CHAPTER 5 TASK 2 IMPROVEMENT OF MPWT LABORATORY EQUIPMENT

5.1 Review and Analysis of Actual Status of Capacity of Laboratory and Staff

Laboratory consists of three departments (Administration, Account and Technical Department) and the technical department is divided to four sections (Geo-technical, Construction Material, Road and Customer Section). As of January 2010, there were 29 staff assigned to the above departments and sections.

The organization of laboratory in January 2010 is shown below.

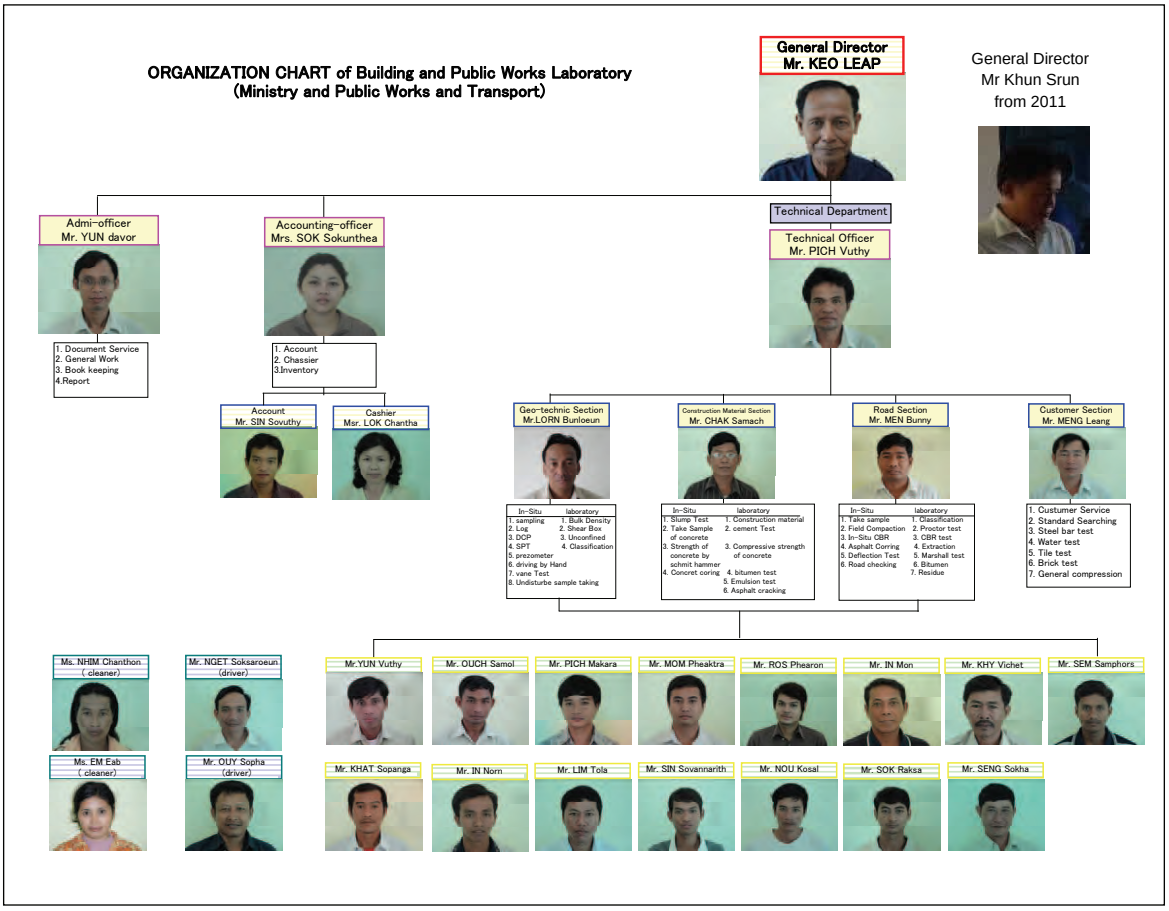


Figure 5.1-1 Organization of Public Work Laboratory (as of January 2010)

Clients and kinds of works are indicated as follows.

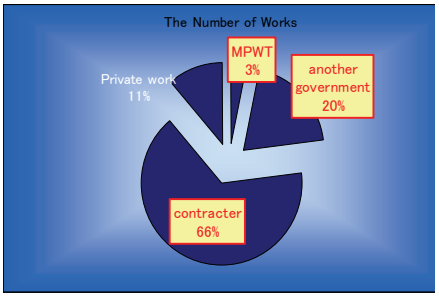
- 89 % of works are from public works.
- 88 % of works are from road works.

More details in term of number and works are shown below.

Number of Works

From 10/Jan/2010
To 10/May/2010 4months

Client	MPWT	another government	contracter	Private work	total nos.
nos.	14	84	281	47	426



Kind of Works

Kind of test	Road work	Building work	another	total
nos.	397	7	44	448

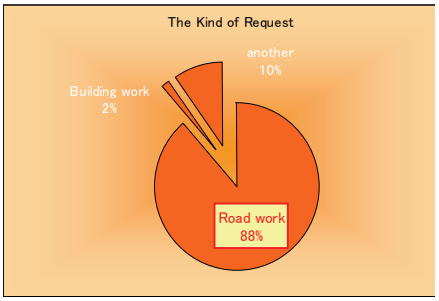


Figure 5.1-2 Details of Number and Kind of Works in Laboratory

Most tests conducted at the laboratory are for construction works in Cambodia and the laboratory is working in various fields, such as tests of soil, concrete and road, and site inspection. Daily activities in the laboratory are shown below.

Photo 5.1-1 Soil Test

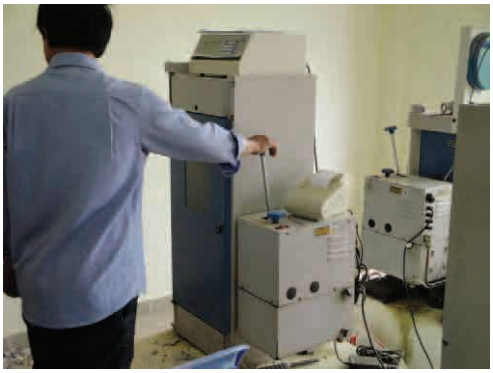



Photo 5.1-2 Concrete Test



Photo 5.1-3 Site Inspection

After observation and review on the activities in the laboratory, it was found that laboratory had sufficient capability of various tests but ability for quality control was in question.

Quality control for road works is divided into the three categories below.

- Search of borrow pit and quarry, and material test for borrow pit and quarry
- Mix design and confirmation of design in the specification
- Daily quality control

The laboratory is currently in charge of the following tasks only.

- Material test for borrow pit and quarry
- Confirmation of mix design in the specification

In future, the laboratory shall be involved in the selection of borrow pit and quarry as well as mix design itself.

In addition, certain deficiencies were found in the test record sheet currently using and the project team suggested redesigning tests sheet shown in Figure 5.1-3.

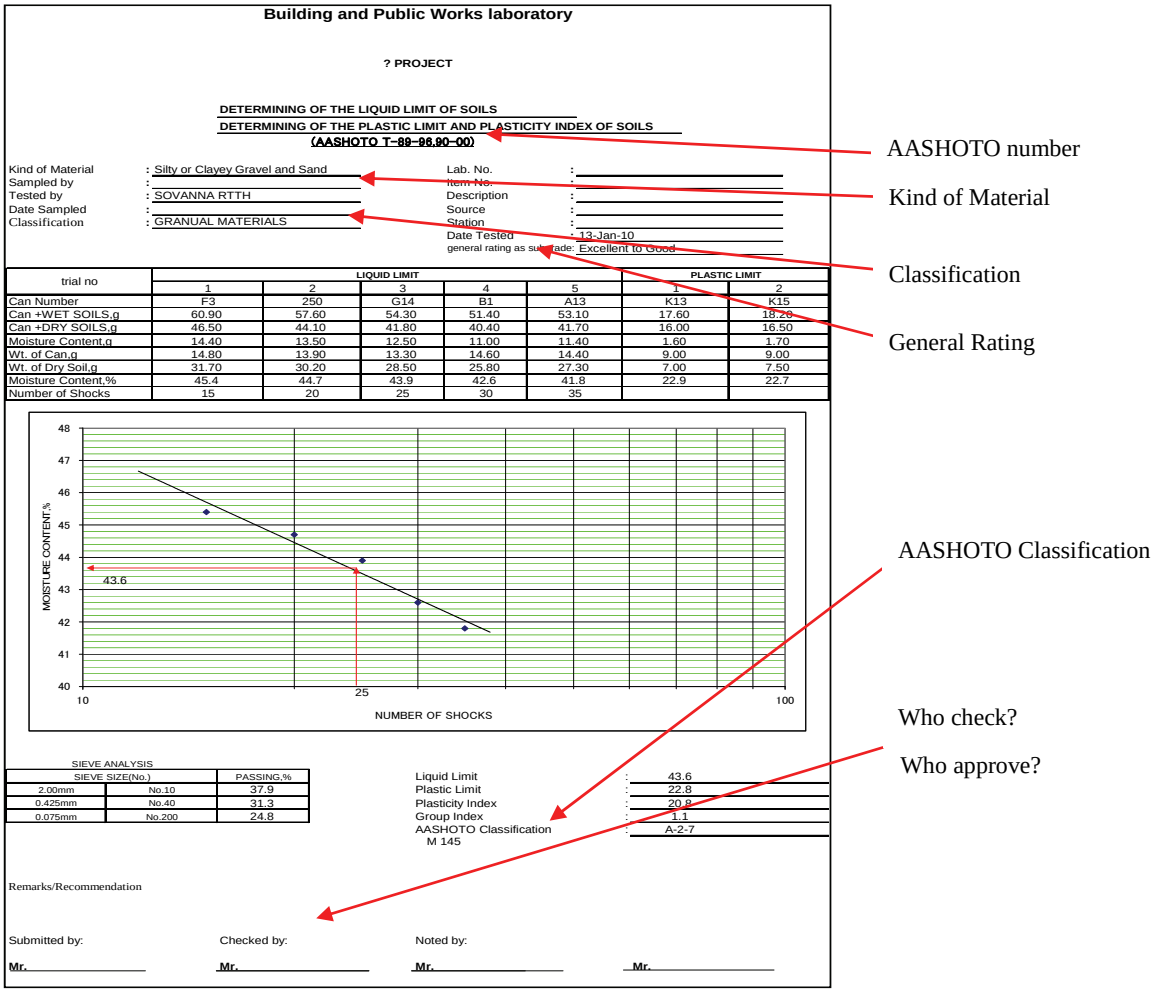


Figure 5.1-3 Sample of Test Report

5.2 Selection and Procedure of Laboratory Equipment Supply

At first, American Association of State Highway and Transportation Officials (AASHTO) test items for quality control of earthworks and pavement works are summarized and shown below.

Earthwork

(1) Embankment

Specification	AASHTO	
Classification	Test Item	Test method
material	Moisture-Density	T 99 or T 180
	Modified CBR	T 193
	Sieve Analysis,	T 27
site	Degree of compaction	T191

(2) Sub-grade

Specification	ASSHTO M145	
Classification	Test Item	Test method
material	Liquid Limit	T 89
	Plasticity Index	T 90
	Moisture-Density	T 99 or T 180
	Modified CBR	T 193
site	moisture content	T 27,T 93
	Sieve Analysis,	T 27
	Degree of compaction	T 191
	proof rolling	-

Pavement Work

(1) Sub-base

Specification	AASHTO	
Classification	Test Item	Test method
material	Sieve Analysis,	T 27
	Liquid Limit	T 89
	Plasticity Index	T 90
	Moisture-Density	T 180
	Modified CBR	T 193
site	Degree of compaction	T 191
	proof rolling	-

(2) Base-course

Specification	AASHTO	
Classification	Test Item	Test method
material	Sieve Analysis	T 27,T2(fine aggregate)
	Abrasion loss %	T 96
	Liquid Limit	T 89
	Plasticity Index	T 90
	Moisture-Density Relations	T 180
	Modified CBR	T 193
	Combined Gradind	-
site	moisture content	T 27,T 93
	Degree of compaction	T 191

(3) Asphalt Base and Surface Courses

(a) Materials

・Coarse aggregate

Specification	AASHTO M80
NAME	test method
Sieve analysis	T 27
Abrasion loss %	T 96
Soundness %	T104
specific gravity	T 85
absorption %	
Clay lumps and friableparticles in aggregate	T112

・Fine aggregate and Filler

Specification	AASHTO M29,M17
NAME	test method
Sieve analysis	T 27
Material Finer than No.4 Sieve	T 11
Soundness %	T104
specific gravity	T 85
absorption %	
Liquid Limit	T 89
Plasticity Index	T 90
Clay lumps and friableparticles in aggregate	T112

・Bituminous Materials

Specification		AASHTO M20
Classification	Test Item	Test method
material	Penetrarion at 25 degrees	T 49
	Flash point,Cleveland Open Cup degrees	T 48
	Ductility at 25 degrees;5cm/min cm	T 51
	Solubility in Trichloroethylene	T 78
	Loss on heating,percent	T 47
	Penetration of residue,percent of original	T 49
	Ductility of residue at 25 degrees;5cm/min cm	T 55
	Softening Point of Bitumen(Ring-Ball Apparatus)	T 53

(b) Mix Design

・Marshall test

Specification		AASHTO
Classification	Test Item	Test method
mix design	MARSHALL TEST	T245
mix design	Kinematic Viscosity	T 201

Quality Controll		
Classification	Test Item	Test method
quality controll	marshall density	T245
	temperature	
	sieve analysis(hot bin)	T 27
	content of bitumen(asphalt mixture)	

survey		
Classification	Test Item	Test method
survey	roughness	portable skid resistance tester
survey	rutting	3m straight edge

In order to make procurement plan for laboratory equipment, review of existing equipment in the laboratory was made together with suggested equipment to procure, and the results are shown below.

Distillation Apparatus

Existing

· Broken

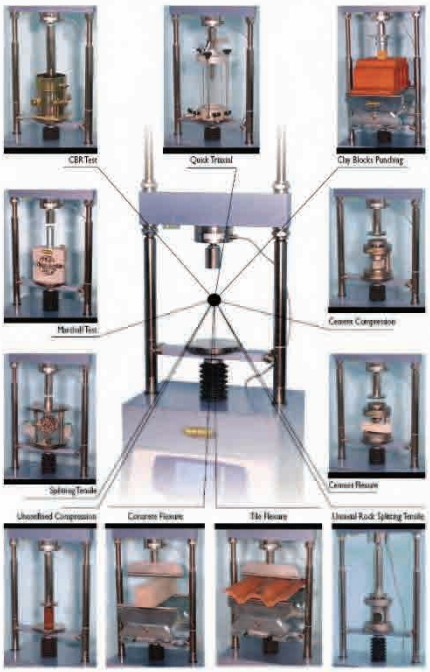
Plan

CBR and Marshall Apparatus

Existing

· Very old or broken

Plan



Sieve

Existing

- Made in many country
- Old and can not combined

Plan

Divided into each purpose

Sub grade and base course　　Asphalt　　Concrete

Sieve sizes

Embankment,Sub-Grade		Subbase,Base-Course		Bituminous Paving Mixtures		concrete		
AASHTO M 57		AASHTO M147		AASHTO M 17,29,43		AASHTO M043,M006		
Inch	mm	Inch	mm	Inch	mm			
3in.	75							1
2in.	50.8	2in.	50.8			2in.	50.8	3
				1 1/2 in.	37.5	1 1/2 in.	37.5	2
1in.	25.4	1in.	25.4			1in.	25.4	3
				3/4 in.	19.0	3/4 in.	19.0	2
				1/2 in.	12.5	1/2 in.	12.5	2
3/8 in.	9.5	3/8 in.	9.5	3/8 in.	9.5	3/8 in.	9.5	4
No.4	4.75	No. 4	4.75	No. 4	4.75	No. 4	4.75	4
				No. 8	2.36	No. 8	2.36	2
No.10	2.0	No. 10	2.0					2
				No. 16	1.18	No. 16	1.18	2
				No. 30	0.6	No. 30	0.6	2
No.40	0.425	No. 40	0.425					2
				No. 50	0.3	No. 50	0.3	2
				No.100	0.15	No.100	0.15	2
No.200	0.075	No.200	0.075	No.200	0.075	No.200	0.075	4

Electric Balance

Existing

Readability is o.1gram

- Not followed AASHTO specification

Plan

0.1 mgram, followed AASHTO specification

Marshall Compaction

Existing

Plan

Automatic compaction , followed AASHTO specification

- mannual
- AASHTO specified temperature and speed

Kinematic Viscometer

Existing

Plan

Automatic visco meter , followed AASHTO specification

- 2 Nos. of Viscometer but broken

In view of the above comparison (existing and plan) and further consideration for quality control on road works, the test apparatuses and devices (the detail list of which is shown in the Appendix 4) were recommended to supply and accepted in the C/P meeting, the management meeting and the EC meeting.

