Classification and comparison result of the technical manuals

Asset	Large Item	Detail Item	Asia								Latin America	Africa	
			Bangladesh	Cambodia	Kyrgyz	Philippines	Sri Lanka	Thailand	Timor-Leste	Vietnam	El Salvador	DR Congo	Kenya
Pavement	Inspection	Daily Inspection								●		●	
		Periodic Inspection		○[1]					○[2]	●		●	
	Diagnostic	Investigation of cause and damage							○[2]	●		○[1]	
		Classification of damage degree		○[1]						●		○[1]	
	Repair plan	Repair planning		○[1]		●				●		●	
	Maintenance	Work method, machine		●		●			○[2]	●		●	
	Repair work	Work method, machine		●		●			○[2]	●		●	
	Record save	Inspection records		○[1]					●	●		●	
		Repair records								●			
	Organizational and institutional accounting	Training program		○[1]						●			
		Training material		○[1]									
	System DB	Inventory, asset DB							○[3]	●		○[3]	
		Management system											
Bridge	Inspection	Daily Inspection	●	●			●	●		●			
		Periodic Inspection	●	●		●	●	●	○[2]	●			
	Diagnostic	Investigation of cause and damage	●	●			●	●	○[2]	●			
		Classification of damage degree	●	●			●	●		●			
	Repair plan	Repair planning	●	●		●	●	●					
	Maintenance	Work method, machine	●	●		●	●		○[2]	●			
	Repair work	Work method, machine	●	●		●	●	○5	○[2]	●			
	Record save	Inspection records	●	●	●		●	●	●	●			
		Repair records					●						
	Organizational and institutional accounting	Training program	●	●									
		Training material	●										
	System DB	Inventory, asset DB	●	○[2]	●		●	●	●				
		Management system					○[4]	●					
Special Bridge	Inspection	Daily Inspection				●							
		Periodic Inspection				●							
	Diagnostic	Investigation of cause and damage				●							
		Classification of damage degree				●							
	Repair plan	Repair planning				●							

Asset	Large Item	Detail Item	Asia								Latin America	Africa	
			Bangladesh	Cambodia	Kyrgyz	Philippines	Sri Lanka	Thailand	Timor-Leste	Vietnam	El Salvador	DR Congo	Kenya
	Maintenance	Work method, machine				●							
	Repair work	Work method, machine											
	Organizational and institutional accounting	Training program											
		Training material											
	Record save	Inspection records											
		Repair records											
Slope Protection	Inspection	Daily Inspection			●				○[2]	●			
		Periodic Inspection							○[2]	●			
	Diagnostic	Investigation of cause and damage			●				○[2]	●			
		Classification of damage degree			●					●			
	Repair plan	Repair planning			●								
	Maintenance	Work method, machine							○[2]	●			
	Repair work	Work method, machine			●				●	●			
	Record save	Inspection records			●				●	●			
		Repair records											
	Organizational and institutional accounting	Training program											
		Training material											
	System DB	Inventory, asset DB							○[1]				
		Management system											
Tunnel	Inspection	Daily Inspection								●			
		Periodic Inspection								●			
	Diagnostic	Investigation of cause and damage								●			
		Classification of damage degree											
	Repair plan	Repair planning											
	Maintenance	Work method, machine								●			
	Repair work	Work method, machine								●			
	Record save	Inspection records			●					●			
		Repair records											
	Organizational and institutional accounting	Training program											
		Training material											
	System DB	Inventory, asset DB			●								
		Management system											
Road accessories	Inspection	Daily Inspection							○[2]	●			
		Periodic Inspection							○[2]	●			

