## RESEARCH STUDY <br> ON

# REVIEW AND APPLICATION OF THE BRIDGE ENGINEERING TRAINING CENTRE PROJECT 

IN<br>MYANMAR

## FINAL REPORT

INTERNATIONAL DEVELOPMENT CENTER OF JAPAN INC.

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## 1. INTRODUCTION

### 1.1 STUDY BACKGROUNDS

JICA has carried out the Bridge Engineering Training Centre Project (the BETC Project) for 6 years from 1979 to 1985 in Burma. Both an In-Center Training and an On-the-Job Training (OJT) at actual construction site of precast concrete (PC) bridge were conducted in the Project and bridge construction technologies were transferred to 57 engineers in the In-Center Training and 25 engineers and 120 technicians in the OJT. Even after completion of the Project, bridge engineers who had taken the training have been carrying out bridge design and construction supervision in Myanmar. These projects helped the trainees to maintain their technologies and also to give young bridge engineers chances of the On-the-Job Training. Bridge technologies which originated from the BETC Project have still been carried on up until today. Bridge construction is essential in Myanmar especially in the Irrawaddy delta in order to ensure all-year traffic, therefore, it can be considered that the BETC Project was successfully completed because design and construction technologies were transferred suitably in the Project and many bridges have been constructed after the Project by their own self-reliant efforts as a result.

On the other hand, there are few reports in which lessons and backgrounds of the BETC Project are compiled systematically, while there are many reports in which result of the Project are retained for record. Compiling and analyzing the lessons learned from the BETC Project become an urgent issue because BETC-related persons are decreasing both in Myanmar and Japan. Chances of activation of JICA Project in Myanmar are high nowadays, therefore, lessons from the BETC Project can be helpful information for JICA's future cooperation to Myanmar.

### 1.2 STUDY OBJECTIVES

Considering above study backgrounds, objectives of the Study are set as follows;
a) To compile Outputs and issues of the BETC Project and identify success factors and lessons by surveying status of utilization of technologies after the BETC Project which were transferred to engineers in the Project and current status of bridge sector,
b) To identify needs for capacity development in Myanmar by researching current status and issues in bridge sector, and

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c) (Considering above a) and b)) To show how to utilize lessons learned from the BETC Project in future projects, such as currently-projected technical cooperation in road technology improvement project in disaster-prone areas and future capacity development project in bridge sector.

### 1.3 STUDY IMPREMENTATION METHOD

Figure 1.1 shows implementation flow of the Study. Firstly, the Study Team reviewed existing reports and carried out an interview survey to the BETC-related persons in Japan. Then, backgrounds, objectives and overall goal of the BETC Project were summarized in a form of Project Design Matrix ${ }^{1}$ (PDM). PDM had not been made at that time, therefore, it was simulated in this study. Next, evaluation grid was made using simulated PDM and review of the BETC Project was conducted based on interview survey and review of existing documents and drawings in Myanmar. Based on results of the evaluation and the site investigation of existing bridges, which had been constructed after the BETC Project, promoting and impeding factors against outcomes of the BETC Project were summarized and lessons were drawn.

And based on survey of existing bridges and present status of road and bridge sector in Myanmar, the Study Team grasped present problems and needs of bridge development in Myanmar and possibility of Japanese future cooperation was studied. Furthermore, the Study Team studied how lessons from the BETC Project could be applied to future Japanese technical cooperation projects, considering local needs and present problems.


Figure1.1 Implementation flow of the Study

[^0]Internal committees consisting of ex－experts of the BETC Project and JICA staff were held three times in this Study．Details of the committee are shown below．

【First internal committee】
－Date： $16^{\text {th }}$ April 2012
－Contents：Confirmation of backgrounds and implementation method of the Study，
Advice to the Study Team from members of the committee
【Second internal committee】
－Date： $26^{\text {th }}$ June 2012
－Contents：Report of field survey
【Third internal committee】
－Date： $7^{\text {th }}$ August 2012
－Contents：Discussion on contents of Draft Final Report

Members of the committee are listed below．
－Hajime ASAKURA（ex－expert of the BETC Project：1979．12．20～1982．3．31）
－Yukitake SHIOI（ex－expert of the BETC Project：1981．2．28～1981．3．16）
－Minoru FUJIWARA（ex－expert of the BETC Project：1984．1．4～1985．7．13）
－Moriyasu FURUKI（JICA expert）
－Koichi YOKOYAMA（ex－expert of the BETC Project：1982．3．3～1984．3．31）

### 1.4 MEMBER OF THE STUDY TEAM, SCHEDULE OF FIELD SURVEY

### 1.4.1 Member of the Study Team

Members of the Study Team are listed below.
Table 1.1 Member of the Study Team

| Assignment | Name | Company |
| :--- | :--- | :--- |
| Team Leader | Isamu GUNJI | ORIENTAL CONSULTANTS CO., <br> LTD. (OC) |
| Deputy Team Leader/ <br> Project Evaluation | Mimi SHEIKH | INTERNATIONAL <br> DEVELOPMENT CENTER OF <br> JAPAN Inc. |
| Road and Bridge Expert-1 | Yoshifumi NAGATA | TECHNOLOGY CENTER OF <br> METROPOLITAN EXPRESSWAY <br> (TECMEX) |
| Road and Bridge Expert-2 | Tadashi MARUYAMA | EAST NIPPON EXPRESSWAY <br> COMPANY LIMITED |
| Construction Management Specialist | Hiroyuki KAKEMOTO | FUKKEN CO.LTD |
| Transport Specialist | Atsushi SAITO | INTERNATIONAL <br> DEVELOPMENT CENTER OF <br> JAPAN Inc. |
| Coordinator | Yasuhisa SUGANUMA | ORIENTAL CONSULTANTS CO., <br> LTD. (OC) |
| Supporting Staff-1 (Bridge Engineer) | Tsuyoshi HIROSE | EAST NIPPON EXPRESSWAY <br> COMPANY LIMITED |
| Supporting Staff-2 (Bridge Engineer) | Isao NAMIKAWA | ORIENTAL CONSULTANTS CO., <br> LTD. (OC) |

### 1.4.2 Schedule of the Field Survey

The Study Team conducted a field survey in Myanmar from $7^{\text {th }}$ May 2012 to $4^{\text {th }}$ June 2012. The survey schedule is shown below.

Table 1.2 Schedule of the Field Survey

| Date | Survey schedule |
| :---: | :---: |
| 7 May 2012 (Mon) | Narita $\rightarrow$ Bangkok $\rightarrow$ Yangon(Gunji, Nagata, Maruyama, Saito, Kakemoto, Namikawa, Suganuma) |
| 8 May (Tue) | (AM)JICA Myanmar Office courtesy call (PM)Site investigation in Yangon |
| 9 May (Wed) | (AM) Move to Nay Pyi Taw (PM) PW courtesy call |
| 10 May (Thu) | (AM) Move to Yangon <br> (PM) Discussion with TOP Consultant |
| 11 May (Fri) | (AM) Meeting with TOP Consultant (PM) Office work in Yangon Hirose's arrival in Yangon |
| 12 May (Sat) | - Office work in Yangon <br> - Site investigation in Mawlamyaine (Maruyama, Hirose) |
| 13 May (Sun) | - Office work in Yangon(Gunji, Saito, Suganuma) <br> - Site investigation in Yangon (Nagata, Kakemoto, Namikawa) <br> -Bridge investigation in Mawlamyaine (Maruyama, Hirose) <br> - Sheikh's arrival in Yangon |
| 14 May (Mon) | (AM) Meeting with TOP Consultant <br> (PM) Meeting with PW Yangon office <br> Visiting Thuwunna Bridge and Thuwunna Training Centre <br> - Survey on national highway from Mawlamyaine to Nay Pyi Taw (Maruyama, Hirose) |
| 15 May (Tue) | - Office work in Yangon <br> - Interview to BETC-related person (Sheikh) <br> - Survey on national highway from Nay Pyi Taw to Mandalay (Maruyama, Hirose) |
| 16 May (Wed) | - Office work in Yangon <br> - Interview to BETC-related person (Sheikh) <br> - Site investigation in Mandalay (Maruyama, Hirose) |
| 17 May (Thu) | - Office work in Yangon <br> - Interview to BETC-related person (Sheikh) <br> - Site investigation in Mandalay (Maruyama, Hirose) |
| 18 May (Fri) | - Office work in Yangon <br> - Interview to BETC-related person (Sheikh) <br> - Move from Mandalay to Yangon (Maruyama, Hirose) |
| 19 May (Sat) | - Ngawun Bridge, Site investigation of Ayarwaddy bridge <br> - Office work in Yangon(Maruyama, Hirose) |
| 20 May (Sun) | -Team meeting, Office work in Yangon (Gunji, Nagata, Saito, Maruyama, Hirose, Suganuma) <br> - Pathein, Site investigation around Myaungmya (Sheikh, Kakemoto, Namikawa) <br> - Yangon $\rightarrow$ Bangkok $\rightarrow$ Japan (Maruyama, Hirose) |
| 21 May (Mon) | - Office work in Yangon <br> - Interview to BETC-related person (Sheikh) |
| 22 May (Tue) | - Office work in Yangon <br> - Interview to BETC-related person (Sheikh) <br> - Interview to Yangon Technological University (Sheikh, Namikawa, Suganuma) |


| Date | Survey schedule |
| :---: | :---: |
| 23 May (Wed) | - Office work in Yangon <br> - Interview to BETC-related person (Sheikh) <br> - Interview to MES (Sheikh, Suganuma) |
| 24 May (Thu) | - Office work in Yangon, Team meeting <br> - Meeting with PW Nay Pyi Taw (Saito, Suganuma) <br> $\cdot$ Visiting Thuwunna Training Centre and reviewing curriculum of bridge training course (Sheikh, Namikawa) |
| 25 May (Fri) | -Progress report to JICA Myanmar Office (Gunji, Suganuma) <br> - Progress report to PW Yangon (Gunji, Suganuma) <br> - Interview to BETC-related person (Sheikh) <br> - Yangon $\rightarrow$ Bangkok $\rightarrow$ Japan (Gunji) |
| 26 May (Sat) | - Move to Mandalay, Site investigation (Yadanarpon bridge (Nagata, Kakemoto, Namikawa) <br> - Office work in Yangon(Sheikh, Saito, Suganuma) |
| 27 May (Sun) | - Site investigation (Pakokku bridge), Move to Bagan (Nagata, Kakemoto, Namikawa) <br> - Office work in Yangon(Sheikh, Saito, Suganuma) <br> - Yangon $\rightarrow$ Bangkok $\rightarrow$ Japan (Sheikh) |
| 28 May (Mon) | $\cdot$ Meeting with PW Yangon (Saito, Suganuma) <br> - Site investigation (Malon bridge), Move to Nay Pyi Taw (Nagata, Kakemoto, <br> Namikawa) |
| 29 May (Tue) | - Office work in Yangon <br> - Move from Nay Pyi Taw to Yangon (Nagata, Kakemoto, Namikawa) |
| 30 May (Wed) | Office work in Yangon |
| 31 May (Thu) | Office work in Yangon |
| 01 June (Fri) | -Meeting with PW Yangon <br> - Office work in Yangon |
| 02 June (Sat) | Office work in Yangon |
| 03 June (Sun) | Office work in Yangon |
| 04 June (Mon) | -(AM)Discussion at JICA Myanmar Office <br> -(PM) Discussion at PW Yangon Office <br> - Yangon $\rightarrow$ Bangkok $\rightarrow$ Japan (Nagata, Kakemoto, Saito, Namikawa, Suganuma) |
| 05 June (Tue) | Arrival in Japan |

## 2. BETC PROJECT REVIEW AND LESSONS LEARNED

This chapter outlines the BETC Project based on existing reports and evaluates the BETC Project according to PDM. It also identifies factors that promote and impede the outcome of the Project as a way to clarify lessons drawn from the Project.

### 2.1 OUTLINE OF THE BETC PROJECT

This chapter was written referring to "Record of technology transfer and activities in Bridge Engineering Training Centre, Thuwunna Kai and JICA: May 1998" and "After the Bridge Engineering Training Centre Project in Burma,Road, Minoru FUJIWARA: January 1986".

### 2.1.1 Project Backgrounds

The Burmese government was promoting development projects on agriculture and industry for the purpose of economic growth of Burma at that time. However, enough outcomes could not be obtained because of insufficient transportation infrastructure. Road network at that time did not satisfy needs as means of transportation because total length and pavement ratio were insufficient and road network development at delta area, such as the Irrawaddy delta, was especially required. In order to improve these conditions and accelerate development of transportation infrastructure, Construction Corporation (present Public Works, hereinafter PW) set a goal of following two points as a key measure;

1) To extend existing road network and to improve pavement ratio and,
2) To build river crossing bridges at important locations in delta area, in order to achieve connection of north-south trunk road

In order to achieve these objectives, the Burmese government requested Japan in May 1975 to provide technical support for training of civil engineers who could design and construct road and bridge which were lacking in Burma at that time.

It was requested as a follow-up project for the planning of the Irrawaddy River Bridge Construction, which had been conducted by JICA from August 1973 to October 1975, because Japanese technology level for road and bridge construction was highly valued by the Burmese government.

Construction Corporation requested Japan again in September 1976 to provide training program for construction method of PC bridge, in which cement was procured in Myanmar and used, for the purpose of establishing it as a core method in Myanmar.

### 2.1.2 Preparation for the Project

(1) Dispatch of preliminary survey team ( $29^{\text {th }}$ November 1976-16 ${ }^{\text {th }}$ December 1976)

Regarding above mentioned request from Myanmar, discussions were made among Japanese authorities concerned and it was decided to carry out training course only for bridge field for the meanwhile. After getting agreement from Burma side, three experts were dispatched as a preliminary survey team which was chaired by Mr.Tetsuo Kunihiro (Director of Public Works Research Institute, Ministry of Construction: at that time).

The preliminary survey team conducted discussions with Burmese authorities concerned, visited existing bridges and construction site and collected related information in order to confirm backgrounds of Burma's request and to study possibility and validity of cooperation by technical cooperation center method. As a result, it was confirmed that the Project would be needed to cultivate bridge engineers capable of contributing to development of infrastructure in Burma and also cooperation from Burma side could be received sufficiently.
(2) Dispatch of Implementation Survey Team ( $16^{\text {th }}$ March 1978 - $\mathbf{2 5}^{\text {th }}$ March 1978)

After receiving the report from the preliminary survey team, a discussion was held among domestic related authorities. As a result, a team with 5 experts headed by Mr.Tetsuo Kunihiro was dispatched. The period was planned to be from $16^{\text {th }}$ March 1978 to $31^{\text {st }}$ March 1978.The purpose was to discussed with Burmese related persons about detailed plan on the BETC Project, such as dispatch plan of Japanese experts, plan for provision of machinery and equipment, acceptance plan of Burmese counterparts in Japan, construction plan of the training center building, plan of actual bridge construction training, treatment for Japanese experts, operation and management of the center, arrangement plan of Burmese staff and schedule and cooperation period of Japanese technical cooperation. And the result of the discussion was entered on the minutes of discussion.

After the team had discussed with Burma side for about a week, a site visit was conducted. But the plane with the Team crashed on $25^{\text {th }}$ March 1978. All experts of the team and two Burmese counterparts died in the line of duty and the minutes of discussion have not been signed.

Table 2.1 is a list of the people who died in the accident.

Table 2.1 List of the airline fatalities

| Position | Name | Affiliation(at project time) |
| :--- | :--- | :--- |
| Team Leader | Mr.Tetsuo Kunihiro | Director of Public Works Research Institute, Ministry of <br> Construction |
| Member | Mr.Takashi Yamaki | Department of Roads, Ministry of Construction |
| Member | Mr.Toshio Furuya | Public Works Research Institute, Ministry of <br> Construction |
| Member | Mr.Yasutoshi Shii | Tokyo Expressway Public Corporation |
| Member | Mr. Sadayuki Kato | JICA |
| Traveling companion | Mr.Norio Aikawa | Ministry of Foreign Affairs |
| Burmese Counterpart | U Aye Pe | Principal, Thuwunna Central Training Centre, Ministry <br> of Construction |
| Burmese Counterpart | U Hla Yin | Administrative Officer, Thuwunna Central Training <br> Centre, Ministry of Construction |

## (3) Dispatch of short-term expert team ( $26^{\text {th }}$ August $1978-2^{\text {nd }}$ September 1978)

Because the Implementation Survey Team had a plane accident, the project had to be temporarily suspended. Three short-term experts of a team that Mr. Tatsuo Asano represented have been dispatched. This purpose was to confirm contents of discussion between the team and Burma side and how to proceed the project. After the discussion, the team fulfilled the purpose and felt the enthusiasm from Burma side for the Project

## (4) Dispatch of Implementation Survey Team (18 ${ }^{\text {th }}$ April $1979-4^{\text {th }}$ May 1979)

Japanese Implementation Survey Team which has five members and headed by Mr.Kozo IMAMURA (Director of Construction Department, Nagoya Construction Bureau, Japan Highway Public Corporation at the time) as a team leader visited Burma. The team surveyed states of bridge construction technology in Burma and local condition for dispatch of experts. And discussions were held with Burmese related agencies on operational management for the BETC Project and result of the discussion was entered on the minutes.

Regarding On-the Job Training which was essential for the Project, minutes were revised at the time of arrangement of budgetary measures of both Japan and Burma, because the budgetary measures had been unclear at the time of dispatch of the team.
"The Record of Discussions between the Japanese Implementation Survey Team" was signed on $12^{\text {th }}$ July 1979 and the BETC Project was started.

## (5) Dispatch of detailed design team ( $19^{\text {th }}$ August $1979-2^{\text {nd }}$ September 1979)

A detailed design team which has six members including Mr.Kiyoshi MIYAMOTO (Japan Highway Public Corporation at the time) as a team leader was sent. Tasks to be done by the team were to conduct necessary data collection on bridge construction plan for On-the-Job Training in the BETC Project, to make necessary design documents for the bridge construction plan and to make a report for provision of machinery and equipment by grant aid assistance.

### 2.1.3 Contents of the Project

Trainees of the BETC Project were engineers of Construction Corporation and training on bridge design and construction was carried out. There were In-Center Training and On-the-Job Training in the BETC Project. 57 engineers studied design of bridge substructure, reinforced concrete bridge and prestressed concrete bridge through the In-Center Training and Thuwunna Bridge was built in the On-the-Job Training. Details of the BETC Project are shown below;

## (1) Project Operation

1) Operating structure of the Project

Operating structure of the Project is mainly stated in the minutes of discussion signed on $12^{\text {th }}$ July 1979 and minutes signed on $22^{\text {nd }}$ May 1981. Based on these minutes, design technology of PC bridge was transferred through lectures, exercises and experiments that were done in In-Center Training in BETC at Thuwunna Central Training Centre. And bridge construction technology was transferred in the On-the-Job Training through Thuwunna Bridge construction project.

Responsibility of both Construction Corporation staff and Japanese experts were stated in above mentioned minutes. Managing Director of Construction Corporation was responsible for the entire project including Thuwunna Bridge construction. Principal of BETC was responsible for management of BETC. Director of Thuwunna Bridge construction office was responsible for the bridge construction. And Team Leader of Japanese expert presided over Japanese experts and gave advice and introduction on technical matters to Managing Director of the Construction Corporation, Director of Road Department, Principal of BETC and Director of Thuwunna Bridge construction office. Japanese experts gave technical advice and instruction to Burmese counterparts.
2) Project Co-ordination Committee and Project Implementation Committee
"Project Co-ordination Committee" was held at the timing of discussion on the bilateral
agreement that were stated in the minutes. It was held only one time on $8^{\text {th }}$ June 1982 for the purpose of deliberation on the pros and cons of extension of the project period. Normal matters were deliberated in "Project Implementation Committee".

With a substantiation of On-the-Job Training, "Project Implementation Committee" which was headed by Managing Director of Construction Corporation and consisting of Construction Corporation staff and Japanese experts, was set up in Construction Corporation for the purpose of success of Thuwunna Bridge construction Project. The committee was held 24 times in total from 1981 to 1985.
3) Domestic support system in Japan
"The BETC Establishment Committee", which was headed by JICA administration officer and consisting of JICA staff and staff of related agencies, was set up in JICA for the purpose of deliberation on basic policy for cooperation of the Project, implementation plan, investigation, dispatch of experts, provision of machinery and equipment and plan of training of Burmese personnel in Japan, etc.

Expert Committee consisting of persons who belonged to dispatching undertaking authority was set up under the committee. This committee contributed to smooth implementation of the Project as a domestic supporting organization keeping close coordination with Japanese experts in Myanmar.

## (2) Support from Japan

The BETC Project was carried out by way of JICA Technical Cooperation Project. This system focuses on dispatch of Japanese experts, provision of machinery and equipment and training of Burmese personnel in Japan. Futhermore, detailed design of Thuwunna Bridge was also done in a JICA development study because a bridge was to be built during the process of techical transfer in this Project. And machineries and equipments that were necessary for the construction were provided by grant aid assistance.

1) Dispatch of Japanese Experts

50 experts in total, 22 long-term experts and 28 short-term experts, were dispatched during 6 years project period. Total amount of cost for the dispatch was about 760 million yen. Short-term experts were dispatched according to the progress of the Project. Regarding the In-Center Training, twelve short-term experts were dispatched to give lectures on soil mechanics, foundation mechanics, microcomputer, etc. Regarding the OJT, thirteen short-term experts were dispatched to teach how to operate construction machineries such as crane. And three experts were dispatched to set up and run the Project.
2) Provision of machinery and equipment

Total amount for provision of machinery and equipment during the Project corresponded to 580 million Yen.
3) Training of Burmese personnel in Japan

Total number of trainees which were accepted through the Project was thirty one and most of them were counterpart or trainee of the Project. Contents of the training in Japan were surveying condition of road and bridge in Japan, studying design technology in private companies and studying construction technology at actual bridge construction sites.
4) Detailed design

Detailed design of Thuwunna Bridge was conducted in fiscal 1979 and working administrative committee for Thuwunna Bridge construction was organized in JICA.
5) Grant aid assistance

Total amount of grant aid assistance in fiscal 1980 for the purpose of constructing Thuwunna Bridge corresponded to 500 million Yen.
6) Dispatch of the Study Team

Thirteen study teams including fifty five members in total were dispatched from preliminary survey team in November of 1976 until evaluation team in June of 1985.

## (3) In-Center Training

1) Outline

Original goal of the In-Center Training was to make Burmese bridge engineers learned how to design PC long-span bridge. At the beginning, the training started with an aim to make 20 engineers in a year, who could design PC long-span bridge. However, conditions in Burma at that time were as follows;

- Lower level of Burmese civil engineering than expected,
- Only a few chances of bridge construction for engineers due to small-scale project,
- No experience of almost Burmese civil engineers on bridge design,
- Ten PC bridges had been already built at that time, but nothing more than copy of New Thaketa Bridge constructed in 1962 by technical aid from Canada,
- No design calculation sheet of reinforced concrete bridge

Because of those above mentioned matters, it was proved that making all 20 trainees learned design method of PC long-span bridge in a year was difficult.

Therefore, the original goal was changed. Being a general bridge design engineer became a goal for trainees in Basic Course. And learing design method of PC long-span bridge was a target in the counterpart training (Advanced Course) only for selected persons amoung counterparts and trainees.
2) Preparation for commencement of the training (from July 1979 to March 1980)

Until dispatching the first expert team in December 1979, following items were preparered in Japan in terms of In-Center Training;

- Policy and contents of In-Center Training,
- Selection of testing equipment and making budget documents such as specifications,
- Reference books and stationery

On April 1980, two counterparts were arranged and 20 trainees were selected for the In-Center Training. The In-Center Training started on 21 ${ }^{\text {st }}$ April 1980.
3) Basic Course (training from fiscal 1980 to fiscal 1982)

From April 1980 to March 1983, one year training course was held. There were 57 trainees in total, 20 trainees in the first year, 17 trainees in the second year and 20 trainees in the third year. Trimester system was applied in each year. In the first term, lectures on basic theory, which was essential for bridge design such as structural mechanics and soil mechanics, were held. In the second term, lectures and exercises on design method of foundation, RC bridge, PC bridge and Dywidag method were held. And in the thrid term, group execises on training items for the second term were done targeting an actual planned bridge.

In the first year, Japanese experts took charge of almost lectures and exercises because experience of Burmese counterparts was not sufficient. In the second year, two counterparts who had completed previous year's training course were joined as a counterpart. And lectures and exercises were done by Burmese counterparts with Japanese expers' advice and support.

In the third year, the counterparts gave lectures and exercises in Burmese because additional two counterparts were joined, educational materials were supplemented and ability of the counterparts was improved. In addition, counterpart training was also given such as design exercises, workshop on the Japanese Specification for Highway Bridges and design of PC bridge. Training method and outcomes are summarized bellow;
a) Training method

- Adoption of trimester system

At the beginning, semester system had been planned. However, additional term for training of basic technology was decided to be supplemented because it had been proved that almost trainees could not apply theory in practical works. The contents are as follows;

- Adoption of the training method by using many examples

In order to improve their understanding, the training method was gradually shifted from theory explanation to lectures using many examples since 1981. Way of training was based on a flow of "theory explanation $\rightarrow$ example explanation $\rightarrow$ exercises" and it produced effectiveness.

- Adoption of group system in the exercises

Group system was applied in the second term training. This way made a positive result due to environment, in which they could easily consult with each other, and provision of detailed teaching depending on each trainee's ability. And grouping by training item was adopted in the third term and it produced effectiveness in a short period.

- Method of lecture

Burmese counterparts held lectures on their own initiative with advice and support from Japanese experts since 1981, while lectures in the first year had been given by Japanese experts based on lecture notes. Lectures in Burmese by the counterparts were easy to understand for the trainees and they resulted in effective training.

- Complement of counterpart

There had been two exclusive counterparts at the beginning, but excellent trainees were selected and additionally appointed to be a counterpart after completion of Basic Course. However, some of them were transferred to other department owing to circumstances of their belonging agency and the training was bit affected.
b) Outcomes

- 57 bridge engineers were trained during the three year's Basic Course
- Standard design of RC bridge and PC bridge, corrected design of Thuwunna Bridge and design document for 9 bridges were obtained in the design practice and result of the training was used in actual bridge construction.
- Burmese counterparts acquired ability to give lectures by themselves after three years experience, while Japanse experts had prepared lecture note and given lectures at the beginning of the Project.
- Lots of time was spent for learning fundamental knowledge because almost trainees had not had basic knowledge on bridge design at the beginning. Technical level of graduate of Basic Course remained at the level of learning basic knowledge and technology for bridge design, and they could not be a engineer who could design PC long-span bridge independently.
- After the BETC Project, many trainees worked not in bridge sector but in a road construction, road maintenance and architecture field, etc. except for persons who studied in Advanced Course as a counterpart. It can be said that there was no way owing to less chances of bridge construction in Burma at that time.
c) Others
- It seems to have been very hard for the trainees to be separated from their families, stayed one year in dormitory and had overtime study and homework.
- Level of trainees in the second and third term was comparatively low because they participated the Project by official order, while that of the first term had been selected among applicants. Futhermore, ensuring 20 trainees was not easy, so only 16 trainees could be obtained at the beginning of the third term.

4) Advanced Course (training from fiscal 1983 to fiscal 1984)

Advanced Course was held for 10 counterparts of Basic Course from April 1983 to March 1985 and training on design of Dywidag bridge, which was similar size as Thuwunna Bridge, was given.

In the first year, superstructure group learned design theory of Dywidag bridge, while substructure group learned design theory of reverse circulation drill method, caisson foundation and temporary structure. In the second year, design practice on Ngawun Bridge, which was similar size as Thuwunna Bridge, was done and data collection and preparation of design calculation sheet and drawings were conducted.

Training method and outcomes of the Advanced Course are summarized below;
a) Training method

- Adoption of two years training

Two years training system was adopted aiming to make trainees learned design technology of PC long-span bridge. In fiscal 1983, design and construction of PC bridge by Dywidag method and temporary structure were taught using translated textbook in English in order to transfer necessary knowledge and design technology for practice of design of PC long-span bridge. And practice for open caisson and steel bar arrangement which was a key of design were
given. In fiscal 1984, design practice of Ngawun Bridge which was planned on Pathein Monywa Road was given aiming to transfer practical design technology of PC long-span bridge in a consistent design work.

- Selection of trainee

Number of trainee was only 10 and excellent personnels were selected from counterparts of the Basic Course and trainees owing to advanced contents of the course.

- Adoption of group work and practical work

Trainees were divided into two groups, superstructure group and substructure group. Group leaders were arranged at each group and training with many excersises were done with their own initiative.
b) Outcomes

- Detailed design documents of Ngawun Bridge were made in a design practice in fiscal 1984.
- After taking the Advanced Course, trainees could almost design PC long-span bridge which was same type and similar size as Thuwunna Bridge. However, the training was given to superstructure group and substructure group separately considering effectiveness of the course, therefore, each trainee lacked in experience in the field which was out of their purview, while the combined group could achieve the design. And comprehensive knowledge and lots of experiences were required to learn high-level technology such as arrangement of PC steel member, therefore, only one time experience in this design practice was not enough.
c) Others
- Advanced Course was an in-service training and trainees were required to have their initiative. However, traditional way of education and work for Burmese engineers was so-called top-down system and they tended to refuse to take action without instruction or order from the top. Therefore, they were not good at carrying out their work from their own motive. After 2 years training, it was improved gradually.