Supplied test equipment was combined with the existing test equipment. Test for road pavement is now complete in one place. Arrangement of all equipment is shown in the figure below.

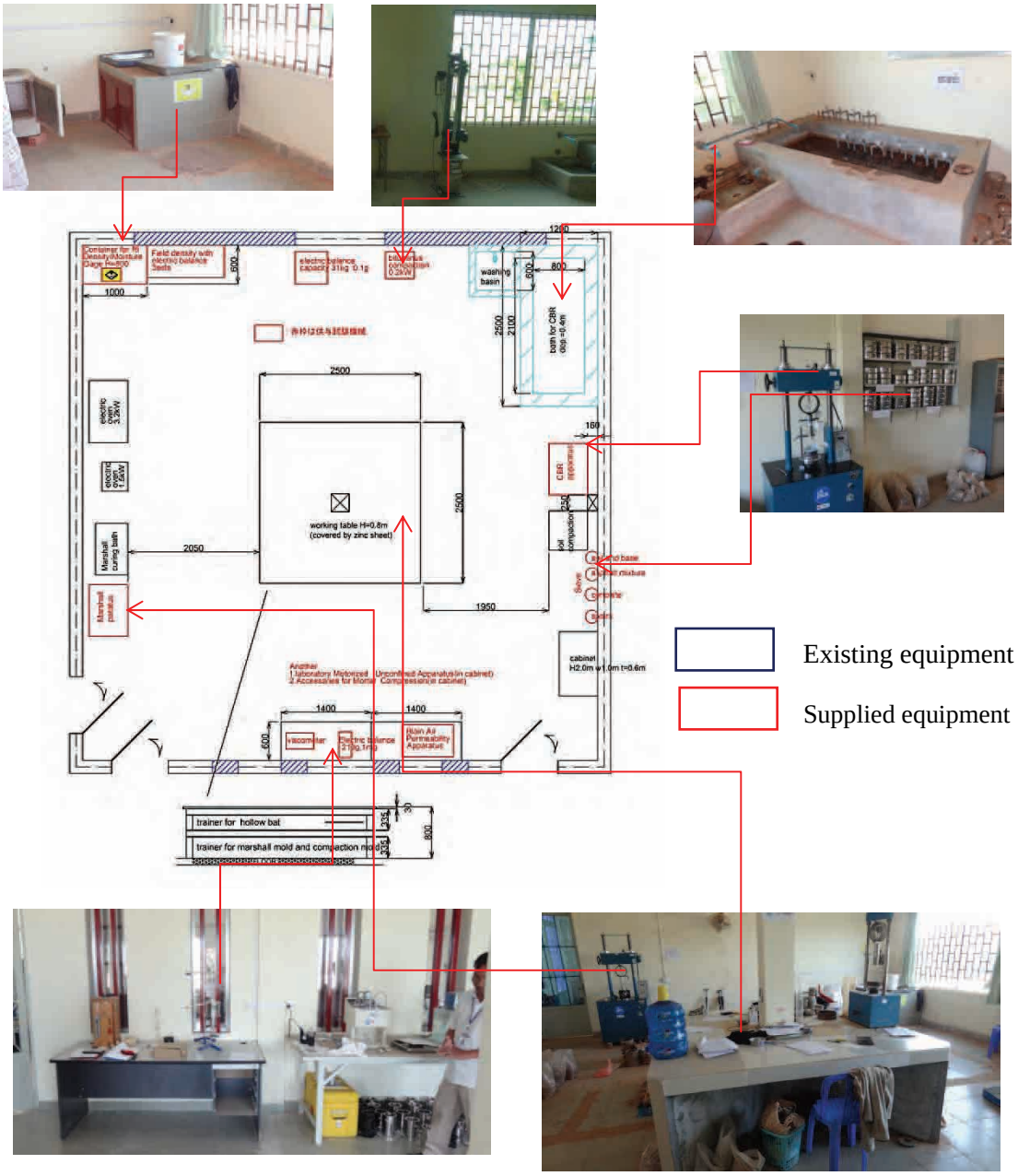


Figure 5.2-1 Arrangement of Equipment in Laboratory

In addition, trainings to laboratory staff were conducted for those new equipment, when equipment was installed. The training was for equipment for kinematic viscosity and radio isotope moisture / density gauge. The following photos show the trainings.

Photo 5.2-1 Trainings for Use of New Equipment

5.3 Monitoring and Maintenance of Supplied Equipment

By the end of September 2011, all equipment provided by the Project was installed in the laboratory as stated in Section 5.2. Equipment then began to be used by staff of the laboratory and they are managing the equipment well by recording of usage with the record books.

The following photos show usage of supplied equipment and daily schedule board at laboratory.

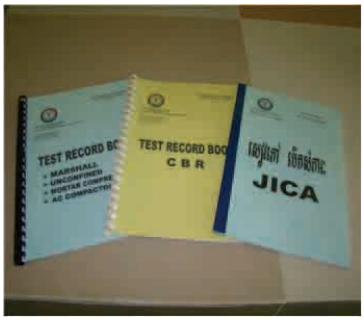


Photo 5.3-1 Record Books

Photo 5.3-2 Usage of Equipment & Schedule Board

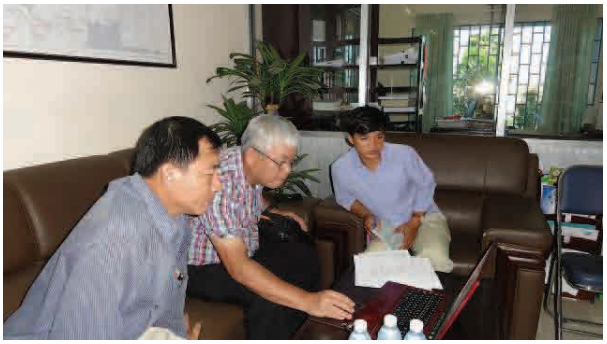
In addition, cleanliness and tidiness at the laboratory was much improved and the following photos show working conditions before and after.

Photo 5.3-3 Working Environment before and after New Equipment Installed

5.4 Recommendation on Improvement of Laboratory Equipment and Function

(1) The project team made several trainings to the laboratory staff as well as MPWT/DPWT staff, such as mix design of base course, mix design of concrete and field density test on job site. The project team recommends that trainings for equipment and test procedures shall be conducted by the laboratory staff to staff in MPWT and DPWT.

Training of Mix Design of Base Course



Training of Mix Design of Concrete

Training of Field Density Test

Photo 5.4-1 Trainings to Staff

(2) It is common practice that equipment in laboratory shall be calibrated regularly to make sure all equipment indicates accurate results. Since certain equipment in the laboratory seems questioned in term of accuracy, particularly those provided from donor projects, the project team recommends that calibration test equipment shall be kept in the laboratory or rules for calibration shall be prepared. Photo below shows some calibration equipment.

Photo 5.4-2 Calibration Equipment

(3) Main job in the laboratory is soil test and there is only equipment in the laboratory that soil is being manually compacted. The project team therefore recommends that automatic soil compactor may be provided.

CHAPTER 6 TASK 3 ESTABLISHMENT OF CENTRALIZED MANAGEMENT SYSTEM FOR COMPLETION DOCUMENTS

6.1 Necessity of Database System

6.1.1 General

Completion documents of construction projects were not kept in MPWT library, but mostly individual department in charge of projects possesses those documents. Further some documents of construction projects were missing. Hence it was extremely difficult to find out completion documents in the past. In addition, only hard copies of some completion documents are stored in space of MPWT and/or space of relevant departments.

The completion documents are considered "assets" and shall be effectively utilized so as to improve quality control in construction projects. To achieve this, information management system shall be established for completion documents of construction projects.

Once information management system is set up, staff in MPWT / DPWT will be able to access completion documents in the past any time, when planning and implementing projects and improving technologies.

6.1.2 Objectives

When and if sorting out completion documents and technical papers of construction projects, data in the past and current projects may be effectively utilized and then productivity in searching data / experiences is much improved. With the above consideration, all data in the past (completed construction documents and technical papers) are converted to electronic data and those data are stored in database. In order to manage, maintain and operate database properly, efficient database system shall be established.

(1) Establishment of Database System
- To incorporate electronic data of drawings (after convert) in completed projects into database
- To incorporate other electronic data (contract documents, technical papers and reports) into the same database, after converting

(2) Function of Database System
- To access database within MPWT
- To edit / add data in database (through intra-net in MPWT)
- To print data after picking up from database
- To access database through web

(3) Expected Results
- Staff of MPWT is able to access database management system simultaneously.
- Staff of MPWT is able to find drawings, necessary documents / information.
- Work efficiency is improved, as work speed becomes faster.

6.2 Process of Formulation of Database System

The work detail and activity process in formulation of database system is indicated below.

6.2.1 Basic Idea and Necessary Equipment

6.2.1.1 Basic Idea of Database System

(1) Database is established including electronic data newly converted.
(2) Specification is formulated, specifying display and configuration of data.
(3) Documents of completed project are converted to electronic data and those data are stored in the database system.
(4) Display and configuration of data are easy and friendly for end-users.
(5) Appropriate user interfaces for data entry and retrieval are designed and developed.

6.2.1.2 Set-up of Network

(1) Database is established through intra-net in MPWT.
(2) Network environment is secured so as not to leak data out nor to infect with viruses.

6.2.1.3 Characteristics of Database System

The characteristics of database management system are as follows.

(1) It is web base application system which enables any type of PCs and operating system to access and can be accessed through web browser, for example Internet Explorer, irefox, Safari etc.
(2) It is implemented using open source software for both server software and application, and thus it is free from copy rights.
(3) The data are centralized and easy to manage as it is a web base application.
(4) There are unlimited simultaneous accesses to the database, which ensures the future expansion for number of users.

6.2.1.4 Required Facilities

Servers (documents data server), personal computers, peripherals and software are to be procured.

(1) Hardware

- Desktop Computer Dell E7500 1 unit
- Data base server Dell PowerEdge E3440 2 unit
- Printer with Scanner 1 unit
- Uninterruptible power system (UPS) 2 unit

(2) Software

- Windows 7 Professional Win Pro 7-32bit 1 set
- Windows Office 2007 1 set
- Acrobat 9.0 Standard 1 set
- Anti-virus software Norton 360 Ver.4.0 1 set

(3) Structure of System

- Linux server OS i.e. Ubuntu 10.10 Server
- My SQL database server
- Apache Web Server
- To install and configure the PHP script
- To install back up feature for database back up
- To install SSH software
- Data programme MySQL (open source)

The network layout of the document management system is shown in Figure 6.2-1 below:

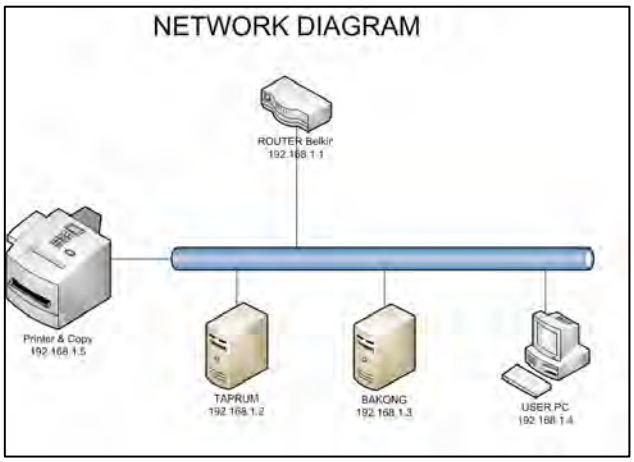


Figure 6.2-1 Network Layout

6.2.1.5 Training and Manual

(1) Training is carried out for management and users for data input and edit, update and trouble shootings etc.

(2) Manual for database is prepared and delivered in English and Khmer language.

6.2.2 Activity of First Stage (January to April 2010)

6.2.2.1 Collecting Completion Documents in Past Projects

(1) Arrangement of collecting completion documents

List of completion documents had been prepared by the former JICA expert and some of these documents in construction projects occupied large space in MPWT. When seeing storage situations of collected documents, these were like waste products. The project team confirmed contents of cardboard boxes one by one and rearranged these documents, until renovation works of library started.

Titles were pasted on the surface of the boxes so that contents were identified.

Photo 6.2-1 Before Arrangement

Photo 6.2-2 Sorting

Photo 6.2-3 After Arrangement

(2) List of Completed Projects

In order to have the past and current status of national roads and subsequent operation and maintenance projects, the list of projects to year 2009 the former JICA expert made was reviewed and checked with the documents in the library. Half of those in the list were not found.

6.2.2.2 Conversion of As-Built Drawings

(1) Preparation of computerization of as-built drawing

The project team prepared to outsourcing for hard copy of as-built drawings to soft copy conversion. The number of sheets of A1 and A3 drawing paper required for conversion work was counted, and the project team examined working method for conversion. The methods (using a digital camera or a scanner) are shown in the comparison table below.

Table 6.2-1 Comparison of Conversion with Digital Camera and Scanner

Type	Equipment	Initial Cost Equipment	Special Skill	Accuracy	File Size (Normal Size)
Digital Camera	Easy-to-Preparation	Cheap	Necessary	Good	2.3M
Scanner	Take time	Expensive	Not Necessary	Good	600kb-1M

Although scanner prevails digital camera in general, the project team found that a digital camera was superior, after considering equipment price and work duration.

General Technical Specification

Subject: A1 size (approx. 750 sheets) and A3 size (approx. 6,000 sheets) of as-built drawings
Files size: 2 kinds of size (High quality: 2M bytes , Normal: 1M bytes)
File type: jpeg

(2) Aspect of Photo Studio

The following figures were prepared in order to explain the image of works to the C/Ps.