Asset	Large Item	Detail Item	Asia								Latin America	Africa	
			Bangladesh	Cambodia	Kyrgyz	Philippines	Sri Lanka	Thailand	Timor-Leste	Vietnam	El Salvador	DR Congo	Kenya
	Diagnostic	Investigation of cause and damage							○[2]	●			
		Classification of damage degree								●			
	Repair plan	Repair planning				●							
	Maintenance	Work method, machine				●			○[2]	●			
	Repair work	Work method, machine				●			○[2]	●			
	Record save	Inspection records							●	●			
		Repair records											
	Organizational and institutional accounting	Training program											
		Training material											
	System DB	Inventory, asset DB							○[3]				
		Management system											
Bidding contract system		Cost estimation method											●
		Anti-collusion system											●
		Contract method								●			●
		Procurement process											●
		Change order											●
Legend and Subscript			● : Items covered fully in the Manuals ○ : Items covered partially or imperfectly										
			○[1] : Limited to simple item (e.g. Inspection item is limited to only IRI) ○[2] : Mentioned outline only ○[3] : Including DB, not inventory, or vice versa ○[4] : Not covered Long-term plan ○[5] : Limited to flood countermeasures										

From the above table, the following tendency is seen.

(1) Many of past JICA's cooperation projects targeted Bridge asset maintenance, and

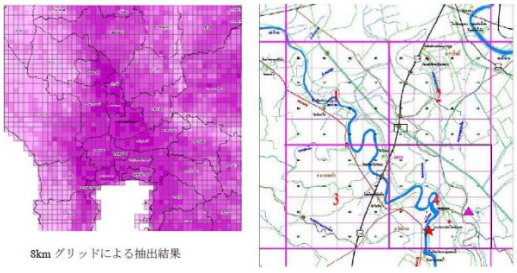
(2) Even in the same asset target, the coverage scopes are considerably varied between projects.

The indicator structure seems to be a good match with the items that should be covered in the technical manuals. It means there is a possibility to consider this indicator in combination with the Road AM evaluation results.

These large variations of coverage come from the project context. Table 6.3 shows the major contexts which are described in reports and project news websites.

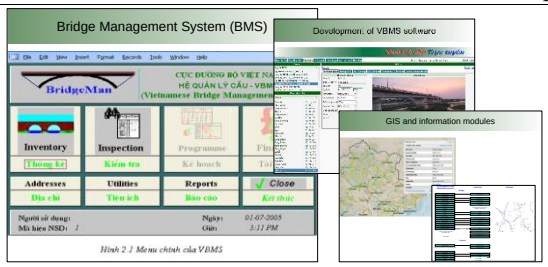
Table 6.3 Major context of each technical cooperation project.

Country	Major context
Cambodia	PMS and Survey vehicles were already installed/provided by other donors (Australian aid, ROMDAS). So JICA's project focused an easy evaluation – management method with IRI (DRIMS).
Thailand	Thailand's original management method was already available, which supports maintenance priority decisions of missing links with 8km x 8km of 8000 matrix which covers the whole country. Based on this, JICA's project focused on inspection/maintenance for flood countermeasure and long-termed BMS with deterioration prediction.
Philippines	BMS was already installed/provided by other donors (WB, ADB). So JICA's project focused on supporting its operation, engineering inspection, special bridges, and nationwide expansion.
Viet Nam	BMS has been developed in another JICA's Yen loan project (Engineering package for "Transport Sector Loan for Road Network Improvement"), and bridge inspection / management assistances were also implemented in other long bridge ODA projects. Moreover, parallel with this WB supported the whole road asset management project (VRAMP). Considering this situation, JICA's project focused on capacity enhancement, organizational improvement, nationwide expansion, and preparation of comprehensive manuals.
Timor-Leste	The road service project was conducted based on a previous road works project. The main object seemed to introduce an initial maintenance and establishment of appropriate repairs.
El Salvador	The project focuses on risk management, causal analysis, and selection of appropriate repair methods.
Kenya	Based on the rapid and strong needs for performance-based contract methods for road maintenance, the Project focused on standardization, simplification, preparation of manuals and organizational improvement.
DR Congo	The project focused on urban road network maintenance with a small number of staffs, simple equipment, and fewer inspection items.



(1) A unique road management method with matrix

Source: Thailand, "Final report of the Project for Bridge Master Plan and Bridge Maintenance Ability in Rural Area"



(2) BMS in engineering package of Yen loan project

Source: Execution agency (Directorate for Roads in Vietnam, MOT)

Figure 6.3 Sample of other or existing management systems

6.5 The Overall Picture of Technical Manuals

As mentioned above, the coverage scopes are considerably varied between the Projects based on their backgrounds or the technical level of target countries and such. However, looking through some of these projects, we can see that most items can be covered in tandem with each other, creating "the overall picture of Technical Manuals."