## (4) On-the-Job Training

1) Outline

Thuwunna Bridge is a PC bridge which was built over the Nga Moe Yeik River for the purpose of connecting Thuwunna region in Thingangyun Township in Rangoon City and Thaketa Township. The bridge length is $300 \mathrm{~m}(30 m+70 m+100 m+70 m+30 m)$ and the width is $11.8 m(0.4 m+1.5 m+8.0 m+1.5 m+0.4 m)$. Main bridge is three spans continuous PC box girder by Dywidag method, which span arrangement is $70 m+100 m+70 m$ with a center hinge, and the approach bridges are simple composite girder bridge of 4 main girders by Freyssinet method with span length of 30 m .

Type of foundations at two piers located at the center of main bridge is open caisson with length of 18 m and 28 m respectively and diameter of 14 m . The foundations were constructed using temporary islands with sheet piles and embankment which were made from both sides' temporary bridges. Other two piers and two abutments were located on shore and the foundations were cast-in-place concrete piles by reverse circulation drill method with diameter of 1.5 m and length of 30 to 45 m .

Design of Thuwunna Bridge was based on the Japanese Specification for Highway Bridges and TL-20 was applied as the design live load. And value of design horizontal seismic coefficient was 0.12 and design strength for concrete of superstructure was $350 \mathrm{~kg} / \mathrm{cm}^{2}$. Quantities of major material were $11.300 \mathrm{~cm}^{3}$ of concrete (substructure $8,500 \mathrm{~cm}^{3}$, superstructure $2,800 \mathrm{~cm}^{3}$ ), 824 t of rebar and 365 t of PC steel bar and wire.

Although there were only two Japanese experts arranged in the construction site, they proceeded the construction work with teaching construction supervision method on various types of work to Burma side. And Japanese skilled workers were sent depending on progress of the construction and training for Burmese skilled workers and opertors was provided. Regarding safety control, enough and sufficient equipments were sent from Japan.

Construction cost of Thuwunna Bridge was about 2 billion and 230 million yen in total which consisted of 990 million yen for provision of machineries and equipments by Japanese grant aid assistance and technical cooperation as part of foreign currency, and 1 billion and 240 million yen (as of end of March 1985 based on information from project engineers office of Thuwunna Bridge construction Project, 1 kyat=30 yen) as part of Burmese domestic currency. Breakdown of the domestic currency was 690 million yen of material cost, 210 million yen of labor cost, 80 million yen of equipment ownership cost, 220 million yen of taking-over cost (tax, shipping cost, etc.) for machineries and equipments and 40 million yen of field office expenses (salary, electric fee, administrative fee, etc.). Above 4 items includes $24.31 \%$ of general overhead expense respectively.


Photo 2.1 Thuwunna Bridge (Left:Overall view, Right:Under slab at approach bridge)(May 2012)


Source: Minoru FUJIWARA: After the Bridge Engineering Training Centre Project in Burma, Road, Jan. 1986
Figure2.1 General view of Thuwunna Bridge
2) Preparation for commencement of construction

Right after commencement of the Project, detailed design team had been dispatched from August 1979 to September 1979 and design condition of Thuwunna Bridge was confirmed. Base on this, detailed design of Thuwunna Bridge was conducted. And a team for explanation of Draft Final Report was dispatched at the time of completion of draft version of detailed design document in January 1980 and contents of the detailed design were confirmed between Japanese experts and Burma side.

Two long-term experts incharge of on-the-job training were dispatched in April 1980 and making construction plan and work for budgetary provision of both countries, which was necessary for procurement of construction machinery and equipment, were carried out based on detailed design documents. These works were mainly done by Japanese experts because it was the first time for Construction Corporation to be involved such kind of construction work and technical cooperation project.

A construction plan document was made in November 1980 and construction order was given after an approval by Minister of Construction. And temporary organization for the construction was made in December 1980 and embankment for access road and construction yard of Thuwunna side was started.
3) Preparation works

A discussion team was dispatched from March 1981 to April 1981 and minutes on the on-the-job training were signed on $22^{\text {nd }}$ May 1981. Based on this, organization of construction office was made and 24 engineers were arranged under the Director of the office for each department. And 330 workers were totally arranged under them consisting of 120 skilled workers such as carpenters and smiths, 50 normal workers, 40 labors for light work (including ladies and children), 50 night guards, 30 drivers, 25 administrative staffs and 15 draughtsmen (The amount was at the peak of the construction.).

After that, collection of aggregate was started, machineries and equipments from Japan began to arrive, building and warehouse were built in August 1981 and short-term experts were dispatched. Construction of temporary facilities, such as fablication of concrete plant and construction of temporary bridges at Thuwunna side, was started from September 1981. Groundbreaking ceremony was carried out on $13^{\text {th }}$ October 1981 at the Thuwunna Bridge construction site.

Operation of concrete plant was started in December 1981 and construction of temporary bridge at Thuwunna side was completed. Construction of temporary island was completed in January 1982. Construction of temporary bridge at Thaketa side was started in January 1982 and construction of temporary island was completed in May 1982.
4) Substructure

Cutting edge of caisson at Thuwunna side which length was 18 m was set on the temporary island in February 1982 and concrete placement and installation were started. After that, concrete placement for pile cap was completed in September 1982 and concrete placement for pier body was completed in March 1983. Cutting edge of caisson at Thaketa side which length was 28 m was set on the temporary island in May 1982 and concrete placement and installation were started. After taking 1 month for removing trees in the ground, concrete placement for pile cap was completed in April 1983 and concrete placement for pier body was completed in November 1983.

Regarding cast-in-place concrete piles on shore by reverse circulation drill method, the first concrete placement was conducted at a pier of Thuwunna Bridge in February 1982. After that,
concrete placement was conducted at each pile, footing and structure until completion of concrete placement at a pier at Thaketa side in October 1982.
5) Superstructure

Fabrication of vorbauwagen was started at main bridge at Thuwunna side in April 1983 and concrete placement was started in May 1983. Concrete placement at construction part of the wagen was completed in November 1983 and concrete placement at support portion was completed in April 1984. At Thaketa side, fabrication of vorbauwagen was started from Thuwunna side in November 1983 and concrete placement was started in December 1983. Concrete placement at construction part of the wagen was completed in June 1984 and concrete placement at support portion was completed in September 1984.

Concrete placement was conducted in January 1983 for the first girder of simple composite girder bridge at the approach bridge of Thuwunna side and concrete placement for slab was completed in April 1984. At Thaketa side, concrete placement was conducted in September 1983 for the first girder and concrete placement for slab was completed in June 1984.

Concrete placement at center hinge at the main bridge was conducted in October 1984. In commemoration of this event, ceremony for the connection was held on $26^{\text {th }}$ October 1984 on the Thuwunna Bridge and Managing Director of Construction Corporation, counselor of Japanese Embassy and Japanese exparts, etc. were attended the ceremony.

Installation of handrail, side walk, lighting device, etc. began in earnest from November 1984 and pavement structure was constructed in March 1985 and all construction work for Thuwunna Bridge was completed. Opening ceremony was conducted on $1^{\text {st }}$ April 1985 at the construction site and many related persons from Burma side including Minister of Construction, Planning and Finance, Transport and Communications, Agriculture and Forests, Labour and Home and Religious Affairs were attended the ceremony. And related persons from Japan side including Japanese ambassador, director of JICA, Japanese exparts, etc. were also attended.
6) Outcomes of On-the-Job Training

Many types of machinery were provided for the construction of Thuwunna Bridge and main contents of the technical transfer using these equipments were as follows. Contents of technical transfer at the stage of preparation work were construction of temporary bridges using large-size H section steel by vibro hummer, construction of temporary islands using large-size sheet piles and fabrication of concrete plant and aggregate plant. Contents of technical transfer at the stage of substructure construction were execution of cast-in-place piles by reverse circulation drill method and execution of large diameter open caisson.

Contents of technical transfer at the stage of superstructure were construction of Dywidag bridge by using vorbauwagen, etc. And production of ready-mixed concrete was transfered as a common subject.

Althogh they were new to Burma, trainees slowly learned due to both ambition and effort of both sides. Especially ability of skilled workers affected result of the construction. Technical transfer was engaged from Japanese skilled workers (machinery operator, etc.) dispatched as an expert to Burmese works overcoming linguistic handicap by using gesture. Thus, 25 engineers including a manager of the construction office and 120 skilled workers learned bridge construction technology within a planned project period without any accident in Thuwunna Bridge construction. Japanese expert team suggested Burma side not to disperse these engineers and skilled workers and to try to improve their technology for constructing PC bridges continuously using machineries and equipments provided from Japan in the Project.

### 2.1.4 Activities after the Project

Capability of construction in Burma was improved dramatically due to technical transfer of construction technology on cast-in-place pile for bridge substructure and temporary work using vibration hummer through OJT of the BETC Project. For example, Construction Corporation started to construct of Nganwun Bridge, which had been designed during In-Center Training of the BETC Project (PC bridge with the length of 355 m and a central span of 110 m ), in May 1985. The Burmese government requested the Japanese government in June 1987 to provide technical cooperation on construction of Ngawun Bridge due to commencement of full-scale construction of substructure from June 1986, and Japanese cooperation resumed from November 1987. For the construction of Ngawun Bridge, less Japanese short-term experts (only 24 MM in total) were dispatched compared with that of Thuwunna Bridge, in which several Japanese experts ( 580 MM in total) were dispatched and resident at the site. The experts conducted training mainly on checking of design documents, design method and construction schedule control. The reason why less experts were required in Ngawun Bridge construction was that many engineers and skilled workers who had been trained in the BETC Project joined the construction and cast-in-place piles which execution was comparatively easy were adopted in the Ngawun Bridge construction, while caisson foundations had been adopted for main bridge of the Thuwunna Bridge.


Photo 2.2 Ngawun Bridge (Left: Overall view, Right: Slab at approach bridge)( May 2012)

Furthermore, several engineers who had participated in training in Japan were engaged in giving technical instructions as a BETC counterpart since returning Burma and they trained many Burmese bridge engineers. The trained engineers have been active in bride construction in Myanmar until now. For example, according to information from PW, 276 bridges with the length of 54 m or more have been built since 1988, while 198 bridges before 1988. Although this can be said only for bridges with the length of 54 m or more, number of bridges which was

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built since 1988 until 2012 exceeds that of before 1988 substantially. In spite of stoppage of assistance from Western countries, graduates of the BETC Project continued to construct bridges by themselves. The BETC Project is evaluated to be a succeeded project among Japanese technical cooperations due to these impacts and durabilities


Photo 2.3 Present training center (May 2012)

### 2.2 STUDY METHOD

The review method of this Study is evaluation based on the New JICA Guidelines for Project Evaluation ${ }^{2}$.While this Study evaluates the Project based on the Project Design Matrix ${ }^{3}$ (PDM), its top priority is the systematic organization of outcomes that have been continuously achieved even after Project completion and identifying important lessons learned from the Project.

### 2.2.1 Subject of evaluation (simulated PDM)

Evaluation means verifying the differences, if any, between the original purposes stated in PDM and the actual result and analysis of the cause of such differences. On the other hand, as of July 2012, 27 years have already passed since completing the BETC Project. Since the Project itself is very old, no PDM was prepared and the Study Team therefore cannot evaluate it. Therefore, information on the purpose of the BETC Project and the means used to achieve its objective has not been theoretically or systematically organized. With this in mind, existing data on the BETC Project were collected and organized, and the Study Team, as a third party, simulated a PDM for the Project based on the data and the interview survey in Japan and used as the subject of evaluation. The project purpose and overall goal in PDM are applied from the documents prepared in the past.

The standard procedure for JICA project evaluation is to evaluate projects by aid modality. But in the planning stage the BETC Project was intended to be a combination of grant aid assistance and technical cooperation, and since the two were intimately connected to each other during the implementation of the Project, it was decided that the support provided by these two schemes be organized in a single PDM. Table 2.2 is an outline of a project extracted from PDM.

[^1]Table 2.2 Project outline

| Overall goal ${ }^{4}$ | Develop the road network necessary for Burma's economic growth |
| :---: | :---: |
| Project purpose ${ }^{5}$ | Develop engineers well-versed in the design and construction of bridges |
| Output ${ }^{6}$ | Output 1: Transfer of PC bridge design technology ( 57 trainees for the Basic Course and 10 for the Advanced Course) |
|  | Output 2: Transfer of construction technology containing the construction of bridges with 100 meter long-spans using the cast-in-place cantilever erection method ( 25 engineers and 120 skilled workers) as a result of the construction of Thuwunna Bridge |
| Activity ${ }^{7}$ | 1) In-Center Training (at Thuwunna Training Centre) <br> [Basic Course (first period to third period) <br> First term: Basic theories of structural mechanics, soil mechanics, foundation engineering, concrete materials, reinforced concrete, and pre-stressed concrete <br> Second term: Basic skills of design for reinforced concrete bridges, PC bridge and substructure <br> Third term: Design practice for actual bridges <br> [Advanced Course (fourth period)] <br> First year: Practical lessons, including design and construction of PC bridges using the Dywidag method, open caissons for substructure, and arrangement of steel bars for superstructure <br> Second year: Practical lesson on design for the purpose of learning long-span PC bridge design techniques <br> 2) Field training (Thuwunna Bridge) <br> Type of bridge:PC bridge, Length of bridge: 300 meters <br> Span arrangement: $30 \mathrm{~m}+70 \mathrm{~m}+100 \mathrm{~m}+70 \mathrm{~m}+30 \mathrm{~m}$ <br> Width: $11.8 \mathrm{~m}(=0.4+1.5+8.0+1.5+0.4)$, Load: TL-20 <br> Superstructure: three-span continuous hinged PC box girder rigid-frame bridge and <br> I-shaped simple composite girder bridge <br> Substructure: caisson foundation bridge pier, cast-in-place large-diameter pile foundation bridge abutment and pier <br> Superstructure: cast-in-place cantilever erection method (Dywidag method) and post-tensioning method using shoring (Freyssinet method) <br> Substructure: open caisson method using the filled cofferdam method, reverse circulation drill (RCD) method <br> Training for 31 Burmese engineers in Japan |

[^2]| Input ${ }^{8}$ | [Japan side] <br> Long-term experts: 22 <br> Short-term experts: 28 <br> Materials and equipment for training in the Center: $¥ 70$ million <br> Materials and equipment for bridge field training: $¥ 470$ million <br> Grant aid assistance (August 1980): About $¥ 500$ million for materials and equipment for construction of Thuwunna Bridge <br> [Burma side] <br> 1. Arranging counterpart <br> 2. Cost of running the training center <br> 3. Land, labor cost, materials cost, machine rent, etc. necessary for construction of Thuwunna Bridge, which is about $35,281,000$ Kyat (equivalent to about $¥ 1,050$ million based on the then exchange rate of 1 Kyat to $¥ 30$ ). |
| :---: | :---: |
| Cooperation money | About $¥ 1,030$ million (excluding the cost to dispatch experts) |
| Cooperation period | 1979 to 1985 |
| Organizations of the counterpart country | Construction Corporation (today's Public Works) |
| Japanese cooperating organization | - Ministry of Construction (today's Ministry of Land, Infrastructure, Transport and Tourism) <br> - Japan Highway Public Corporation (today's NEXCO) <br> - Metropolitan Expressway Public Corporation (today's Metropolitan Expressway Company) <br> - Honshu-Shikoku Bridge Authority (today's Honshu-Shikoku Bridge Expressway Company) <br> - Kajima Corporation <br> - Sumitomo Construction Co., Ltd. (today's Sumitomo Mitsui Construction Co., Ltd.) <br> - Chiyoda Engineering Consultants, Co., Ltd. |
| Related projects | Irrawaddy River Bridge Construction Project (1973 to 1975) <br> Study Report on The Thuwunna Bridge Construction Project, Burma (Design Outline) <br> (1980) |

### 2.2.2 Implementation procedure of evaluation

## (1) Major study items

Major study items were organized in the evaluation grid according to the simulated PDM, and the details of those items were shared at the first internal committee. For DAC evaluation criteria--meaning relevance, effectiveness, efficiency, impact, and sustainability--the basic policy was to analyze all of them, but a lot of time was allotted to studying effectiveness, impact, and sustainability because they are factors considered to be deeply related to identifying success factors and lessons. When the evaluation was made, facts were always checked based on the evidence. The viewpoints of the DAC evaluation criteria are shown below. ${ }^{9}$

[^3]Relevance: The degree of consistency between the subject development assistance and the priority and policy of the target group, recipient nation, and donor

Effectiveness: Criterion to measure the degree of achievement of the development assistance goal

Efficiency: Qualitative and quantitative measurement of outputs relative to inputs. This is an economic term indicating that the subject development assistance uses the least costly resources to achieve the expected outcome. To confirm if the most efficient process has been adopted, it is usually necessary to compare it with other approaches.

Impact: Negative and positive changes that occur directly or indirectly from development assistance either intentionally or unintentionally. These include major influences or effects that the subject development assistance has on local society, economy, environment, and on other development indicators.

Sustainability: Whether or not development assistance benefits continue even after the donor's support has ended is measured. Development assistance must be sustainable both environmentally and financially.

## (2) Collection of information and data

Relevant information and data were collected mainly from 1) reviews of existing materials and bridge drawings, 2 ) interview surveys with relevant people, and 3 ) field survey. The details are shown below

1) Review of existing materials and bridge drawings

Relevance of bridge drawings, including drawings of Thuwunna Bridge and Ngawun Bridge, as well as drawings of PC bridges constructed after completing the Project was verified by checking them against the technology transferred as a result of the Project.
2) Interview surveys with relevant people

Interview surveys were conducted with 7 Japanese ex-experts and 17 Burmese engineers related to the BETC Project using a questionnaire (Burmese interviewees were listed in Table 2.3). The subjects comprise $40 \%$ of the total number of the In-Center trainees, or $41 .^{10}$ On the other hand, although there are 145 people, including engineers and skilled workers, who were involved in field training, only three were available for the interview. It was difficult to find engineers and skilled workers because they were sent to construction sites all over the country after the Project was completed.

[^4]Table 2.3 List of interviewees

|  | Name | Attended Term | Role in BETC Project |
| ---: | :--- | :--- | :--- |
| 1 | U Han Zaw | 4th (Advance) | CP (In-Center-Training) |
| 2 | U Khin Maung Oo | 4th (Advance) | CP (In-Center-Training) |
| 3 | U Aung Min | - | CP (OJT) Machine management |
| 4 | U Than Tun | - | CP (OJT) Electric Equipment <br> Management |
| 5 | U Htay Myint | 1st | CP (OJT) Vice Director at the <br> Project Site |
| 6 | U Win | 1st, 4th (Advance) | CP (In-Center-Training) |
| 7 | U San Lwin | 1st | CP (In-Center-Training) |
| 8 | U Tint Lwin | 1st | - |
| 9 | U Ohn Han | 1st | - |
| 10 | U Myint Lwin | 2nd, 4th (Advance) | CP (In-Center-Training) |
| 11 | U Khin Maung Sai | 2nd | - |
| 12 | U Than Swe | 3rd | - |
| 13 | U Myint Aung | 3rd | - |
| 14 | Daw Yi Yi Myint | 3rd, 4th (Advance) | CP (In-Center-Training) |
| 15 | U Khin Mg. Win | 3rd | - |
| 16 | U Soe Aung | 3rd, 4th (Advance) | CP (In-Center-Training) |
| 17 | U Soe Tint | 3rd | - |

Source: Study Team
Notes: CP=Counterpart

### 2.2.3 Evaluation restrictions

As mentioned earlier, the BETC Project was completed nearly 30 years ago, and many of the people that had been involved in the Project are already retired. It was therefore decided to hire the local consultant TOP ${ }^{11}$ to find people who had worked on the Project and make arrangements for interviews and group discussions. As a result, the Study Team successfully met and interviewed 17 people who had been involved in the BETC Project during the field survey period. Other than PW, the Study Team was unable to find trainees and field trainees sent from governmental organizations. Although information on people involved in the project but unavailable for interview could not be obtained, information obtained from interviews with people involved in the In-Center Training was used to make up for this lack.

When the Project was conducted, no institutional arrangement was in place requiring the preparation of PDM in project planning. There was no other project purpose or output indicator established either, let alone PDM. Therefore, evaluation was made using actual quantitative data collected in the past as the baseline.

[^5]
### 2.2.4 Outline of past evaluations

The BETC Project was evaluated in 1983 and 1985. Both evaluations analyzed the project purpose, the status of activity achievement, and problems to be solved. In this section, the major points of these past evaluations are reviewed to provide feedback, particularly for the analysis of relevance, efficiency, and sustainability.
(1) First evaluation (1983): Burma Bridge Technical Training Centre Evaluation Team Study Report, March 1983, Social Development Department, JICA

Purpose: The evaluation aims to make sure that human resources development, which is conducted through In-Center Training, has been smoothly promoted and that materials and equipment provided to local recipients at the time of human resource development are being used effectively at the Thuwunna Bridge construction site. In addition, an evaluation should be made with a specific focus on the relation between In-Center Training and field training and requests for technical assistance after completion of the Project.

In-Center Training: The training through the Project has steadily produced positive results, thereby helping Burma foster bridge engineers and experts, which are currently insufficient in number. On the other hand, since civil engineering trainees had less knowledge than expected, after a year of training, the goal of "developing engineers skilled at the design of long-span bridges" has yet to be fulfilled. Nonetheless, the In-Center Training is definitely bearing fruit as a provider of knowledge and skill that will form the basis for bridge design. Technical transfer is still insufficient in terms of planning (survey, condition setting, selection of construction method, and type of bridge and span arrangement). More success in this field is expected as a result of future cooperation. Furthermore, it is recommended to continue counterpart training, arranging in the field training stage appropriate coordination with oncoming superstructure work, and try to "foster core bridge engineers capable of professional independence".

Field training (On-the-job-training): The organization necessary to perform the work has mostly been established, and the techniques and skills for substructure work have been transferred to local engineers. The Project will enter the stage of erecting the superstructure, which requires transfer of the most advanced technology. This requires, therefore, extending the duration of the Project. Technical transfer of equipment maintenance, inspection, operation, and management is steadily being advanced through daily work.

Future tasks: The BETC Project is cultivating many Burmese bridge engineers. It is recommended that the recipient country start a long-span bridge project following the Project as a way to consolidate technical transfers facilitated by the Project in Burma.

Others: The Burma leadership saw this as a project to construct Thuwunna Bridge rather than as a project that transfers bridge construction technology and insisted on completing the bridge by March 1985. The efforts of Japanese experts who have made every effort to advance construction and technical transfers without accident so far is worthy of recognition.
(2) Second evaluation (1985): Burma Bridge Technical Training Centre Evaluation Team Study Report, June 1985, Social Development Department, JICA

Purpose: With completion of the Project around the corner, the results of cooperation, ranging from the start to the present day, needs to be evaluated, and whether or not this Project can be transferred to Burma also needs to be discussed.

In-Center Training: Lectures and exercises on design techniques for concrete foundation work, substructure work, superstructure work, and on concrete materials were provided to 57 trainees over three periods. In the fourth period, an Advanced Course was provided to a select group of 10 trainees, chosen from counterparts and trainees who finished the Basic Course, and including a review of the design of Thuwunna Bridge and training on the design technique in the first year and the design exercise using a bridge of similar scale (Ngawun Bridge) in the second year. The conclusion was that the design technique of PC long-span bridges had been mostly transferred by completion of the fourth period.

Field training (OJT): The opening ceremony was held in April 1985 with no accidents, and a PC bridge with a central span of 100 meters was completed using the Dwydag method. This achievement is evaluated as the outcome of the successful transfer of construction technology.

Future tasks: It is necessary to accumulate more experience in bridge planning, including the determination of span arrangement and type of bridge, and field related to the series of management procedures ranging from bridge maintenance to bridge project survey and management

### 2.3 RESULTS OF EVALUATION (RELEVANCE, EFFECTIVENESS, IMPACT, EFFICIENCY, AND SUSTAINABILITY)

### 2.3.1 Relevance ${ }^{12}$

## (1) Consistency with development policy and the needs of Burma

The 20-year long-term economic development plan formulated by the Burma Socialist Plan party in June 1971 prioritized (1) maximum development of natural resources for export, (2) development of import substitution industries, and (3) development of heavy industries based on domestic mineral resources. But development of social infrastructure centering on a road network was indispensable to the development plan's success. One of their most important tasks was constructing bridges, particularly in areas with many rivers and estuaries, like the Irrawaddy Delta area, to ensure smooth east-west traffic in the delta and to extend the total length of roads and improve the road pavement ratio.

On the other hand, Construction Cooperation faced an extreme shortage of engineers skilled at bridge construction. Here the Study Team will look at the state of bridge technology in Burma at the time the Project was requested. New Thaketa Bridge, a PC bridge with a 30 meter span length constructed in Yangon city with Canadian grant aid assistance in 1962, was the first PC bridge constructed in the country. It was a post-tensioned composite girder bridge constructed with the Freysinnet method. A total of 9 bridges of this type were constructed before the BETC Project started. For the substructure, a very large scale open caisson work was prepared, and RC piles were also used. Other than these bridges, many multi-span cantilever RC bridges with a span length of about 20 meters were also constructed.

When promoting its development plan, the Burmese government realized bridges with a span length of about 30 meters were not good enough for a country that needed to construct bridges over wide rivers, and they felt an urgent need to establish the technology for constructing longer span bridges. They also wanted to establish PC bridge construction technology as one of their core bridge construction methods, because the country can procure cement domestically ${ }^{13}$. In other words, in those days Burma did not have steelmaking

[^6]technology and had to rely on imported materials if they were to construct steel bridges, but the construction costs would be very high. Therefore, constructing bridges mainly with concrete was the right choice for Burma since it lessens the need for foreign currency and utilizes domestic resources.

The In-Center Training on design and construction technology of long-span concrete bridges and the field training of actual construction of the 300 meter long Thuwunna bridge, the core of the Project, was exactly what the Burmese government needed.

## (2) Consistency with Japan's assistance policy

Japan started providing the Burmese government with loan assistance in 1968 and grant aid assistance in 1975. Grant aid assistance constructed the Baluchaung power plant and factories for assembling buses, trucks, agricultural instruments, and electric appliances. Japanese technical assistance provided assistance to a virus research laboratory, a dentist college, forestry development of the Arakan Mountains, and livestock development. In the 1970s, the Foreign Ministry did not have priority policies or fields by country like they do today. Therefore, the Study Team cannot verify the consistency by checking the documents on political measures between the Project and the Japanese assistance policy at the time. But it is reasonable to assume that the Project was appropriately defined in light of the history of the bilateral relationship between Japan and Burma, including war reparations.

## (3) Appropriateness of the target group

The target group contains counterparts and engineers selected by Construction Corporation and engineers of other ministries (intended only for In-Center Training). As explained in detail in the section on impact, it was found that Construction Corporation personnel effectively used the technology and knowledge transferred by Japan in the bridge, road, and construction fields after completion of the Project. This proves that the appropriate target group was selected for the Project. On the other hand, personnel from organizations other than Construction Corporation (namely, 13 from the Ministry of Defense, Burma Railways, Irrigation Department, etc.) were selected based on the government's objectives, but since the Project was mainly focused on bridge design, it is assumed that, compared to Construction Corporation personnel, these employees had only limited opportunities to use the technology and knowledge they obtained from the Project after its completion.

## (4) Appropriateness of assistance means

In regard to Japan's comparative advantage in the assistance field, JICA provided the Burmese government with support of the Irrawaddy River bridge construction plan from August 1973 to October 1975. As a result, Burma was very impressed with the technical standards of Japan's road and bridge construction and requested implementation of this

Project as a follow-up project. At the time, Japan had a high level of technical expertise on long-span concrete bridges as well as extensive construction experience. It was therefore appropriate that Japan provided support to Burma in this field.

The assistance means adopted included a combination of In-Center Training by technical assistance and OJT (field training) by grant aid assistance along with periodic training in Japan. It was not easy for JICA to promote assistance in step with In-Center Training and field training, as explained in the section on effectiveness, but it is judged that simultaneous implementation of a dual training scheme was essential to achieving the Project's purpose.

As analyzed above, it is concluded that the Project was appropriate in terms of responding to the needs of the Burmese government and the assistance means selected and was highly relevant.

### 2.3.2 Effectiveness ${ }^{14}$

The degree of output achieved is summarized as follows;

## (1) Output 1: Achieving "transfer of PC bridge design technology"

In-Center Training was intended to transfer bridge design technology to a total of 57 engineers. 10 trainees in the Advanced Course achieved a level of technical mastery sufficient to design a real PC bridge using the technology they obtained when working together as a group. The remaining 47 trainees achieved the purpose in terms of developing bridge engineers. But as suggested by past evaluations, the level they attained was not enough to actually design long-span PC bridges.

As explained above, the wide difference in the level of technology and knowledge the trainees obtained is mainly attributable to the unevenness in the original ability of the trainees. All those who took In-Center Training from 1980 to 1982 had almost no experience in the design and construction of bridges. Their basic knowledge of bridges was less than the Japanese experts expected. As a result, In-Center Training started with lectures on structural mechanics and, after a year of training, ended successfully with the trainees having learned the design techniques for RCT girder bridges and post-tensioned PC girder bridges of about 30 meters in span length. This final result, however, was not the kind of technical transfer that the Project originally aimed for.

[^7]In an interview survey, the counterparts who participated in the In-Center Training commented that they were unable to master the ability to design a PC bridge even after one year of training and that they could not move on to understanding superstructure design. Civil engineers in Burma are generally inclined to prefer field work to indoor work, and it is said that some of the trainees were not very interested in bridge design to begin with. So the background is that trainee's motivation was not at the same level, because the trainees who joined in the second period did so at the order of their superiors while most of the trainees selected in the first period were interested in receiving the training.