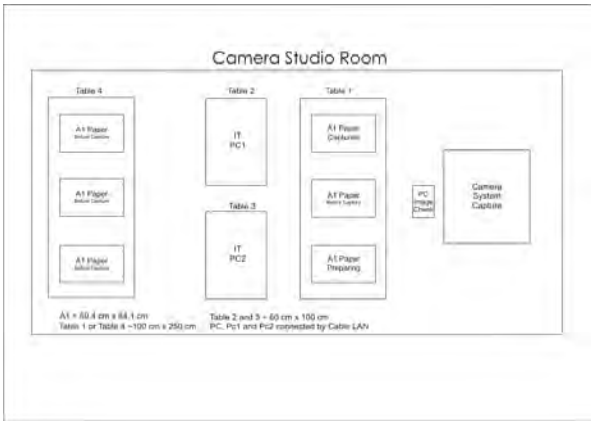


Figure 6.2-2 Room Layout

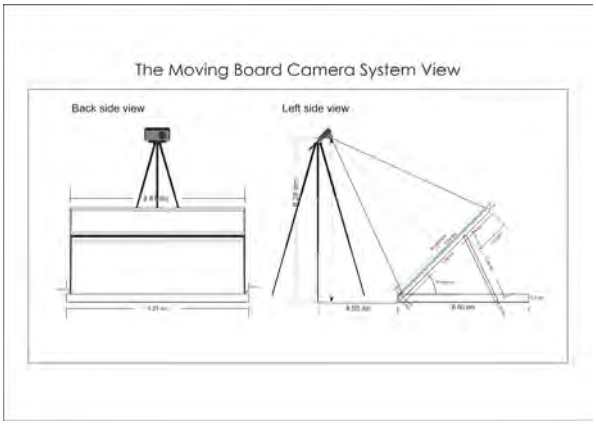


Figure 6.2-3 Photo Capture

(3) Terms of reference (TOR) for capturing and making electronic files of A1 size drawings

The specifications were formulated below.

Conversion to image and data

(a) Method
- Original document is fixed on the special table on and photos of documents are taken by camera set up right above the document.
- Special attention is paid for handling documents in order to prevent original document from damage.
- Serial number is put on the original sheet for identification.

(b) Working Place and Working Hour
- Working place: Photo studio for taking photos is set at library in MPWT. Outside office is for carrying out processing and /or collecting data.

(c) Equipments and Personnel

Capturing team shall prepare and allocate necessary equipment and personnel as follows;
- Equipments: A digital camera, personal computers (3), table for photographing documents (drawings), lighting apparatus, few tables and chairs.
- Personnel: A manager and sufficient number of staff for photographing and data processing etc.

(d) Quality of Data
- Data format is JPEG or PDF.
- Data size is more than 200 dpi and less than 3 mega bytes and another data with 1 mega bytes (down-grade) shall be prepared for quick operation of reference.
- Image data is corrected (contrast uniformity, editing, etc.) so as to confirm brightness, readability and repeatability in gray scale data.
- Orientation of data is unified and adjusted, if required.
- In case of extra size of documents, number of photos are taken for one documents and those be joined with special software such that quality of joint is equal quality to other part (joint error to be less than 0.2 mm)

(e) Data File Creation
- For preparation of database, thumbnail, documents title, code and grouping etc. are input.
- Serial number put at the time of photo taking becomes file name.
- Some items unable to input this time are kept blank for future insertion.
- Input data in each document is listed in excel file and contents in the list and input data are to be cross checked.

Store of these Data
- All data are stored in external hard disk prepared by the Project.
- All data are saved to at least two other media, in case of accident to original data.

Prior inspection
- Before commencing photo taking, all documents have to be thoroughly checked.
- When finding any damage to documents, it is reported to and discussed with the project team.

Delivery inspection
- Delivery inspection is carried out at the completion of every 250 numbers of the data.
- When finding defects at the inspection, those data are re-produced and same process (delivery inspection) is followed.
- List of data delivered to the project team is prepared for easy reference.

(4) Capturing and making electronic files using digital camera

- Working duration : from March 1 to March 26, 2010
- Working place : Library in MPWT

Photo 6.2-4 Photo Scanning

Photo 6.2-5 Digital Editing

6.2.2.3 Preparation on Specification of Database System Structure

Technical specification of database system was prepared for the items below.

- Planning of system component
- Image of network environment
- Index key code
- Data record form
- Flow chart of design windows
- Operational windows view

(1) The technical specification of database system was distributed to C/Ps and, then discussed among them. The expert recommended that they needed to make some corrections and modifications into it, when it was necessary to discuss with local consultant while the expert was away from Cambodia.

(2) Based on the specifications, the expert requested local consultant submit quotation of database system structure and the expert confirmed expertise and degree of knowledge of local consultant through hearing.

6.2.2.4 Employment of Consultant for Consultation of Database System

In order to advance for Task 3, the project team hired local consultant for consultation to PWRC. The project team also prepared proposal for local consultant selection shown below.

(1) Objectives

In order to proceed to set up database system for completed construction documents smoothly, local consultant was employed for the following tasks, who had enough knowledge in regard to set-up of database system and network.

(a) to prepare basic specification for the system
(b) to provide know-how for the system
(c) to advise professional views to the project team for other field

With the above arrangement, planning of database system was continued, while the expert was away from Phnom Penh.

(2) Detailed Works

(a) to prepare specification for database system and network

(b) to recommend suitable equipment for database system and network

(c) to prepare detailed programme for setting up database system and network

(3) Duration for Works

The works was executed from the middle of March to the end of April 2010.

(4) Others

(a) to discuss every aspect in regard to the system with the project team for system through mails, correspondences and/or telephones
(b) to report minutes for important meetings to the project team for the system
(c) to have consents from the project team for system, when determining final specification for the system

6.2.3 Activity of Second Stage (May 2010 to March 2011)

6.2.3.1 Collecting the Completion Documents

Many as-built drawings from Vietnam and China funded projects which had been completed were found in MPWT. Under the new regulation, all of as-built drawings in force account projects shall be delivered in the library. Since library system was not functioned yet, drawings were requested to keep somewhere else.

6.2.3.2 Formulation of Database System

(1) Scanning work of as-built drawings

6,750 as-built drawings stated in Section 6.2.2.2 were increased during the works, and eventually about 8,000 as- built drawings were scanned by August 2010.

(2) Preparation of technical specification for outsource

The Project employed local consultant in March to April 2010 as stated in Section 6.2.2.4 to share common recognition with MPWT and to achieve consensus with MPWT for database system. The specification for building database was also prepared with MPWT and the overall output image was confirmed. With the above, the draft of technical specification was compiled and submitted to the project team.

(3) Selection of Consultant

For establishment of database system for completion documents, local consultant was needed. Chronology of selection of local consultant is shown below.

Table 6.2-2 Chronology of Selection of Consultant

Date		Details	Remarks
8 June	Tue	Announcement to local consultants: JICA office announced to local consultants to submit proposal and cost quotation. Nominated companies 1. CAM INFO SERVICES 2. JNS Co., Ltd 3. RESOLVO	
11June	Fri	Closing date & time of proposal and quotation: Proposal and quotation from these companies are shown below. 1. CAM INFO SERVICES USD 6,240 2. JNS Co., Ltd USD 12,000 3. RESOLVO USD 12,800	Submission before 16:00 June 11, 2010
14June	Mon	Evaluation (JICA Cambodia office) Based on the background and experiences of companies, proposal and quotation, CAM INFO SERVICES was decided to be the company to negotiate first.	
16 June	Wed	Contract negotiation The selected company agreed on the draft contract of details, work schedule, cost and payment term.	
18 June	Fri	Signing the Contract	
21June	Mon	Job Starting	

(4) Building Database system

In the second quarter of 2010, new counterpart joined to Task 3 from PWRC and carried out works for this Task. The consultant and the project team discussed progress every Friday. Explanation of working conditions and improvement of screen design and interface design were also discussed to avoid any misunderstanding.

Photo 6.2-6 Presentation of Database System at C/P meeting

Photo 6.2-7 Demonstration of Database System at Weekly Meeting

In regard to procurement of computer and server, it unexpectedly took longer time, and hence delivery of computer and server was informed to be late from the original schedule. With this situation, the project team conducted system setting and demonstrations using the server supplied by the consultant. Server and computer were eventually delivered to the Project in November 2010.The project team requested the consultant to prepare training plan and user manual and to train the administrator and operator by the end of October 2010 in order to commence operation promptly after delivery of computer and server.

6.2.3.3 Issues after Formulation of Database System

After establishment of centralized management system for the completion documents, MPWT management shall update and maintain the system by themselves. However, administrators and operators were not confirmed yet at this stage. Issues were (a) what approval is obtained after the completion documents are delivered, (b) how hard and soft data is incorporated into the database and (c) how data is stored. Database system would not be sustainable in the future, unless taking measures on the following issues and problems below.

(1) Scanning of as-bulit drawings / documents

For as-built drawings and documents, submission of hard and soft copy shall be compulsory for force account projects stated in the Regulation, however that under donor funded projects was not ruled yet. Upon submission, the drawings and documents shall be scanned. A3 size drawings and documents can be scanned with the equipment at the library JICA provided. A1 size or special size drawings shall be dealt with outsourcing. With view of cost, as-bult drawings and documents shall be submitted with A3 or A4 size.

(2) Administrator and operator

When the datatbse system is set up, administrator and operator in charge shall be assigned immediately. Otherwise, time and effort spent will be wasted.

(3) Maintenance

Maintenance shall also be considered for future operation. Set-up of database sysytem and maintenance are categrized in separate tasks. Maintenance is not included in the system set-up contract. The Project does not cover maintenance of the system. Actually, maintenance and design changes shall be done by staff with technical knowledge of database system. Therfore, it is necessary to contract with outsource or to develop such staff in MPWT.

(4) Flow of management strucutre

Image of the overall structure is shown below from the filing of completed drawings and documents into a database, storage, management, operation and maintenance.

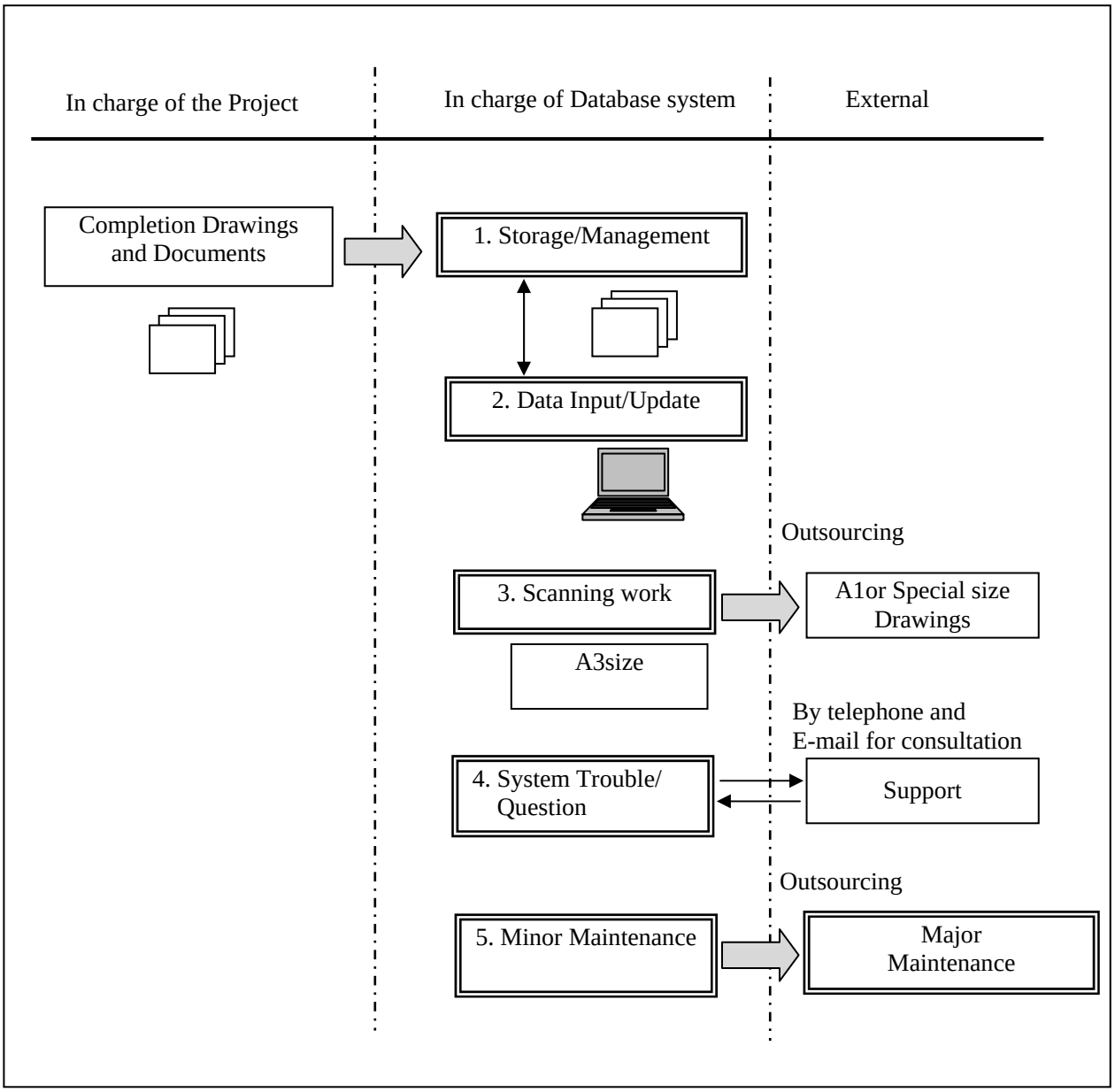


Figure 6.2-4 Flow of Management Structure

6.2.4 Activity of Third Stage (January to May 2012)

In order to improve and update the database system, the project team conducted and discussed the activities in third stage (2012) below.

(1) Scanning of as-built drawings was carried out (A1 size: 1,250 sheets/ A3 size: 2,000 sheets).
(2) Rules for database system are still processing.
(3) Document scanning manual and User's manual for document management database were revised and improved (refer to Appendix 5).

6.3 Issues and Suggestions for Improving Database System

6.3.1 Activities for Dissemination of Database System

The database system was completed in 2011. After building the system, the project team conducted various works, including the following activities.

- Local consultant (system developer) trained counterparts how to use the system.
- Video clip was prepared and used for demonstration.
- Workshops and seminars were held for MPWT and DPWT in ad-hoc basis.
- Public relation was arranged for briefing the database system.

Activities	Details
(1) Training	● Demo video clip of using database system for Users was created. ● Counterparts explained the database system using demo video clip. ● Regular trainings were held in June and July 2012.
(2) Workshop / Seminar	● Presentation tools for workshop seminar were prepared. ● Annual technical seminar was held in December 2011. ● Technical seminar was held in February 2012. ● Workshops to DPWTs were held in May to July 2012.
(3) Public relation to MPWT	● Database system into the MPWT intranet system environment was integrated. ● Project introduced at JCC meetings in December 2011 and August 2012.

6.3.2 Rules and Responsibilities for Database System

Rules and responsibilities for database system were discussed and defined (ref. Table 6.3-1), however nominations for necessary staff were not done yet at this stage.

Table 6.3-1 Rules and Responsibilities for Database System

Items	Possible Solution
Storage location for the submitted completion documents	Library in MPWT
Person in charge who submits the completion documents	Project manager or other person in charge (Party A or PMU)
Person in charge who manages the database system (Instruction to Administrator and Operator)?	Deputy Director Class in PWRC
Person in charge who receives completion documents and administers those documents	Administrator in PWRC

Items	Possible Solution
Person in charge who scans the completion documents	Operators in PWRC
Person in charge who converts data	Operators in PWRC
Person in charge who inputs data into the database	Operators in PWRC

Two staffs were appointed as administrator during the Project period. They were already trained for database system and have a lot of knowledge. They may be candidate for administrator after the Project. Manager for database system shall be appointed as soon as possible as well as administrator and operator for sustainability. Otherwise the database system will not be functioned after the Project.

6.3.3 Training

(1) Training of trainer for database system

Training shall be again arranged for administrator and operator from the consultant, so that they will perform user training.

(2) Training course for user in the MPWT regular training program

Since database system is assets of MPWT and DPWT, training for database system shall be included in the regular training course of MPWT, so that every staff in MPWT and DPWT will be made known database system and how to use it.