(1) The draft overall picture

Figure 6.4 shows the draft of the overall picture of Technical Manuals, formulated by complementing each manual with references to the road AM evaluation indicator. This picture should serve as a Master plan for road maintenance management and should be customizable with components that can be attached or detached according to various situations of target countries. The concept of customization is roughly divided into five directions, and are shown conceptually as blue arrows in Figure 6.4,or described in Table 6.4.

Table 6.4 Points to be customized according to local situation or needs

Item	Explanation	Remarks or Examples
1. Selection or adjustment in Project design stage	Coordination of support area / scope during request-adoption Expansion to other assets or nationwide Combination with other projects	Expansion to other assets: Kyrgyz: Capacity Building of Road Maintenance -> Maintenance of Bridges and Tunnels -> Road Slope Disaster Prevention Management Nationwide expansion Philippines: Phase I, II ... implemented with selected regional offices -> Phase III ... whole of counterpart agency Combination with other projects Vietnam: To integrate the other cooperation projects, JICA's Phase 2 project covered inspection manuals for all assets (Pavement, Bridge, Slope, Tunnel, Accessories)

Item	Explanation	Remarks or Examples
2. Adjustment to technical level	Deepening or simplifying to meet the availability of material/machines, or target assets.	Simplifying: Cambodia: simple road management with IRI DR Congo: simple diagnosis with photos on vehicle Deepening: Vietnam: Additional item on pavement condition survey
3. Deepening of Asset Management	Higher functions of management systems for Mid/Long-term maintenance plan	Thailand (BMS) and Vietnam (PMS) Implementation of long-term deterioration forecast.
4. Multi-function of support system	Extension of Database, integration of various systems, nationwide unified system with web connectivity	Integration of systems: Sri Lanka: Bundling each system with the portal site Electronic library to store the latest manuals Vietnam: Web systemization of local input system which developed in Phase 1, to expand nationwide
5. Respond to changes of implementation body and institutional transition	Changes such as. - Direct operation -> Outsourcing -> Performance based contract scheme, - Cooperation with private sector.	Outsourcing: Philippines: Manuals including standard contract documents, procurement process, supervising, defect liability etc. Cooperation with private sector Vietnam: Registration and reference system for new technology in public sector Performance based contract Kenya: PBC guidelines, standard tender documents