Aware of this difference in level, Japanese experts engaged in the In-Center Training checked training progress every term and improved the contents and procedure to match the level of the trainees and the degree of improvement of the counterparts. For example, the second and third terms of the first period training were originally intended for design exercises, but since the result of the first term final examination was poorer than expected, the focus was shifted to acquiring basic techniques. In the second period training, more examples were introduced in lessons to help trainees better learn theory whereas lessons in the first period training focused on theoretical explanations. In addition, those counterparts who did well in the first period training and attained an adequate level of skill and knowledge were invited to serve as lecturers for the second period training.

Table 2.4 below summarizes the major contents of the first to fourth period training, describes their relationship with field training, and outlines the training policy of each term in the remarks column.

Table 2.4 Descriptions of training from the first to fourth period

| Training <br> period | Description | Remarks |
| :--- | :--- | :--- |
| First period <br> (April 1980 <br> to the end <br> of March <br> 1981) | 1st term: structural mechanics, soil <br> mechanics and foundation engineering, <br> reinforced concrete, pre-stressed concrete, <br> and concrete materials (lecture in AM and <br> exercise in PM) <br> 2nd term: design of reinforced concrete <br> bridge, design of foundation work, design of <br> PC bridge, and design of Dywidag bridge <br> (lecture in AM and exercise in PM) <br> 3rd term: Design exercises in four groups <br> Dywidag bridge for Group 1, PC bridge for <br> Group 2, foundation design for Group 3, and <br> actual bridge design for Group 4 | Although the second and third terms <br> were originally meant for design <br> exercises, the results of the first term <br> to mastering basic techniques. |

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|  | [Relationship with field training] <br> Since construction of Thuwunna Bridge had yet to start, there were no field visits, but trainees did visit construction sites for Dontami Bridge and a PC bridge between Pathein and Monywa Road. |  |
| :---: | :---: | :---: |
| Second <br> period <br> (April 1981 <br> to the end <br> of March <br> 1982) | $1^{\text {st }}$ term: Same as the first period <br> $2^{\text {nd }}$ term: Same as the first period <br> $3^{\text {rd }}$ term: Design exercises distributed among six groups <br> Ngawun Bridge for G1, Zawgyi-Chaung Bridge for G2, Kun Chaung Bridge for G3, Thuwunna Bridge for G4, standard design of PC composite girders for G5, and review of a bridge for Prom-Magwe Road for G6 <br> [Relationship with field training] <br> Sheathing, installation of temporary bridges, and filled cofferdam works were conducted at the construction sites, which the trainees observed. When the third term started, lecturers met with the Construction Corporation headquarters bridge design manager every Saturday to discuss the progress and problems of trainees during the previous week's training. Counterparts engaged in field training were also called to the center and assigned to review substructure design. | - More case examples were introduced in lessons as compared to the theory-centered instruction of the first period. <br> - Counterparts were assigned to serve as lecturers (in English). |
| Third period (April 1982 to the end of March 1983) | $1^{\text {st }}$ term: Same as the first period $2^{\text {nd }}$ term: Same as the first period $3^{\text {rd }}$ term: Design exercises were conducted on the substructure of an actual bridge whose design was requested by the Construction Corporation Head Office. Trainees were divided into five groups. <br> Padaw Chaung Bridge for G1, Ma Mya Chaung Bridge for G2, Kanyin Chaung Bridge for G3, Thebyu Chaung for G4, and Pa Shin Chaung for G5. <br> [Relationship with field training] <br> Substructure work started at the site. Construction of RCD piles, abutments, and open caissons was conducted, and trainees visited and observed the work depending on its progress. | - 20 trainees were expected, but only 16, including those from other organizations, took part. Counterparts were added to the group of trainees. <br> - In the third term, based on the report of the evaluation team sent in December 1982, training shifted more to planning and application. Trainees learned superstructure techniques using the PC standard design developed by the counterparts, and practiced substructure design in the exercise section. |


| Fourth <br> period <br> (1983 to <br> 1985) | $1^{\text {st }}$ year: Thuwunna Bridge was used as the teaching subject. Training on the basics of the design of a long-span concrete bridge was provided to trainees. <br> $2^{\text {nd }}$ year: Trainees learned practical design routines, from planning to design and construction, with Ngawun Bridge as the subject. <br> Specifically, the program consisted of: <br> Superstructure: structural analysis, design, and computer programs <br> Substructure: design of piers of a general bridge, concrete quality control, design of open caisson, design of pile foundation, and temporary structures <br> [Relationship with field training] <br> Construction of the superstructure started at the work site. Trainees visited the site to observe, depending on the progress of construction. | - Lesson focus shifted from lecture-centered instruction to group lessons and learning through application. <br> - Trainees were divided into a superstructure group and a substructure group to conduct exercises (6 for the superstructure and 4 for the substructure group). |
| :---: | :---: | :---: |

Source: Prepared by the Study Team based on Project-related reports
As indicated in the above table, the relationship with field training changed over the period from the first period to the third period. In the first period, field training had just started, and there were no visits to the Thuwunna Bridge construction site. Instead, trainees visited nearby bridge construction sites. In the second period, trainees learned construction of sheathing and temporary piers. In the third period, the construction of the substructure had finally started, and work on RCD piles, abutments, and open caissons were available for field visits. Construction of the superstructure, however, had not yet begun. When the third period ended, the level of trainees had not reached "the level of mastery of design and construction technology for a long-span PC bridge." Since construction of the superstructure of Thuwunna Bridge was about to start, the trainees of the first to third period completed their training without seeing the superstructure work of a long-span bridge.

The 1983 evaluation pointed out that the In-Center Training output goal of "developing engineers' expert in designing long-span bridges" had yet to be achieved. This conclusion was shared among Project team members. According to the local interview survey, the Managing Director of Construction Corporation knew that Burmese trainees were not yet capable of designing and constructing bridges by themselves even with Japanese technical assistance, and even though Project completion was just around the corner, told the Burma Project counterparts that the goal must be achieved in the remaining two years. The Burma counterparts strongly felt that the Project needed to change course by extending the Project.

As a result, the original training programs were rearranged in 1983 so that the first, second, and third period training comprised the Basic Course and the fourth period was the Advanced Course. In the Advanced Course, a total of 10 trainees, including 8 trainees who had obtained an adequate level of ability in the Basic Course and two counterparts who joined the training when it started, were given more practical training than provided in the Basic Course. A group-based learning system was used to provide training to these 10 trainees, who were divided into the superstructure group and substructure group. In the first year, the superstructure group and substructure group learned design theory and conducted exercises for PC bridges, with the former using the Dywidag method and the latter the basics of caisson and temporary structures. In the second year, design exercises were conducted with Ngawun Bridge, which was of a scale similar to that of Thuwunna Bridge and was planned to be constructed using Burma capital, for which the trainees conducted a whole set of design operations, including collecting data and preparing design calculations and drawings. It was Burma's strong desire from the beginning of the project that Burmese engineers design a long-span bridge on their own, and this desire was met by completing the Advanced Course.

As explained above, it is concluded that "Output 1: Transfer of PC bridge design technology" was fulfilled.

## (2) Output 2: Transfer construction technology for constructing bridges with 100 meter long-spans using the cast-in-place cantilever erection method

For this Project, 25 engineers and 120 skilled workers who received technical know-how of bridge construction through OJT were engaged in the construction of Thuwunna Bridge. Construction of Thuwunna Bridge was not conducted as an ordinary grant aid assistance project; use of the OJT system was intended to allow Japanese engineers to join construction in a leadership role while Burmese engineers carried out the actual work. There is a difference between bridge construction by ordinary grant aid assistance and bridge construction using the OJT system. The former aims to simply complete construction, whereas the latter aims to teach and transfer technical know-how for bridge construction processes to Burmese engineers so that they can construct the same kind of bridges on their own after the Project is completed. Since a bridge constructed by technical transfer requires the same level of quality and completion date as that of a bridge constructed by ordinary grant aid assistance, the contribution of the Japanese experts who participated in the Project is beyond measure.

The bridge was completed as scheduled and without any major problems upon completion. Also worthy of praise is the fact that no accidents occurred during the Project. This must be the result of including "safety controls" for technical transfer items and implementing it during the Project. Evaluation of work upon completion of the Project and the main reasons for the
conclusions reached are shown in Table 2.5. The majority of items were given an "A" evaluation. This means that technical transfer through OJT obtained outstanding results.

Table 2.5 Evaluation of work and main reasons for the conclusions reached

|  | Evaluation criteria | A: Burmese engineers can sufficiently accomplish on their own <br> B: Some concerns arise if Burmese engineers work unassisted <br> C: Burmese engineers cannot complete without assistance |
| :---: | :---: | :---: |
| Preparation work |  |  |
| Check design plan items | B | Cannot adequately apply design standards, as required by changes. |
| Prepare execution plan and execution drawings | B | They cannot create a clear image of a new work item and basically need instruction from experts. |
| Ordering and load-in of materials and equipment | A | There is almost no process delay. Trainees can functionally plan ordering and load-in. |
| Construct materials and equipment storage site | B | Insufficient application capability. |
| Construct offices and dormitories | A | The counterparts voluntarily planned room arrangement of the office and construction of a dormitory. |
| Construct unloading temporary bridge | A | The counterparts can plan and construct a temporary bridge on their own if it is wood construction. |
| Temporary work |  |  |
| Install and maintain power facilities | B | They can almost voluntarily manage facilities but their checking and maintenance of power cables in terms of safety is unsatisfactory. |
| Install and maintain water supply equipment | A | They can perform task most with no problems, but their water supply equipment is not extensive enough to provide water for the office and dormitory. |
| Electric power equipment | A | They received three months of technical instruction on the construction planning stage and are fully capable. |
| Concrete plant equipment | A | They can keep equipment operational without any problems. |
| Sheathing | A | They have acquired enough knowledge to carry out future planning on their own. |
| Construct temporary bridge | Planning and construction A Safety and crane operation B | Their attention to safety during construction is still insufficient. The same applied to their crane operating technique. |
| Remove temporary bridge | A | They completed work almost as scheduled. |
| Construct filled cofferdam work | B | Though they were trained to always have an in-depth talk before starting work, this practice did not go down to the terminal worker level. |
| Remove cut-off wall | A | They removed the wall as planned. |

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| Substructure |  |  |
| :---: | :---: | :---: |
| Install RCD piles | A | Instruction was completed. <br> Their technique will improve if given many opportunities to work at sites in the future. |
| Construct abutment | A | The counterparts voluntarily conducted the work and needed little guidance. |
| Construct open caissons | A | They have acquired sufficient technique in terms of planning and construction. <br> They need more experience on responding to unexpected developments. |
| Superstructure |  |  |
| Construct sheath | A | They completed work with almost no trouble. |
| Concrete work (P2) | A | Although they sometimes had problems, they, including laborers, were able to complete work smoothly. |
| Concrete work (P3) | A | Although their work was not outstanding in regard to concrete surfaces because of form problems, their overall work receives a passing grade. |
| Formwork | A | Although they had difficulty removing forms, their work was excellent. |
| Stressing (P2) | A (partly B) | Putting values from calculation sheets into stressing tables was completely performed by Japanese. |
| Stressing (P3) | A | They conducted work under the guidance of Japanese in attendance. They completed work smoothly with no major problems. |
| Anchoring | A | Whenever a problem occurred, the trainees were instructed and corrected by Japanese. They had difficulty with limited locations during work. |
| Anchoring (P3) | A | Despite some problems, their work receives a passing grade. |
| Joint work (P2) | A | A problem occurred due to improper jointing, and trainees conducted retouching and restressing, which made them very attentive of their subsequent work. |
| Joint work (P3) | A | Their jointing work was accurate and fast. |
| Construct intermediate cross beams (P2) | A | They completed the work with almost no guidance. |
| $\begin{aligned} & \text { Construct intermediate cross beams } \\ & \text { (P3) } \end{aligned}$ | A | They completed the work with almost no guidance. |
| Reinforcement work (P2 side bridge pier and superstructure) | A | Their rebar fabrication and arrangement was better than in Japan. |
| Reinforcement work (P3 side bridge pier and superstructure) | A | Their rebar fabrication and arrangement was better than in Japan. |
| PC steel bar production work | A | Although they did the work manually, it took a lot of time, but the result was sufficient. |
| Assemble traveling form (P3 side) | A | They completed their work relatively smoothly. When assembling the second form, they did not need very much guidance. |
| Column capital support planning (P2 side) | B | They completed the work but lacked confidence unless they checked the results with Japanese personnel. |


| Column capital support planning (P3 side) | B | They completed the work but lacked confidence unless they checked the results with Japanese personnel. |
| :---: | :---: | :---: |
| Column capital work (P2 side) | A | They could handle the work. |
| Column capital work (P3 side) | A | They could handle the work and cope flexibly with the process. |
| Travelling form equipment plan (P2 side) | A | Although they used materials different from those used in Japan, the work was good. |
| Traveling form equipment plan (P3 side) | A | Same as above |
| Erect traveling form construction blocks (P2 side) | A | They completed the work with both sides proposing ideas and working on them. The work was not of such good quality because of the use of veneers, with which the Japanese had little experience, but they managed to get the work completed. |
| Erect traveling form construction blocks (P3 side) | A | Based on the experience of P2, they used lumber to cope with the reduction in strength The results were good. |
| Setting of the traveling form (P2 side) | A | The Japanese took the lead until the fifth setting, and thereafter the Burmese trainees took the initiative. In the $26^{\text {th }}$ setting the trainees did all the work on their own. |
| Setting of the traveling form (P3 side) | A | Same as above |
| Dismantle traveling forms (P2 side) | A | They completed the work although it took them time to do it. |
| Dismantle traveling forms (P3 side) | A | They completed the work using what they learned from P2. |
| Side span support plan (P2 side and P3 side) | B | Trainees proposed additional piles (for reinforcement) and used this method. |
| $\begin{aligned} & \text { Construct side span support (P2 } \\ & \text { side) } \end{aligned}$ | A | Japanese experts and Burmese trainees exchanged ideas and completed the work. |
| Construct side span support (P3 side) | A | Same as above |
| Construct central connections | A | A 55 mm gap occurred among 25 blocks at P2 and P3, and the trainees were advised on how to cope with the gaps and conducted the work under the guidance of Japanese experts. |
| Grouting (P2 side) | A | They repeatedly corrected the plan, solved the problem, and completed the work. |
| Grouting (P3 side) | A | Having learned the lesson from P2, they smoothly completed the work. |
| Simple girder production planning | B | The trainees could not complete all processes by themselves and needed Japanese help. |
| Construct simple girders (P1 to A1 side) | A | They had the experience, and the completed work was of comparatively high quality. |
| Set shoes | A | They used Burma-made Portland cement with good results. |
| Correct expansion joints | A | The height of the sidewalk had to be changed, which was handled by Japanese. The Burmese trainees were then advised to correct three joints out of five, and the remaining two were fully corrected by Burmese personnel. |

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| Common work |  |  |
| :---: | :---: | :---: |
| Management of construction schedule | B | This is beyond the effort, capability, and responsibility of engineers. Their ability to study the method, calculation and arrangement of materials, making preparations and managing the work flow continued to improve. |
| Quality control (concrete) | A | Although it took them time, they completed almost all the work on their own. |
| Quality control (other than concrete) | A to C | Their results show a high degree of precision, but they have not fully applied what they learned as a system approach. |
| Safety control | B (partly C) | Although their basic thinking could not be changed, they learned enough to determine how to do safety checks. Further standardization is necessary. |
| Labor management | - | They flexibly coped with the task and organized workers within the assigned range. |
| Equipment management (machines and spare parts) | B | They learned how to manage spare parts using a balance sheet, but their equipment management ability for future plans based on operation condition and repair condition needs more improvement. |
| Equipment management (other than machinery) | B | They need to put more effort into improving their equipment management skills as well as process management skills. |
| Vibration work | A | They completed change work with excellent results. They are also sufficiently capable of maintaining equipment. |
| Repair of cranes | B | They don't have sufficient basic abilities in both servicing and technical aspects. |
| Crane operation and maintenance | A (technical) B (safety and maintenance) | They became skilled in operating techniques but have not made daily maintenance and inspection a part of their daily routine. |
| Operation and maintenance of vibration hammer | A | They have mostly mastered operation and maintenance skills. |
| Gas handling | A | They have learned enough to conduct gas fusing and fusing dimensioning. |
| Electric welding | A to B | They can do most of it properly, but they still need more practice when it comes to removing sputters after tack-welding, inclusion of blow holes, pin holes, and slag during welding of the first pass, and overhead position welding. |

Source: Prepared by the Study Team base on Burma Bridge Technical Training Centre Record of Technical Transfer and Activities, May 1998, Thuwunna Association, JICA

When the Study Team visited Thuwunna Bridge, our visual inspection did not find any cracks on the concrete surface even though construction was completed 20 years ago and cracks are the most common type of damage for concrete structures. There was also heavy traffic on the bridge.

Based on the interview survey, it is considered that major factors contributed to constructing such a high quality bridge, including accurate application of technical know-how of bridge construction by Burmese engineers through the technical transfer from Japanese experts to the actual construction of the bridge, as well as the partial participation of Japanese engineers in construction work based on the judgment of the local engineers'
 technical competence. For instance, Japanese experts took the initiative in executing work and providing guidance to Burmese engineers for some operations which the local engineers could not do on their own such as work plan development, cost estimation, and materials and equipment planning prior to commencement of work, as well as preparation and temporary work stage, detailed work planning for substructure and superstructure, preparing materials and equipment, and process coordination and supervision. Limiting the scope of field training was necessary if the Project was to be successfully completed in the limited Project period. Those plan developments conducted by the Japanese were incorporated into the list of lesson items for the In-Center Training, and the skills were transferred to local trainees. For Ngawun Bridge, which was constructed after completing the Project, all processes from design to construction were handled by Burmese engineers. This corroborates the judgment that transferred technology was successfully applied to constructing Ngawun Bridge and that they assimilated the expertise. Ngawun Bridge is discussed in detail in the section on sustainability analysis.

As explained above, it is concluded that Output 2 "transfer of construction technology for constructing bridges with 100 meter long-spans using the cast-in-place cantilever erection method" was fulfilled.

## (3) Status of achieving Project purpose

The purpose of the BETC Project was to "develop engineers well-versed in the design and construction of bridges." This includes not only the ability to construct bridges but also the transfer of all bridge technology from "design" to "construction" as a total package and Burma's mastering the ability to reproduce all of this technology after assistance has ended.

Japan assisted Burma in fulfilling the purpose of this Project over a six year period through the In-Center Training and the OJT. As a result, technology was transferred from Japanese experts to 57 trainees through the In-Center Training and to 25 engineers and 120 skilled
workers through the OJT. As explained in the Output 1 section, there is a difference among the 57 engineers who took part in the In-Center Training in the technical level they mastered. Not all the OJT trainees reached Level A in all processes in Output 2. But their effort resulted in Thuwunna Bridge being completed with no accidents. The bridge still underpins Myanmar's economy.

The Study Team therefore concludes that the combined technical ability and knowledge of the Burmese people who received technical transfer from the Project accomplished the goals of the Project at a high level. This is fully proven by the successful construction of Ngawun Bridge, as explained in the section on sustainability that follows.

As explained above, the Project was very effective because it fulfilled its goals at a high level as a result of the In-Center Training and the OJT.

### 2.3.3 Impact $^{15}$

## (1) Status of achievement of the overall goal

It is reasonable to say that the overall goal of "developing the road network necessary for Burma's economic growth" is being achieved because of the following conditions:

In order to improve the road network in Burma, it was essential to construct bridges in the area rich in rivers and estuaries, mainly the Irrawaddy Delta. When the BETC Project was the first planned in the 1970s, the strong desire of the Burmese government to maintain smooth east-west traffic in the Irrawaddy Delta pushed forward implementation of the Project. Graduates of the BETC Project play pivotal roles in design and at construction sites in the government's pursuit of an improved traffic network. Specifically, bridge statistics available at PW show that there are about 2,800 bridges longer than 50 feet managed by PW. Moreover, among bridges longer than 54 meters ( 180 ft. ), 198 were completed before 1988 when the BETC Project was completed, and 276 more were completed for a total of 474 as of April 2012. As shown in Table 2.6, Rakhine State, Yangon Region, and Ayeyarwady Region are the three major areas where bridges constructed after the BETC Project are located. This shows that bridges have been constructed over wider rivers, mainly in the delta. The 276 bridges constructed after the Project are long-span bridges built in these areas. Their characteristics are very different from the 198 bridges built before the Project.

[^8]The construction of these bridges greatly benefited from the counterparts and former trainees of the BETC Project who benefited from technical transfer. For example, it was confirmed that 20 Project graduates participated as field supervisors in the construction of 102 of the 276 bridges longer than 54 meters, as shown in Table 2.7. For bridge design, Project graduates also checked the substructure and superstructure designs of 263 out of 276 bridges.

Even for bridges in which no Project graduates participated as field supervisors, some used the reverse circulation drilling method, technology transferred by the Project, in their foundation work. According to the local interview survey, a conventional earth drill can only drill to a depth of 40 meters, while piles need to be driven to a depth of about 80 meters for some construction sites in Myanmar where the soft ground is thick. It is reported that equipment and construction technology provided by the BETC Project was put to effective use in this construction.

Along with this bridge improvement efforts, Myanmar's road network gradually expanded. Road length by type of road before the Project and in 2011 is shown in Table 2.8. It indicates that total road length in the days of the Project was 21,111 kilometers and increased to 146,537 kilometers in 2011, an increase of about 7 times. ${ }^{16}$ On the other hand, the economic output of Myanmar from 1990 to 2011 (Table $2.9^{17}$ ) shows that gross domestic product (GDP) increased from 151,941 million Kyat in 1990-1991 to 40,507,942 million Kyat in 2010-11. This shows how an expanded road network contributes to the country's economic growth.

[^9]Table 2.6 Number of bridges over 54 m (180 feet) managed by PW (As of April 2012)

| State I Division | Before 1988, <br> 180 feet and above Span Bridges | After 1988, <br> 180 Feet and above Span Bridges |
| :--- | :---: | :---: |
| Kachin State | 27 | 22 |
| Kayar State | 6 | 2 |
| Chin State | 2 | 3 |
| Sagaing Region | 17 | 21 |
| Magwe Region | 20 | 25 |
| Manadalay Region | 18 | 16 |
| Shan State (East) | 4 | 4 |
| Shan State (South) | 5 | 7 |
| Shan State (North) | 15 | 8 |
| Kayin State | 8 | 8 |
| Tanintharyi | 8 | 7 |
| Bago Region | 36 | 23 |
| Mon State | 3 | 4 |
| Rakhine State | 11 | 37 |
| Yangon Region | 7 | 30 |
| Ayeyarwady Region | 11 | 59 |
| Total | $\mathbf{1 9 8}$ | $\mathbf{2 7 6}$ |
| Grand Total |  | $\mathbf{4 7 4}$ |

Source: Prepared by the Study Team based on the data provided by PW
Table 2.7 BETC project's graduates in charge of bridges over 54m (180feet) ${ }^{18}$

| CP•Trainee | Role in BETC Project |  | Number of bridegs <br> supervsed at the <br> construction site |  |
| :---: | :--- | :--- | :--- | ---: |
| 1 | 1st | C/P | OJT | 6 |
| 2 | 3rd | C/P | OJT | 1 |
| 3 | 2nd | - | - | 6 |
| 4 | 3rd | - | - | 1 |
| 5 | - | C/P | OJT | 8 |
| 6 | Advance | C/P | Training in Japan | 1 |
| 7 | 1st | C/P | OJT | 10 |
| 8 | 2nd, Advance | C/P | Training in Japan | 4 |
| 9 | 3rd | - | - | 3 |
| 10 | 2nd | - | - | 5 |
| 11 | 3rd | - | - | 1 |
| 12 | 2nd, Advance | C/P | Training in Japan | 12 |
| 13 | 1st | - | - | 1 |
| 14 | 1st | - | - | 13 |
| 15 | 3rd, Advance | C/P | Training in Japan | 15 |
| 16 | 3rd | C/P | OJT | 8 |
| 17 | 3rd | - | - | 7 |
| 18 | - | C/P | OJT | 1 |
| 19 | 1st | - | - | 2 |
| 20 | - | C/P | OJT | 2 |
| Total |  |  |  | 102 |

Source : Data provided by PW and TOP

[^10]Table 2.8 Road length by type in Myanmar (Km)

| Year | Paved | Rubble | Gravel | Soil or Others | Total |
| :--- | :--- | :--- | :--- | :--- | :--- |
| $1982 / 83$ | 8,631 | 2,530 | 6,239 | 3,711 | 21,111 |
| 2011 | 30,702 | 26,064 | 12,483 | 77,289 | 146,537 |
| Growth (times) | 4 | 10 | 2 | 21 | 7 |

Source: Prepared by the Study Team based on the data provided by PW

Table 2.9 Economic trends in Myanmar

|  |  |  | 1990-1991 | 1995-96 | 2000-01 | 2005-06 | 2010-11 | Remark (USD) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| GDP |  | Million Kyat | 151,941 | 604,729 | 2,562,733 | 12,286,765 | 40,507,942 |  |
| GDP growth rate (annual average) |  | (\%) | 3 | 7 | 14 | 14 | 10 |  |
| GDP per person |  | (Kyat) | 3725 | 13515 | 50927 | 221799 | 677,617 | 816 (year 2011) |
| GDP growth per person per year |  | (\%) | 1 | 5 | 12 | 11 | 9 |  |
| GDP structure | Primary Sector | (\%) | 57\% | 60\% | 57\% | 47\% | 36\% |  |
|  | Secondary Sector | (\%) | 11\% | 10\% | 10\% | 18\% | 26\% |  |
|  | Teritiary Sector | (\%) | 32\% | 30\% | 331\% | 36\% | 38\% |  |

Source : Statistical Year Book 2010,Central Statistical Organization, 2012

## (2) Qualitative impact

The following qualitative impacts were confirmed:

1) Standardizing substructure design

The Study Team has confirmed that the design standards for concrete bridges used in Japan and transferred to Burma by the BETC Project have been applied in Myanmar. Since no national design standard have yet to be established, the Japanese Specification for Highway Bridges translated into English by the Project have been and continue to be the effective standard from the time of the Project until today. The updated version of the Japanese Specification for Highway Bridges was obtained by a BETC Project graduate, who worked for the Design Department of the PW Bridge Division from the start of the Project until he retired, which the Department has retained and used. This fact proves that the BETC Project has contributed to standardizing bridge substructure design in Myanmar.

On the other hand, the applicable superstructure design standards change depending on who is awarded the contract. In recent years, there has been movement to establish the country's own design standard, with Myanmar Engineering Society (MES) cooperating with the Ministry of Construction in this regard.
2) Quality improvement of concrete structures

According to the interview survey, some BETC Project graduates assigned to departments other than bridge construction have had opportunities to apply what they learned from the Project to various construction sites. For example, graduates who had spent a lot of time
during the Project learning how to handle concrete, which is also used in road and building construction, have successfully applied the techniques and knowledge they learned to construction besides bridges. They said they would have been unable to recalculate on the spot and make the appropriate corrections when design errors were found without the knowledge they learned from the Project.

### 2.3.4 Efficiency ${ }^{19}$

## (1) Japan's input

Japan's input is analyzed in Table 2.10, which compares planned input and resulting input.

Table 2.10 Japan's input - comparison between planned input and resulting input

| Input factors |  | Plan $^{20}$ |
| :--- | :--- | :--- |
| 1) Expert | Long-term: 2 | Input results |
| Team leader | Long-term: 5 <br> Short-term: as many as <br> appropriate | Long-term: 3 <br> In-CenterTtraining <br> Short-term: 12 |
| OJT (field training) | Long-term: - <br> Short-term: - | Long-term: 10 <br> Short-term: 13 |
| 2)Acceptance of <br> trainees in Japan | A few trainees every year | 31 |
| 3)Provision of <br> equipment and <br> materials | $¥ 230$ million | $¥ 540$ million |
| 4)Grant aid assistance | A set of materials and equipment <br> for bridge construction that cannot <br> be procured by Burma | Total ¥500 million |

For both theln-Center Training and the OJT, the appropriate dispatch of long-term and short-term experts was conducted in terms of quantity, quality, and timing depending on the process of the Project. Past evaluation reports and interview surveys in and out of Japan confirm that those experts were effectively used and contributed to fulfilling the Project purpose.

For OJT, especially, skilled workers assigned to provide instructions on temporary work and PC work involving crane operation, reverse circulation drill piles, and vibration hammers were

[^11]also sent to Burma so that guidance was provided for all technical aspects necessary for bridge construction. Burmese engineers were seeing many of the materials and machines used for OJT for the first time, and the experts took note of this fact by taking the appropriate step of providing sufficient instructions for the safe handling of equipment and then allowing the Burmese engineers to apply what they had learned to actual work. This process took time, but considering Thuwunna Bridge was completed without accident, it also turned out to be an effective approach. This type of Japanese technical guidance was very useful in helping trainees surely and steadily acquire technical expertise and was highly regarded by the Burmese people involved in the Project, as demonstrated by interviews with them.

Equipment and materials provided for the Project include those for the In-Center Training education, for concrete-related testing necessary for quality control and testing of concrete for training bridges, and soil test equipment related to the construction of the superstructure of training bridges. Upon completing the Project, past evaluations have confirmed that this equipment and material has been put to good use. It is now difficult to do follow-up checks of this equipment and material because much of it has been discarded due to aging.