(3) Publication for Users

Concurrently with user training, the department managing the database system (most likely PWRC) shall announce and publish database system in MPWT to staff of MPWT / DPWT.

6.3.4 Recommendation for Rules of Collecting Completion Documents

In order to maintain the storage of the completion documents to database system, collection rule of completion documents for force account and donor funded projects shall be formulated, which are shown below.

Force Account Project

(1) Submission

Party B shall submit the project information and all contract documents, including as-built documents and other important papers as agreed to Party C in form of one hard copy and soft copy with PDF. Upon the submission, Party C checks and reviews them. After the acceptance, Party C delivers them to Party A to store at library for database.

(2) Data Input

PWRC shall store them to database in accordance with storage manual and also keep and manage them.

Donor Funded Project

(1) Submission

After completion of donor funded project by the contractor, person in charge of MPWT shall receive completion documents from the consultant / contractor and submit Project Management Unit (PMU). PMU shall deliver the project information and a soft and hard copy of completion documents to PWRC.

(2) Data Input

PWRC shall store them to database in accordance with storage manual and also keep and manage them. Work procedure for collecting completion documents is shown in Figure 6.3-1.

As stated earlier, it is equally important that manager, administrator and operators for database system shall be nominated and appointed as soon as possible.

6.3.5 Other Recommendation

(1) Sustainability

In order to keep the system with good quality, system shall be updated and upgraded by inputting new data from completion documents of construction projects year by year. More data are in the system, more staff will access the system. To do this, collection of completion documents shall be encouraged by top management in MPWT.

(2) System support and maintenance

Depending on the operational status, the system maintenance and support is deemed necessary. The project team recommends to make support contract with appropriate system maintenance company.

(3) Coordination with library system (utilize data sauce)

Library system was developed and the new library system has some relation with database system. Now wide range of information becomes available to users. The project team expects synergistic effects from some integration of database and library system.

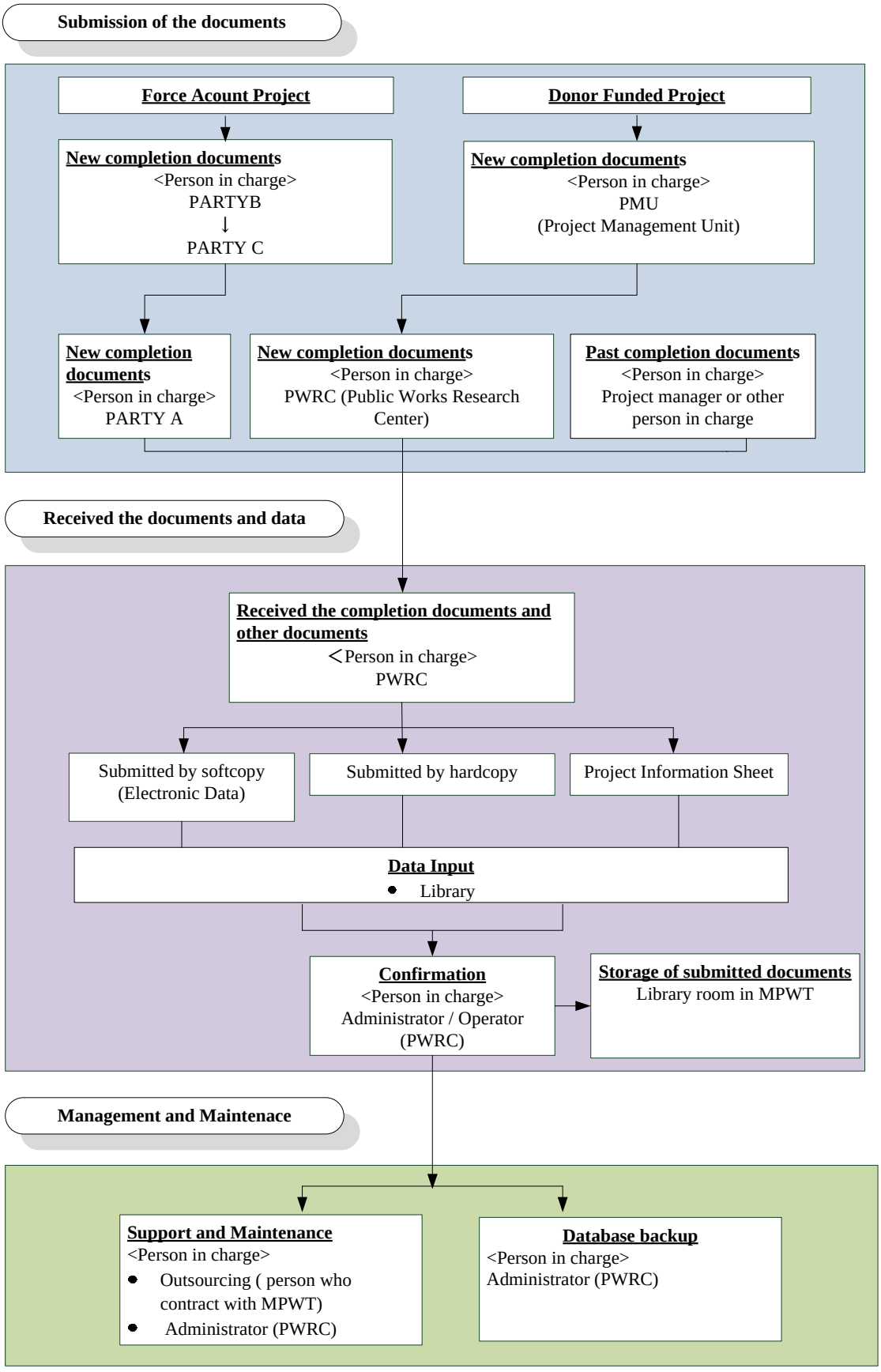


Figure 6.3-1 Flow Chart of Work Process

CHAPTER 7 TASK 4 IMPLEMENTING TECHNICAL TRAINING FOR QUALITY CONTROL / QUALITY ASSURANCE

7.1 Introduction

Training of relevant staff is one of the main measures to upgrade institutional capacity of an organization. Another main measures for upgrading institutional capacity are preparing manuals, guidelines and standards for work procedures. However, manuals/guidelines/standards need to be disseminated through training or workshop in order to be effectively used. Thus, training is an essential item for upgrading institutional capacity. The target of Task 4 is to establish a sustainable training system for Quality Control (QC) / Quality Assurance (QA). To be sustainable, main source of lecturers of the training events need to be staff of Ministry of Public Works and Transport (MPWT). Thus, Task 4 includes Training of Trainers (TOT), in addition to preparation of training program.

Like any other task, improvement of training program follows the Plan-Do-See cycle. Before prepare training plan, review of current status of training and assessment of training need are conducted before planning.

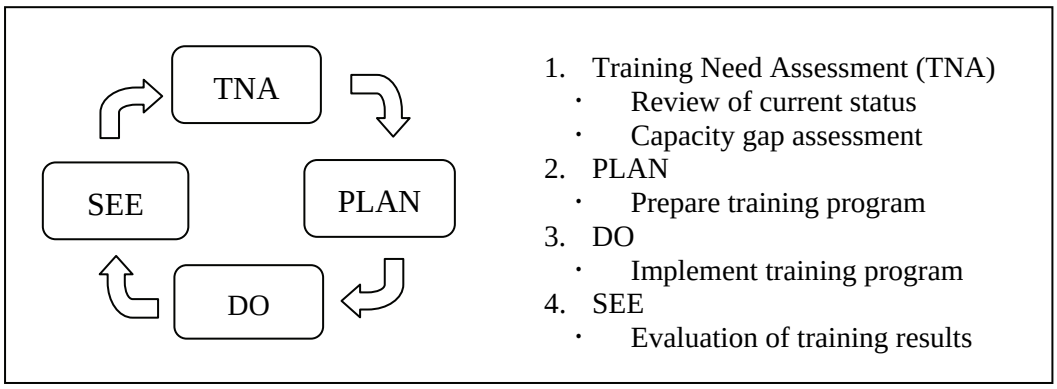


Figure 7.1-1 Plan-Do-See Cycle of Training

7.2 Review and Analysis of Actual Status of Training and Capacity Gap Assessment in MPWT

As the first step of preparing training plan for quality control, the current status of training in MPWT was reviewed.

7.2.1 Existing Training Course of MPWT

MPWT is delivering a training course every year since year 2005. In January 2010, the project team obtained the booklet on this training and translated the essential part of it into English, and analyzed this training course. Although there are several sessions in this training course where engineering subjects are covered, these sessions are considered to cover general topics of each field and are not designed to teach practical skill or knowledge of engineering judgment from the time spent on each subject. Therefore, the main objective of this training seems to be strengthening of the general knowledge, as government officials, of middle to upper level managers of MPWT and provincial Department of Public Works and Transport (DPWT), and not to strengthen any particular fields of engineering practice.

Composition of position levels of the participants of this training is summarized in Table 7.2-1. As can be seen in Table 7.2-1, the majority of the participants are senior to middle class managers of MPWT and senior managers of DPWT. It is noted that the largest portion of the participants in

the first year (2005-06) was senior-level managers such as deputy directors of MPWT proper and directors of DPWT, and then has been shifting to middle-level managers. This shift is well understandable if the fact that the number of senior-level managers is rather limited is considered. If this training course is delivered every year in a sustainable manner, it is expected that junior-level managers will participate in a few years and even engineer-level staff will start to participate within 10 years.

Table 7.2-1 Summary of Participants of Existing Training Course of MPWT

Position Level	Year			Total
	05 - 06	06 - 07	08 - 09	
Auditor	-	2	-	2
Deputy Director of Dpt. of Ministry & Director of Provincial DPWT	31	3	13	47
Deputy Director of Provincial DPWT	11	32	20	63
Officer and Vice Officer	8	34	58	100
Chief & Deputy Chief of Div. of MPWT	-	6	4	10
Director and Deputy Director of School	-	-	2	2
Deputy Director of Public Enterprise	5	-	-	5
Engineer & Technician	-	10	2	12
Others	-	1	1	2
Total	55	88	100	243

The trainers were top management of MPWT, including secretaries of state, undersecretary of state, director general and directors. This arrangement is very reasonable in view of the following:

- The highest position level of the trainees was director of DPWT and deputy director of MPWT proper, and the trainers need to be of the higher position than the trainees.
- Although it may be better to invite outside trainer(s) depending on the subject and availability of competent outside resource, it is realistic to invite the trainers within the Ministry, including affiliated institutions.

7.2.2 Training Events Implemented in ADB-Financed Projects

Two ADB-financed projects provided training. As a component of Primary Road Project (Loan NO. 1697), an on-the-job training was implemented for the period of 2000 to 2004. In this training, officials of DPWT were attached to the resident engineer for 4 weeks to learn contract management, site management, quality control and construction technology. About 40 persons underwent the on-the-job training. Although substantial numbers of DPWT staff were trained in this program, some people feel that the impact is not apparent.

In Cambodia Road Project (Loan No. 1945), training on road maintenance management was held in year 2002. A set of manual was prepared by the pavement and material engineer of this project. Although this manual is being used by some of MPWT staff, it has not been widely disseminated.

7.2.3 Conclusions as of February 2010

From those described above, the followings may be concluded:

(1) The existing training course of MPWT is designed for upgrading the capacity of MPWT staff as government officials and not particularly designed for quality control.
(2) Some of the training events implemented as parts of ADB-financed projects covered the problem of quality control but were sporadic and the impact was limited.
(3) Therefore, it is recommended that the training plan specifically designed for quality control be prepared in the Project with joint effort of the C/P and JICA experts, and implemented in a sustainable manner.

7.2.4 Capacity Gap Assessment

Capacity gap assessment is the starting point and essential part of a capacity enhancement project because it makes apparent the strength and weakness of the organization for which the capacity enhancement project is implemented.

7.2.4.1 Methodology

One of the most commonly employed methods for assessing the existing capacity of an organization is to distribute questionnaires to the staff of the organization and let each staff member evaluate his/her capacity. This method cannot avoid subjective judgement of each staff member but the average of the whole is supposed to indicate the existing situation correctly. Thus, this method was adopted in this Project.

The questionnaire was first prepared in English by the project team. There are 25 questions covering the following 9 factors involved in quality control of construction works.

(1) Road condition survey
(2) Design of road maintenance and construction works
(3) Technical standard and specification
(4) Material test
(5) Work execution planning
(6) Cost estimate
(7) Site supervision
(8) Knowledge and skill of inspection for quality control
(9) Filing of data/drawings

The questionnaire asked two kinds of knowledge;

(1) level of knowledge needed for carrying out his/her duties, and
(2) level of knowledge he/she actually possesses.

The level of knowledge was rated in the following 5 levels.

- Level 1: I do not know the subject at all; I have never heard of this word.
- Level 2: I know the subject but do not know what it is; I have heard the word but never learned anything about it.
- Level 3: I know what it is but cannot use in the actual work. I learned about it in school (university) or I have attended seminar/workshop but I have not used it and need some training to be able to use it in daily works.
- Level 4: I have used or referred or kept the subject to carry out the work in the past experience.
- Level 5: I can use the knowledge/skill in the daily works, perfectly and can teach other staffs.

The difference between the above two is considered to be the gap of knowledge for each item.

7.2.4.2 Distribution and Collection of Questionnaire

The questionnaire was translated into Khmer language and distributed to about 500 persons working in engineering-related departments of MPWT and 24 provincial DPWTs in early January 2010. The date for collection of the filled questionnaire was 5 February 2010. However, only a little less than 60 filled questionnaires were received by the project team. This recovery rate was much lower than expected.

7.2.4.3 Data Compilation

To analyze the data, non-numerical data, *i.e.* organization and position level of each staff member, it is necessary to assign code number for these data.

As for organization, each DPWT was given one code number of 1 to 24. MPWT-proper departments were grouped into, 'road-related departments' (RID, HEC, PWRC and Laboratory) and 'non-road-related departments' (Department of Waterway and Department of Transport). As for position level, coding numbers of 1 to 5 were given to various levels as shown below:

Table 7.2-2 Coding for Position Level

Code No.	MPWT	DPWT
1	Deputy Director, Chief of Office	Director, Deputy Director
2	Deputy Chief	Chief of Office
3	Sr. Engineer	Sr. Engineer
4	Engineer	Engineer
5	Technician	Technician

7.2.4.4 Analysis of the Obtained Data

Although the number of filled questionnaires received by the project team was smaller than expected, the result of analysis of these data showed some interesting features.