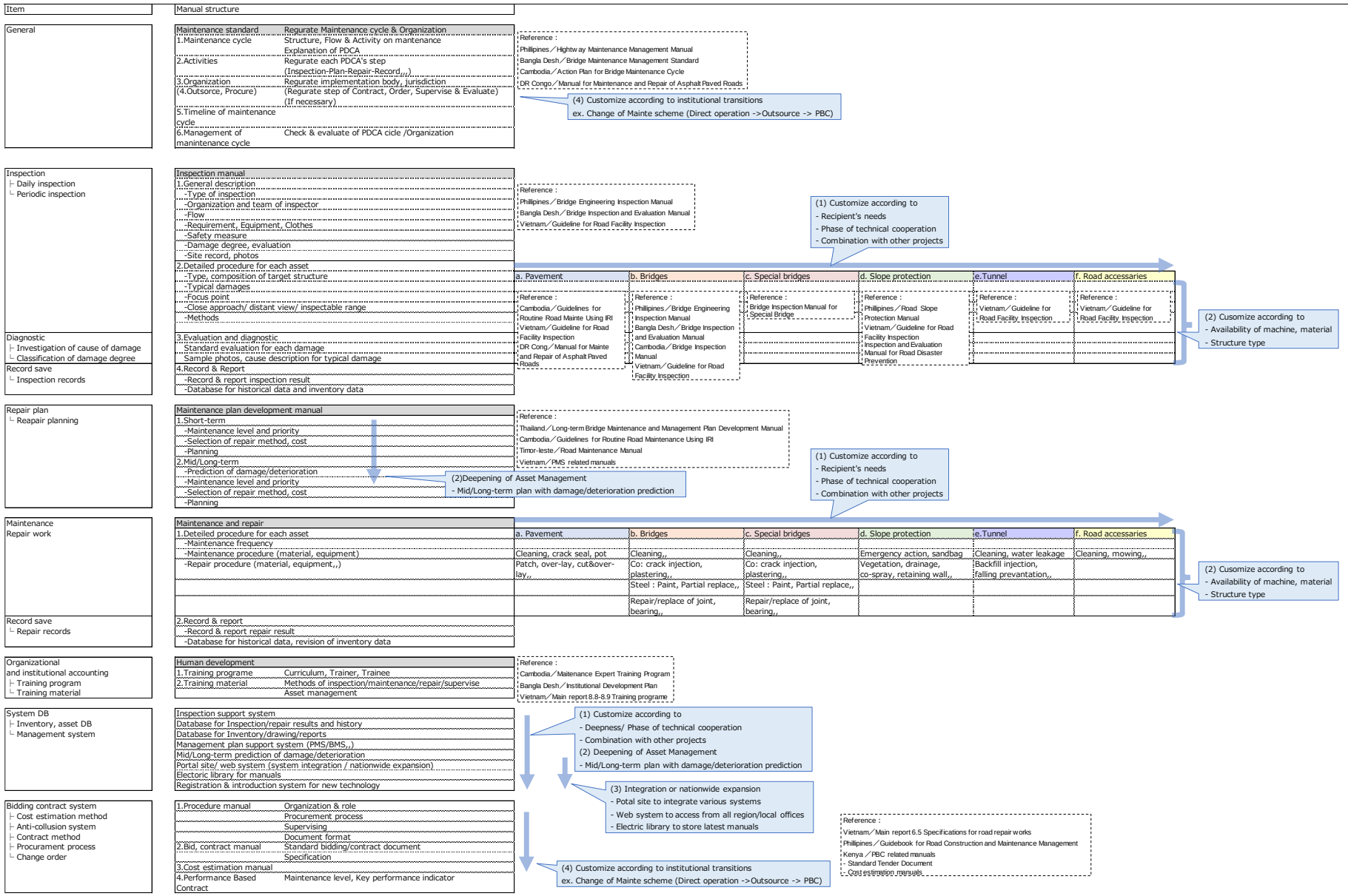


Figure 6.4 The draft "overall picture of technical manuals" and Points to be customized

(2) Usage of "overall picture of the Manuals" (proposed)

The above-mentioned overall picture is customizable to suit many countries and situations to develop new technical manuals. Furthermore, it could also act as a "Portfolio" of the whole manual system which JICA can support.

During a technical cooperation project, the achievements of the project sometimes may deviate from the C/P's expectations, therefore it is important to adjust and coordinate the direction between donor and recipients. By presenting this overall image in a timely manner for the project progress, both sides would be able to properly share this concrete image. More specifically, this image could help show and explain the step by step process of cooperation, from the early stages of maintenance technology with simple equipment and limited items to latter, more advanced stages.

Table 6.5 Time lapse usage of "overall picture of the Manuals" during projects

Step of the project	Items	Usage
Project design stage	Request - Adoption Adjustment & coordination of survey mission. Initial formulation of Project design.	✓ Add or remove to the scope of project based on the overall picture ✓ Check the existing manuals or other projects, and discuss possible combinations (if any) ✓ Examine hidden needs
Implementation stage	Holding JCC (Kick-off Mtg) Dispatch of experts Assign of C/P personnel	✓ Check and confirm the manuals to be developed ✓ Develop the manuals collaboratively
Monitoring	Progress check and monitoring by JCC Revision, measuring, and recommendations (if any)	✓ Consider and adjust items which should be added or revised.
At project completion	Confirmation of achievement	✓ Confirm the manuals which were developed in the project.
Post project monitoring	Check continuity and rooting of the project achievement	✓ Share the concrete image and discuss any further cooperation (deepening, expansion)