A lot of the equipment and materials necessary for constructing Thuwunna Bridge were provided for the OJT. As shown in Table 2.10, there is a great difference between the plan and the result in the amount of money allotted for the provision of equipment and materials. The 1983 evaluation report mentioned that the Project was launched relatively prematurely, with the In-Center Training as the main contents of the Project, and without determining details such as training content or the financial burden on both countries. This is probably the reason for the cost difference. In the detailed design stage, the estimate suggested capital of 1.3 billion yen for constructing Thuwunna bridge, but the capital procured was actually only 500 million yen. Materials and equipment equivalent to $¥ 800$ million, which could not be covered by the available capital, had to be procured by the Burmese government or, if local procurement was impossible, by a technical cooperation scheme. But JICA's progress management of grant aid assistance and technical cooperation was excellent, with JICA administration officer playing a core role, so that local experts seemed to feel no serious burden in this respect.

A total of 31 trainees were accepted for training in Japan. Their stay per training was about 0.5 months to 3.5 months. What the trainees learned included the current status of Japanese roads and bridges, acquisition of design techniques at the design section of a private company, and acquisition of construction techniques at bridge construction sites. According to the interview survey, since Burmese people at that time could not go abroad without a foreign invitation, training in Japan was an invaluable opportunity for former trainees and counterparts to experience the feel and touch of overseas technology. Also reported in the interview survey was that training in Japan provided a great incentive and was highly useful.

## (2) Burma's input

Burma's input included a financial burden of $35,281,000$ Kyat in total for arranging counterparts, running cost of the In-Center Training, and land, labor cost, materials cost, and machine rent for constructing Thuwunna Bridge. Since there was no fully established system for Project implementation in the first year, the Project did not go as smoothly as planned due to, for example, process delays. But progress was smoother in the second year and thereafter. The OJT scheme required Burma inputs for smooth implementation, and the Burmese government made domestically available resources, such as concrete and wood, preferentially available to the Project, helping it to proceed smoothly.

In addition, the Project was positioned as one of the nation's most important projects and the government sent its most outstanding engineers to take part in it. This is also true of the counterparts. Among the counterparts for the In-Center Training, 15 were selected from trainees judged to be very excellent during the process of the Project, except for 2 who were selected at the start of the Project. Among the 25 trainees assigned to the OJT, 5 were also selected through the same process. Furthermore, Japanese experts gave a part of lecture to the counterparts, and took a role to support them from the second training period. Although it is said that neither technology nor design capability will not be mastered through a passive lecture, the BETC Project made an arrangement to improve their ownership and learning motivation. This is also considered one of the pivotal factors that facilitated the fulfillment of the Project purpose.

## (3) Appropriateness of the cooperation period

The BETC Project started upon the signing of the Record of Discussions (R/D) in July 1979, which agreed on a duration lasting until $12^{\text {th }}$ July 1983 . But the period was extended another two years, until July 1985. Before this extension, an evaluation was conducted, in December 1983, as explained earlier, which recognized the need for superstructure training and additional cooperation for training. When the evaluation was made, Thuwunna Bridge construction, which was underway as part of the OJT scheme, completed the substructure and was about to begin the superstructure. A Project extension was inevitable, therefore.

The Evaluation Team's survey report (1983), on the other hand, recorded the launch of the Project with the lecture scheme as the main content without any detailed determination of the contents or of the countries' financial burden for the OJT scheme. An old record also mentions that Japan explained to the Burmese government the difficulty of completing the Project in four years as intended in the planning stage. But as it turned out, the Project period was set to four years because Burma strongly preferred four years as the period for Japan's assistance. Consequently, the Project had to be extended for two more years, and Thuwunna Bridge was
completed with Japanese assistance spanning a total of six years. In other words, the Project was extended already with the expectation from the beginning of the Project that it would be extended.

This was Burma's first attempt to construct a long-span bridge, and it was understandable that the country would not easily accept the construction period that Japan suggested in the planning stage. Ultimately, Japan accepted Burma's position and extended the Project based on the achievements thus far obtained, a decision that is considered to have been reasonable.

## (4) Appropriateness of the Project operation system

The BETC Project was implemented based on the following four committees described below. Members, session frequency, and major discussions are shown in Table 2.11. The committees facilitated smooth internal and external communication among Project team members. According to the interview surveys in Myanmar and Japan, the Expert Committee made especially noteworthy contributions. As mentioned earlier, the Project had a single purpose. But since two assistance schemes--grant aid assistance and technical cooperation--were used, there were eventually two managing entities. ${ }^{21}$ It therefore took time to adjust the assistance schemes and internal procedures for expenditures between the Ministry of Foreign Affairs and JICA. According to the interview survey in Japan, the Expert Committee viewed them as part of an integrated scheme, thought up ways to solve problems posed by local experts, provided explanations and made requests, mainly to JICA (the Ministry of Foreign Affairs through JICA or the Ministry of Construction), and tried to realize early procurement of necessary equipment and materials with the help of the head offices of the members. The interview surveys in Japan and Burma confirm that the activities of the Expert Committee played a key role in the smooth implementation of the Project.

The Project Implementation Committee, which was a monthly meeting chaired by Managing Director of Construction Cooperation, was also effective in smoothing communication between Japanese experts and Burmese stakeholders in Burma. Decision-making in Burma is traditionally based on the top-down approach. When a matter involving people, things, or money beyond the control of ordinary engineers occurred, the involvement of the Managing Director could smoothly settle it. The minutes of the Implementation Committee reported the progress of Thuwunna Bridge construction and the policies for responding to it, showing that both countries greatly cooperated with each other to achieve the Project's purpose. The rate of once a month was generally considered appropriate timing for the Managing Director to hold a committee meeting. It also proves the enthusiasm that Burma had for the Project.

In addition to these high-level Committees, Japanese experts and Burmese counterparts met

[^12]on the project level once a week to discuss the progress of the Project. As explained above, various efforts were made at various levels to smooth communication related to the BETC Project, an effort that surely enhanced the Project's efficiency.

Table 2.11 Committees of the BETC Project

| Committee | Chairman and members | Frequency of meetings | Discussion |
| :---: | :---: | :---: | :---: |
| Local system |  |  |  |
| Project Co-ordination Committee | - MD of Construction Corporation (Chairman) <br> - Burmese engineers <br> - Japanese experts <br> - People from the Japanese Embassy and the bureau of the Ministry of Planning and Finance related to external economy (observers) | Held only once on June 8, 1982 | Discussed the decision to extend the Project |
| Project Implementation Committee | - MD of Construction Corporation (chairman) <br> - CC-related officers <br> - Japanese experts <br> - U Khin Maung Yi (manager of field office) <br> - Director, Yangon Regional Construction Bureau <br> - U Han Zaw (manager) | Monthly (held 24 times in total) | - Budget coordination for construction of Thuwunna Bridge <br> - Received and coordinated materials and equipment for bridge construction provided by Japan <br> - Operated bridge construction <br> - Supervised and coordinated technical training and technical transfer |
| System in Japan |  |  |  |
| BETC <br> Establishment Committee | - JICA administration officer (chairman) <br> - Ministry of Foreign Affairs <br> - Ministry of Construction (then) <br> - Japan Highway Corporation (then) <br> - Metropolitan Expressway Public Corporation (then) <br> - Honshu-Shikoku Bridge Authority (then) <br> - JICA relevant staff | As required | Discussed basic policy for the Project, execution plan, survey, dispatch of experts, provision of equipment and materials, acceptance of trainees, and other planning |



Source: Prepared by the Study Team based on data related to the BETC Project

As explained above, the input factors of the Japanese government and Burmese government were effectively and efficiently utilized throughout to fulfill the Project purpose. On the other hand, both Project length and cost showed a considerable increase compared to the original plan. At the beginning of the Project, it was already understood that financial resources were inadequate, and the delay in procedural matters and the start of work due to measures against overruns also contributed to the increase in cost. These factors have been determined to have not impeded the efficiency of the Project, however.

### 2.3.5 Sustainability ${ }^{22}$

## (1) Aspects of the political system

The situation in Burma drastically changed after the BETC Project. In September 1988, the socialist regime that had been in power for 26 years collapsed due to nation-wide demonstrations demanding democratization. But the army suppressed the demonstrators, formed the State Law and Order Restoration Council (SLORC), and took over the regime. (The SLORC was reorganized as the State Peace and Development Council, or SPDC, in 1997). The country was ruled by the military until a new government was formed in March 2011.

The change of regimes resulted in the introduction of a new bridge construction policy. Two major government policies have greatly impacted the sustainability of the BETC Project. One is the increase of long-span bridge construction to a faster pace than before. The number of construction projects for bridges longer than 54 meters from 1985 to 2011 is shown in Figure 2.2.


Figure2.2 Number of long-span bridges constructed (from 1985 to2011) ${ }^{23}$

As the graphs shows, before 1993 less than 10 long-span bridges were constructed per year, but the number jumped to 16 per year in 1994 and further went up, to 25 per year, in 2000 . The interview survey revealed that many of the trainees were assigned to departments other than bridge construction, as there were only a few long-span bridges being constructed when the

[^13]Project ended. But as the 90s began, these former trainees returned to the bridge department from road or construction departments and were sent to bridge construction sites where they were once again able to use the skill and knowledge that they had learned from the BETC Project.

The second influential policy was that Burma began to construct more steel bridges than the PC bridges that were the subject of technical transfer in the BETC Project. 276 bridges longer than 54 meters constructed by PW after the end of the Project were classified by the type of superstructure, as shown in Table 2.12. The table shows that a variety of bridges, including steel truss bridges, cable-stayed bridges, and suspension bridges, were constructed in addition to PC bridges that were the object of the Project's technical transfer.

Table 2.12 Superstructure by bridge type as of April 2012 (bridge span of over 54 m )
(Unit: bridge constructed)

|  | $1988-1993$ | $1994-1998$ | $1999-2003$ | $2004-2008$ | $2009-2012$ | Total |
| :--- | :--- | :--- | :--- | :--- | :--- | :---: |
| Steel Truss <br> Bridge | 8 | 5 | 14 | 16 | 10 | 53 |
| Suspension <br> Bridge | 2 | 5 | 4 | 5 | 6 | 22 |
| Cable-stayed <br> Bridge | 0 | 1 | 2 | 0 | 0 | 3 |
| Bailey Bridge | 0 | 24 | 20 | 3 | 58 |  |
| Reinforced <br> Concrete <br> Bridge | 2 | 15 | 36 | 16 | 97 |  |
| PC bridge ${ }^{24}$ | 12 | 4 | 7 | 10 | 4 | 37 |
| Others | 0 | 2 | 3 | 1 | 6 |  |
| Total | 24 | 56 | 86 | 51 | 59 | 276 |

Source : PW
The reason for the change in the type of bridge built is strongly related to the aforementioned acceleration of bridge construction. The government preferred to construct steel bridges rather than PC bridges because the former could be constructed in a shorter period of time and in order to construct as many long-span bridges as possible within a short time. The local survey shows that it generally took two to three years to construct a bridge regardless of its length from route selection and basic survey to final completion. In addition to the construction period issue, cost is another factor. Although Myanmar does not have the capability to design steel bridges, they can purchase the superstructure for such bridges from China at a low price. It is assumed that steel truss bridges are particularly favored because they satisfy the need for short-term completion. In contrast, it takes Myanmar many years to construct a bridge with PC

[^14]construction like Thuwunna Bridge or Ngawun Bridge using the PC cantilever method, whose technology was transferred by Japan to Burma. Moreover, PC bridges cannot have long-spans.

In recent years, the priority has been to extend and widen existing north-south roads, construct new east-west roads, and develop regional multi-national highways based on a framework of economic cooperation with neighboring countries, such as ASEAN, GMS, BIMSTEC, and ACMECS member countries, as explained in detail in 3.1 of Chapter 3.

## (2) Project Counterpart

For the BETC Project, 17 counterparts were assigned to the In-Center Training and 25 to the OJT. These counterparts were all engineers of Construction Cooperation except for two persons, a Rangoon Technical University (today's Yangon Technological University) employee and a Yangon city hall employee. After the Project, these counterparts returned to their respective work places, continued their ordinary work, and utilized the skills and knowledge they mastered in their work. On the other hand, the BETC Project left the consolidation and diffusion of transferred technology to individuals, and no system was established to promote consolidation and sharing of transferred skills and knowledge with others during the Project period.

Construction Cooperation owned three training centers: Thuwunna Central Training Center, where the Project was established, Insein Mechanical Training Center, and Mandalay Mechanical Training Center. The Thuwunna Central Training Center chosen as the base of the BETC Project is the largest of these training centers and provides a variety of training courses. This Center employs full-time lecturers qualified to train workers, but not full-time lecturers qualified to teach engineers. Engineers from the relevant department of Construction Cooperation come to serve as lecturers depending on the course. Each lecturer is supposed to provide their own teaching materials. Some of the teaching materials prepared by the BETC Project are used by Project graduates in their lectures at the Central Training Center, but the majority of them have not been effectively used since the Project. There was also no system established to store and share teaching materials.

## (3) Technology

1) Technology after the Project until construction of Ngawun Bridge

Ngawun Bridge was designed and constructed by the Burmese government after the Project. 355 meters in total length and 110 meters in central span length, Ngawun Bridge is a PC box girder bridge constructed with the same cantilever erection method as Thuwunna Bridge. Thuwunna Bridge was basically constructed under the guidance of Japanese experts who checked the whole process of construction from design to erection. Although the necessary technology


Photo 2.5 Ngawun Bridge photographed in May 2012 was transferred to Burmese engineers, and at a high level, they remained uneasy about some of the construction processes. It was Burmese engineers who played the main role from design to erection in constructing Ngawun Bridge, while Japanese involvement was limited to the short-term dispatch of experts and providing materials and equipment. The interview survey confirmed that the completion of Ngawun Bridge gave Burmese engineers the confidence to construct long-span PC bridges without Japanese assistance.

Construction of Ngawun Bridge started in 1985 and ended in 1991 without any accidents. Onsite safety was one of the training items prioritized by experts at the time. The fact that onsite safety was achieved not only for Thuwunna Bridge but also for Ngawun Bridge is worthy of praise. The Study Team visited Ngawun Bridge, and a visual inspection of the bridge showed no visible problems even though it had been completed over 20 years earlier, as is the case for Thuwunna Bridge. In addition, Ngawun Bridge was awarded the Tanaka Award ${ }^{25}$ (Excellence in Bridge Design and Construction) by the Japan Society of Civil Engineers in recognition of the outstanding accomplishment of the Burma people of making full use of the technology transferred from Japan and constructing the bridge with their own engineers.

[^15]As explained above, technology transferred from Japan to Burma is judged to have been firmly consolidated by 1991 when the Project was completed.
2) Technology after the Ngawun Bridge Project

After construction of Ngawun Bridge, no long-span bridges using the cast-in-place cantilever erection method were constructed due to the change in the government's policy. This suggests that substructure technical expertise transferred in the Project is being lost. Since completion of the BETC Project, many long-span bridges have been constructed, and the outcome of the Project has been effectively utilized in their construction. Table 2.13 showing the allocation of work (design and construction) by type of bridge in Burma indicates how transferred technology has been applied. Cells shaded in light gray are the fields where technical transfer by BETC applies. Currently PW personnel are engaged in the design and construction of various bridges; including 30 meter span length class PC bridges, as well as their substructures, and cast-in-place pile installation and erection for every type of bridge.

Table 2.13 Current role of PW in bridge design and construction

|  | PC Bridge |  | Steel Truss Bridge |  | Cable-stayed Bridge |  | Suspension Bridge |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Design | Contruction | Design | Contruction | Design | Contruction | Design | Contruction |
| Foudation | PW | PW | PW | PW | PW | PW | Foreign Company | PW |
| Lower Structure | PW | PW | PW | PW | PW | PW | Foreign Company | PW |
| Upper Structure | PW | PW | MEC/Foreign Company | PW | Foreign Company | PW | Foreign Company | PW |
| Remarks: |  |  |  |  |  |  |  |  |
| 1) Technology transferred during BETC Project |  |  |  |  |  |  |  |  |
| 2) Technology not transferred during BETC Project |  |  |  |  |  |  |  |  |
| 3) MEC: Myanmar Economic Corporation |  |  |  |  |  |  |  |  |
| Source: Study Team |  |  |  |  |  |  |  |  |

The onsite survey also confirmed the following:

- A check of the design calculations of the substructures confirms that they use the same calculation process as derived from the Japanese Specification for Highway Bridges.
- A check of the drawings of the substructure of Maubin Bridge, opened to traffic in 1998, and the drawings of Ngawun Bridge confirmed that those structural drawings were based on the same concept.
- Burmese engineers created the foundation design based on piles driven to a ground depth with an $N$ value of 60 according to the boring log, as described in the soil test survey report. This confirms that they conducted a soil investigation in advance and properly identified the bearing layer as they were taught in the BETC Project.

Although no long-span bridges using the cast-in-place cantilever erection method have been constructed since Thuwunna Bridge and Ngawun Bridge, the substructure technical standards and the knowledge of construction management from planning to construction of long-span bridges they learned from the Project are still utilized and adequately maintained.

As shown in Table 2.13, the main factors that have maintained the Project's transferred technology even after 27 years are described as follows:
a) Many Project graduates took important posts at PW after the Project and have played important roles in the construction of many bridges.

Many of the counterparts and trainees who participated in the Project were in their late 20s and early 30s and took lower ranking engineering positions, such as technical engineer (TE) or assistant engineer (AE). But the Study Team studied the final career of the In-Center Training graduates in the field survey and found that many of them had been promoted. Among them is one who assumed the role of Vice Construction Minister (a position he still holds), two who assumed the post of Managing Director of PW (now retired), and one who held the office of Regional Directorship of Ministry of Construction (now retired). They contributed not only to the technical aspects but also to the managerial aspects of the Ministry of Construction and PW. The highest posts assumed by the In-Center Training graduates are summarized in Table 2.14.

Why the BETC Project graduates ultimately obtained such high levels of achievement can be explained as follows; Trainees studied hard because the Project was a prestigious national project and they dedicated themselves to hard study when faced with unfamiliar content in lectures, and all this effort helped them to attain high levels of achievement in their later careers.
b) Former counterparts and trainees transferred what they learned to coworkers and juniors.

According to the interview survey, engineers and skilled workers who received the benefit of technical transfer in the BETC Project were reassigned to various positions and locations after the Project, used the know-how they had mastered in their respective workplaces, and handed down what they learned to young engineers who would shoulder the future of their country. For instance, two engineers who were counterparts for the In-Center Training and trainees of the Advanced Course delivered lectures on the basic techniques of bridge design and construction at Thuwunna Central Training Center based on what they had learned from the Project. One counterpart who participated in the OJT served as a lecturer on electric equipment and management at Insein Mechanical Training Center two to three times a year. Transmitting technical knowledge was also confirmed for other engineers, although not in the form of lectures. Instead, they taught their know-how to other engineers and workers in the form of the OJT at construction sites. Interviews with the BETC Project graduates confirmed that the technology they mastered was transferred to over 100 engineers and over 200 skilled workers in the period after the end of the Project and until their retirement.
c) Trainees had many opportunities after the Project to refine their experience.

It is important to accumulate experience that can consolidate technical knowledge, and this is true for any project. Although there was no high demand for bridge construction when the Project was completed, the number of bridge construction projects soared going into the 1990s, as shown in Figure 2.2. As explained earlier, graduates who were once assigned to road or building departments following the Project returned to the bridge department later on in step with this trend. Engineers who learned technology from the BETC Project accumulated experience through the construction of many long-span bridges and continued to refine their expertise. The transfer of know-how to their juniors mentioned above could not have occurred without these kinds of construction opportunities.
d) Burmese engineers continue to receive advice from Japanese experts.

Under the former regime, long-span bridges were constructed rapidly. It was reported that they faced various technical difficulties during the design and construction process. Burmese people were deprived of assistance from abroad due to the political situation and hence had only limited access to foreign information. Under these circumstances, some of the experts involved in the BETC Project maintained contact with Burmese engineers on a personal basis after the end of the Project, providing advice on bridge technology and checking up on the situation in Myanmar. This sort of ongoing relationship with some Japanese engineers is also considered to have helped to consolidate and diffuse transferred technology.
3) Technical problems: Quality of concrete (salt damage, rock pocket of concrete, and tilting of bridge abutments)

Quality control of control was one of the technical transfer items of the BETC Project. Quality control techniques had been successfully transferred to local people upon completing the Project. But bridge inspections indicated that there were problems, including salt damage to concrete. Furthermore, according to the result of bridge site survey (expressway bridge), technical challenges such as rock pocket of concrete and insufficient compaction aspect were observed. The details concerning this damage are explained in Paragraph 3.3 Bridge inspection. The damage was caused primarily because quality control was left to individual discretion and no national criteria for quality control had been established. The BETC Project did not include establishing such a standard within the scope of the Project, but considering the importance of technical sustainability, it will be given priority in the future.


## (4) Financial affairs

The Study Team does not have specific financial data because we cannot obtain budget data from 1985 to 2004, but judging from the change in the number of long-span bridges constructed after 1985, we can speculate that although PW had difficulty securing budgets, they were given preferential budget treatment to construct bridges in their country because the government was very satisfied with their performance when constructing Thuwunna Bridge and Ngawun Bridge. Recent budget trends are shown in Table 3.4 in Paragraph 3.1.

Sustainability is evaluated to be basically high because of three major reasons: no major changes in the government's policy about promoting bridge construction; while technical sustainability is very different between the six year period after the end of the Project and the period thereafter, substructure technology, especially, has been consolidated and diffused in Myanmar at a high level; and, no evidence of any major financial problems.

Table 2.14 Present statuses of trainees of the In-Center Training ${ }^{26}$

| 1st Group |  |  |  | 2nd Group |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Affiliate at the time of BETC Project | Position at the time of BETC Project | Last Position / <br> Current Status | No. | Affiliate at the time of BETC Project | Position at the time of BETC Project | Last Position/ Current Status |
| 1 | CC | AE | DSE/Retired | 21 | CC | SOIII | EE/Resigned |
| 2 | CC | SOIII | SE/Passed Away | 22 | Railways | - | - |
| 3 | Irrigation | TE | - | 23 | CC | AE | EE/Retired |
| 4 | CC | TE | EE/Resigned | 24 | CC | TE | EE/Retired |
| 5 | Education | - | - | 25 | CC | AEE | DSE/Resigned |
| 6 | CC | TE | CE/DY. Ministe | 26 | CC | AE | SE/Retired |
| 7 | Railways | - | - | 27 | CC | SOIII | EE/Retired |
| 8 | CC | TE | CE/Retired | 28 | CC | SOIII | DCE/Retired |
| 9 | CC | TE | SE/Retired | 29 | Army | - | - |
| 10 | CC | AE | Retired | 30 | Army | - | - |
| 11 | YCDC | - | - | 31 | CC | SOIII | SE/Retired |
| 12 | CC | AE | DSE/Passed Away | 32 | CC | TE | MD/Retired |
| 13 | CC | TE | Resigned | 33 | CC | TE | SE/Retired |
| 14 | CC | TE | EE/Retired | 34 | CC | AEE | SE/Retired |
| 15 | CC | SOIII | DSE/Retired | 35 | CC | TE | DSE/Retired |
| 16 | Army | - | - | 36 | Education | - | - |
| 17 | Army | - | - | 37 | YCDC | - | EE/Passed Away |
| 18 | CC | TE | EE/Retired |  |  |  |  |
| 19 | CC | TE | EE/Passed Away |  |  |  |  |
| 20 | CC | TE | EE/Retired |  |  |  |  |


| 3rd Group |  |  |  | 4th Group (Advance Course) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Affiliate at the time of BETC Project | Position at the time of BETC Project | Last Position / Current Status | No. | Affiliate at the time of BETC Project | Position at the time of BETC Project | Last Position / Current Status |
| 38 | CC | SOII | CE/Retired | 58 | CC | AE | MD/Retired |
| 39 | CC | AE | DCE/Retired | 59 | CC | AE | DCE/Retired |
| 40 | CC | AE | CE/Retired | 4 | CC | TE | EE/Resigned |
| 41 | CC | SOIII | SE/Retired | 28 | CC | SOIII | DCE/Retired |
| 42 | CC | AE | EE/Resigned | 21 | CC | SOIII | EE/Resigned |
| 43 | CC | AE | EE/Retired | 31 | CC | TE | MD/Retired |
| 44 | YCDC | - | - | 41 | CC | SOIII | SE/Retired |
| 45 | CC | TE | DSE/Retired | 42 | CC | AE | EE/Resigned |
| 46 | CC | AE | DCE/Resigned | 47 | CC | AE | DSE/Resigned |
| 47 | CC | AE | DSE/Resigned | 51 | CC | AE | DMD/Retired |
| 48 | CC | TE | EE/Passed Away |  |  |  |  |
| 49 | Railways | - | - |  |  |  |  |
| 50 | CC | TE | CE/Retired |  |  |  |  |
| 51 | CC | AE | DMD/Retired |  |  |  |  |
| 52 | CC | AEE | SE/Retired |  |  |  |  |
| 53 | CC | AE | EE/Retired |  |  |  |  |
| 54 | CC | SOIII | DSE |  |  |  |  |
| 55 | CC | SOIII | SE/Minister** |  |  |  |  |
| 56 | CC | SOIII | DSE/Retired |  |  |  |  |
| 57 | CC | SOIII | CE |  |  |  |  |
| ** C | : Construction Cooper | eration |  | ** CC: Construction Cooperation |  |  |  |

[^16]
### 2.4 COMPREHENSIVE EVALUATION OF THE BETC PROJECT

The goal of the BETC Project was to train engineers in Burma capable of bridge design and construction by providing design technology through the In-Center Training and supporting the construction of Thuwunna Bridge through the OJT. Evaluation results conclude that the relevance of the Project is high because the purpose of the Project matches Burma's development policy, and the necessity of the Project has also been confirmed. The output of both In-Center Training and OJT was achieved at a high level based on the degree of technical transfer evaluated by experts at the time. Therefore, the effectiveness of the Project is also considered to have been very high. On the other hand, despite effectively and efficiently utilizing all input elements, the Project period was extended two years, and Project cost greatly exceeded planned cost. At the same time, it was already understood at the beginning of the Project that the financial resources were insufficient, and the delay in procedural matters and in the start of work due to measures against overruns also contributed to the increase in cost. These factors are judged to not to have impeded the efficiency of the Project.

Regarding the sustainability of the effects produced by the Project, the unexpected political developments in Myanmar resulted in no PC box girder bridges using the cantilever erection method being constructed after completion of Ngawun Bridge. But substructure design and construction techniques and construction management for long-span bridge construction are still present, although not systematically. Therefore, sustainability is considered to be basically high. Furthermore, the impact is also considered to be high because the BETC Project graduates contributed to the construction of long-span bridges and roads that support the country's economic growth and stability of civil administration.

As explained above, it is concluded that the BETC Project receives a high evaluation.

## Column 1: Career of BETC Project graduates after the Project ended (based on the interview survey)

After the Project was completed, Project graduates returned to their original positions. These positions were in a variety of departments, such as bridge, road, and building construction, and many of them were with PW. Since there were not many bridge construction projects right after the Project, especially, most of the graduates could not directly apply the techniques and knowledge they learned from the Project to actual projects.

But after the start of the 1990s, bridge construction projects gradually increased due to government policy. Project graduates assigned to departments other than bridge construction were assigned to bridge construction sites because of their past experience with the BETC Project. One example of this was the construction of Myaung-Bwe Bridge, a 225 meter long Bailey bridge. The general site supervisor and two field supervisors, each assigned to either side of the bridge, were BETC Project graduates.

Trainees who took the In-Center Training of the BETC Project also took a one-year training course in Japan. The relationship of the OJT trainees to bridge construction is much longer. Engineers and skilled workers engaged in the five year construction of Thuwunna Bridge also worked on the six year construction of Ngawun Bridge. While not all, many of them spent a total of 11 years together on these construction projects. Thus a mutual bond was established among BETC Project graduates during that period. After completing the Project, they remembered the hard days they went through together, empathized with one another, and worked together constructing long bridges. 27 years have passed since the end of the Project, and many of them have now retired, but they still keep in touch with each other. How BETC Project graduates who were not from PW utilized their skills and knowledge after the Project is not well known. One of them, who came from the Defense Ministry, was promoted to the rank of colonel in the Ministry. He taught the skills and knowledge he learned from the Project to university students at the Defense Service Technical University. The technology transferred through the BETC Project has been applied to various fields in Myanmar, including bridge construction, and has surely contributed to the country's growth.

### 2.5 LESSONS LEARNED FROM THE BETC PROJECT

### 2.5.1 Promoting and impeding factors

Major promoting and impeding factors in DAC evaluation criteria are summarized in Table 2.15.

Table 2.15 Promoting and impeding factors in DAC evaluation criteria

## Relevance

1. The urgent need for technology to construct large-span bridges (promoting factor)
2. Choosing a combination of In-Center Training and OJT as the assistance approach (promoting factor).

## Effectiveness

3. Appropriately modifying activities to match the competence of trainees (promoting factor).
4. Having Japanese experts handle some processes while judging the ability of Burmese engineers (promoting factor).

## Impact

5. BETC Project graduates excelled in their bridge design role at construction sites (promoting factor).
6. Translating the Japanese Specification for Highway Bridges into English and passing it on to BETC Project graduates (promoting factor).

## Efficiency

7. The involvement of the Managing Director of Construction Cooperation in implementing the Project that improved communication between Japanese Experts and Burmese stakeholders in Burma (promoting factor).
8. Forming a support team in Japan, centered on the staff of Japan's Ministry of Construction that provided powerful support to the Project (promoting factor).
9. Inviting Burmese counterparts and trainees to train in Japan to give them the opportunity to experience what was at the time Japan's up-to-the-minute bridge construction sites (promoting factor).
10. Providing appropriate number and quality Japanese long and short term experts at the right timing according to the project process for both In-Center Training and field training (promoting factor).
11. Dispatching special engineers necessary for the front line of bridge construction from Japan to also support the technical transfer in terms of local engineers and skilled workers (promoting factor).
12. Refill counterparts on a phased schedule to gradually develop counterparts who were reliable and competent (promoting factor).
13. Appropriately providing material and equipment necessary for the construction of Thuwunna Bridge through both grant aid assistance and technical cooperation.
14. Unable to obtain Burma's consent to the time necessary to complete the Project in the Project planning stage (impeding factor).