(1) Number of Answers

Answers were from total 59 staff members of MPWT and provincial DPWTs. The numbers of received answers by position level are as shown in the table below:

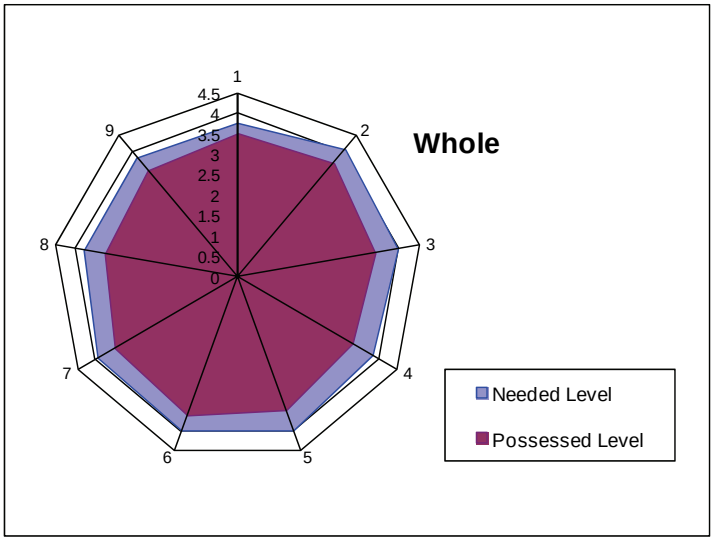
Table 7.2-3 Number of Received Answers by Position Level

Position Level	No. of Answer
1	19
2	14
3	1
4	14
5	11
Total	59

(2) Average of Whole

Figure 7.2-1 shows the average of level of knowledge of the whole. Major feature of this chart are;

- Needed level is 4 (I can use it in daily works) or a little less than 4 for all the items, while possessed level is 3.5 or little more than 3.5. This means that possessed level is not enough for carrying out daily duties.
- Capacity gap is around 0.5 for almost all items.
- Relatively large capacity gaps are seen in Item 4 (material testing), Item 5 (work execution planning) and Item 8 (knowledge and skill of inspection for quality control)

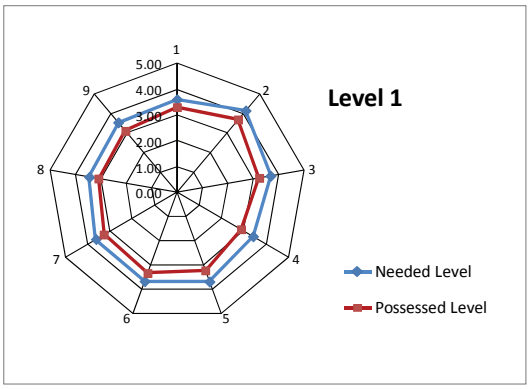


Denotation of Task Category in Road Maintenance
1. Road condition survey
2. Design of road maintenance and construction works
3. Technical standard and specification
4. Material test
5. Work execution planning
6. Cost estimate
7. Site supervision
8. Knowledge and skill of inspection for quality control
9. Filing of data/drawings

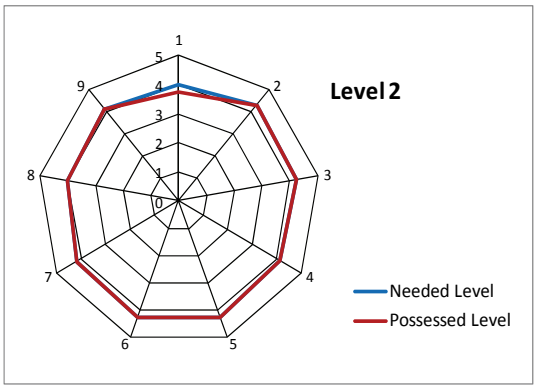
Figure 7.2-1 Average Capacity Gap of Whole Answered Questionnaire

(3) Features of Each Level

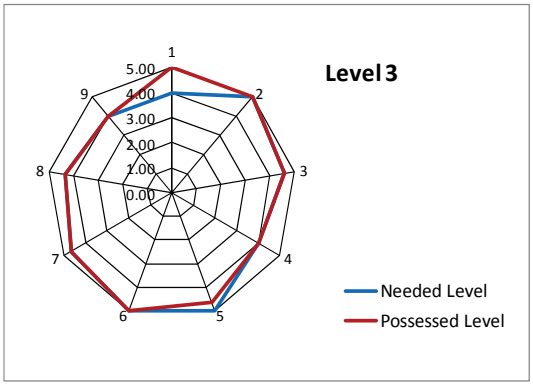
Figure 7.2-2 (a) to (e) show the self-assessed capacity gaps by position level. The features of each position level are summarized in Table 7.2-4.



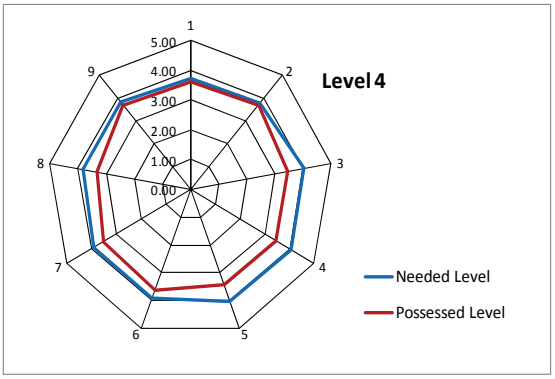
(a) Level 1



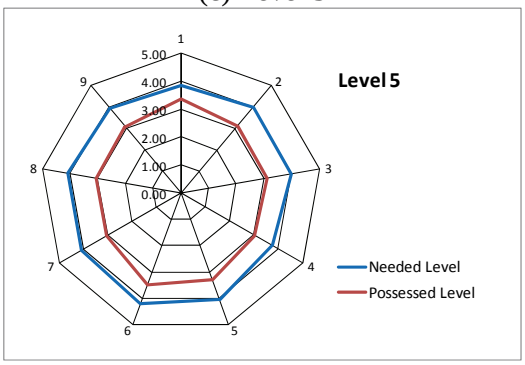
(b) Level 2



(c) Level 3



(d) Level 4



(e) Level 5

Figure 7.2-2 Capacity Gap of Each Position Level

Table 7.2-4 Features of Answer to Capacity Gap Assessment Questionnaire

Position Level	Figure	Interpretation of Graph
Level 1 MPWT: Deputy Director & Chief of Office DPWT: Director & Deputy Director	7.2-2 (a)	➢ Level 1 staff seems to think that they do not need practical knowledge/skill for quality control, except design. ➢ This may be understandable since Level 1 staff are senior managers and may not be directly involved in daily works of quality control.
Level 2 MPWT: Deputy Chief DPWT: Chief of Office	7.2-2 (b)	➢ Level 2 staff seems to believe that they have sufficient knowledge/skill in almost all the items. ➢ This may be reasonable since they are the top level or supervisor of the working-level staff and need to give approval/instruction to working- level staff in daily practices.
Level 3 MPWT: Sr. Engineer DPWT: Sr. Engineer	7.2-2 (c)	➢ This figure of Level 3 staff is based on the data of only one answer, and thus, cannot be analyzed.
Level 4 MPWT: Engineer DPWT: Engineer	7.2-2 (d)	➢ They consider that their knowledge/skill are not sufficient in almost all the items. This may be interpreted that they find their capacities are not sufficient since they are facing various problems in the daily practices and feel necessity of upgrading their capacities.
Level 5 MPWT: Technician DPWT: Technician	7.2-2 (e)	➢ Their capacity gap is the largest among various levels of staff in all items. The interpretation seems to that for Level 4 staff may be applied also to Level 5 staff. One of the unique features of Level 5 staff is that they are feeling large capacity gap in 'knowledge and skill of inspection for quality control' (Item 8) which is one of their major tasks.

7.2.4.5 Conclusion Derived from the Capacity Gap Assessment

- Working-level staffs (Level 4 and Level 5) are feeling that their knowledge/skills are not sufficient to fulfill their duties.
- Level 5 staff feel particularly large capacity gap in knowledge and skill of inspection for quality control
- Training for the working-level staff (Level 4 and Level 5) needs to be strengthened to improve the institutional capacity for quality control of road works because they are directly involved in the works.

7.3 Process and Set-up of Technical Training Course

The first draft of Training Plan was prepared based on the discussions between the relevant officials of MPWT as well as the result of the review of the current status of existing training of MPWT. This Training Plan showed overall policy, process of deciding the items of training program and syllabi of proposed training courses, but does not show details of implementation of the training courses.

7.3.1 Methods of Improving Institutional Capacity

When someone hears the word 'training', he/she may think of a training event delivered to a group of a people who are allowed to leave their daily work place (called 'group training). However, there are various ways to improve one's capacity. Methods of improving one's capacity are usually categorized those as shown in Figure 7.3-1. These methods are explained below:

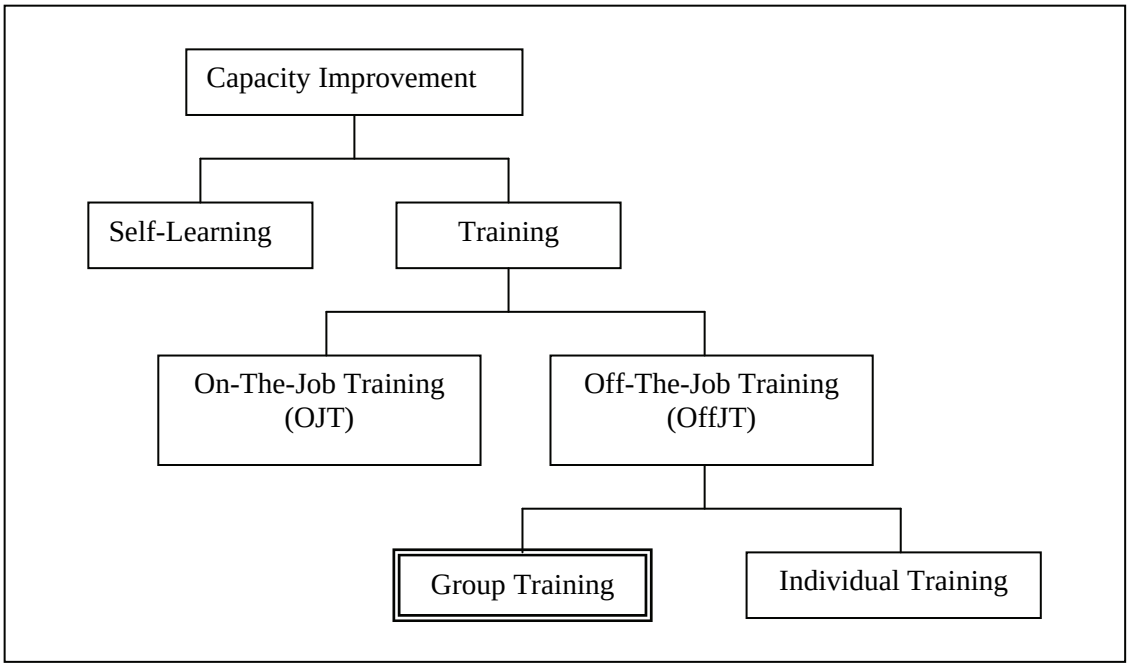


Figure 7.3-1 Methods of Capacity Improvement

7.3.1.1 Self-Learning (Self-Development)

Before training is discussed, most basic way of improving one's capacity is learning by him/herself. This fact is often overseen. Suppose that someone is assigned to a new position, he or she has to acquire knowledge/skill needed in performing daily tasks. This is usually done through learning by him/herself with assistance of available reference such as manuals/guidelines. Actually, self-learning is often very effective way of improving his/her capacity.

Evidently, self-learning, or self-development, needs good motivation on the side of the person who intends to learn. His/her manager or employer should try to create an atmosphere which encourages self−development. One of commonly adopted method for encouraging self-development is a conference where employees present achievement of their effort for improving their jobs; for example, how to improve quality of pothole repair. Many organizations, either public institution or private firms, in Japan holds annual meeting/conference for presentation on improvement of the jobs by the employees. In case of MPWT, it is recommended to consider holding such meeting/ conference. Publication of 'Annual Technical Reports' proposed by JICA expert is one of good examples of motivating the staff of MPWT for self-development.

Encouraging self-development is also desirable to make training effective, because desire to improve his/her capacity is indispensable for trainees.

7.3.1.2 Types of Training

So-called 'training' is usually classified into the following types:

(1) By the place of training:

- On-the-job training (OJT): Training given in one's working place.
- Off-the-job training (OffJT): Training given outside of one's work place.

(2) By the number of participants (usually applied to OffJT)

- Group training: Training where large number of trainees are trained together.
- Individual training: Training given on individual basis.

These types of training are compared in the following tables.

Table 7.3-1 Comparison of OJT and OffJT

	OJT	OffJT
Description	• Training given through day-to-day work in one's work place. • Trainer can be trainee's manager or senior	• Trainee is discharged from daily duties and allowed to participate in training. • Usually implemented at location other than trainees work place (but can be in the same building).
Advantage	• Usually efficient and effective because training is done through actual works. • The outcome can be used immediately after completion of training. • Cost is minimal and usually does not need special budget. • Daily duties need not to be interrupted.	• Trainee can concentrate in the training. • Trainers can be selected from qualified persons. • Due to above, training can be efficient and effective, and can be implemented in shorter period than OJT.
Disadvantage	• Unless systematically planned, often interrupted/ignored when urgent works come in, or for any other reasons. • Can be biased or have some problem if the knowledge of trainer (manager or senior) is biased.	• Daily duties need to be interrupted. • Need certain amount of budget.

Table 7.3-2 Comparison of Group Training and Individual Training

	Group Training	Individual Training
Description	• Large number of trainees are trained at the same time. • Contents of training are decided before trainees are selected.	• One trainee or small number of trainees are trained at one time. • Trainee is selected first and outline of training is decided. • Typical example is studying abroad for high-level education.
Advantage	• Many trainees can be trained at one time. • Cost per trainee is usually lower than individual training. • Thus, effective when large number of people need to be trained on particular subject in a short period. • Network of trainees is often created which later can help further improvement of trainees' capacity.	• Level of training can be freely set based on the objective and level of trainee. • Thus, high-level training, such as study of state-of-the-art engineering, is possible.
Disadvantage	• Effectiveness and efficiency may not be uniform over all trainees.	• Number of trainee is limited. • Therefore, it is not suitable when large number of people need to be trained in a short period. • Cost per person is high.

Type of training has to be adopted considering the advantages and disadvantages as shown above. The Training Plan adopts group training because it is most suitable to strengthen the capacity of MPWT and provincial DPWTs on quality control in shortest period. However, importance and effectiveness of OJT should not be underestimated.

7.3.2 Training Subject

Main focus of this Training Plan is quality control of road works. Ordinary road works, except small-scale repair works, requires three major fields of expertise;

- earthwork,
- pavement work, and
- concrete works (for bridge, culverts and drainage).

For each expertise fields, three kinds of knowledge/skill need to be taught;

- technical standard and specification,
- laboratory material test and field test, and
- execution planning and execution supervision.

7.3.3 Target Level of Knowledge to be Acquired through Training

A training course is designed to let the trainees acquire targeted level of knowledge and/or skill. Also, target group of staff to be trained is selected. These are necessary to achieve the objectives of the training course.

After the discussions with the officials of MPWT and DPWT of Kandal Province on 29 January 2010, the project team considered it appropriate to deliver training courses in two levels, intermediate level and advanced level, as briefly explained below:

Table 7.3-3 Level of Training

Level	Description
Intermediate	Target is to teach how to actually supervise the works at the site. Main topics of training are fundamental points of specification/standard, checking material, method of execution, checking the performance of works (and interrelation between them).
Advanced	After training, trainees are expected to know how to secure required quality, meaning and interpretation of specification/standard, procedures of lab tests and field tests and their problems, how to prevent use of sub-standard material, how to realize good execution. They are expected to be leader or advisor to other staff in quality control.

7.3.4 Training Material

In any training, some type of training material is necessary. It is recommended that approved Standard Guideline (SG), Regulation (RG), existing technical standards, specifications, manuals and guidelines, and other similar documents be used as the major training material, since these technical standards, specifications and manuals are the established criteria of the quality to be attained or the procedures to be followed. As a result of this survey, 10 documents were listed. Table 7.3-4 shows these technical standards and guidelines.

Table 7.3-4 Usage of Standards / Guidelines

No	Standards / Guidelines
1	Second edition of Standard Guideline (SG) (2012)
2	Second edition of Regulation (RG) (2012)
3	Road Design Standard (2003)
4	Bridge Design Standard (2003)
5	Standard Traffic Control Devices
6	Construction Specification (2003)
7	Guideline for Supervision of Routine Maintenance (2008)
8	Guideline for Repairing Defects of Roads (2008)
9	Guideline for Regular Inspection (2008)
10	Guideline for Supervisor Regular Inspection (2008)
11	IB Performance Evaluation Form (2008)

7.3.5 Trainer

In order to make this training plan sustainable, trainers should be selected among MPWT and provincial DPWT staff. Basic qualifications of trainers are as listed below:

Table 7.3-5 Qualification of Trainer

Condition	Description
Academic Knowledge	• Sufficient academic knowledge is required. This typically includes minimum university-level, or desirably graduate-level educational background on the subject. This criterion may be eased in case of trainer for material/field tests. Nevertheless, basic theories of these tests need to be taught by trainer(s) with university-or-above educational background. • The trainer needs to be able to teach basic theory of the subject.
Practical Experience	• Rich experience obtained through positive participation in actual projects of the subject. The trainer is required to possess sufficient knowledge on actual cases of problems and solutions, prevention of the problem, etc.
Working Knowledge	• Based on the sufficient academic knowledge and practical experience as cited above, the trainer needs to have organized knowledge which can be used in actual works of the subject.
Presentation Skill	• The trainer needs to have good presentation skill. If a candidate for trainer needs improvement, 'training of trainers' (TOT) should be given.

7.3.6 Training of Trainers (TOT)

As stated above, securing competent trainers are one of essential item for implementing a training program. To make the training program of quality control, the majority of the trainers need to be secured among the staff of MPWT. Thus, Training of Trainers (TOT) was implemented with participation of the counterpart members as the trainee of TOT.

TOT was implemented 2 times; first in November 2010 and second in May 2012. Eight persons and five persons participated in the first and second TOT, respectively. The contents of the two TOTs were the same. Table 7.3-6 shows the outline of the first TOT held in November 2010.

Table 7.3-6 Outline of the First Training of Trainer

Date & Time	November 3, 2010; 8:30 AM – 3:00 PM
Venue	Meeting Room of MPWT
Objective	1. Secure the trainers for introduction workshop of 'Standard Guideline' & 'Regulation'. 2. 1 step of the 'Training Plan' prepared and submitted by the project team in February 2010.
Trainee	8 persons
Trainer	T. Sakurai, Training/HRD Specialist, JICA expert
Target Level of Achievement	1. To let the participants understand basics of planning and implementation of training events. 2. To give basic knowledge on presentation skills.
Teaching Material	Planning of Training Events and Presentation Skill

The textbook of TOT is attached as Appendix 6-1.

Two Pilot Workshops were implemented to let the trainees of TOT have practical experiences as trainers. Table 7.3-6 shows the outline of these Pilot Workshops.

Table 7.3-7 Outline of Pilot Workshop

	First Pilot Workshop (Kandal)	Second Pilot Workshop (Kampong Cham)
Date & Time	November 24, 2010, 8:00AM-5:00PM	February 8, 2011, 9:00 AM- 4:00PM
Venue	Conference Hall of Kandal DPWT	Conference hall of Kampong Cham
Trainer	Messrs. Samrangdy Namo, Chao Sopheak Phibal, Uy Sophal, Kry Thong	Messrs. Koun Bunthoeun, Samrangdy Namo, Kry Thong, Hum Vuthy, You Dara, Meng Leang, Laing Onit.
	(Support cum candidate trainer) Messrs. San Sinaveth, Nin Manakak, Phy Ratha, Laing Onit	(Support cum candidate trainer) Messrs. Sang Sinaveth, Sok Pounnaraiy and Nin Menakak
Participants	16 persons (Deputy Directors and other staff of Kandal DPWT)	21 persons (Staff of Kampong Cham DPWT)
Textbook	i. Standard Guideline for MPWT Force Account Project ii. Regulation for MPWT Force Account Project	

7.3.7 Approval of Training Program

Lectures on quality control are to be delivered in the Regular Training Course of MPWT in Fiscal Year 2012. The contents of these lectures were planned to be similar to what were delivered in the Regular Training in Fiscal Year 2011.

The project team was preparing a training program for a next few years in Table 7.3-8. This program has been approved by JCC meeting on August 30, 2012. The syllabi of these main training courses are shown in Appendix 6–2.

Table 7.3-8 Training Course in 2012

No	Description	Topic	Trainer	Institution	Other
1	1-Standard Guideline (SG)	1-Introduction of SG 2-Quality Control Document 3-Quality Control Testing 4-Inspection	1-Mr. You Dara 1-Mr. Pou Manith 2-Mr. Bou Veasna 2-Kry Thong 2-Mr. Phibal 3-Mr. Meng Leang 4-Mr. Laing Onit	1-RID 1-RID 2-PWRC 2-HEC 2-RID 3-Labo/MPWT 4-RID	5Hours /day
2	1-Regulation (RG) 2-Standard Drawings 3-Database System Management	1-Application of RG 2-Concept of Standard Drawings 3-How to use Database System	1-Mr. Namo 2-Mr. Hum Vuthy 2-Mr. Kun Soth 2-Mr. Menakak 3-Mr. Phy Ratha 3-Mr. Sok Lay	1-PWRC 2-RID 2-PWRC 2-RID 3-PWRC 3-PWRC	4.5 Hours/ day
3	1-Testing Method 2-Soil Mechanic 3-Earth Work	1-Sand Cone Test, Limit Liquid, Proctor Test… 2-Plasticity of Soil, Compaction of Soil and Soil Classification	1-Mr. Meng Leang 2-Mr. Chea Dara	1-Labo/MPWT 2-RID	5Hours /day
4	1-Safety Management 2-Road Safety	1-Safety on Construction Site	1-Mr. Sovicheano 2-Mr. Kong Sophal	1-DGD of Public Works 2-DIR, MPWT	5Hours /day
5	1-Bridge Engineering 2-Bridge Maintenance	1-Prestress Concrete I Beam Design	1-Dr. Yen Sereyvuth 2-Mr. Uy Sophal	1-RID 2-GDI MPWT	5Hours /day

No	Description	Topic	Trainer	Institution	Other
6	1-Contract Management 2-Road management System 3-Social Enviroment	1-Contract Manager 2-Road Data Collection and Analysis	1-Mr. Namo 2-Tou Samnang 3-Kry Thong	1-PWRC 2-HEC 3-HEC	5Hours /day
7	1-Survey 2-Mapping, GIS		1-Mr. Khun Soth 2-Dr. Khun Sokha	1-PWRC 2-PWRC	5Hours /day

7.4 Implementation of Workshops on SG / RG, Standard Drawings and Database System

7.4.1 Outline of Workshops

Workshops on 'SG / RG, Standard Drawings and Database System' were implemented at 4 locations with participation of the staff of DPWT of 22 Provinces, except Kandal and Kampong Cham for which workshops had been implemented as the Pilot Workshop in 2010 and 2011. Outline of these 4 workshops are summarized in Tables 7.4-1 and 7.4-2.

Table 7.4-1 Outline of Workshop (1)

Item	Workshop I	Workshop II
Date & Time	May 21, 2012; 8:00 AM – 2:50 PM	May 28, 2012, 8:00 AM – 3:00PM
Venue	Conference Room of DPWT, Battambang Province	Conference Room of DPWT, Preah Sihanouk Province
Participants	31 persons: Staff of DPWTs of 5 Provinces (Batttambang, Steung Meanchey, Oddor Meanchey, Preah Viher and Pursat)	22 persons: Staff of DPWTs of 5 Provinces (Takeo, Kep, Kampot Koh Kong and Preah Sihanouk)
Trainer	Messrs. Samrangdy Namo, Chao Sopheak Phibal, Kry Thong, You Dara, Laing Onit, Bou Veasna, HumVuthy, Nin Menakak	Messrs. Koun Bunthoeun, Samrangdy Namo, Kry Thong, Hum Vuthy, You Dara, Meng Leng, Laing Onit.
Textbook	i. Standard Guideline for MPWT Force Account Project ii. Regulation for MPWT Force Account Project iii. Road and Road Structure Standard Drawings iv. Database Management System for Completion Documents	

Table 7.4-2 Outline of Workshop (2)

Item	Workshop III	Workshop IV
Date & Time	June 15, 2012; 8:00 AM – 3:00 PM	July 10, 2012, 7:45 AM – 2:50PM
Venue	Conference Hall of MPWT	Conference Hall of MPWT
Participants	21 persons: Staff of DPWTs of 5 Provinces (Phnom Penh, Prey Veng, Svay Reang, Kampong Chhnang and Kampong Speu)	11 persons: Staff of DPWTs of 4 Provinces (Kraite, Mondourkiri, Rattanakiri and Steung Treng)
Trainer	Messrs. Koun Bunthoeun, Samrangdy Namo, Kry Thong, Hum Vuthy, You Dara, Meng Leng, Laing Onit, Pou Manith, Nin Menakak.	Messrs. Koun Bunthoeun, Samrangdy Namo, Kry Thong, Hum Vuthy, You Dara, Meng Leng, Laing Onit, Nin Menakak, Phy Ratha.
Textbook	i. Standard Guideline for MPWT Force Account Project ii. Regulation for MPWT Force Account Project iii. Road and Road Structure Standard Drawings iv. Database Management System for Completion Documents	

7.4.2 Evaluation of Result of Workshops

Two kinds of evaluation were conducted in every workshop:

(i) Comparison of tests (pre-test and post-test) assigned to the participants (trainees) before and after the training. The differences of the scores of the two tests are to show degree of improvement of knowledge of the trainees on the subject of training.
(ii) Evaluation of training course by the participants (trainees): This is to evaluate training program itself, performance of trainers and appropriateness of textbook used in the training.

The results of comparison of pre-test and post-test of the four workshops are shown in Table 7.4-3.

Table 7.4-3 Difference of Score between Pre-Test and Post-Test

Difference between Pre-Test and Post-Test		Workshop I	Workshop II	Workshop III	Workshop IV
Ave. Score	Pre-Test	8.25	6.78	9.0	7.9
	Post-Test	9.19	8.22	10.11	9.6
	Improvement	0.94	1.44	1.11	1.70
Minimum Score	Pre-Test	3	4	5	6
	Post-Test	7	4	6	6

Note: Full mark is 15 points

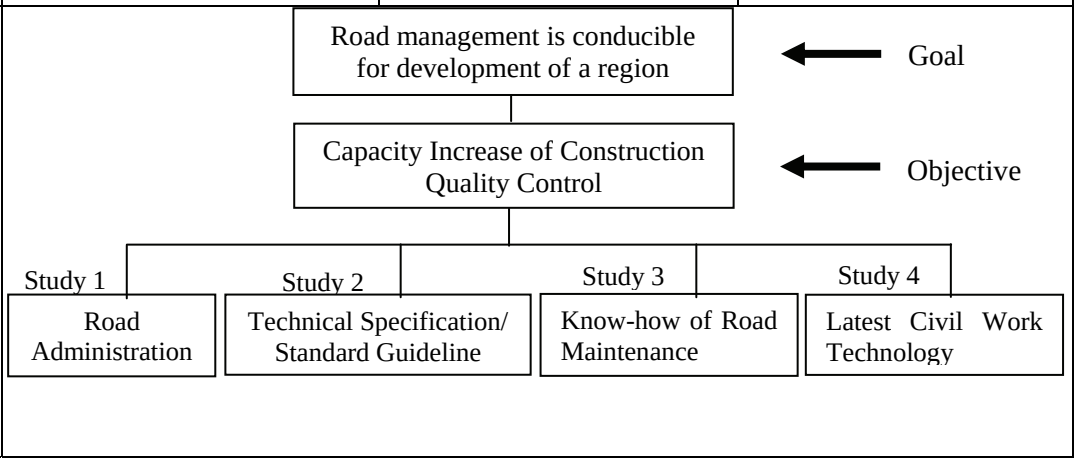
Following s are the observation:

(i) Although the differences of average scores are not so large, minimum scores were improved.
(ii) The trainees whose scores were low are considered to have very limited knowledge and may cause problem in daily works. Improvement of these staff is expected to contribute reduction in such risks.
(iii) Although there is not so large improvement of score, it can be expected that the trainees will improve their capacities through use of Standard Guideline and Regulation day-to-day use in the actual works.

Lecturer was remarkable achievement that the project team expected. It is also proposed that workshops on SG and RG be repeated in Fiscal Year 2013 to achieve better dissemination of these rules to all provinces which is expected to result in better quality of road works through force account.

7.5 Counterparts Training in Japan

(1) Outline of training

Item	First Trip	Second Trip	Third Trip
Duration	July 4 to July 22, 2010	November 6 to November 25, 2011	July 16 to August 4, 2012
Trainee	Mr. Chao Phibal Mr. Uy Sophal Mr. Sang Sinaveth	Mr. Kry Thong Mr. Laing Onit Mr. Nin Menakak Mr. Bou Veasna	Mr. You Dara Mr. Meng Leang Mr. Theng Socheat Mr. Pou Manith
Basic Concept			

(2) Schedule of training

MPWT sent staff to this enhancing the construction quality control program for three (3) times. Schedule of training in third trip is shown in Table 7.3-1.

Trainees had a good opportunity to participate all of class and site visit. They were very aggressive to attend the course and to have many questions to lecturers, especially how Japan maitained the road condition after second world war till today.

They may take advantage of this experience for not only this Project but also future activities in MPWT.

Table 7.5-1 Schedule of C/P Training in Japan

No	Date & Day		Time	Contents	Contact	Training Place
1	July 16	Mon		*Phnom Penh → Seoul, Seoul → Narita, Japan*		
2	July 17	Tue	9:00-12:00	Briefing	Tokyo International Center	Hotel
			13:30-14:00	Program Orientation	KEI	KEI
			14:00-17:00	Lecture Road Administration of Japan	KEI	KEI
3	July 18	Wed	09:00-12:00	Lecture Road Network Development, Road Fund& Private Sector Participation	KEI	KEI
			13:00-16:30	Lecture Road maintenance & Road Design Standard	- ditto -	- ditto -
4	July 19	Thu	9:30-12:00	Lecture Outline of Metropolitan Expressway in Japan &Maintenance Management	MEX	Tokyo Office, MEX
			13:00-16:30	Lecture Traffic Controller System of Metropolitan Expressway	- ditto -	- ditto -
5	July 20	Fri	9:00-16:00	Site Visit Observation the Pavement Technology & Evaluation Test for Material	MEX	Nichireki Co., Ltd Research Laboratory
6	July 21	Sat	-	Holiday	-	-
7	July 22	Sun	-	Holiday	-	-
8	July 23	Mon	9:50-12:00	Lecture Approach to the Upgrading of Quality Control and Traffic Control Outline in Japan	MEX	Tokyo Office, MEX
			13:00-16:30	Site Visit Maintenance Management in large size of Bridge (Rainbow Bridge), Traffic Control	- ditto -	East Tokyo Office
9	July 24	Tue	10:00-16:00	Site Visit Observation the Highway and Tunnel Construction at Metropolitan Expressway	MEX	Tokyo Office, MEX
10	July 25	Wed	10:00-12:00	Site Visit Observation the Bridge Construction Site Tokyo Gate Bridge	MEX	Tokyo Office, MEX
			13:00-16:00	Lecture Training Follow-up	- ditto -	- ditto -
11	July 26	Thu	A.M.	(Move) Tokyo ⇒ Osaka		
			P.M.	Lecture, Site Visit The Construction Quality Control and Maintenance, Discussion of Safety Management	Hanshin Expressway Co., Ltd.	Hanshin Expressway Co., Ltd.
12	July 27	Fri	A.M.	Homework		Hotel
			P.M.	Visit Akashi-Kaikyo Bridge	Honshu-Shikoku Bridge Expressway Co., Ltd.	Akashi-Kaikyo Bridge
13	July 28	Sat		Lake Biwa Canal Museum (Move) Kobe ⇒Kyoto⇒Tokyo		
14	July 29	Sun	-	Holiday	-	-
15	July 30	Mon	14:00-16:00	Visit NEXCO Research Institute	Nippon Expressway Research Institute Co., Ltd. (NEXCO)	NEXCO Research Institute
16	July 31	Tue	9:00-18:30	Site Visit Observation the Highway Construction Site at Chubu Oudan Expressway	NEXCO Central	NEXCO Central Minami Alps Construction office
17	Aug 1	Wed	10:00-16:00	Lecture Company Overview, Quality Control in Intercity Expressway	NEXCO Central	Tokyo Branch, NEXCO Central
18	Aug 2	Thu	10:30-15:00	Site Visit Observation the Road Construction (Embankment)	Chiba Kokudo Office, Kanto Regional Development Bureau, MLIT	Construction Office
19	Aug 3	Fri	14:00-16:00	Evaluation of Training, Overall Discussion	JICA HQ	JICA HQ
20	Aug 4	Sat		*Narita → Seoul , Seoul → Phnom Penh*	-	-

(3) Syllabus

The key syllabus is described in the following table. All of courses were related to road construction of quality control, especially how to record for quality aspect and how to test the material at job site and laboratory from management point of view.