## Sustainability

15. Political upheaval drastically changed on bridge construction policy to one that favored steel bridges (impeding factor).
16. The Burmese government constructed Ngawun Bridge at its own cost during the Project period (promoting factor).
17. In-Center Training results were not retained by Thuwunna Central Training Center (impeding factor).
18. Many Project graduates took important posts at PW after the Project and played important roles in the construction of many bridges over a period of many years (promoting factor).
19. Many BETC Project graduates further transferred technology transferred from Japan to their coworkers and juniors (promoting factor).
20. Project graduates had many opportunities to accumulate experience after the Project (promoting factor).
21. Japanese experts continued to provide advice to Burmese engineers after the Project (promoting factor).

### 2.5.2 Lessons learned from the BETC Project

Evaluation results of the BETC Project and the factor analysis presented in 2.5.1 identified the following lessons drawn from the BETC Project. How a particular lesson is connected to a particular promoting or impeding factor described in 2.5.1 (relationship with the evaluation analysis) is indicated in parenthesizes on the right of each lesson.

## 【Lesson drawn from the project plan】

(1) Great results can result from the timely transfer of the necessary technology appropriate to a nation's stage of development (relevance 1, sustainability 16, and sustainability 20).

The BETC Project transferred large-span bridge construction technology that Burma absolutely needed to secure future economic development. Given the situation, the Burmese
government made the BETC Project one of the nation's top priorities and fully supported the Japanese assistance. Following construction of Thuwunna Bridge, Burma spent its own money to construct Ngawun Bridge, showing the strong enthusiasm and commitment of the Burmese government at that time. The BETC Project could not have succeeded without the effort of Japanese experts and the overall cooperation of the Burmese government. But technology related to bridges improves day by day, and there are many other countries other than Japan that can offer such technology. When technology for which Japan has a relatively dominant position and which complements the recipient's country's stage of development is provided at the right time, it is sure to be an influential factor for assuring the project's success. The BETC Project is a case in point. To assure sustained success, it is important to periodically follow up after the end of the Project and formulate and provide support in step with changes in Burma.
(2) It is essential to advance sufficient examination of the project sustainability from a long-term viewpoint (sustainability 16, sustainability 17, sustainability 19, sustainability 21, impact 5 and impact 6).

The BETC Project constructed Thuwunna Bridge with an on-the-job-training scheme. Later on, Burma took the lead in constructing Ngawun Bridge. As discussed in the section on sustainability, construction of Ngawun Bridge was not anticipated nor mentioned during the planning stage of the BETC Project. Eventually, construction of Ngawun Bridge helped Burmese engineers become more confident and helped consolidate the technology and knowledge transferred to Burma by the Project. During the Ngawun Bridge construction project, Japanese experts made short-term visits to Burma to provide supplementary technical support, which also eventually provided indirect support to enhancing the abilities of Burmese engineers. This is also considered to have served as a great incentive for them.

From this we can learn that since it takes significant time to transfer a whole new technology to a recipient country, providing support in just one single act of assistance is not enough. It is very important to allow for a phased transfer scheme in the beginning of project planning. To this end, planning from a long-term standpoint is important. The results of technical transfer can be enhanced by checking in the planning stage if the recipient country has a plan to continue the project at their own cost in terms of human resources and budget availability and by studying how Japan can be involved in the project to the extent that it is feasible based on such a plan.

It is also important to further spread transferred technology by establishing a mechanism for handing down technology to the next generation. It is apparent that transferred technology and know-how transferred by the Project is being handed down to the next generation and playing a vital role in bridge construction, but as explained in the section on sustainability, there are
many promoting factors, including an increase in the number of bridge construction project that provide opportunities for BETC Project graduates to apply their skills, voluntary re-transfer of technology that graduates have mastered to coworkers and junior engineers, and continued support from Japanese experts. But these factors were not a consequence of the project as originally planned but are very much affected by external factors and individual discretion.

Documents such as the Japanese Specification for Highway Bridges are handed down to the next generation, although this partly depends on individual discretion, and it is considered important to document and systematize teaching materials and reference data as a comprehensive package and set up a mechanism for handing them down to the next generation. It is also important, therefore, to select the base for implementing the project by considering how easy it is to pass on technical knowledge and how likely this will occur. For example, the BETC Project selected Thuwunna Central Training Center as the base for the In-Center Training, but even today this training center has no full-time lecturers qualified to teach engineers. A better idea would have been to set up a training base at a place where full-time lecturers are available, such as Yangon Technological University, plan a project scheme that involves university professors, and integrate the skills and knowledge transferred by the In-Center Training into the curriculum of the university so as to ensure systematic maintenance and diffusion of transferred skills and knowledge.

## 【Lessons drawn from the implementation method】

(3) A combination of classroom training (In-Center Training) and field training (on-the-job-training) is an effective way to transfer a whole new technology to the recipient country (relevance 2).

JICA divides its assistance into three schemes: technical cooperation, grant aid assistance, and loan assistance. When the BETC Project was implemented, the standard procedure was to carry out each scheme independently. Today, cooperation among schemes is fairly common. For instance, technical cooperation is conducted by partly using OJT in the program on a pilot basis. But even today it is very unique to attempt a bridge construction project under a general grant aid assistance scheme conducted almost entirely, and from beginning to end, by OJT. In this regard, it was an extremely innovative form of assistance for JICA.

How much field exercise is conducted in the classroom and the field training framework needs to be determined by analyzing how much the recipient country understands the technology being transferred. The purpose of the BETC Project was to help Burma design and construct a PC box girder bridge using the cantilever erection method on their own, but many Burmese engineers had never seen a PC box girder bridge using that method before the start of the Project, not to mention possessing the technical knowledge needed to do so. As a result, the
preliminary Study team decided that it was important to teach the entire technology set from scratch in a classroom and field training framework appropriate to the skill level of the Burmese engineers, and the Project plan was formulated accordingly. Consequently, Burma successfully mastered the ability to design and construct a PC box girder bridge own their own within the limited six year period, as explained in the section on effectiveness.

The BETC Project emphasized the importance of design engineers understanding the construction site and, vice versa, the importance of local engineers understanding the design. According to the survey, besides the five trainees who participated in both the In-Center Training and the OJT, the trainees who received only the In-Center Training also became capable of identifying design defects and requesting someone to revise them or revising them on the spot on their own. Such impressive results would have been impossible without a combination of classroom training and field training.
(4) Reinforcing the domestic support system (effectiveness 3, efficiency 8, efficiency, 9 , efficiency 10 and efficiency 13)

Various ideas were developed and implemented with a flexible approach in order to meet the local demands of the BETC Project. For instance, the In-Center Training originally planned to transfer to the first to third period trainees a level of technical knowledge nearly equal to that meant for a fourth period trainee. But as it turned out, trainees varied in competence. Therefore, the contents of lectures were revised. Ultimately, the first to third period training was reorganized into the Basic Course, while the fourth period was the Advanced Course, thereby fulfilling its initial purpose. For the OJT, many materials and equipment necessary for bridge construction that were originally assumed to be locally available turned out to be unavailable, so whatever was locally available and considered applicable was put to use or the necessary materials were sent from Japan or a neighboring country.

These changes as well as the subsequent need for people, materials, and money were promptly supported by the Expert Committee formed by the organizations that dispatched Japanese experts. Constructing a bridge by means of the OJT placed a great burden on the Japanese experts. In addition, they had to stay on schedule and pay the utmost attention to safety. The Expert Committee responded to these challenges, offering complete and concerted support for the dispatched experts to help them overcome these challenges.

When a project is implemented in a field that has not been covered in the past, it is impossible to anticipate every possible occurrence in the planning stage. The most feasible and desirable option, as demonstrated by the BETC Project, is flexibility in response to changes in local needs. Moreover, organizational backup that enables flexible coordination and response that can cope with the various elements that emerge from such changes is also indispensable.

For a technical cooperation project using JICA's direct-managed expert dispatch approach, that is, an approach in which experts from various organizations take part in a single project has no organization responsible for the project management, in contrast to a technical cooperation project based on an operation agreement, setting up a supporting organization at JICA and the senders is recommended for the former case as a general principle.

## (5) Phased refilling of counterparts (impact 5, efficiency 12, sustainability 18)

Two capable engineers who had studied in Russia participated in the Project as early as its inception stage and supported the operation and expansion of the Project. It was sheer luck that such qualified engineers were made available to the Project. Other engineers were periodically replenished from among human resources which distinguished themselves during the In-Center Training and the OJT, as explained earlier in the efficiency section. This reinforcement greatly facilitated the smooth operation of the Project. Furthermore, the fact that counterparts were also trainees created sympathy among other trainees and local engineers. In fact, these counterparts also served as private consultants and advisers for other trainees on a daily basis.

The BECT Project shows that since it is difficult to select people who appear highly qualified and are so by the objective judgment as counterparts in the planning stage, it is important to replenish human resources on a phased basis throughout the project.
(6) Diversification of training content to match the abilities and needs of the recipients (effectiveness 3, effectiveness 4, efficiency 7 and efficiency 11)

Although the Project purpose was undoubtedly completed at a high level, some aspects of field training based on OJT were judged to not have been fully established as standard procedures, such as quality control and the safety management system. Enhancing only the skills of engineers is not sufficient for effective quality control and safety management. Such systems need to be incorporated into the government's policy and regulations from a long-term viewpoint. It is effective, therefore, to include high-level government officials responsible for policymaking among the trainees, in addition to engineers, depending on the content being transferred. Since it is often difficult for high-level officials to be away from their offices for the time required to participate in training, holding short seminars and workshops is a feasible way for them to learn this technical knowledge.

## 【Lessons drawn from the aftermath of the Project】

(7) Follow-up after completing the Project (sustainability 15, sustainability 21, and relevance 1)

After the BETC Project ended, some experts voluntary stayed in touch with former
counterparts and trainees and provided advice from time to time. This enhanced the level of sustainability of transferred technology. On the other hand, JICA was not in a position to carry out large-scale projects due to subsequent political developments. Following seminar type assistants had been provided during the period.

- Seminar for designing steel type bridge by International Development Institute : August $1^{\text {st }}$ - August $4^{\text {th }}, 2000$ (JICA experts participated as the special lecturer)
- Seminar for designing steel type bridge by JICA : September $5^{\text {th }}-$ September $27^{\text {th }}, 2001$
- Seminar for designing steel type bridge by JICA : February $4^{\text {th }}-$ February $27^{\text {th }}, 2002$

But it should have been possible to continue a bilateral relationship using a small-scale assistance scheme, such as training in Japan or in a third country. Technology evolves every day, and in order to ensure the "timely transfer of the necessary technology appropriate to a nation's stage of development", as explained in Lesson (1), it is important to continuously monitor the growth of Myanmar's bridge construction technology.

## 3. SEQUEL TO THE BETC PROJECT

Nearly 30 years has passed since the end of the BETC Project, and the situation in Myanmar has greatly changed. This chapter outlines the road and bridge sectors in present day Myanmar and clarifies the support needs in those fields centering on capacity development in Myanmar as a way to promote discussion on the future applicability of the lessons drawn from the BETC Project discussed in Chapter 4.

### 3.1 OUTLINE OF ROAD AND BRIDGE SECTOR IN MYANMAR

### 3.1.1 Characteristics of the transport network

## (1) Transport network

Before outlining the transport network of Myanmar, this section reviews the topographical features of Myanmar that determine how it carries out its socioeconomic activities. Myanmar is about 1.8 times larger than Japan and has a land area of $570,000 \mathrm{~km}^{2}$. It is shaped like a lozenge stretched from north to south and shares borders with India and Bangladesh on the northwest, China and Laos on the northeast, and Thailand on the southeast. The border zones with these countries are mountainous areas populated by several minorities. The country has a coastline along the Bay of Bengal and Andaman on the southwest and southeast. The borderline is about $4,600 \mathrm{~km}$ altogether, while the coastline is about $2,000 \mathrm{~km}$. The area sandwiched between the mountainous border zone and the southern coastline is occupied by a vast alluvial plain that drains mostly north to south by major rivers, including the Ayeyarwady, Sittaung, and Thanluwin, and the delta zone formed by the estuaries of those rivers.

Myanmar has developed its transport network based on these topographical features. The roads, railways, harbors and airports that constitute the country's transport network are outlined below:

1) Roads

The total length of the road network is about $140,000 \mathrm{~km}$. Major highways consist of a total of 8 major routes, including the expressway that was entirely opened to traffic at the end of the last year connecting Yangon, Nay Pyi Taw, and Mandalay, as well as National Highways No.1, 2, $3,4,5,6$, and 8 . Although they are called "highways," they are mostly single-lane paved roads in either direction.

Expressway: Yangon suburbs - Nay Pyi Taw - Mandalay
National Highway No.1: Yangon - Bago - Toungoo - Mandalay
National Highway No.2: Yangon - Pyay - Paleik
National Highway No.3: Mandalay - Muse (border with China)
National Highway No.4: Meiktila - Taunggyi - Kyaing Tong - Tachilek (border with Thailand)
National Highway No.5: Toungoo - Loikaw - Tangui
National Highway No.6: Yangon - Pathein
National Highway No.8: Yangon - Mawlamyaing - Dawei
2) Railways

Railway network in Myanmar totals $5,830 \mathrm{~km}$. 2,009 km of this total comprise four routes, including the Mandalay - Yangon line (617 km), Mandalay - Lashio line (313 km), Mandalay Kalay line (539 km), and Bago - Thanbyuzayat line (270 km).
3) Inland water transportation

In Myanmar, inland water transportation using major rivers serve as an important means of transporting materials and passengers. Today, rivers and water areas used for inland water transport are the Ayeyarwady, Chindwin, Thanluwin (Mon State and Kayin State), the delta zone in Ayeyarwady Region, and the coastal zone of Rakhine State. The service length of inland water transport is $12,044 \mathrm{~km}$. Water transport in the delta is the longest route at $3,464.7$ km , followed by the passenger transport route of the Ayeyarwady River at $2,811 \mathrm{~km}$. Passenger transport along the Ayeyarwady River begins from Yangon and ends at Myithkyna in Kachin State. Cargo transport is mainly conducted on the Ayeyarwady River and Chindwin River for a total service length of $2,247 \mathrm{~km}$. Cargo transport is conducted from Yangon to Kamti in Sagain Region along the Chindwin River and to Bhamo in Kachin State on the Ayeyarwady River.
4) Ports and harbors

Myanmar has a total of eight ports: Sittewe, Kyukphyu, Tandwe, Pathein, Yangon, Mowlamyine, Mieik, and Tawthoung. Pathein and Yangon are river ports. Yangon Port serves as an international interface, handling about 95\% of the county's exports and imports. Other ports are used for the domestic water transport of cargo and passengers. Myanmar has a plan to develop international ports at Kyukphyu, Kaleglauk, Dawei, and Bokpyin.
5) Airports

Myanmar has three international ports: Yangon, Mandalay, and Nay Pyi Taw. Yangon Airport has a total of 13 international regular flights, including routes to Bangkok, Hanoi, Kuala Lumpur, Singapore, Kumming, and Chittagong, and Mandalay Airport has regular flights to

Kunming. Nay Pyi Taw Airport currently has no regular international flights.

Domestic flights are operated at a total of 32 airports. Private regular and irregular flights use 14 airports. Major domestic airports are Bagan, Heho, and Tandwe. Yangon International Airport is the country's hub for domestic flights.

Thus, major routes of the transport network are developed in the north and south directions reflect the county's topography and population and city distribution. Large rivers have been a hindrance to east-west roads and railways.


Source: The Study Team
Figure 3.1 Transport Network in Myanmar

## (2) The role of the road sector in terms of modal split

In Myanmar, inland water transport using major rivers has always played a major role. In 1877, the country's first railway was opened between Yangon and Pyay. In 1948, the railway route was extended to about $3,100 \mathrm{~km}$. With the progress of railway development, railroad transport became an alternative to inland water transport and came to play a greater role in cargo transport. As road development continues, roads have also become a means of cargo transportation.

Table 3.1 shows the modal split in cargo transport over the past two decades. In 1990, inland water transport occupied about half, or $47 \%$, of cargo transport, while railways and roads occupied $36 \%$ and $17 \%$, respectively. In 2010, the share among inland water transport, railway, and road was $45 \%, 32 \%$, and $23 \%$, respectively. Although inland water transport is still important, road transport is gradually increasing in importance over railway. This is probably because of negative factors such as poor railway maintenance and the degradation of route and railway transport capacity. About transport distance by mode, railway and water routes are long. That is, long-haul transport is performed by inland water transport and railway, while relatively short-haul transport is by road. Recently, road transport distances are increasing, suggesting an increasing importance of road transport.

Table 3.1 Modal Share of Flight Transport During 1990 to 2010
Freight

|  | $1990-91$ | $1995-96$ |  | $2000-01$ |  | $2005-06$ | $20.3 \%$ | 3,327 | $31.9 \%$ |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| Railway | 1,930 | $36.2 \%$ | 3,112 | $40.7 \%$ | 3,551 | $39.9 \%$ | 2,879 | 30.3 | (Thousand Ton) |  |
| Air | 2 | $0.0 \%$ | 2 | $0.0 \%$ | 2 | $0.0 \%$ | 1 | $0.0 \%$ | 1 | $0.0 \%$ |
| Inland Water | 2,491 | $46.7 \%$ | 3,176 | $41.6 \%$ | 3,863 | $43.4 \%$ | 4,262 | $44.9 \%$ | 4,685 | $44.9 \%$ |
| Road | 914 | $17.1 \%$ | 1,352 | $17.7 \%$ | 1,485 | $16.7 \%$ | 2,349 | $24.8 \%$ | 2,411 | $23.1 \%$ |
| Tota | 5,337 | $100.0 \%$ | 7,642 | $100.0 \%$ | 8,901 | $100.0 \%$ | 9,491 | $100.0 \%$ | 10,424 | $100.0 \%$ |

Freight Tom Mile

|  | $1990-91$ | $1995-96$ |  | $2000-01$ | 200 | (Thousand Ton Mile) |  |  |  |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| Railway | 306,861 | $43.2 \%$ | 551,594 | $54.0 \%$ | 750,040 | $58.4 \%$ | 570,124 | $44.0 \%$ | 658,252 | $39.6 \%$ |
| Air | 688 | $0.1 \%$ | 482 | $0.0 \%$ | 705 | $0.1 \%$ | 294 | $0.0 \%$ | 162 | $0.0 \%$ |
| Inland Water | 325,643 | $45.9 \%$ | 322,601 | $31.6 \%$ | 344,381 | $26.8 \%$ | 455,175 | $35.1 \%$ | 687,207 | $41.4 \%$ |
| Road | 76,841 | $10.8 \%$ | 147,393 | $14.4 \%$ | 189,893 | $14.8 \%$ | 271,079 | $20.9 \%$ | 315,614 | $19.0 \%$ |
| Tota | 710,033 | $100.0 \%$ | $1,022,070$ | $100.0 \%$ | $1,285,019$ | $100.0 \%$ | $1,296,672$ | $100.0 \%$ | $1,661,235$ | $100.0 \%$ |

Fright Km

|  | $1990-91$ | $1995-96$ | $2000-01$ | $2005-06$ | (Ton Km) |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Railway | 159.0 | 177.2 | 211.2 | 198.0 | 197.9 |
| Air | 344.0 | 241.0 | 352.5 | 326.7 | 324.0 |
| Inland Water | 130.7 | 101.6 | 89.1 | 106.8 | 146.7 |
| Road | 84.1 | 109.0 | 127.9 | 115.4 | 130.9 |
| Tota | 133.0 | 133.7 | 144.4 | 136.6 | 159.4 |

Source: Statistical Year Book 2010,Central Statistical Organization, 2012

### 3.1.2 Current status of roads and bridges

## (1) Current status of road and bridge improvements

As discussed in the previous paragraph, the Myanmar road sector is playing an increasingly important role. It is logically considered that its rise in importance is mostly attributable to the progress of road improvements. Road length (see Figure 3.2) was $69,732 \mathrm{~km}$ in 2001, but by 2011 had almost doubled to $142,395 \mathrm{~km}$. During this period, the number of registered vehicles in the entire country increased five times, from 445,000 to 2,332,000 registered vehicles. It seems logical to conclude that in addition to this dramatic rise in the number of cars that the increase in road length has made using the road network more convenient and therefore eventually boosted the importance of roads for cargo transport.

| Year | Number of Registered <br> Vehicle | Road Length (Km) |
| :---: | ---: | ---: |
| 2001 | 445,167 | 69,732 |
| 2002 | 461,692 | 73,843 |
| 2003 | 476,350 | 78,266 |
| 2004 | 960,341 | 90,713 |
| 2005 | 978,522 | 92,859 |
| 2006 | 991,566 | 104,058 |
| 2007 | $1,024,372$ | 111,737 |
| 2008 | $1,997,358$ | 125,355 |
| 2009 | $2,067,839$ | 127,942 |
| 2010 | $2,298,677$ | 130,050 |
| 2011 | $2,331,663$ | 142,395 |



Source: PW
Figure 3.2 Road Length in Myanmar
The following is a detailed analysis of the country's road conditions. PW, under the supervision of the Ministry of Construction, is responsible for road improvements in Myanmar. Other actors include the Ministry of Border Affairs, the city of Yangon, the city of Mandalay, the city of Nay Pyi Taw, and the military. As an organization under the supervision of the Ministry of Construction, PW is technically a state economic enterprise, in effect a company owned by the national government. As such, PW is seen as a public corporation in charge of public works rather than as a bureau of the Construction Ministry. Because of this organizational characteristic, the head of PW is called "Managing Director."

Roads supervised by PW account for about $26 \%$ of all roads in the country. On the other hand, roads managed by the Ministry of Border Affairs occupy about 63\%. Roads managed by PW include expressways, national roads, and local roads. The pavement ratio is $47 \%$, higher than average. Roads managed by the Ministry of Border Affairs include dirt roads (64\%) and gravel roads (21\%), with a poor pavement ratio.

Table 3.2 Road Length by Type of Road and by Responsible Organization (2011)

| No. | Type of Road | Concrete | Asphalt | Gravel | Macadum | Earth | Total | Composition |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Ministry of Comstruction Public Woeks |  |  |  |  |  |  |  |  |
| 1 | Highways | 567.9 | 11,175.4 | 2,978.1 | 2,625.7 | 1,297.3 | 18,644.4 | 13.2\% |
| 2 | Regional \& State Roads | 38.6 | 5,835.6 | 3,938.5 | 2,562.7 | 4,893.8 | 17,269.3 | 12.3\% |
|  | Sub-total | 606.6 | 17,011.1 | 6,916.6 | 5,188.4 | 6,191.1 | 35,913.7 | 25.5\% |
| Ministry of Boder Affairs |  |  |  |  |  |  |  |  |
| 3 | Urban | 3.4 | 4,532.8 | 2,126.0 | 635.1 | 3,455.9 | 10,753.2 | 7.6\% |
| 4 | Village \& Border Road | 99.4 | 3,863.0 | 16,256.6 | 4,654.7 | 53,340.1 | 78,213.8 | 55.6\% |
| 小計 |  | 102.8 | 8,395.7 | 18,382.6 | 5,289.9 | 56,796.0 | 88,967.0 | 63.2\% |
| 5 | Yangon City Development Committee | 1,240.2 | 1,748.3 | 12.9 | 455.1 | 473.1 | 3,929.6 | 2.8\% |
| 6 | Mandalay City Development Committee | 10.8 | 1,539.7 | 119.8 | 0.0 | 310.0 | 1,980.2 | 1.4\% |
| 7 | Naypyitaw City Development Committee | 246.2 | 129.4 | 43.0 | 735.2 | 1,131.3 | 2,285.1 | 1.6\% |
| 8 | Military Engineering | 260.0 | 55.5 | 335.1 | 379.0 | 6,673.6 | 7,703.1 | 5.5\% |
| Total |  | 2,466.6 | 28,879.6 | 25,809.9 | 12,047.6 | 71,575.0 | 140,778.7 | 100.0\% |
|  |  |  |  |  |  |  |  |  |
| No. | Type of Road | Concrete | Asphalt | Gravel | Macadum | Earth | Total |  |
| Ministry of Comstruction Public Woeks |  |  |  |  |  |  |  |  |
| 1 | Highways | 3.0\% | 59.9\% | 16.0\% | 14.1\% | 7.0\% | 100.0\% |  |
| 2 | Regional \& State Roads | 0.2\% | 33.8\% | 22.8\% | 14.8\% | 28.3\% | 100.0\% |  |
|  | Sub-total | 1.7\% | 47.4\% | 19.3\% | 14.4\% | 17.2\% | 100.0\% |  |
| Ministry of Boder Affairs |  |  |  |  |  |  |  |  |
| 3 | Urban | 0.0\% | 42.2\% | 19.8\% | 5.9\% | 32.1\% | 100.0\% |  |
| 4 | Village \& Border Road | 0.1\% | 4.9\% | 20.8\% | 6.0\% | 68.2\% | 100.0\% |  |
|  | Sub-total | 0.1\% | 9.4\% | 20.7\% | 5.9\% | 63.8\% | 100.0\% |  |
| 5 | Yangon City Development Committee | 31.6\% | 44.5\% | 0.3\% | 11.6\% | 12.0\% | 100.0\% |  |
| 6 | Mandalay City Development Committee | 0.5\% | 77.8\% | 6.0\% | 0.0\% | 15.7\% | 100.0\% |  |
| 7 | Naypyitaw City Development Committee | 10.8\% | 5.7\% | 1.9\% | 32.2\% | 49.5\% | 100.0\% |  |
| 8 | Military Engineering | 3.4\% | 0.7\% | 4.3\% | 4.9\% | 86.6\% | 100.0\% |  |
| Total |  | 1.8\% | 20.5\% | 18.3\% | 8.6\% | 50.8\% | 100.0\% |  |

Note 1: Highways include expressway between Yangon and Mandalay via Nay Pyi Taw.
Note2: This data of road length is not the same as the data in Figure 3.2 due to different data source.
Note 3: Asphalt road includes simple pavement method like DDST
Source: PW
There are bridges on some $36,000 \mathrm{~km}$ of roads under management of PW, but PW does not have the exact data about how many bridges there are. At minimum, there are about 2,800 bridges longer than 15 meters. There are 517 bridges that are relatively long, at least 54 meters. 276 of these longer bridges were constructed after 1988.

The number of long bridges spanning major rivers such as the Ayeyarwady, Chindwin, Sittaung and Thanluwin as are follows: 12 over the Ayeyarwady, 2 over the Chindwin, 4 over the Sittaung, and 7 over the Thanluwin. For details about bridge improvements, see Table 3.3 for a list of major bridges.

Table 3.3 Long-span Bridges across Major Rivers in Myanmar

| No. | Name | Span(ft) | Type of Bridge |
| :---: | :---: | :---: | :---: |
| Ayeyarwaddy River |  |  |  |
| 1 | Innwa Bridge(Sagaing) | 3,960 | Steel Truss |
| 2 | Nawaday Bridge | 4,183 | Steel Truss |
| 3 | Maubin Bridge | 2,362 | Steel Truss+ RCC |
| 4 | Bala Min Htin Bridge | 2,688 | Steel Truss |
| 5 | Bo Myat Htun Bridge | 8,544 | Steel Truss |
| 6 | Anawrahtar Bridge | 5,192 | Steel Truss |
| 7 | Ayeyarwaddy Bridge(Magwe) | 8,989 | Steel Truss+ PC+RCC |
| 8 | Dadaye Bridge | 4,088 | Steel Truss+ RC |
| 9 | Ayeyarwaddy Bridge(Yadanarpon) | 5,641 | Steel Truss |
| 10 | Ayeyarwaddy Bridge(Naungdone) | 7,402 | Steel Truss |
| 11 | Ayeyarwaddy Bridge(Pakokku) | 11,431 | Steel Truss |
| 12 | Ayeyarwaddy Bridge(Sinkhan) | 3,215 | Steel Truss+ PC+RCC |
| Sittaung River |  |  |  |
| 13 | Sittaung Bridge | 2,320 | Steel Truss |
| 14 | Sittaung Bridge(Taungngu-Mawchi-Loikaw) | 680 | CH Steel Girder |
| 15 | Sittaung Bridge (Shwe Kyin-Madauk) | 500 | PC+RCC |
| 16 | Sittaung Bridge(Mokepalin) | 2,393 | Steel Truss+Plate Girder+RC |
| Thanlwin River |  |  |  |
| 17 | Kwan Lon Bridge | 789 | Steel Suspension |
| 18 | Tar Kaw Bridge | 780 | Steel Truss |
| 19 | Thanlwin Bridge(Pha An) | 2,252 | Steel Truss |
| 20 | Thanlwin Bridge(Tarsan) | 900 | Suspension |
| 21 | Thanlwin Bridge(Mawlamyine) | 11,575 | Steel Truss+ PC+RCC |
| 22 | Thanlwin Bridge(Tarpar) | 600 | Steel Suspension |
| 23 | Thanlwin Bridge(Tarkaw At) | 600 | Bailey |
| Chindwin River |  |  |  |
| 24 | Shinphyushin Bridge | 4,957 | Steel Truss |
| 25 | Chindwin Bridge(Monywa) | 4,730 | Steel Truss |
| Total Span(ft) |  | 100,771 |  |

Source: The Study Team

## (2) Budget for road and bridge improvements

Road and bridge improvements have been steadily implemented, as discussed above. The Myanmar's government seems to be aware of the importance of road infrastructure development and therefore has made the appropriation of the necessary budgets to improve roads as a top priority. According to Table 3.4, although the road budget has been increasing since 2005, the bridge budget seems to be declining. It is suggested that the maintenance budget is also increasing although it tends to fluctuate greatly. Specifically, the annual budget plan of PW for 2008/2009 was about 120 billion Kyat. Of that total, the road-related budget was about 50 billion Kyat, the bridge-related budget about 30 billion Kyat, and maintenance
about 30 billion Kyat. Although the PW budget seems to remain almost the same, its ratio to the national budget decreased from $6.6 \%$ in 2005/2006 to $2.6 \%$ in 2008/2009.