Course Title	・ Outline of Road Administration of Japan
Objective	・ To study the road administration of Japan such as organization, road fund, regulation and legal system
Point of Study	・ Current status in road development of Japan ・ Tradition of national road improvement of Japan ・ Organization of road administration (central, region, highway) ・ Secure of road fund

Course Title	・ Quality control system of expressway ・ Specification and design standard of road construction ・ Database management system for completion documents
Objective	・ To study the quality control system and outline of design standard ・ To study the database management system for completion documents
Point of Study	・ Quality control system and technological standard ・ Check sheet for quality control ・ Design standard ・ Database management system

Course Title	・ Quality control in civil work site
Objective	・ To study the role of responsibility such as construction supervising, and inspection
Point of Study	・ Role of responsibility of supervisors on site ・ Procedure of quality control ・ Importance of quality control ・ Inspection item and method

(4) Achievement

When the course was over, evaluation of the training program was held in JICA Headquarter with presentation for result and questionnaire method. All of trainees said “pretty good”. They understood how important quality control is for construction works.

However, there were a few things to raise the comments or suggestions from C/Ps for improvement to next chance.

- Lectures were very high standard which C/P cannot apply for their country soon.
- If possible, C/P wanted to get the soft copy of all of lectures to disseminate the QC action to the other MPWT and DPWT staffs in Cambodia.
- C/P wanted to observe in small scale of construction site like Cambodia current project.

[Road & bridge maintenance]

[Traffic control room in MEX]

[Construction site at Chubu Odan expressway]

[Construction site at Tunnel construction]

[Construction site at embankment work]

[Soil test at site]

[Lecture in MLIT site]

[Evaluation meeting in JICA]

Photo 7.5-1 Counterparts Training in Japan

7.6 Conclusion and Recommendation

(1) **Importance of On-the-Job Training and Self-Development**: Although group training such as Workshops and Regular Training Course of MPWT are one of the most common and effective way of upgrading capacity of an institution such as MPWT, it is not all. The most important factor of capacity improvement is 'self-learning'. Without motivation to improve his/her own capacity, any type of training cannot be effective. Together with self-learning, On-the-Job Training (OJT) is also important and effective method of capacity development. Newly introduced rules such as SG and RG cannot be practically used just by implementation of workshops but needs actual use or reference in daily works. Effectiveness of workshops should not be evaluated simply with the scores of pre-test and post –test.

(2) **Sustainability in Implementation of Training:** Training program needs to be sustainably implemented to obtain desired results. Knowledge and skills need to be shared by majority of the concerned people to be effectively used. For this reason, training has to be given to as many people as possible. Thus, training on one subject needs to be repeatedly delivered over several years.

(3) **Support of Management of MPWT for Sustainable Implementation of Training Program**: The effect of training program may not be felt in a short period. Rather the outcome of the training will be noticed at least a few years after the road work is completed since the outcome of training is improvement of quality of road works. The result of good quality of road works will decrease frequency and magnitude of repair works. Thus, the management of MPWT is recommended to patiently monitor the improvement of quality of road works and support the implementation of training program.

(4) **Incentive to Trainers**: Trainers have accumulated sufficient experiences in delivering lecture. They need to be maintained for future workshops. These trainers are the candidates for future TOT to be implemented by Cambodian resources. Actually trainers need to spend a lot of effort to prepare for lecture. Such effort includes preparation of textbook and PowerPoint presentation. Management of MPWT is recommended to consider giving some incentives (additional overtime etc) to these trainers for their contribution.

(5) **Supporting Structure in MPWT**: In order to maintain and apply the SG and RG at construction or maintenance site, MPWT should formulate the supporting unit in MPWT. This unit is to support for technical aspects in regard to the SG and RG so that when DPWT or other Party B have any questions or inquiry, this unit may suggest or answer the adequate comments timely.

(6) **Securing Funds**: This is important factor for sustainable implementation of planned training program. Stable allocation of budget for training needs to be secured. For this purpose, good understanding by the financing organization, Ministry of Economy and Finance (MEF), is indispensable. Therefore, consultation with this organization should be started as soon as possible for next fiscal year. However, realistic training program needs to be prepared to convince these organizations that sustainable training can be implemented.

CHAPTER 8 TASK 5 COMPILATION OF ROAD AND ROAD STRUCTURE STANDARD DRAWINGS

8.1 Necessity of Standard Drawings

8.1.1 History of Adoption of AUSTROAD Standard in MPWT

Review about design standard in MPWT was carried out from year 1998 with Australian aid. Australian Standard (AUSTROAD 1992), USA Standard (AASHTO), Canada Standard (Ontario Highway Bridge Design Code), New Zealand Standard, Russia Standard, Japan Standard and China Standard were compared and finally Cambodia Design Standard was confirmed to prepare, based on Australia Standard. Subsequently, Bridge Design Standard 2003 in MPWT was completed as shown in Photo 8.1-1.

Photo 8.1-1 Bridge Design Standard (2003)

Even after release of the Bridge Design Standard (2003), each donor applies their own design standard for bridge and other structure in donor project.

In such circumstances, as-built drawings were collected, which were designed with different design standards. Normally, new bridge drawings for force account project are copied from similar bridge projects (same span length and same carriageway width, etc.) obtained from the as-built drawings. But the as-built drawings were not always based on Austrian Standard. Hence, Standard Drawings are needed in MPWT in accordance with Australian Standard.

In Japan, the design standard provides two types of load intensity by economical reason for main road and provincial road. In case of MPWT, provincial road may be upgraded to main road, if it is necessary in future. With this reason, Cambodian Standard is confirmed to prepare in accordance with Australian Standard for main road and provincial road.

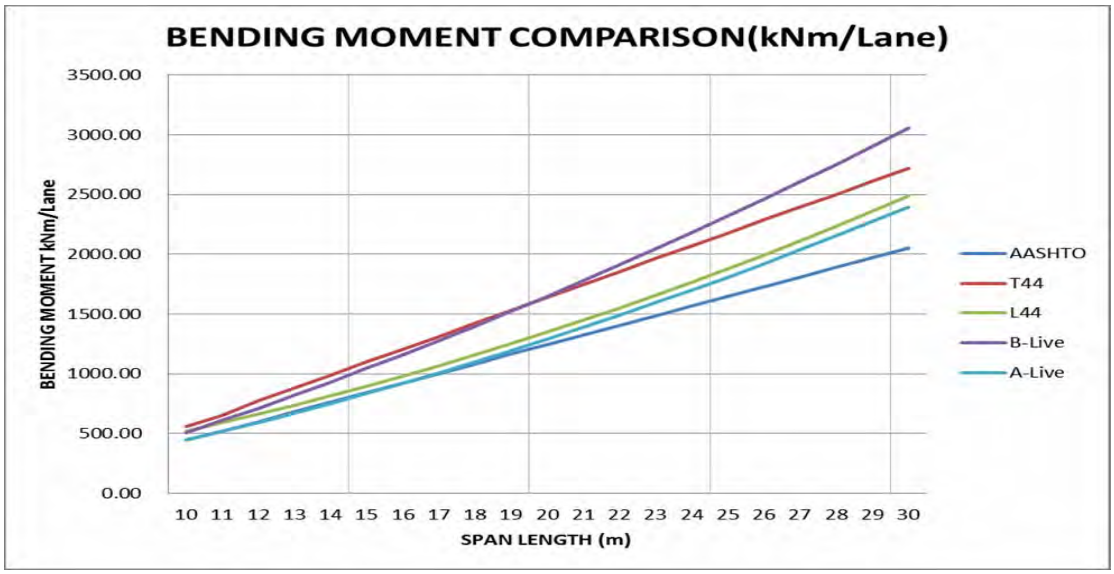


Figure 8.1-1 AUSTROAD (T44) Load, AASHTO Load, Japan B-Live and A-live Load

8.2 Process and Compilation of Standard Drawings

8.2.1 Collecting As-built Drawings

As-built drawings were collected and converted to digital data (picture data) in Task 3.

These collected data about road, pipe culverts, box culverts and several types of bridges were analyzed and selected for basic as-built drawings. Collected as-built drawings are shown in Table 8.2-1 and 8.2-2. There are 96 bridge drawings in Table 8.2-1 and 58 box culvert drawings in Table 8.2-2.

Table 8.2-1 Result of As-built Drawings(Bridge) Collected and Analyzed

Road No.	Donner	Bridge name	Type of bridge	Span (m)	Carriageway width(m)	Curb (m)	Total (m)	girder height H (m)	Main Rebar size D (mm)	PC wire size
R3	KOREA	Wat Kampot	Flat slab	10	10.1	0.5	11	0.75	29	-
R3	KOREA	Rokar Bridge No.6	Flat slab	10	10.1	0.5	11	0.75	29	-
R3	KOREA	Prek Romdual Brigdge No.7	Flat slab	2x12.5=25	10.1	0.5	11	0.75	29	-
R6A	Japan	Bridge No24	PCDG	6x25=150	9	1	11	1.55	-	5Strand12.7Φx7
R6A	Japan	Bridge No25	PCDG	2x25=50	9	1	11	1.55	-	5Strand12.7Φx7
R6A	Japan	Bridge No26	PCDG	4x25=100	9	1	11	1.55	-	5Strand12.7Φx7
R5	ADB 1945	Bridge No28	PCDG	3x25.3=76.3	10	0.45	10.9	1.57	-	4strand-12.7Φ x 7
R5	ADB	Toek Thla	PCDG	4x25.6=101.9	10	1.5	12.9	1.57	-	4strand-12.7Φ x 10
R6	ADB	Ta Ponn	PCDG	3x30.3=91.3	10	1.5	12.9	1.60	-	4strand-12.7Φ x 10
R7	Japan	Moat Khmong Bridge	PCDG	6x35=210	10	0.5	11	2.10	-	5 Strand12.7Φx7
R1	ADB	Prek Kg Trabek	PCDG	6x20.35=122.1	10.5	1.0	12.5	1.00	-	2strand-12.7Φ x 7
R1	ADB	West Vayko	PCDG	6x20.35=122.1	10.5	1.0	12.5	1.00	-	2strand-12.7Φ x 7
R1	ADB	Stoeng Slot	PCDG	6x24.75=148.5	10.5	1.0	12.5	1.00	-	unknown
R1	Japan	Bridge No2	PCDG	4x24.1=103	12	1.25	14.5	1.37	-	3Strand12.7Φx7
R7	China	Secong River Bridge	PCDG PCDG PCBOX PCDG PCDG	5x30+ 5x50+ 55+100+55+ 6x50+ 3x30=1000	8.5	1.35	11.2	18+ 2.6+ 2.6-5.6+ 2.6+ 1.8	-	5 Strand7Φ5 7Strand 12.7Φx12 20strand 15Φ x 5 7Strand 12.7Φx12 5 Strand7Φ5
R7	China	Prek Chang Krong	Post tension Hollow slab	20	10	0.5	11	0.90	-	4strand-15Φ x 6
R7	China	Otanoeng River Bridge	Post tension Hollow slab	3X20=60	10	0.5	11	0.90	-	4strand-15Φ x 6
R7	China	Okandia River Bridge	Post tension Hollow slab	2X20=40	10	0.5	11	0.90	-	4strand-15Φ x 6

Table 8.2-2 Result of As-built Drawings(Box Culvert) Collected and Analyzed

No.	Road No.	Donner	Box culvert name	Type of Box culvert	Width (m)	Depth(m)	Length(m)	D1(cm)	Slab thickness ts (cm)	Wall thickness tw(cm)	Slab thickness ts (cm)	Main Rebar size D (mm)
43	Mean Chey	ADB No.1969	-	1-Box	1.2	0.9	31	120	30.0	30.0	30.0	16
40	R31, R33	WB PIU2	-	1-Box	1.2	1.2	-	50	20.0	20.0	22.5	16
22	R1	ADB No.1659	BC-22	1-Box	1.5	0.9	12	56	22.5	20.0	25.0	16
27	R1	ADB No.1659	BC-26A	1-Box	1.5	0.9	12	50	22.5	20.0	25.0	16
28	R1	ADB No.1659	BC-26B	1-Box	1.5	0.9	12.4	62	20.0	20.0	22.5	16
30	R1	ADB No.1659	BC-28	1-Box	1.5	0.9	12.3	70	20.0	20.0	22.5	16
32	R1	ADB No.1659	BC-30	1-Box	1.5	0.9	12	50	22.5	20.0	25.0	16
33	R1	ADB No.1659	BC-31	1-Box	1.5	0.9	12	50	22.5	20.0	25.0	16
34	R1	ADB No.1659	BC-32	1-Box	1.5	0.9	11.4	50	22.5	20.0	25.0	16
35	R1	ADB No.1659	BC-33	1-Box	1.5	0.9	12	50	22.5	20.0	25.0	16
36	R1	ADB No.1659	BC-34	1-Box	1.5	0.9	12	50	22.5	20.0	25.0	16
37	R1	ADB No.1659	BC-35	1-Box	1.5	0.9	12	50	22.5	20.0	25.0	16
39	R1	ADB No.1659	BC-41	1-Box	1.5	1.0	12	70	22.5	20.0	25.0	16
38	R1	ADB No.1659	BC-37	1-Box	1.5	1.2	12.4	70	20.0	20.0	22.5	16
14	R1	ADB No.1659	BC-15A	1-Box	1.5	1.5	12	50	22.5	20.0	25.0	16
41	R31, R33	WB PIU2	-	1-Box	1.5	1.5	-	50	22.5	22.5	25.0	16
18	R1	ADB No.1659	BC-18A	1-Box	1.75	0.9	12	50	22.5	20.0	25.0	16
42	R31, R33	WB PIU2	-	1-Box	1.8	1.8	-	50	25.0	25.0	27.5	16
45	R7	China	k120+266	1-Box	2.0	1.5	14	74	30.0	30.0	30.0	16
4	R1	ADB No.1659	BC-04	1-Box	2.1	2.1	12.6	65	20.0	25.0	22.5	16
52	R2	Rehabilitation of	100+558	1-Box	3.0	2.4	15.6	130	28.0	28.0	28.0	16
54	R2	Rehabilitation of	124+642	1-Box	3.0	3.0	18.5	191	28.0	28.0	28.0	16
1	R1	ADB No.1659	BC-01	2-Box	2.4	2.1	16	190	22.5	25.0	25.0	16
2	R1	ADB No.1659	BC-02	2-Box	2.4	2.1	17	210	22.5	25.0	25.0	16
3	R1	ADB No.1659	BC-03	2-Box	2.4	2.1	19.4	303	25.0	25.0	27.5	16
51	R2	Rehabilitation of	88+177.8	2-Box	1.3	1.0	12.8	83	18.0	18.0	18.0	20/12
49	R2	Rehabilitation of	81+572	2-Box	1.5	1.0	13.6	85	20.0	20.0	20.0	16

8.2.2 Classification of Standard Drawings for Force Account Project

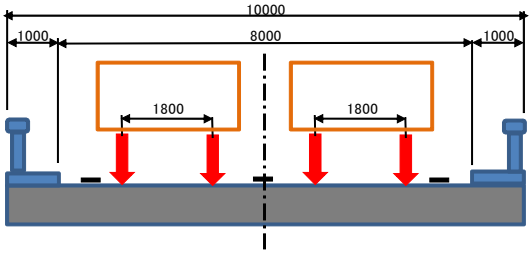
Collected as-built drawings from donor project were mainly based on American Association of State Highway and Transportation Officials (AASHTO) standard not AUSTROAD standard. Cambodia standard is based on AUSTROAD, which adopts larger load intensity than AASHTO truck loading. Standard drawings had to be prepared by adjusting these differences.

Further, data of collected as-built drawings were photo data not CAD data. CAD data were not available from projects. Hence, the project team decided to make CAD drawings for all Standard Drawings. Number of hearings was conducted to C/Ps, undersecretary and related directors in MPWT in order to make classifications for pipe culverts, box culverts and bridges.

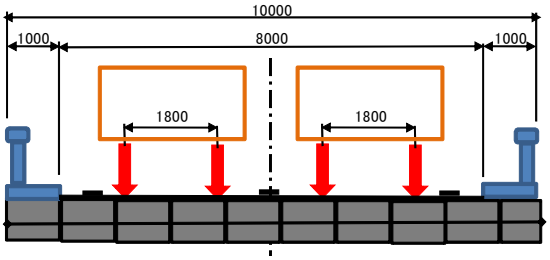
Combinations of CAD drawings were confirmed as shown in Table 8.2-3 for pipe culverts, box culverts and several bridge types. Detail hearings were also conducted for appropriate conditions in Cambodia (tropical weather, seldom seismic damage, etc.). Specially, drawings were adjusted from as-built drawings in viewpoint of economical efficiency, runnablity and durability in accordance with necessity of Standard Drawing in Cambodia.

Table 8.2-3 Classification of Standard Drawing

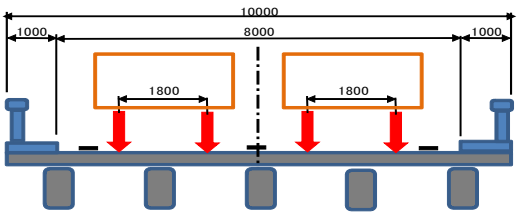
Item		Content	Remarks
Pipe culvert		1Pipe, 2Pipe, 3Pipe type	1.0m,1.2m,1.5mdiameter
Box culvert		1Box, 2Box, 3Box type	1.5mx1.0m - 3mx3m
Bridge	Span	10,12,15,18,20,25,30m	7 cases
	Carriageway width	7, 8, 10,12m	Carriagewaywidth 4 cases
	Bridge type	RC Flat Slab	Span length 10m－18m
		RCDG	12m – 18m
		PC Hollow Slab	15m － 25m
		PCDG	18m － 30m



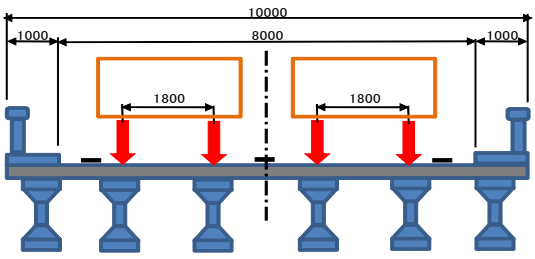
RC FLAT SLAB BRIDGE(CAST－IN PLACE)



RC, PC Hollow SLAB BRIDGE(PRECAST)



RC DECK GIRDER BRIDGE (CAST－IN PLACE)



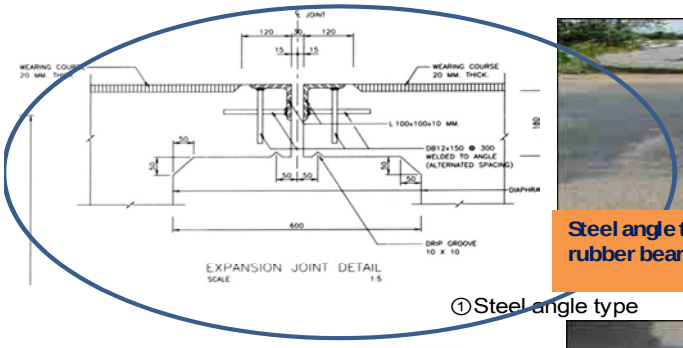
PC,RC DECK GIRDER BRIDGE（PRECAST）

Structural details for expansion joint, bearing, flat slab bridge and hollow slab bridge are shown below as results after review and discussion with C/Ps and stakeholders.

Table 8.2-4 Structural Detail of Expansion Joint

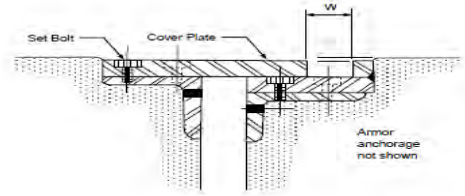
Expansion Joint Page-1

No.	Item	Status	Improvement	Judgment	
1	Improvement of Expansion Joint	①Steel angle type	Joint less type (filled up by cement mortar and continuous asphalt pavement with/without saw cutting)	Yes	No
		②Steel plate type		Yes	No
		③Rubber type		Yes	No
		④Sealing type		Yes	No
		⑤Joint less type		Yes	No

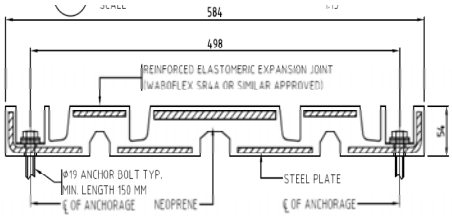


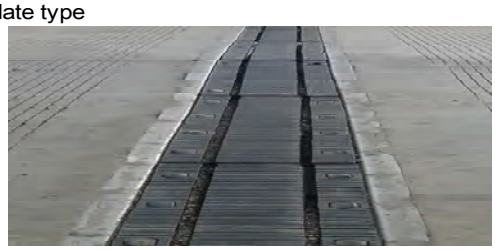
Steel angle type shall be applied for RCDG with rubber bearing as multiple span bridge.

①Steel angle type

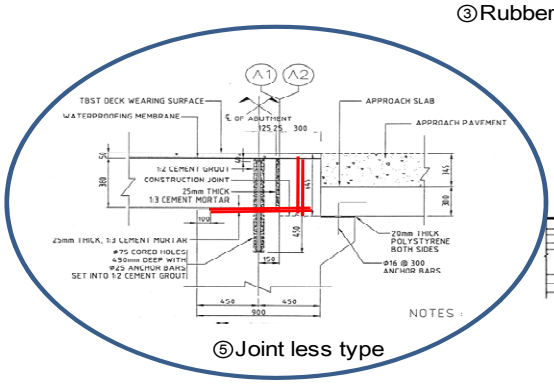


②Steel plate type

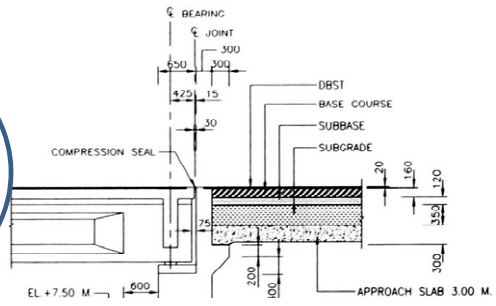




③Rubber type



⑤Joint less type



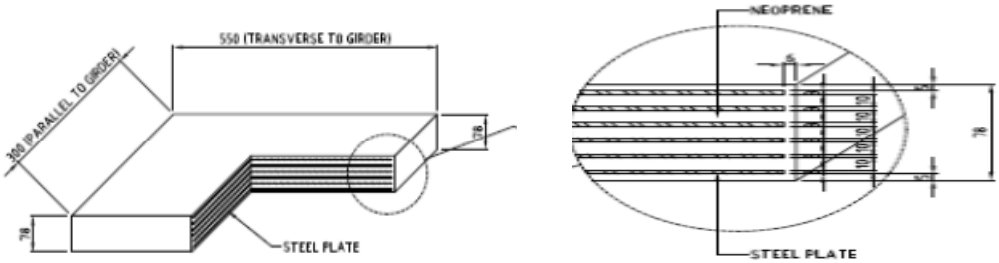
④Sealing type

Table 8.2-5 Structural Detail of Bearing

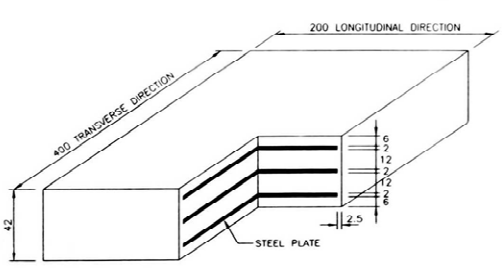
Bearing Page-4

No.	Item	Status	Improvement	Judgment	
4	Bearing	①Steel type	Plate type 100year durability with paint maintenance	Yes	No
		②Rubber type	Elastomeric rubber	Yes	No
		③Without bearing	With minimum maintenance	Yes	No
		④		Yes	No
		⑤		Yes	No

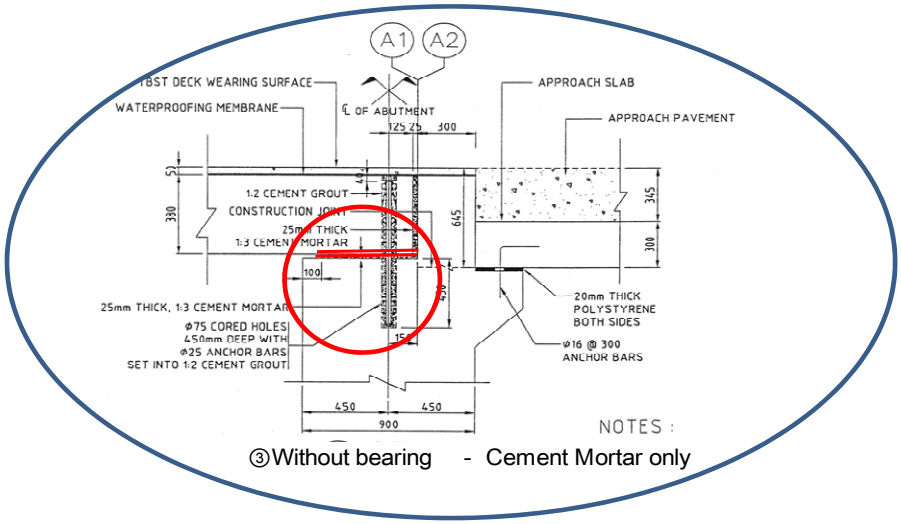
※ **Elastmeric rubber bearing shall be applied for RCDG and PCDG.**
Thickness of elastomeric bearing shall be less than 50mm.



②Rubber type (Elastomeric rubber) Duro 60 hardness



ELASTOMERIC BEARING 200×400×42
(HARDNESS 60)



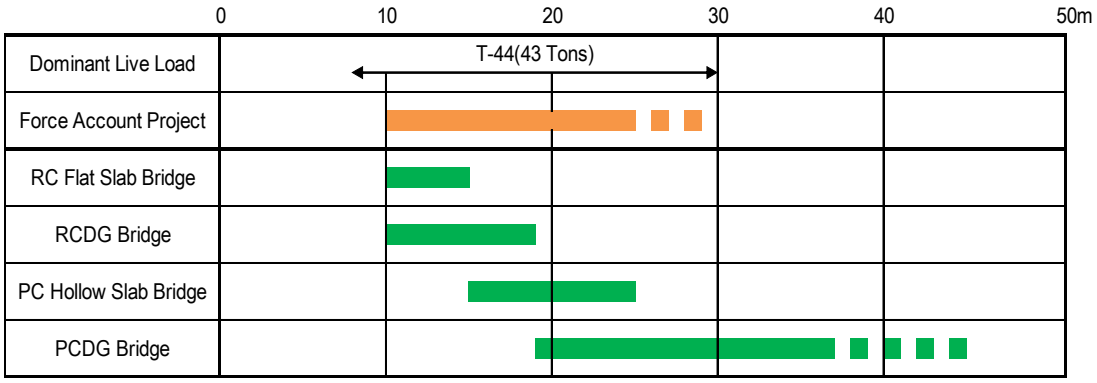
③Without bearing - Cement Mortar only

Table 8.2-6 Structural Detail of Flat Slab Bridge

Flat Slab Bridge Page-6

No.	Item	Status	Improvement	Judgment	
6	Bridge type (Flat Slab Bridge)	①Flat Slab Bridge	Precast RC Flat Slab	Yes	No
			Precast PC Flat Slab	Yes	No
		②		Yes	No
		③		Yes	No
		④		Yes	No

RC/PC Flat Slab Bridge		Carriageway width (m)			
		7	8	10	12
Span length (m)	10	●	●	●	●
	12	●	●	●	●
	15	●	●	●	●
	18	●	●	●	●

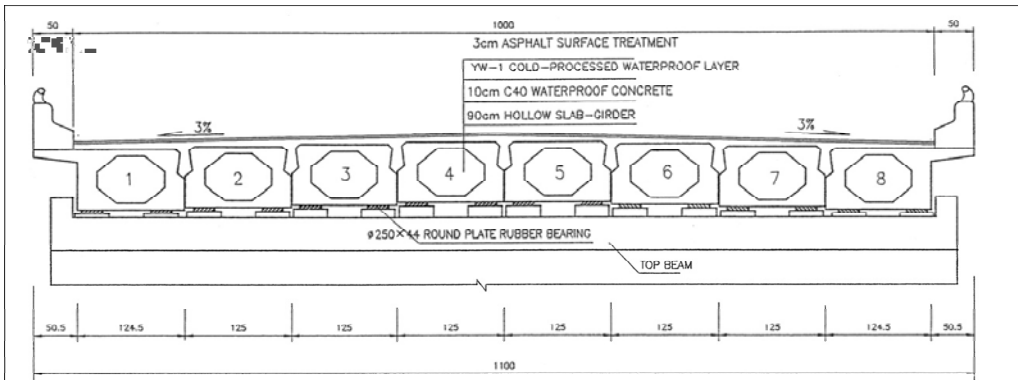


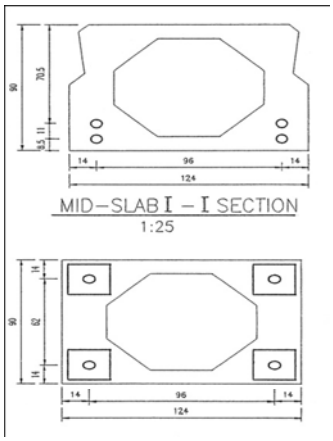
Precast PC Flat Slab Bridge

Table 8.2-7 Structural Detail of Hollow Slab Bridge

Hollow Slab Bridge Page-7

No.	Item	Status	Improvement	Judgment	
7	Bridge type (Hollow Slab Bridge)	①Hollow Slab Bridge	Pretension / Post tension	Yes	No
		②		Yes	No
		③		Yes	No
		④	Span & width combination	Yes	No
		⑤		Yes	No





Postension hollow slab type

Pretension/Post tension hollw slab type

Pretension Hollow Slab Bridge		Carriageway width (m)			
		7	8	10	12
Span length (m)	15	●	●	●	●
	18	●	●	●	●
	20	●	●	●	●
	25	●	●	●	●