But according to JICA's Study of "The Project for Improvement of Road Technology in Disaster Affected Area (2012)", road and bridge spending after 2009/2010 was 182 billion Kyat in 2009/2010 and again increased to 315 billion Kyat in 2010/2011. Considering the future growth of the national budget, it is believed that a budget greater than the present level will be allocated to PW, with an emphasis on road construction, bridge construction, and maintenance.

Table 3.4 Budget for Road and Bridge in PW

|  | 2005-2006 | 2006-2007 | 2007-2008 | 2008-2009 |
| :---: | :---: | :---: | :---: | :---: |
| National Budget (a) | 1947 | 2972 | 4004 | 4637 |
| PW Budget | 128 | 126 | 119 | 120 |
| Road Budget (b) | 35 | 48 | 47 | 52 |
| Bridge Budget '(c) | 52 | 33 | 34 | 28 |
| Maintenance (d) | 15 | 24 | 16 | 28 |
| Sub-total (e=b+c+d) | 102 | 105 | 97 | 108 |
| Composition of PW budget in National Budget (e/a) | 6.6\% | 4.2\% | 3.0\% | 2.6\% |
| Road and Bridge Budget in PW Budget ((b+c)/a) | 79.7\% | 83.3\% | 81.5\% | 90.0\% |

Source: Compiled by JICA Study Team based on the data from Statistical Year Book 2011 and "Detailed Planning Survey for Technology in Disaster Affected Area" of JICA in 2012

### 3.2 STUDY ON CURRENT STATUS AND PROBLEMS OF BRIDGE PROJECT MANAGEMENT SYSTEM IN MYANMAR

### 3.2.1 General situation after the BETC Project

The major objectives of the BETC Project are considered as below;
(1) Capacity building for Burmese engineers to design and construct bridges by themselves.
(2) Technical transfer for bridge design and construction technology which utilize the resources domestically available.

For objective (1), since many bridges have been constructed after the BETC Project, it is reasonably believed that the technology and know-how of bridge design and construction has been successfully transferred to BETC trainees and contributed to the development of bridge sector in Myanmar.

However for objective (2), despite its advantages in terms of low cost and/or easy maintenance, the technology of PC box girder bridge has not been utilized after Ngawun Bridge construction due to national policy in which construction speed was prioritized.

If the technology of PC box girder bridge was widely transferred to the private companies and the fair competition mechanism worked in bridge construction field, the further technical development and wide spread of PC box girder bridge might have been achieved.

However, as described in the following paragraphs, since major road and bridge projects have been directly controlled / implemented by PW from the planning/design stage to the construction stage,

- High priority of construction speed and
- Consideration for cost minimizing alternatives or value engineering is not necessary since no competitor exists at present.

Subsequently, the steel truss bridges with same span arrangement have been widely built in order to re-use the same design repeatedly.

### 3.2.2 Current status and problems

## (1) Organization and capacity of PW

Major road and bridge projects have been directly controlled / implemented by PW from planning/design stage to construction stage.

Figure 3.3 exclusively shows the organization chart of sections in charge of bridge projects in PW. PW has its own construction teams so called Bridge Construction Unit and Special Construction Project Team (hereafter BCU and SCPT respectively), and those have directly implemented the bridge construction works. Thus there have been rare cases for the private companies to participate in the bridge projects, however the cases of subcontracting a part of works to the private companies are recently increasing though number of such works are still limited to the approach bridges on land only.

Many long-span bridges such as the steel truss, cable stayed and suspension bridges have been built by foreign companies (mainly Chinese companies). Since PW implements the construction works by itself, scope of foreign company's works is limited to the design (superstructure only in most case), fabrication, import and transportation of superstructural members, delegation of supervisors for erection and supply of equipment for erection.


Figure 3.3 Organization chart of PW (focused on bridge sector)

In the organization chart, BCU exists in each state or region (total 7 states and 7 regions) and responsible for the construction of small to medium scale bridges within each state or region.

5 SCPTs have been specially established to implement large scale projects such as Yangon Mandalay Expressway and Ayeyarwady River Bridges. Projects implemented by each SCPT so far are shown in Table 3.5;

Table 3.5 Summary of Special Construction Project Team (SCPT)

| Name | Project responsible | Project cost $/$ Project period |
| :---: | :--- | :--- |
| SCPT No.1 | Yangon - Mandalay Expressway | $1,291.3$ billion.Kyat, Period $=7$ years |
| SCPT No.2 | Ayeyarwady River Bridge (Sinkhan) | 36.3 billion.Kyat |
| SCPT No.3 | Ayeyarwady River Bridge (Pakokku) | 122.6 billion.Kyat, Period $=2$ years |
| SCPT No.4 | Ayeyarwady River Bridge (Malun) | 45.3 billion.Kyat, Period (actual) $=3$ years |
| SCPT No.5 | Ayeyarwady River Bridge (Nyaungdone) | 88.9 billion.Kyat, Period $=2$ years |

The following Table 3.6 shows an example of manpower and machinery of SCPT No. 3 and No. 5 .

Each SCPT has the similar resources and capacity to implement a long-span bridge project with project cost of over 10 billion yen within about two (2) years.

Table 3.6 List of manpower and machinery (example of SCPT No. 3 and No.5)

| No. | Description | SCPT No. 3 | SCPT No. 5 |
| :---: | :---: | :---: | :---: |
| 1 | Manpower |  |  |
| 1.1 | Project Manager | 1 | 1 |
| 1.2 | Deputy Project Manager | 1 | 1 |
| 1.3 | Executive Engineer | 3 | - |
| 1.4 | Engineer | 67 | 102 |
| 1.5 | Worker | 1,750 | 2,010 |
| 2 | Machinery |  |  |
| 2.1 | Reverse circulation drill | 3 | - |
| 2.2 | Earth auger | 4 | 9 |
| 2.3 | Crawler crane | 12 | 10 |
| 2.4 | Tire crane | 4 | 12 |
| 2.5 | Generator | 8 | 8 |
| 2.6 | Vibration hammer | 4 | - |
| 2.7 | Barge for working platform | 5 | 8 |
| 2.8 | Sand barge | 2 | 1 |
| 2.9 | Tug boat | 1 | 2 |
| 2.10 | Barge for equipment transportation | 2 | 5 |
| 2.11 | Backhoe | 5 | 3 |
| 2.12 | Loader | 1 | 2 |
| 2.13 | Pump car | 3 | - |
| 2.14 | Bulldozer | 2 | 2 |
| 2.15 | Trailer | 3 | 7 |
| 2.16 | Batching plant | 5 | 3 |
| 2.17 | Concrete mixer car | 14 | 7 |
| 2.18 | Dump truck | 5 | 7 |

## (2) Procedure from planning to construction stage in bridge project

The following flow chart shows the typical procedure from planning to construction stage in steel truss bridge projects which have been widely adopted in Myanmar.


Figure 3.4 Flow chart of implementation of steel truss bridge project

> INVITATION FOR TENDER TENDER NO. BRIDGE/AYW/ 2011-2012/ NPT/ST-002
> 1. Opened Tender is invited by Public Works, Ministry of Construction, Nay Pyi Taw, Myanmar for the supply of Steel Truss and Accessories for BRIDGE (Two lanes Highway Bridge Construction Project) in Ayeyawady Region:
> 2. Fender application form of BRIDGE (including Technical Specifications, terms of Tender, Tender Schedule and Offer Form) can be purchased with USD 2000.
> 3. The payment for tender application must be paid to Public Works' Account No.SEE IIOI5, Myanmar Economic Bank (2) through Myanmar Foreign Trade Bank
> 4. The Tender documents can be obtained from Bridge Division, Building No.(11), Public Works, Ministry of Construction, Nay Pyi Taw, Myanmar only with tho Cash Receipt delivered by account Division, Public Works.
> 5. Tender should be submitted to the above address not later than 16.30 hours on $19^{\text {di }}$ March 2012.
> 6. For further detail information, Please contact to Telephone No.067-407276, 407602 Managing Director
> Public Works

Figure 3.5 Tender call on newspaper (example)

## (3) Contract in a bridge project

As described in the previous paragraphs, many long-span bridges such as steel truss, cable stayed and suspension bridges have been constructed by foreign companies but the scope of works for such foreign companies are limited to the following items;

- Design (superstructure only in most cases)
- Fabrication of superstructural members
- Import and transportation of superstructural members
- Delegation of supervisors for erection
- Supply of equipment for erection

Thus, contents of usual contract documents are simple as shown in Table 3.7;

Table 3.7 Contents of Contract Documents (Example)

| No. | Contents | Remarks |
| :--- | :--- | :--- |
| 1 | Scope of works | - |
| 2 | Contract sum | - |
| 3 | Specification of material | JIS etc. |
| 4 | Design load | ASSHTO HS-25 load is <br> usually applied. |


| 5 | Contract period | Required period between <br> contract signing and delivery <br> of structural member. |
| :--- | :--- | :--- |
| 6 | Performance bond | - |
| 7 | Force Majeure | - |
| 8 | Liquidation damage | - |
| 9 | Dispute resolution | - |

## (4) Design control for bridge project

1) Procedure to decide the type of bridge

It is understood that steel truss, cable stayed and suspension bridges are commonly selected as long-span bridge for river crossing in Myanmar, and the determination of such bridge type is generally governed by the capacity of pile driver.

- Location of pier is selected according to river depth not to exceed 20 m which is the limitation of available capacity of pile driver.
- $\quad$ Subsequently, interval of each pier (= bridge span arrangement) is determined.
- If span length is less than 120 , the bridge type is determined as steel truss.
- If span length exceeds 120 m , cable stayed or suspension bridge type is selected.


Figure 3.6 Procedure to determine type of river crossing long-span bridge
2) Bridge design standards

At present, many long-span bridges such as steel truss, cable stayed and/or suspension bridges have been designed by foreign company (mainly Chinese companies), and the applied design standards for those bridges are generally as shown below;

Table 3.8 Applied design standard for long-span bridges (example)

| Item | Applied Standard | Remarks |
| :--- | :--- | :---: |
| Design load condition for | ASSHTO | Design standard in contractor's country of |
| Design truss, <br> superstructure(steel <br> cable stayed, suspension <br> bridge) | origin (mainly China) |  |
| Design for substructure | Japanese design standard used in the BETC <br> Project (the Japanese Specification for <br> Highway Bridges) | Design by PW <br> itself |

As shown above, there are many cases to apply the different design standard between the superstructure and substructure.

In the field survey, it is not confirmed whether the Chinese companies properly submitted the design calculation sheets or not and whether those calculation sheets were checked / evaluated by PW or not.

There are some cases that the construction of substructure has been commenced before completion of the superstructure design (some contract documents clearly describes "The substructure has already been constructed").

Putting higher priority on the rapid construction, designers shall take a great risk into their design, for example;

- In case that design reaction force from superstructure exceeds the assumed one used for substructure design, it may result in a design change of substructure and subsequent extension of time and additional cost for the construction work.
- In order to avoid above risk, designers may make the rather conservative assumption than actually required in terms of the reaction force from superstructure. In such situation, it is possible for the substructure design to be too conservative (not economical).


## (5) Construction supervision for bridge project

1) Procurement of major material

Major construction materials such as cement and re-bar are obliged to be procured from the following factories of state-owned company shown in Table 3.9 and 3.10.

Table-3.9 Cement factory (state-owned company)

| No. | Location | Capacity |
| :--- | :--- | :--- |
| 1 | Thayet (300km north-west from Yangon) | 700ton/day (max.) |
| 2 | Kyangin (200km north-west from Yangon) | 1,200ton/day (max.) |
| 3 | Kyaukse (near Mandalay) | 500ton/day (max.) |

Table-3.10 Re-bar factory (state-owned company)

| No. | Location | Capacity |
| :---: | :---: | :---: |
| 1 | Insein (near Yangon) | Approx. |
| 2 | Aunglan (300km north-west from Yangon) | $\int$ 20,000ton/year/2 factories |

2) Site organization

Figure 3.7 shows a general site organization of SCPT to control the site works.


Figure 3.7 Site organization chart
3) Execution / progress control

Generally, following documents are prepared to control a construction and the progress;

- Overall construction schedule
- Construction / shop drawings

Written documents such as construction plan and/or quality control plan are usually not prepared on site, and such construction and quality control procedure/method is deemed as the implied / assumed ability of experienced engineers / supervisors.

Most of the project offices are obliged to keep the very tight schedule especially for the Ayeyarwady River crossing bridge projects, thus those projects have been arranged to work 24 hours/day (3 shifts/day) and 7 days/week.
4) Quality control

Though there are some cases to omit the testing of cement and re-bar procured from the said state owned factories, the following quality control tests are usually carried out and recorded on site.

Table-3.11 Test items for quality control

| Test item | Frequency | Remarks |
| :--- | :--- | :--- |
| Grain size distribution of coarse aggregate | Each delivery |  |
| Grain size distribution of fine aggregate | Each delivery |  |
| Concrete compressive strength | Each casting | $3,7,28$ days strength |

Water for concrete mixing is usually exploited from deep-well but test report of water quality is not confirmed.

Since there are some bridges on which salt damage of concrete are observed, it is possible that some of bridge projects used unsuitable salty water without quality checking.

It was also confirmed that the loading test on bored piles and RC driving piles has not been carried out, thus, it is not confirmed whether the actual piles have the sufficient bearing capacity or not for all bridges in Myanmar,

## (6) Maintenance of bridge

For the completed bridges, BCU and SCPT are responsible for inspecting bridges at least 2 times per year (usually before and after rainy season, in May and October) by using a bridge inspection sheet.

Those inspection results are submitted to Managing Director, Deputy Managing Director and Director of Bridge Section of PW, and they hold the meeting and decide the priority of bridge to be repaired and the budget allocation.

However, quantitative criteria and procedure for decision making on priority of repairing works are not confirmed.

### 3.3 STUDY ON CURRENT STATUS AND PROBLEMS OF EXISTING BRIDGES IN MYANMAR

### 3.3.1 Bridge survey (local roads)

## (1) Design

The Study Team checked the contents of design calculation documents of the substructure of bridges designed by PW after the BETC Project and confirmed that the contents adopted the same calculation theory as that in the Japanese Specification for Highway Bridges. The Study Team also checked the drawings of the substructure of Maubin Bridge opened to traffic in 1998 and the drawings of Ngawun Bridge, and confirmed that those structural drawings were also based on the same theory. In the superstructure, PC girders are designed as simple composite girders taking account of the cross section of the deck slab, but RC cross girders are used for both pretensioned and post-tensioned girders for economic reasons. In pretensioned girders, main girders are combined with cross girders by placing reinforced steel bars with semicircular hooks on the main girder in advance. In post-tensioned girders, main girders are combined with cross girders by making openings of approximately $40 \varphi$ on the main girder in advance and passing the reinforced steel bars through those openings when assembling the cross girder.

The types of bridges which can be designed in Myanmar are PC bridges introduced through the technical transfer by the BETC Project and bridges made up primarily of concrete structures, such as concrete piers and cast-in-place piles. The Study Team checked the drawings and design calculation documents of some of the representative structures and confirmed that these structures were designed based on the Japanese Specification for Highway Bridges, because Myanmar does not have any well-organized bridge design standards. Substructural design calculation was performed basically according to the Japanese Specification for Highway Bridges and was checked using American design calculation analysis software. These practices show that technologies transferred in the BETC Project have been sustained successfully.

As for steel truss bridges, cable-stayed bridges and long suspension bridges, which were not in the scope of the BETC Project, many bridges of these types have been constructed after the BETC Project. They are designed/manufactured mainly in other countries, but recently, MEC (Myanmar Economic Corporation), a state-owned company, has designed/manufactured steel truss bridges and steel girder bridges at its manufacturing plant. About 4-5 bridges have been already erected by the PW engineers over large rivers like the Chindwin River.

As for suspension bridges, however, all components ranging from the foundation including anchorages to the superstructure are designed in other countries. In recent years, the Study Team have seen cases where it takes a lot of time to sort out repair/reinforcement measures against problems on suspension bridges. One of the major reasons for this can be that PW does not have the design calculation documents for design verification.

According to a contract document between China and PW on design/construction of a steel truss bridge designed/manufactured in China, manufactured steel members are supposed to be transported into Myanmar within six months. Even though steel truss bridges are straight bridges and are similar to one another in terms of structures to be manufactured, the time needed for bridge design seems to be very short given the time needed for material arrangement/processing. As for design verification, the contract stipulates that two PW employees take responsibility for checking the design and drawings as the contractor. Considering the process, however, such verification seems to be practically impossible. The Study Team also confirmed that the contents of design drawings of a steel truss bridge were the same as those of another steel truss bridge, which may be an indication that the design calculation document of an older bridge was used for a new bridge. Therefore, it is necessary to strictly ensure that contractors submit the design calculation documents as clearly specified in the contracts. In a standard construction of a steel truss bridge, span length is 120 m with some adjustments made according to river width as shown in Figure 3.8. In Myanmar, however, river transportation is still predominant and therefore there will be a need for plans of steel truss bridges with longer span lengths. To meet such a need, the PW employees will also need to enhance their technical abilities to design steel structures themselves.

## AYEYARWADDY BRIDGE (PAKOKKU) <br> PROPOSAL-1



Figure 3.8 Common span length of a steel truss bridge (Pakokku Bridge)

## (2) Erection of concrete deck slab

In 2011 and 2012, Authorized NPO Japan Infrastructure Partners conducted surveys on bridges in Myanmar (i.e. "Survey on Technical Transfer Support on Repair and Reinforcement of Bridges in Myanmar" in 2011 and "Technical Transfer Support on Repair/Reinforcement of Bridges in Myanmar" in 2012.) Those surveys revealed that precast concrete was commonly used for deck slab in many bridges in consideration of workability and shortening of construction period and that there were different types of deck slabs. In Myanmar, there are no standard design/structural drawings for concrete deck slabs, and concrete deck slabs are designed by steel bridge manufacturers as part of the steel bridges.

In general, deck slabs in Myanmar are actually thinner than those stipulated in the Japanese Specification for Highway Bridges. In Japan, deck slab thickness was revised around 1965 when there were an increasing number of depressions due to thin deck slabs. Considering that some damage events on the deck slab, such as depressions, have already been reported in Myanmar despite low traffic volume, it is necessary to quickly develop/improve the design standards and drawings for the deck slab in anticipation of increase in traffic volume.

The Study Team learned, especially from the workability point of view, that some of the bridges had deck slabs separated into two parts in the cross-sectional direction as shown in Figures 3.9 and 3.10, and the bottom part was made of precast slabs which were also used as formwork. This type of deck slab is constructed by pouring concrete on site on the precast slabs placed on the stringers of the truss floor system, where deck slab tension bar is placed inside the precast slabs. This type of structure was initially adopted for bridges designed in Switzerland in the 1980s and is still used today for Maubin Bridge and other bridges even after more than 20 years.


Figure 3.9 Cross section of deck slab (two-part construction)


Figure 3.10 Cross section of precast deck slabs (bottom part)

Another case is Phyar Pon Bridge, which was designed/manufactured by JFE and was completed in 2008. JFE initially submitted to PW drawings (of cast-in-place concrete deck slab) designed based on the Japanese Specification for Highway Bridges but eventually executed the construction of the deck slab in two vertical parts by request from PW. PW requested that the deck slab is built in two vertically separate parts and that the bottom part is constructed with precast slabs which are also used as formwork, because it was difficult to build formwork over the river with the materials and equipment owned by PW. Some executional ideas were carried out to better combine the two parts, such as surface texturing on the upper surface of the bottom deck slab and extension of haunch reinforcement steel to the upper deck slab. It should be noted that it is not possible to confirm in the drawings that the bridge was actually constructed according to this method, and thus it is not clear as to how many bridges have been constructed according to this method.

For this structure, combining the top and the bottom slabs is an important aspect, and in general, damage is concentrated in the joint between the two parts. In case the adhesion between the top and the bottom slabs is lost due to such reasons as increased traffic volume, reduced adhesive force or presence of moisture, the deck slab may lose its functionality. Therefore, implementation of this construction method needs to be stopped promptly. When upper surface thickening work is performed in Japan, cleaning/texturing of old concrete surface using steel shot blast requires utmost care in terms of work management to secure adhesive strength between the concrete surfaces. In Myanmar, some bridges were erected by single-step precast deck slab construction as opposed to segmental construction, which indicates a need for standardization of construction methods. These issues concerning design/construction methods of concrete deck slabs may be attributed to the fact that they are designed mainly by foreign companies.

## (3) Substructure movement on soft soil

Surveys of Bayinaung Bridge, Maubin Bridge and others revealed that the abutments of these bridges were pushed forward by earth pressure on the structure wall as shown in Photo 3.1. There is lateral flow in general, and when calculating the lateral flow of Maubin Bridge with a formula provided in the Japanese Specification for Highway Bridges IV, the lateral flow value (I value) determining the chance of lateral flow of the abutment was 1.96 , indicating that "there is a chance of lateral flow." When the I value is 1.2 or above, it is determined that "there is a chance of lateral flow."


Photo 3.1 Substructure movement (Maubin Bridge)
On Myaungmya Bridge, a suspension bridge whose towers are tilted inward, I value was 1.88 at A1 (YGN side) and 3.93 at A2 (MM side), significantly exceeding the lateral flow threshold (1.2). In Myanmar, the pile foundation is commonly embedded into strata with $N$ value of 60 or above. However, the Study Team checked the boring log of this suspension bridge and found out that the tips of the pile foundation of the anchorages on the Yangon side and on the other side were in the strata with $N$ value of 10 . The Study Team cannot deny the possibility of movement of the anchorages (see Picture 3.2). Given that the Japanese Specification for Highway Bridges used in the BETC Project says, "It is difficult to quantitatively capture the level of lateral flow at the time of designing," the Study Team assume that it was not possible to transfer the techniques regarding lateral flow.


Photo 3.2 Substructure movement (Myaungmya Bridge)

Some of the bridges on the expressway between Yangon-Nay Pyi Taw opened in 2009 had tilted abutment bodies. The abutment foundation may have been scoured by the river flow, causing the abutment to be pushed by earth pressure on the structure wall. If this is the case, certain actions need to be taken. The Study Team also found some cases where a part of block revetment around the abutment had sunk due to tilting of the abutment.

## (4) Material quality

1) Concrete quality (salt damage)

In general, there are no standard values in place for quality control.

The coastal area along the Bay of Bengal is a vast delta where there are many swamps containing sea water. Sand and fresh water are not easily accessible due to high cost of collection/transportation of salt free sand and fresh water from remote locations, and therefore water containing sea sand and salt was used when constructing the concrete bridges. This has resulted in concrete


Photo 3.3 Salt damage (Min Chaung Bridge) spalling and corrosion of reinforced steel shown in Photo 3.3. It is costly to collect and transport salt free sand and fresh water from remote locations, and because of this, there is a possibility that concrete had been mixed with
salt already at the time of initial erection. It is necessary to consider introducing values for salt control in concrete manufacturing.
2) High tension bolts

High tension bolts were found to be missing and damaged on Yadanarpon Bridge, Pathein Bridge and other bridges. As these bridges were designed in China, one commonality among them is that the high tension bolts used on them were made in China. This time, the Study Team conducted a site inspection of Yadanarpon Bridge, where 50-80 bolts are found to be missing every month. Given that the bridge was completed in 2008, the number of damage events is just extraordinary. The problem seems to be caused by the material of bolts rather than construction work. It is advisable that appropriate material specifications and quality control values are established to ensure adequate quality. (See Photo 3.4 and 3.5.)

3) Painting of steel bridges

According to a tender document for new girders, a paint process is composed of five coats: two coats at factory; one middle coat; and two top coats, which clearly specifies that the steel girder manufacturer is responsible for painting of two coats at the factory and preparation of materials and equipment (e.g. sprays) for the remaining three coats. This document clearly specifies the film thickness but does not explicitly refer to the ingredients of paint materials. In Myanmar, there are no standards for painting and paint design is performed by foreign companies. Thus, there is little awareness about basic quality control in this country.

Also, their standard repainting process necessary for the maintenance of bridges contains a total of two coatings, one coating of primer and one coating of anticorrosive paint. When a
bridge is repainted repeatedly with low-quality materials, its steel members become thinner, and this may ultimately cause the truss or the girder to break.

Repainting of the girders of Myaungmya Bridge is shown in Photo 3.6 to 3.9.


Photo 3.6 Myaungmya Bridge corrosion (before repainting)


Photo 3.8 Myaungmya Bridge repainting (first coat)


Photo 3.7 Myaungmya Bridge repainting (surface preparation)


Photo 3.9 Myaungmya Bridge repainting (second coat)

It is generally known that steel bridges in the coastal areas are subject to accelerated paint deterioration by the influence of sea breeze. Steel bridges in Myanmar are also subject to accelerated damage and corrosion in major parts like bolted joints. The Study Team saw some bridges that were in pressing need of repainting.

Lattputar Bridge (suspension bridge) is repainted every 1-2 years, but repeating similar painting only worsens the damage on the steel bridge.

Considering that the paints that are currently used have low specifications, it is necessary to introduce paints with better anticorrosive properties.

One of the causes of accelerated paint deterioration is problematic painting quality. Poor painting quality results from: absence of specifications; use of improper paint materials which are prone to peeling or have poor anticorrosive properties; poor painting work; and inadequate system for acceptance test and inspection. These issues need to be tackled effectively.

On Myaungmya Bridge (suspension bridge) completed in 1996, strands of the main cable were partially broken/corroded. The cable was repaired through a six-step process: 1) primer, 2) primer, 3) inner wrap, 4) primer, 5) outer wrap and 6) color. If breakage of the main cable progresses, there is high risk of collapse of the bridge. Therefore, it is advisable to establish proper painting specifications and quality control values to ensure adequate quality. (See Photo 3.10 and 3.11.)


## (5) Maintenance

PW has a system to regularly carry out structural inspections and to report the results to the top management. They have inspection sheets for different structure types, and the inspectors determine the level of damage and give ratings as shown in Table 3.12. The rating appears to be based on qualitative judgment and therefore may be affected by the ability of the inspector. Theoretically, results of an inspection should always be consistent regardless of who performs the inspection and under what circumstances it is performed. Looking at the present conditions of PW's inspections, however, the Study Team cannot say that they have a quantitative evaluation method. In order to make the inspection as quantitative as possible, it is necessary to minimize the rating variation between inspectors by preparing a visual portfolio of damage events by member and by damage level. It is also necessary to perform sufficient measurements to identify the causes before carrying out repair work on severe damage events.

Also, the inspection results need to be managed and compiled as data. This will help the inspectors know where to pay attention to during the inspection and will lead to more effective and efficient inspection practices.

Table 3.12 Damage rating

| Rating | Condition |
| :---: | :--- |
| 9 | New condition |
| 8 | Good condition - no repaer required |
| 7 | Minor items in need of repairs by maintenance forces |
| 6 | Major items in need of repairs by maintenance forces |
| 5 | Major repair by special unit forces |
| 4 | Minimum adequacy to tolerate present traffic - immediate rehabilitation required <br> to keep open |
| 3 | Inadequate tolerance to present heavy load - warrants closing bridge to all traffic |
| 2 | Inadequate tolerance to any live load - warrants closing bridge to all traffic |
| 1 | Bridge repairable, if desirable to reopen to traffic |
| 0 | Bridge conditions beyond repair - danger of immediate collapse |

### 3.3.2 Bridge survey (major trunk roads)

Myanmar's first expressway, the Yangon-Mandalay Expressway, opened to traffic in 2009 with the interval between Yangon and Nay Pyi Taw. Currently, this expressway extends a total of approximately 590 km from Yangon to Mandalay by way of the capital Nay Pyi Taw, and remains the country's only expressway.

In the expressway there are approximately 490 bridges. These bridges surveyed are appropriate for learning about the present status of road technology level of Myanmar because the expressway was opened to traffic within 3 years.

In addition to the construction technology of roads and bridges, the expressway requires a lot of know-how such as drivability and safety technology. The Study Team also here outlined some conditions of the expressway.

## (1) Bridge survey

This time 18 points of the expressway bridges survey were conducted and the following are some typical conditions of damage.

- Concrete main girders show numerous rock pockets, and some are insufficiently compacted.
- On PC crossbeams, transverse pre-stressed steel compression plates and anchor nuts are rusted. Steel may be corroded.
- Steel re-bars of some RC deck slabs needed for future widening are exposed and rusting. Some re-bars are wrapped in concrete or cured with anti-rust treatment. Connecting the bars in this condition may cause problem when widening bridge.
- Some shoes are rusted and supports and abutments show traces of rust fluid.
- Exterior of piers shows no signs of damage.
- Some abutments are structurally tilted. It is possible that the abutment foundations have been scoured by the river scouring, and are pushed by earth pressure in the rear of the abutment. Measures to address this must be considered.
- Some stacks of blocks mansory retaining wall surrounding the abutment have caved in due to the tilting of the abutment.
- In the points on the abutments which have steel finger expansion joints, these have a water drainage structure and are subject to water leakage from road surface.
- Water drainage pipes are laid in handrails and water drains into rivers. There is no plumbing draining water from embankment surrounding abutments, and water is scouring soil in front of abutments.
- Numerous rock pockets of concrete at handrail can be seen, resulting from overabundance of water when concrete was set.


Photo 3.12 Steel beams of deck slabs for widening are rusting


Photo 3.14 The bottom of the block is greatly scooped out.


Photo 3.13 Scouring of pier foundations


Photo 3.15 Both the abutment parapet and girders are cracked

## (2) Technical problems on bridges

The following are common technical problems on expressway bridges.
[Scouring] * Possibility of elevated pile design

- Necessary to fix soil in place to prevent scouring, reinforce scoured portions, and halt tilting of abutments due to scouring. (measures; wall foundations, cast-in-place diaphragms walls etec.)
- Scouring occurs because bottom surface of footing has higher elevation than riverbed, and abutments are positioned in rivers.
Necessity of appropriate determination of river areas, design riverbed levels, etc.
- Road surface water flows out of earthworks around abutment sections, carving paths in front of abutments and causing erosion.
Appropriate water treatment is required.
[Concrete quality]
- Concrete may be made with excessive amounts of water.

More thorough quality control of fresh concrete during manufacturing and pouring, and more effective compaction is requireed.
[Corrosion of bearing pressure plates and anchor nuts of PC girder steel member]

- Already rusted sections must be re-examined continuously.

If nuts come loose, steel members may fall out. Anti-rust measures must be taken. The anchor sections of Japanese bridges feature blocked-out concrete, which is filled in with mortar after tension anchoring.
[Water leakage form girder ends]

- Water is leaking whether or not expansion joints are in place, and road surface water is reaching abutments and piers. As there is no salt damage resulting from spreading of anti-freeze materials, like that found on Japanese expressways, this problem is not thought to be serious. However, it is thought advisable to prevent rusting on girder ends of steel bridges and to make steel-plate support bearings on RC and PC bridges rust-proof by giving them a non-water drainage structure.


## (3) Condition of expressway

In addition to bridge survey, the Study Team also here outlined some conditions of the expressway. Myanmar's expressway was completed as the road, but as a high-standard road (expressway) to allow high-speed driving, it has a lot of weak points due to lack of the accumulation of know-how in construction, management and operation.Therefore, the Study Team describe some notable points here. Among them, shall be performed here is to comment on the part especially noticeable.

1) Design technology

- In the main carriageway around entry and exit point at Interchange, a deceleration lane and acceleration lane do not have sufficient length. When driving from or to rump, a driver nececitates drastic maneuvering with the steering wheel.
- As clothoids were not incorporated into curve entrances and exits when the road path was designed, curves seem to be sharp.


Photo 3.16 Diverging point at IC

- Superelevation of the curve, relatively when the length of curve is short or curvature is small, (not preferable to run stable) applies reversed superelevation or level. This is considered that there is no adequate central drainage function (for example, longitudinal drainage) at median. In addition, some ditches at the median have set up to rain flow to the opposite lane in case of the level curve, but it is no acceptable because of forming thick surface water on the downstream of the road.
On the other hand, when curvature is relatively large, normal superelevation is applied. In this case, expressway have simple center drainage at the median, it can not be consider there is enough capacilty of flow.
It is necessary to consider the design of road with sufficient drainage for smooth driveability.


Photo 3.18 Drainage at median


Photo 3.19 Simple center drainage
2) Construction supervision

- At many points, concrete pavement which has approximately 45 cm thickness is caused a uneven settlement. Particularly, the road surface is uneven at either end of bridges and in areas where structures are added on to crossings. It was caused by insufficient supervision for earthwork in the construction stage.


Photo 3.20 Settlement at a box culvert


Photo 3.21 An uneven settlement at back filling

- Sections for future additional lane and many portions at median are composed of earth, making them permeable to rainwater. The future lane sections are in good shape in places where drainage are installed to drain water away, but in the future lane sections and slopes are noticeably eroded/washed away in many places.

3) Safety control

- At the ends of bridges, there are walls or concrete poles to prevent vehicles from falling in a river. As the expressway has no guardrails, there is a risk that cars can go out of the lane and collide with these walls, resulting in major, fatal accidents. Particularly at small bridges such as the one shown in Photo 3.22, this risk becomes greater diuring nighttime. There is an urgent need to take measures such as installation of reflectors and cushion drums, etc.


Photo 3.22 Bridge area with high risk of collision

- Cases to regulate the traffic flow, such as a lane regulation, will increase for implementing various maintenance or improvement work in the future. In the current state, it is seen that the repair works are done without regulatory or guards, and in case of closing both 2 lanes, vehicles need to go to the sections kept for future additional lane. For safety measure, it is necessary to establish the regulations/rules of regulatory method.


### 3.4 NEEDS IN BRDIGE SECTOR

### 3.4.1 Needs from road and bridge sector study

## (1) Necessity of Network development

1) Economic Development of Myanmar

It seems that Myanmar economy is in stagnation due to economic sanction of the western countries, but it is not current understandings regarding Myanmar economy. Table 3.13 shows that Myanmar economy continuously grew with more than 10\% of annual economic growth rate after year 2000. As a result, Myanmar is in the similar level of GDP per capita with Laos and Cambodia, and is one-sixth of that of Thailand. Looking into industrial composition of Myanmar economy, primary sector decreases to 36\% in 2010 from 57\% in 1990, while secondary sector increases to $26 \%$ from $11 \%$ and tertiary sector also increases to $38 \%$ from $32 \%$ in the same period. Growth of the secondary sector largely depends on natural gas production.

Table 3.13 Trends of GDP

|  |  |  | 1990-1991 | 1995-96 | 2000-01 | 2005-06 | 2010-11 | Remark (USD) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| GDP |  | Million Kyat | 151,941 | 604,729 | 2,562,733 | 12,286,765 | 40,507,942 |  |
| GDP growth rate (annual average) |  | (\%) | 3 | 7 | 14 | 14 | 10 |  |
| GDP per person |  | (Kyat) | 3725 | 13515 | 50927 | 221799 | 677,617 | 816 (year 2011) |
| GDP growth per person per year |  | (\%) | 1 | 5 | 12 | 11 | 9 |  |
| GDP structure | Primary Sector | (\%) | 57\% | 60\% | 57\% | 47\% | 36\% |  |
|  | Secondary Sector | (\%) | 11\% | 10\% | 10\% | 18\% | 26\% |  |
|  | Teritiary Sector | (\%) | 32\% | 30\% | 331\% | 36\% | 38\% |  |

Source: Statistical Year Book 2010, Central Statistical Organization, 2012
Based on the above mentioned socio-economic development of Myanmar, it is gradually required more capacity, and reliability and efficiency of transport and logistics. Accordingly, it is considered continuous needs to develop more roads and bridge to meet the demand. For example, comparing road development level among the neighboring countries in Table 3.14, road density of Myanmar is a little higher than that of Laos, but is far below level from Thailand and Indonesia. Road pavement level of Myanmar is in the similar level of Cambodia, but is below level from Laos. Accordingly, there seems to have much demand to develop roads and bridges in Myanmar.

Table 3.14 International Comparison of Road Length

| Country | Year | Country <br> Area <br> $\left(1000 \mathrm{Km}^{2}\right)$ | Road <br> Length <br> $(1000 \mathrm{~km})$ | Road <br> Density <br> $\left({\left.\mathrm{Km} / \mathrm{Km}^{2}\right)}^{2}\right.$ | Paved <br> Road <br> Ratio | GDP <br> per capita <br> $($ USD $)$ |
| :--- | :--- | :---: | :---: | :---: | :---: | ---: |
| Myanmar | 2011 | 677 | 142 | 0.21 | $22 \%$ | 816 |
| Thailand | 2010 | 510 | 458 | 0.90 | $95 \%$ | 4,696 |
| Indonesia | 2010 | 1,182 | 446 | 0.38 | - | 3,017 |
| Vietnam | 2010 | 330 | 295 | 0.89 | $64 \%$ | 1,981 |
| Laos | 2010 | 237 | 38 | 0.16 | $36 \%$ | 1,055 |
| Cambodia | 2007 | 181 | 11 | 0.06 | $21 \%$ | 656 |
| Japan | 2010 | 377 | 1,202 | 3.54 | $81 \%$ | 42,836 |

Remark: Road length of Thailand subjects only the road managed by the Road Bureau of the Ministry of Transport.
Source: PW (Myanmar), Statistical Year Book 2008 (Cambodia),Ministry of Transport (Thailand), and AJTP (others) for road data; AJTP for land data; Statistics Year Book 2010 (Myanmar) and ADB Key Indicator 2011 (others) for GDP per person.
2) Road Development Strategy

Roads and bridges sector in Myanmar could have large development potential. And, Myanmar drastically goes ahead with democracy process and peace process in 2011. It changes the mission of road development, which emphasizes not only "development of every region " but also "contribution to friendship and consolidation of all people of Myanmar".

Based on the mission, basic road strategy is to strengthen extension and widening of existing roads in south-north direction, new road development in east-west direction, effective linkage of inland waterway with road transport. In addition, network with neighboring countries is emphasized to promote economic development in particular foreign trade and tourism. In this regard, development regional highways is emphasized along the international cooperation framework such as ASEAN, GMS, BIMSTEC and ACMECS .

Meanwhile, Ministry of Construction prepared 30-year plan and five-year plan to develop road sector, which were introduced in 2001. Those plans are a basis to decide priority among road and bridge development projects as well as annual budget. The 30-year plan, consisting 6 phases, indicates budget of five-year duration, and is revised $3^{\text {rd }}$ to $6^{\text {th }}$ five-year plan after completion year of the year 2010, which applies from the year 2011. The new mission mentioned above is applied to this $3^{\text {rd }}$ five-year plan as a basic principle of the strategy.

Five-year plan from $3^{\text {rd }}$ onward have the following two priority developments:

- Development of access highways to ASEAN countries with international standard
- Development of Union Highways to connect among states and regions

Development of access highways to ASEAN countries aims at improving accessibility of major cities in neighboring countries with Myanmar to promote cross border trade in response to tariff liberalization under AFTA in 2015, which consists of the following five important projects:

- Asian Highway (AH1, AH2)
- Greater Mekong Sub-region (GMS) economic corridors
- BIMSTIC Highways
- India-Myanmar-Thailand Tripartite Highway
- India-Myanmar Highway

In particular, the road section between Myawady and Kawkareik which is a part of GMS Economic Corridor as well as a part of Asian Highway of AH1, and the road section between Monywa and Kalay/Kalewa which is a part of Asian Highway of AH1 as well as a part of India-Myanmar-Thailand Tripartite Highway are paid special attention as highest priority projects.
3) Bridge Development Strategy

PW emphasizes strengthening of construction of new bridges and maintenance of existing bridges as a basic strategy. For the construction of new bridges, following six projects are taken into account:

- Ayeyarwady Bridge (Ayeyarwady Region)
- Yangon River Tunnel (Yangon Region)
- Hlaing River Bridge (Yangon Region)
- Bayinaung Bridge (Yangon Region)
- New Boat Twin Bridge (Shan State)
- Wataya Bridge (Yangon Region)

Bridges in Myanmar have been developed based on the technologies obtained through Japanese assistance and Chinese projects. Myanmar's government has accelerated to develop bridges with allocating adequate budget since 1988. Accordingly aged bridges built more than 20 years ago increase in number. It results in increasing number of bridges requiring maintenance. It is a reason of recent importance of bridge maintenance. In this regard, maintenance of those aged bridges is the most urgent issue in the short term, and organization, maintenance and repair technology, and monitoring technology will be significant important in the medium/long term.

Table 3.15 Bridges to be urgently maintained

| Bridge | Place | Bridge Type | Year of Problem Occurred | Problem Places | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Maubin | Ayeyarwady Region | Steel Truss | 2000 | Bearing, joint,abutments-of-a-bri <br> dge wall | Pressure from the bridge pier via approach-span |
| Balaminhtin | Kachin State | Steel Truss | Before 2009 | Tilting of the truss by the corrosion of substructure | No problem on corrosion. but the position of a truss is not correctable |
| 13 bridges currently corroded at the place near the sea of a Rakhine state | Rakhaine <br> State | - | Before 2005 | Degradation of concrete | Due to the use of salt contained concrete. <br> Currently under repair |
| Twantay/Pathein | Yangon / <br> Ayeyarwady <br> Region | Steel cable-stayed | Before 2009 | Degradation of bridge plate of main span and joint approach-span | Unknown cause |
| Myanugmya | Ayeyarwady Region | Bailey Suspension | 1996 | Tilting of main span tower, cable corrosion | Over 2 years ago, the problem started at the time of construction |
| Gaing | Mon State | Zartha/ <br> Attarayan | 2000 | Breakage of the steel bridge board by fault loading of a track | Near the border with Thailand |

Remark: Maei, Kyaukkyipauk, Sanepauk, Lonetawpauk, Dadokepauk, Thamnthamagyi, Thanthamachay, Thazintanpauk, Wunphite, Minkyaung, Yamanung, Kisspanaddy, Minhaung
Source:PW

JICA
4) Conclusion

As mentioned above, potential needs of road development is high and the Ministry of Construction as well as PW prepares 30-year plan and five-year plan to steadily develop roads with a planned manner. So, there is a high possibility to continue road and bridge projects in the future too. It this sense, it is necessary to keep and improve planning, designing and constructing technologies on roads and bridges. From the different point of view, it means continuous increase of stock of road and bridge infrastructure. In accordance with the increase of the stock, asset management will be more important in future. In this regard, it is reasonable that the 30-year plan of PW points out the importance of bridge maintenance.

## (2) Needs of roads and bridge from human security point of view

There is variety of weather pattern in Myanmar and a period from November to April is considered as dry season and the period from May to October is rainy season. Table 3.16 shows monthly average rainfall and average temperature in Yangon and Mandalay. Yangon and Mandalay has yearly total rainfall of $2,877 \mathrm{~mm}$ and 896 mm , respectively. Among them, rainfall from May to October occupies $96.5 \%$ and $90.2 \%$ of the yearly total rainfall.

Table 3.16 Temperature and Rainfall of Yangon and Mandalay

|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Yangon |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Average <br> Temperature | 24.8 | 26.6 | 28.7 | 30.4 | 27.9 | 26.5 | 26.0 | 26.1 | 26.4 | 27.4 | 26.9 | 24.9 |  |
| Average <br> Precipitation | 1 | 2 | 12 | 43 | 442 | 562 | 612 | 520 | 467 | 173 | 31 | 12 | 2,877 |
| Mandalay |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Average <br> Temperature | 21.9 | 24.5 | 28.7 | 32.0 | 30.7 | 30.8 | 30.8 | 30.4 | 29.8 | 28.9 | 27.5 | 22.4 |  |
| Average <br> Precipitation | 2 | 2 | 6 | 42 | 190 |  | 79 | 136 | 183 | 116 | 31 | 5 | 896 |

Source: Statistical Year Book 2010,Central Statistical Organization,2012

Such concentration of precipitation and rise of temperature in certain period affects largely on Myanmar society. For example, Myanmar suffers from cyclone and flood in the rainy season, while decrease of electric generation due to lower water level in water reservoirs and increase of electric demand due to cooling in the dry season (Some cities fails to have electric breakage of 6 hours a day in the dry season). In particular, transport gets large damages in the rainy
season. Accessibilities between Yangon and a remote area become worse in the rainy season due to inadequate pavement of roads and inadequate bridges. Cyclone and flood cause heavy damages in this situation in particular at Rakhine State and Ayeyarwady Region. It makes damages more serious in those areas.

Table 3.17 Number of Disasters

|  |  | $2005-2006$ | $2006-2007$ | $2007-2008$ | $2008-2009$ | $2009-2010$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Flood | Number of Cases | 9 | 25 | 12 | 7 | 7 |
|  | Amount of Damage | 0.65 | 5.59 | - | 9.00 | 2.49 |
|  | Amount of Relief | 6.05 | 37.47 | 8.15 | 3.67 | 37.13 |
| Cyclone | Number of Cases | 12 | 26 | 35 | 27 | 20 |
|  | Amount of Damage | 44.02 | 198.90 | 40.80 | 218.41 | 26.10 |
|  | Amount of Relief | 1.08 | 26.12 | 21.22 | 568.18 | 6.27 |

Remark: Unit of amount of damage and relief are one million kyat.
Source: Statistical Year Book 2010, Central Statistical Organization, 2012

Road and bridge development is accordingly important for the Rakhine State and Ayeyarwady Region to ensure year-through use of roads from a human security point of view.

## (3) Needs of roads and bridge from poverty reduction point of view

GDP per capita of Myanmar is approximately 820 USD in 2011. This is lower than Laos and Cambodia (Laos has 1,060 USD of GDP per capita in 2011 and Cambodia has 1,170 USD of it in 2011). Even though there is not adequate information on basic human needs of Myanmar, BHN in rural areas seems to be in insufficient level and there seems to be much people below poverty line in Myanmar. It may be more important for the Myanmar's government to support people in rural area to reduce poverty as well as improve level of BHN. It must be important for the Myanmar Government to improve BHN and poverty reduction in the areas of the minority groups in order to accelerate peace process and reconciliation. In this aspect, the demand for road and bridge development in the rural area is considered to be large.

### 3.4.2 Needs from the survey on the software side of bridge sector

In this paragraph, based on survey results on current status of bridge construction management by PW, problems and proposed countermeasures are identified as future needs in the following aspects;

- Organization
- Procedure of bridge project
- Contract (with foreign companies)
- Design control
- Construction supervision
- Maintenance


## (1) Needs to facilitate the utilization of private companies

It is understood that the technology and know-how of bridge design and construction have been concentrated into PW, and PW has its own resources/organization to implement the bridge project from planning/design stage to construction stage by itself.

Such system is recognized as an important and advantageous factor to complete many big projects even in a very tight schedule.

However, taking into consideration of further rapid increase of road and bridge construction demand in the near future, those may not be afforded only by current PW's capacity.

Furthermore, in the present situation that PW is solely and directly implementing the whole stages of project, process of cost estimation/allocation and technical evaluation in each project stage (i.e. planning, design, construction and maintenance stage) seems to be unclear to third party, and it may cause the difficulty for the private companies including foreign companies to participate in future bridge projects in Myanmar.

Toward the further globalization in Myanmar, in order to establish the fair competition environment / system in the bridge projects, the followings are recommended;

1) To separate the "administrative agency" and "executing agency (for design and construction)" with clear duty and responsibility.
2) To make clear the standard/guideline of procurement in each project stage (i.e. standard/guideline for cost estimation and/or technical evaluation).
3) To develop a capacity of private bridge construction companies and facilitate the utilization of those private companies in the bridge projects.

## (2) Needs for establishment of appropriate procedure/schedule in a project and demarcation between administrative agency and executing agency

As shown in Figure 3.4, period from the planning stage to construction stage is very short.
For the projects applying international tender, there are some cases that the construction of substructure is commenced without waiting the completion of superstructure design.

In such case, there is a possiblity that the design reaction forces of superstructure exceed the estimated one for substructure design, and subsequently the design change and modification works of substructure are required with the extension of time and additional cost.

As long as PW acts as the monopolistic agency to implement the whole stages of project, it may be difficult to identify and disclose the cause and responsibility of such defects.

In order to secure the quality, safety and accountability of projects, the followings are recommended;

1) As a target in short term, to establish the proper procedure for design, evaluation and approval and set up the appropriate schedule for above procedure,
2) As a target in long term, to separate the "administrative agency" and "executing agency (for design and construction)" with clear duty and responsibility to facilitate to utilize the private companies as a "executing agency" and to establish a system for those agencies to check each other.
(3) Needs for establishment of appropriate contract system to cope with future participation of foreign companies

As described in Paragraph 3.2.2 (3), PW has been implementing the bridge design and construction by itself, and then private companies have had a little opportunity to experience and develop their capacity of bridge design and construction.

In such a circumstance, when foreign consultants and contractors are going to participate in the bridge project in conjunction with a resumption of aid/investment by the foreign counties toward Myanmar, there is a difficulty to find an experienced private subcontractor, because only PW which belongs to the client organization is implementing a project at present. Thus, a possible contractual structure for foreign companies to participate in a bridge project shall be as below;

1) Foreign company acts as construction manager (Construction Management Contract) and assists design and construction divisions of PW shown below;

2) Foreign company acts as a main consultant or a main contractor and utilizes a private subcontractor whose experience is inevitably less than that of PW (main contract and subcontract shall require an OJT for such subcontractors as a condition of contract);


When foreign countries resume their aid in Myanmar, many international companies will participate in the projects and the scope of works may become more various and wider compared with a current contracts with Chinese company.

Subsequently, an increase of claim or dispute which will occur due to participation of experienced international companies is anticipated.

Thus, in order to mitigate such claim or dispute, more detailed conditions of contract and/or technical specification need to be established.

## (4) Needs for establishment of appropriate design control system

From the findings described in Paragraph 3.2.2 (4), the followings are recommendable:

- To apply the consistent standard for superstructure design and substructure design.
- In order to identify the cause of problems / defects found in the operation stage and apply an appropriate countermeasure, it is necessary to secure the submission of design calculation sheet by foreign company and capacity development for design checking and evaluation in Myanmar side.
- To establish a proper procedure for design, evaluation and approval and allocate an appropriate schedule for the above procedure.
- In order to secure a quality, safety and accountability of bridge design, it is necessary to consider an introduction of design checking system by a third party.


## (5) Needs for establishment of appropriate construction control system

From a point of view of construction control and quality control, the following improvements are recommended;

1) Especially for the Ayeyarwady River crossing bridges, those have been put the highest priority and obliged to complete under very tight schedule following the national policy. However, in order to secure the quality and safety of bridge structure and the safety for site staff and workers as well, an appropriate construction schedule should be planned.
2) In order to identify any causes of defect in the construction process, it is recommended to prepare a construction plan and quality control plan which describe and make the followings clear, but not limited to;

- Applied construction method/procedure
- Key person in charge
- Necessary equipment and manpower
- Schedule of inspection and testing, etc.

3) It is observed that concrete was casted under high-temperature in daytime without any control. It is recommended to secure the control measure for hot-weather concreting.
4) In order to prevent salt damage and/or alkali aggregate reaction, it is recommended to conduct a test for chemical composition of aggregate and water quality.
(6) Needs for establishment of appropriate maintenance system

Bridge inspection results have not been managed systematically and there is no database for inspection results in PW.

It order to determine the priority of bridge systematically and establish a standard repairing method for each damage type and grade, it is recommended to establish the database for the regular inspection results which may include, but not limited to,

- Location of damage
- Type of damage
- Grade of damage
- Possible cause of damage
- Recommended repairing method, etc.


Figure 3.11 Bridge inspection report (example of cable suspension bridge)

### 3.4.3 Needs from the survey on the hardware side of bridge sector

It has been about 20 years since fully-fledged bridge construction started in Myanmar. As described earlier in this report, the existing damage events must not be left unaddressed because the progress of damage may be accelerated. For PW and other bridge administrators, cooperation between the bridge design section and the maintenance section is extremely important. In the field of maintenance, bridge administrators need to have a keen awareness of inspection and to strengthen their efforts in bridge maintenance. Given the damage conditions of the bridges the Study Team saw in the survey, these efforts need to be accelerated.

The challenge here is whether the bridge administrators can carry out proper maintenance work to deal with the damage events on the bridges in Myanmar. There is a major gap between Japan and Myanmar in technical levels of inspection/repair/reinforcement, and it is an imminent challenge for Myanmar's bridge administrators to reach a standard level.

Concretely, the following items are to be considered;

## (1) Technical guidance on maintenance through OJT

When performing an inspection, it is efficient and important to focus on the locations developing specific damage events. As this requires advanced techniques, it is effective in an initial stage to have a Japanese inspection team provide OJT to the PW employees. Repair/reinforcement design, which will be needed in the subsequent stages, is one of the most difficult areas in bridge engineering and therefore should be performed by experienced engineers with good understanding about bridge design and high maintenance skills. As Japan is one of the most advanced countries in the field of repair, the latest technical information can be provided.

And it is necessary to prepare textbooks on inspection, repair and quality control and provide inspection equipment and training courses for engineers.

## (2) Technical guidance on bridge structures

In Myanmar, where bridges are built one after another over wide and long rivers, there is a demand mainly for truss bridges, cable-stayed bridges and suspension bridges. Considering the recent reports on the problems on suspension bridges and the damage events on other types of bridges, it is necessary to improve the technical levels of the PW employees in designing. When providing technical guidance in this area, it is important to include not only those who are in charge of design but also employees who were involved in the construction work of long-span bridges, so that they can share common awareness.

PW's engineers are thought to have technical ability to design the foundation as well. However, there is a need for an additional series of technical guidance on the foundation as the Study Team have seen some bridges with damage on the bridge body due to scour and lateral flow affecting the foundation.

## (3) Support in preparing the standard technical specifications

One of the fundamental causes of these various damage events was inadequate contents of technical specifications (e.g. design standards, material specifications, quality control) signed between the client and contractors upon construction. Myanmar needs to promptly formulate the standard technical specifications to be used as the basis of technical specifications of individual bridges, and Japan could provide technical support for Myanmar in formulating its standard technical specifications.

Various standard specifications used in Japan could be applied for use in Myanmar, but it is more important to promptly prepare the standard technical specifications matching the conditions in Myanmar reflecting the procurement situation of local materials/equipment.

## (4) Support in building a stronger system for the maintenance section

PW carries out maintenance work in different regions, but at present they do not have much information about design and contents of construction. There is a need to provide them with BMS (Bridge Management System) including database management as it is actually operated by the Japanese road administrators. Sharing the information on construction/administration and centralizing (sharing) the information on maintenance work carried out in different regions is a shortcut to successful bridge maintenance. In order for Myanmar to sustain its road and bridge infrastructure, it is necessary to implement such sharing of information not only on bridges managed by PW but also on other bridges within the country. They need support in building a stronger system.

Ministry of Land, Infrastructure and Transport and Tourism of Japan and the Japanese road administrators, such as expressway companies, have abundant experience and techniques in bridge construction and management, and therefore they are expected to be capable of effectively providing technical support on bridge maintenance. Such support, when provided on a long-term basis rather than short-term basis, will help PW accumulate maintenance information and will eventually enable them to operate BMS in a sustainable manner.

### 3.5 POSSIBILITY OF JAPANESE FUTURE COOPERATION IN BRIDGE SECTOR IN MYANMAR

Problems and possibility of Japanese future cooperation in bridge sector in Myanmar are shown below from the perspective of three viewpoints of "people (technology)", "things" and "institution/organization" based on site survey result and local needs on bridge development and maintenance.

## (1) Problem and Possibility of Cooperation on "People (Technology)"

## Current Problems

- Technologies seem to be rigid and deteriorate after the BETC Project.
- Education level of university has decreased substantially during the former administration. Quality and quantity of teacher and equipment are also inadequate.
- Construction of PC long-span bridge with materials obtained in Myanmar has not been executed after the BETC Project.
- Because of inadequate research development system, it is impossible to develop new technology and identify problems.
- Insufficient facility and system of laboratory for design and construction, insufficient human resources
- There has so far been no unified format for design standard.
- Feedback into design of defective bridge is difficult.
- Technologies on bridge planning (setting of bridge location, river area, planned riverbed, etc.) are lacking (insufficient area of revetment block, scoring at bridge abutment due to embedment of foundation, severe settlement and crack of road surface due to incline of abutment).
- Safety control for high-speed running is insufficient (inadequate length of acceleration and deceleration lane, lack of traffic sign, transition curve, lack of a control system to prevent trucks from veering out of their lanes, lack of construction control, etc.)
- Technology of construction supervision is lacking (differential settlement at embankment due to inadequate rolling compaction, inadequate compaction of concrete, etc.).
- Technology for design and checking of steel structure is lacking.
- Technology for maintenance of steel structure is lacking. And recognition is poor not only on steel structure but also maintenance of foundation facility.
- Because of no accumulation of inspection results, sharing information on damage condition, progress degree and repairing method is difficult.


## Possibility of Cooperation for Problem-solving

$>$ Technical cooperation project on method of Inspection, investigation and repair for bridge maintenance (as BETC Project Phase-2)
$>$ Technical transfer to engineers of local government and private company
$>$ Re-training on bridge technology (concrete block method for making concrete bridge common, technical assistance on bridge planning, consideration of maintenance from plan/design stage, design of each bridge type, construction method, seismic design, consideration of landscape and safety control, etc.)
$>$ Technical guidance on design of steel structure
> Support for making design standard
> Support for both technology and policy making
> Improvement of road experimental laboratory (provision of machinery and equipment and human resources development, foundation of a research institution which can develop and introduce new technology by cooperating with domestic universities)

## (2) Problem and Possibility of Cooperation on "Things"

## Current Problems

- Main tower of suspension bridge inclines. High tension bolts of steel bridge are missing. Foundation structures are moving. Salt damage of concrete bridges occurs.
- Conditions of steel slab of suspension bridge and wrapping of cable are in bad condition and tolerance for future-increased load is insufficient.
- Quality control for paint is insufficient. (corrosion of steel bridge, heavily-damaged main cable of suspension bridge)
- Bearing plates and fixing nuts of steel of PC slab corrode.
- Water leakage from end of girder is seen.
- Bridge abutments incline by scouring.
- Concrete main girders show numerous rock pockets, and some are insufficiently compacted.
- Bridge superstructures move on soft soil (lateral flow of soil because of back side earth pressure)
- Construction method of concrete slab is unsuitable.
- Inspection equipment and measurement equipment for bridge maintenance are lacking.


## Possibility of Cooperation for Problem-solving

$>$ Support for making technical specifications (design standard, material specification, quality control, etc.
> Making a uniform manual for paint and corrosion control
> Making a basic technical standard for concrete
$>$ Training on quality control
$>$ Making technical standard for substructures on soft soil, Training on design and construction method of foundation
$>$ Training on soft soil treatment measures by a technical cooperation project, provision of machinery and equipment for soft soil improvement
> Provision of inspection/measurement equipment for bridge maintenance

## (3) Problem and Possibility of Cooperation on "Institution/Organization"

## Current Problems

- Construction period is very short
- Technical specifications (design standard, material specification, quality control, etc.) exchanged between contractor and contractee at construction stage are inadequate.
- Responsibility sharing, estimates and allocation of budget are unclear against third perty at each stage from survey/design to construction because of a structure which concludes only in organization of contractee
- Design and construction procedure is at high risk. (possibility of change of assumed design reaction force, because of starting of substructure construction before completion of superstructure fabrication)
- Increases of claim and dispute are expected due to future participation of foreign companies and diversification of contract detail (PW's uniform management from project planning to construction at present).
- Participation of private companies in bridge sector is behind.
- Communication between design section and maintenance section is lacking.
- Ensuring huge amount of construction funds is difficult although needs for construction of bridge and tunnel with newest technology are high.


## Possibility of Cooperation for Problem-solving

$>$ Training to high-level government official (by holding seminar/workshop, etc.)
> Support for PW's privatization
> Construction of road, bridge and tunnel by using Yen loan
> Strengthening system of maintenance section
> Support for making construction plan and quality control plan (explorations/inspection items, control standard, frequency, etc.)
> Technical transfer of concrete block method for shortening the construction period

As stated above, there are many possibilities of Japanese future cooperation in order to solve problems in bridge sector in Myanmar. In this Study, the Study Team picks a "Technical Cooperation Project for bridge maintenance in Myanmar" as a case study from the crowd of other cooperation. A project plan and ways of application of lessons from the BETC Project are described in Paragraph 4.3.

## 4．SUGGESTION TO FUTURE TECHNICAL COOPERATION PROJECTS

In this Chapter，the Study Team studies how to apply lessons learned from the BETC Project to future technical cooperation projects which will be done in both Myanmar and other countries．

## 4．1 SUGGESTION TO GENERAL TECHNICAL COOPERATION PROJECTS

Ways of application of lessons from the BETC Project to future technical cooperation project in Myanmar and other countries are described below；

## 【Lesson drawn from the project plan】

（1）Great results can result from the timely transfer of the necessary technology appropriate to a nation＇s stage of development．
$\checkmark$ Overall cooperation of the recipient country is essential for success of the project．
$\checkmark$ When technology for which Japan has a relatively dominant position and which complements the recipient country＇s stage of development is provided at the right time，it is sure to be an influential factor for assuring the project＇s success．
（2）It is essential to advance sufficient examination of the project sustainability from a long－term viewpoint．
$\checkmark$ Since it takes significant time to transfer a whole new technology to a recipient country， providing support in just one single act of assistance is not enough．It is very important to allow for a phased transfer scheme at the beginning of project planning．
$\checkmark$ It is important to set up a mechanism for handing transferred technologies down to the next generation．It is also important，therefore，to select the base for executing the project by considering how easy it is to pass on technical knowledge and how likely this will occur．

## 【Lessons drawn from the implementation method】

（3）A combination of classroom training（In－Center Training）and field training（OJT）is an effective way to transfer a whole new technology to the recipient country．
$\checkmark$ Practicing theory learned in In－Center Training in actual OJT helps trainees to enrich the degree of acquirement．It is necessary to determine how much field exercise is conducted in the classroom and the field training framework needs to be determined by analyzing how much the recipient country understands the technology being transferred．When transferring a whole new technology，it is required to teach from fundamental knowledge in accordance with the level of trainees．Therefore，it is important to make project plan and set a suitable project
period in consideration of the level of trainees.
$\checkmark$ Although it is said that neither technology nor design capability will not be mastered through a passive lecture, the BETC Project made an arrangement to improve their ownership and learning motivation. This is also considered one of the pivotal factors that facilitated the fulfillment of the Project purpose.
$\checkmark$ It is effective to combine multiple and suitable aid schemes, for example, combination of technical cooperation project with provision of machinery and equipment by grant aid assistance.
(4) Reinforcing the domestic support system
$\checkmark$ When transferring a whole new technology, it is impossible to grasp all changes which will occur during project implementation at the planning stage. In order to make measures suited to the occasion according to needs from the site, it is important to keep close cooperation between persons at the actual site and persons in Japan with receiving a backup from Japan, such as a working group which conducts prompt support on "people", "things" and "money".
$\checkmark$ For a technical cooperation project using JICA's direct-managed expert dispatch approach, that is, an approach in which experts from various organizations take part in a single project has no organization responsible for the project management, in contrast to a technical cooperation project based on an operation agreement, setting up a supporting organization at JICA and the senders is recommended for the former case as a general principle.

## (5) Phased refilling of counterparts

$\checkmark$ Since it is difficult to select people who appear highly qualified and are so by the objective judgment as counterparts in the planning stage, it is important to replenish human resources on a phased basis throughout the project.
$\checkmark$ It is necessary for experts to enhance the counterparts' independence by giving a part of lecture to the counterparts, and taking a role to support them.
(6) Diversification of training contents to match the abilities and needs of the recipients
$\checkmark$ In order to get successful completion in the limited period, a partial participation of Japanese experts in construction work based on the judgment of the local engineers' technical competence is necessary.
$\checkmark$ Nowadays, it is difficult to force trainees to have a long-term training as it used to be. Therefore, devising curriculum, such as introduction of credit system and buildup of short-term courses, is needed.
$\checkmark$ It is preferable not only to enhance ability of engineers but also to try to make high-level government officials understand importance of the project in order to reflect it in the government policy and regulations.

## 【Lessons drawn from the aftermath of the Project】

## (7) Follow-up after completing the Project

$\checkmark$ For the purpose of enhancing sustainability of the project, it is necessary to continue to support trainees even after completion of the project.
$\checkmark \quad$ In order to ensure the "timely transfer of the necessary technology appropriate to a nation's stage of development", as explained in Lesson (1), it is important to continuously monitor the growth of recipient country's technology.

### 4.2 SUGGESTION TO THE PROJECT FOR IMPROVEMENT OF ROAD TECHNOLOGY IN DISASTER AFFECTED AREA

Ways of application of the lessons to "The Project for Improvement of Road Technology in Disaster Affected Area", which is now under preparation, are shown in this paragraph. For writing this paragraph, final report of "The Project for Improvement of Road Technology in Disaster Affected Area (2012)" was refered.

## 【Lesson drawn from the project plan】

(1) Great results can result from the timely transfer of the necessary technology appropriate to a nation's stage of development.
$\checkmark$ Enhancement of technology for road development and maintenance in the Irrawaddy delta in which cyclone damages occurs frequently is emphasized in the Project. Introduction of stabilization method in the delta area and improvement of technology for embankment on the soft ground with thick alluvial formation are requested from Myanmar side. Big-size crashed stones which size is in the 10 to 20 cm are used in the road development projects in the Irrawaddy delta at present. The aggregates are brought from a place 100 km northwest from the Irrawaddt area by 3 days' shipping. Introduction of new measures instead of existing ones is required now, because road development in this area will be accelerated from now. Regarding soft soil treatment, it has not a direct relationship with a natural disaster but settlement of embankment at existing roads and location behind bridge abutment has been serious problem already. Therefore, repair and improvement of the existing roads are necessary as well as road development. Priority is high for improvement of both stabilization method and soft soil treatment method and Japanese technology on these can fully respond to request from Myanmar. However, there are many alternatives for stabilization of subbase and subgrade and soft soil treatment measure, therefore it is necessary to transfer suitable technologies considering needs from Myanmar and substantivity of the measure in Myanmar.
(2) It is essential to advance sufficient examination of the project sustainability from a long-term viewpoint.
$\checkmark \quad$ In a cyclone-prone region, it is necessary for the recipient country to ensure human resources and budget by own fund continuously due to possibility of damages of road infrastructure in the future because of recurring natural disaster. So it is necessary to confirm whether the recipient country has a plan to continue the project by own fund at the stage of project planning from the aspect of human resources and budget. And studying how Japan can get engaged to the extent possible considering the plan leads to enhance more certainty of the technical transfer.
$\checkmark$ Settlement of embankment at the location of behind abutment is common problem not only in the Irrawaddy delta but also in everywhere in Myanmar. It is important to study at the project planning stage how to make a system to enhance spillover effects through transferring technology from persons who are trained in the Project to their co-workers and their juniors.

## 【Lessons drawn from the implementation method】

(3) A combination of classroom training (In-Center Training) and field training (OJT) is an effective way to transfer a whole new technology to the recipient country.
$\checkmark$ It is preferable to switch from ex-post control method like existing repair method for road pavement to preventive maintenance method from the view point of transfering new technology for Myanmar on maintenance method of pavement. It is necessary to grasp current status of pavement in case of applying several measures of maintenance and repair including a preventive maintenance against functional decline of pavement surface, such as rutting or cracking, and to build management system to support to make a prediction of future road surface condition or make an annual plan of pavement maintenance and repair work. To do that, combining In-Center Training with OJT is effective. And it is necessary to teach trainees the ABCs of pavement in the In-Center Training in order to learn above mentioned pavement technologies.
$\checkmark$ By combining technical cooperation project with provision of machinery and equipment by grant aid assistance suitably, it is effective not only to provide machineries for stabilization, soft soil treatment and maintenance of pavement such as stabilizer but also to dispatch Japanese experts who can teach how to operate construction machineries in order to train local skilled workers. Especially in the Irrawaddy delta in which pilot projects will be conducted in this Project but machineries and equipments are lacking at present, it is necessary to provide suitable machineries and equipments considering future maintenance by Myanmar after the provision.

## (4) Reinforcing the domestic support system

$\checkmark$ Although foreign aid has been resumed in Myanmar in recent years, it is still hard for foreigner to work at the site. Especially in the Irrawaddy delta region in which pilot projects are planned, it is hard for experts to spend everyday business and life because the area is located in a remote area. It is important to keep close cooperation between persons at the actual site and persons in Japan with receiving a backup from Japan, such as a working group which conducts prompt support on "people", "things" and "money". Therefore, setting up a supporting organization at JICA and the senders is recommended.

## (5) Phased refilling of counterparts

$\checkmark$ Implementing agency of the Project in Myanmar will be PW, therefore, it is expected that PW staff will be arranged as counterparts of JICA enperts. PW staff is very busy now due to many construction sites all over the country with limited number of engineer. Therefore, it will be meaningful to recruit the counterpart in a step-by-step manner during the Project valuing level and motivation of trainees, because it may be difficult to ensure excellent counterparts at the beginning of the Project.
(6) Diversification of training contents to match the abilities and needs of the recipients
$\checkmark$ It is important to make high-level government officials understand necessity of maintenance in order to ensure enough amount of budget for road maintenance. Therefore, it is necessary to
reflect importance of maintenance into the government policy and regulations by conducting training to them. However, it is preferable to hold a short-term seminar or workshop because they are busy and it seems to be difficult for them to be out of office for a long time.
$\checkmark \quad$ It is necessary to make Myanmar's own technical standards and manuals on road design and maintenance as soon as possible and needs from Myanmar requesting Japanese technical cooperation are high. However, it is necessary to make technical standars and manuals which are tailored to Myanmar's condition depending on condition of procurement. Therefore, it is important to make a system in which PW staff can get involved actively.
$\checkmark \quad$ It is essential to improve level of soil testing which is important for study of measures in order to improve technology of soft soil treatment. Therefore, it is important to provide machinery and equipment which are necessary for soil investigation and soil testing and also give training to staff of soil laboratory on implementation methods of boring and methods of analysis of test result.

## 【Lessons drawn from the aftermath of the Project】

## (7) Follow-up after completing the Project

$\checkmark \quad$ It is important to make a system in which the trainees can be given technical advice from the experts with close communication even after the Project in order to enhance substantivity of the technical transfer.

### 4.3 CASE STUDY "SUGGESTION TO TECHNICAL COOPERATION PROJECT FOR BRIDGE MAINTENANCE"

The Study Team shows a project plan and ways of application of lessons from the BETC Project in case of assuming execution of technical cooperation project for bridge maintenance in Myanmar, considering needs and issues on bridge sector mentioned in Chapter 3.

### 4.3.1 Project Plan

(1) Project Objective

To conduct capacity development for implementing agencies of bridge maintenance in Myanmar for the purpose of improving bridge maintenance condition in Myanmar
(2) Project Site

Long-span bridges in Yangon Region and Irrawaddy delta area
(3) Beneficiary

Bridge engineers of PW and private company
(4) Project Schedule (Cooperation Period)

Three years
(5) Total Project Cost (Japan side)

XX million yen
(6) Overall Goal

Increase of service life of existing bridges and improvement of safety of bridges in Myanmar (index ex:maintenance, cutting repair cost, lifetime)
(7) Project Purpose

Capacity development on bridge maintenance in Myanmar
(8) Outputs

Output-1: Establishment of PW's action policy on bridge maintenance
Output-2: Establishment of operation system on bridge maintenance
Outout-3: Enhancement of knowledge and technology on bridge maintenance
(9) Activities

Activities for output-1: Establishment of PW's action policy on bridge maintenance (including personnel policy, such as increasing number of engineer by training technician and enhancing operation system for maintenance)

Activity-1: Problem analysis by PW on bridge maintenance technology by type of bridge and area

Activity-2: Clarification of issues by PW on inspection method, inspection table, data collected from inspection table and technical standard and manual

Activity-3: Making PW's medium- to long-term activity plan on bridge maintenance
Activity-4: Holding a seminar to high-level government officials of Ministry of Construction and PW, sharing outputs and enhancing understanding of high-level government officials

Activities for output-2: Establishment of operation system on bridge maintenance
Activity-1: Study on existing condition of organization and improvement
Activity-2: Problem analysis by PW on issues for bridge maintenance by analyzing inspection method, inspection table, data collected from inspection table and technical standard and manual

Activity-3: Updating existing documents on bridge maintenance, such as guideline, manual and inspection table, based on result of Activity-2

Activity-4: Computerization for introducing Bridge Management System (BMS)
Activity-5: Making manual and guideline of BMS
Activity-6: Holding a seminar on introduction of BMS
Activity-7: Rationalization of design by considering maintenance at the plan and design stage
Activities for output-3: Enhancement of knowledge and technology on bridge maintenance
Activity-1: Formulating enhancement program for bridge maintenance
Activity-2: Holding a seminar on bridge maintenance to engineers and technicians of PW staff and private company

Activity-3: Conducting pilot project as an On-the-Job Training (several projects at several places with different condition)

Activity-4: Holding a training and seminar on inspection for bridge maintenance to PW's engineers in the states where pilot project is conducted by using guideline and manual that are made in Output-2

Activity-5: Accumulating know-how on technical support of Activity-1 to 4 and holding a feedback seminar which can enable to provide information for road management staff including rural areas
(10) Inputs

1) Japan side

- Dispatch of experts: Chief adviser / Bridge development policy and technology, Bridge technical standards, Bridge planning and evaluation, Survey and design, Construction technology, Quality control, Bridge management system, Geological survey, etc.
- Seminar in Japan and third countries (Vietnam, Thailand, etc.)
- Provision of machinery and equipment for project activities
- Cost for activity in Myanmar

2) Myanmar side

- Project Office
- Cost burden for the pilot project
- Operating expenses
(11) External conditions

1) External condition from activities to expression of outputs

- Ensuring suitable amount of project budget and administrative support from Myanmar's government
- No frequent transfer of project beneficiaries

2) External conditions for accomplishment of outputs to project purpose

- Application of maintenance system across the country

3) External conditions for accomplishment of project purpose to overall goals

- Ensuring necessary budget and human resources due to continuous support by high-level government official for bridge maintenance


### 4.3.2 Application of lessons from the BETC Project

(1) Great results can result from the timely transfer of the necessary technology appropriate to a nation's stage of development.
$\checkmark$ Japan is one of the most advanced country in the field of bridge inspection and repair technology in the world. When technology for which Japan has a relatively dominant position and which complements the recipient country's stage of development is provided at the right time, it is sure to be an influential factor for assuring the project's success. To do so, first of all, it is necessary to analyze issues on bridge maintenance technology in Myanmar by bridge type and by districts and study the timing of technical transfer.
$\checkmark$ Many steel bridges which require less construction period have been built after the BETC Project. Nowadays, problems such as corrosion of steel member become obvious on these bridges. Steel bridge needs more maintenance cost than concrete bridge such as repainting, therefore, it is necessary to consider life cycle cost at the planning and design stage and to study alternatives such as consrete bridge or steel bridge with atmospheric corrosion resisting steel. And adoption of concrete block method is also effective for minimizing construction period.
(2) It is essential to advance sufficient examination of the project sustainability from a long-term viewpoint.
$\checkmark$ It is important to enhance the structure of a maintenance section by establishing Bridge Management System (BMS) including database management and sharing information on bridge construction and maintenance. Because it takes long time to establish it, it is important to conduct technical transfer gradually in the long-term view. Regarding BMS, it is necessary to teach a procedure to input existing cheking results and also to make trainees realized importance of accumulation of data.
$\checkmark$ A better idea will be to set up a training base at a place where full-time lecturers are available, such as Yangon Technological University, plan a project scheme that involves university professors, and integrate the skills and knowledge transferred by In-Center Training into the curriculum of the university so as to ensure systematic maintenance and diffusion of transferred skills and knowledge.
(3) A combination of classroom training (In-Center Training) and field training (OJT) is an effective way to transfer a whole new technology to the recipient country.
$\checkmark$ Regarding bridge maintenance, technical transfer on bridge inspection is the most important. For inspection and design for repair, learning advanced knowledge on bridge engineering is necessary. Therefore, it is necessary to enhance level of design technology by combining In-Center Training with OJT in parallel. It is necessary to give lectures on basic knowledge to a trainee whose technological level is low.
$\checkmark$ It is necessary to set up suitable training contents and training period according to trainees' level because bridge maintenance technology is new to Myanmar engineers.

## (4) Reinforcing the domestic support system

$\checkmark$ For a technical cooperation project using JICA's direct-managed expert dispatch approach, that is, an approach in which experts from various organizations take part in a single project has no organization responsible for the project management, in contrast to a technical cooperation project based on an operation agreement, setting up a supporting organization at JICA and the senders is recommended for the former case as a general principle.
(6) Diversification of training contents to match the abilities and needs of the recipients
$\checkmark$ It is necessary to make Myanmar's original design standards and guidlines on bridge maintenance and Myanmar's needs for Japanese technical assistance are high. However, they should suit to Myanmar's typical condition regarding procurement condition of local materials and equipments, therefore, it is important to make a system to involve PW staff in the process of making the documents.
$\checkmark$ Damage of bridge is progressing day by day though it has not come to the serious problem yet at present fortunately. If it is left as it is, a major accident may happen in the near future. In order to solve the problem fundamentally, enhancing ability of engineer is not enough. It is necessary to enhance consciousness of high-level government official who decides national policy as soon as possible for the purpose of ensuring enough budgets for maintenance and repair work. Since it is often difficult for high-level government officials to be away from their offices for a long time, holding short seminars or workshops shall be a feasible way.

## APPENDIX

| Sr | Bridge Name | Road Name | State/Division | Name of | Length | Width | Type |  |  | Date of |  | Date of Completion |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Bridge Name | Road Name | State/Division | River / Creek | (ft) | (ft) | Foundation | Substructure | Superstructure | Year | Month | Year | Month |
| 1 | Nga-Wun | PTN-MYA | Ayeyarwady | Ngawun | 1,164 | 38' | R.C bored Pile | R.C | R.C Box Girder | 1986 | 4 | 1991 | 4 |
| 2 | Kyauk-Chaung | PTN-MYA | Ayeyarwady | Kyauk-Chaung | 246 | 31' | R.C. Pile | R.C | P.C | 1986 | 11 | 1990 | 11 |
| 3 | Kyaun-Gon | YGN-PTN | Ayeyarwady | Ngawun | 600 | $24^{\prime}$ | R.C bored Pile | R.C | Steel Truss+RC | 1987 | 1 | 1989 | 3 |
| 4 | Pathwe | YGN-PTN | Ayeyarwady | Pathwe | 420 | $24^{\prime}$ | R.C bored Pile | R.C | Steel Truss+RC | 1987 | 1 | 1989 | 1 |
| 5 | Kyone-Ka-Naung | YGN-PTN | Ayeyarwady | Kyone-Ka-Naung | 240 | $27^{\prime}$ | R.C bored Pile | R.C | Steel Truss+RC | 1989 | 3 | 1989 | 6 |
| 6 | Bawde | YGN-PTN | Ayeyarwady | Bawde Chaung | 180 | $24^{\prime}$ | R.C. Pile | R.C | Steel Truss+RC | 1989 | 4 | 1990 | 3 |
| 7 | Mezale | YGN-NDN | Ayeyarwady | Mezale | 240 | $27^{\prime}$ | R.C. Pile | R.C | Steel Truss+RC | 1989 | 4 | 1990 | 3 |
| 8 | Ka Nyin | PTN-MYA | Ayeyarwady | Kanyin | 328 | 32'-6" | R.C Pile | R.C | P.C | 1990 | 1 | 1992 | 3 |
| 9 | Ma Mya | PTN-MYA | Ayeyarwady | Mamya | 328 | 32'-6" | R.C Pile | R.C | P.C | 1990 | 1 | 1992 | 3 |
| 10 | The'-Phyu | PTN-MYA | Ayeyarwady | The'-Phyu | 246 | 33' | R.C Pile | R.C | P.C | 1990 | 9 | 1992 | 3 |
| 11 | Ein-Me | KGN-MMA | Ayeyarwady | Ein-Me | 276 | 21.45' | R.C Pile | R.C | R.C + Bailey | 1992 | 10 | 1994 | 3 |
| 12 | Tha-Nat-Pin-Yoe | NTC-GWA | Ayeyarwady | Tha-Nat-Pin-Yoe | 180 | 32'-6" | R.C Pile | R.C | R.C | 1993 | 1 | 1994 | 3 |
| 13 | Apin-hnit-se | YGN-PTN | Ayeyarwady | Apin-hnit-sel | 220 | 32'-6" | R.C Pile | R.C | R.C | 1993 | 2 | 1994 | 3 |
| 14 | Ma-U-Bin | SML-MK | Ayeyarwady | Toe | 2,362 | 40' | R.C bored Pile | R.C | Steel Trus + P.C | 1994 | 3 | 1998 | 2 |
| 15 | Myaung-Mya | MMA-EM | Ayeyarwady | Mying-Mya | 1,270 | 34'-7" | R.C bored Pile | R.C | Bailey Suspension | 1994 | 3 | 1996 | 9 |
| 16 | Kat-Hti-Ya | TTY-NUP | Ayeyarwady | Pin-Hlaing | 420 | 12'-4" | R.C | R.C | Bailey | 1994 | 4 | 1997 | 7 |
| 17 | Dae-Da-Lu | KDN-AMR | Ayeyarwady | Dae-Da-Lu | 400 | 12'-4" | Steel Pile | Steel Pipe | Bailey | 1994 | 7 | 1997 | 3 |
| 18 | Nat-Chaung | PPN-BGY | Ayeyarwady | Nga-Pe | 300 | 12'-4" | Steel Pile | Steel Pipe | Bailey | 1994 | 7 | 1997 | 1 |
| 19 | Seik-Ma | KDN-AMR | Ayeyarwady | Seik-Ma | 280 | 12'-4" | R.C Well | Steel Pipe | Bailey | 1994 | 7 | 1997 | 4 |
| 20 | U-Yin-Chaung | KLD-MUP | Ayeyarwady | U-Yin-Chaung | 300 | 12'-4" | R.C Pile | R.C | Bailey | 1995 | - | 1997 | 6 |
| 21 | Bo-Myat-Htun | YGN-PTN | Ayeyarwady | Ayeyarwady | 8,544 | 40' | R.C Precast \& bored Pile | R.C | Steel Truss | 1996 | 6 | 1999 | 11 |
| 22 | Lattputar | MMA-LPT | Ayeyarwady | Pin-Le/lay | 1,300 | 19'-8" | R.C bored Pile | R.C | Bailey Suspension | 1996 | 10 | 1998 | 1 |
| 23 | U-To-Chaung | PTN-CTR | Ayeyarwady | U-To-Chaung | 900 | 12'-4" | R.C Pile | R.C | Bailey | 1997 | 1 | 2000 | 1 |
| 24 | Lin-Lun-Pin | BMTN | Ayeyarwady | Lin-Lun-Pin | 180 | 34' | R.C Pile | R.C | R.C | 1997 | 12 | 1998 | 4 |
| 25 | Auk-Su | BMTN | Ayeyarwady | Auk-Su | 180 | 34' | R.C Pile | R.C | R.C | 1998 | 1 | 1998 | 5 |
| 26 | Be'-Zar-Inn | PTN-MYA | Ayeyarwady | Be'-Zar-Inn | 360 | 34' | R.C Pile | R.C | Bailey | 1998 | 4 | 1999 | 5 |
| 27 | Chaung-Dwin | KLT-PPN | Ayeyarwady | Chaung-Dwin | 236 | 34' | R.C Pile | R.C | R.C | 1998 | 6 | 1999 | 9 |
| 28 | Gon-Nyin-Than | KLT-PPN | Ayeyarwady | Gon-Nyin-Than | 1,940 | 34'-6" | R.C bored Pile | R.C | R.C | 1999 | 2 | 2001 | 2 |
| 29 | Pan-Tanaw | YGN-PTN | Ayeyarwady | Pan-Tannaw | 420 | 36' | R.C bored Pile | R.C | R.C | 1999 | 4 | 2000 | 3 |
| 30 | Ywar-Le-Yoe-Gyi | PTN-MYA | Ayeyarwady | - | 300 | 34' | R.C Pile | R.C | RC | 1999 | 11 | 2000 | 12 |
| 31 | Ta-Leik-Gyi | KLT-PPN | Ayeyarwady | Ta-Leik-Gy | 180 | 34' | R.C bored Pile | R.C | R.C | 1999 | 12 | 2001 | 2 |
| 32 | Kon-Min-Yoe | YKI-GWA | Ayeyarwady | - | 240 | 34' | R.C Pile | R.C | Bailey | 2000 | 4 | 2001 | 5 |
| 33 | Wakema | Pantanaw-Shwe <br> Laung-Wakema | Ayeyarwady | Wakema | 3,020 | 30 | R.C Bored pile | R.C | Bailey Supension+ R.C | 2000 | 5 | 2003 | 1 |
| 34 | DDY | KCK-DDE-PPN | Ayeyarwady | Ayeyarwaddy | 4,088 | 40 | R.C Bored Pile | R.C | Steel Truss RC | 2000 | 6 | 2003 | 3 |
| 35 | Shwe Laung | Pantanaw-Shwe Laung-Wakema | Ayeyarwady | Shwe Loung | 1,900 | 20'-0' | R.C Bored Pile | R.C | R.C | 2000 | 7 | 2002 | 3 |
| 36 | Thegon | YGN-PTN | Ayeyarwady | Thegon Chaung | 300 | 34' | R.C Pile | R.C | R.C | 2000 | 8 | 2001 | 8 |
| 37 | Yoe-Nyi-Naung | PIN-MYA | Ayeyarwady | - | 180 | 34' | R.C Pile | R.C | R.C | 2000 | 12 | 2001 | 5 |
| 38 | Da Ka | YGN-PTN | Ayeyarwady | Da Ka | 1,400 | 38 | R.C Bored pile | R.C | R.C | 2001 | 2 | 2003 | 7 |
| 39 | Lam Tha Mine | Wakema-Kyonmange-Mawlamvine- | Ayeyarwady | Lam Tha Mine | 220 | 23 | R.C pile | R.C | R.C | 2002 | 5 | 2002 | 12 |
| 40 | Pyapon | DDY-Pyapon | Ayeyarwady | Pyapon | 3,933 | 40 | R.C Bored Pile | R.C | Steel Truss + R.C | 2003 | 4 | 2007 | 3 |
| 41 | PTN | PTN-Shwe-Myin Tin Wa-Yah Chaung | Ayeyarwady | Nga Won | 2,140 | 36 | R.C Bored Pile | R.C | Steel Truss Suspension+ R.C | 2003 | 7 | 2004 | 11 |

LIST OF COMPLETED BRIDGES, 180FT AND ABOVE IN LENGTH, SINCE 1988

| Sr |  |  |  |  |  |  | Type |  |  | Date of |  | Date of Completion |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Bridge Name | Road Name | State/Division | River / Creek | (ft) | (ft) | Foundation | Substructure | Superstructure | Year | Month | Year | Month |
| 42 | Ma Yan Ngu | Einmel Myaungmya | Ayeyarwady | Tha Yet Kon Chaung | 240 | 30 | R.C Bored Pile | R.C | P.C + R.C | 2004 | 2 | 2005 | 8 |
| 43 | Pammawaddy (Myin Ka Seik) | PTN-Myaungmya | Ayeyarwady | Pamma-Waddy | 1,260 | 26 | R.C Bored Pile | R.C | Bailey Supension + R.C | 2004 | 5 | 2006 | 3 |
| 44 | Nga Won (Myo Kwin) | HTT-Kwin Kauk | Ayeyarwady | Ngawon | 2,835 | 34' | R.C Bored Pile | R.C | Steel Truss + P.C | 2005 | 3 | 2009 | 3 |
| 45 | Kyun Kon | Einmel- Wakema | Ayeyarwady | Pyar Ma Lot | 500 | 11'-3" | R.C Bored Pile | R.C | Bailey Suspension | 2006 | 7 | 2009 | 10 |
| 46 | Kan Gyi | MMA - Einmel | Ayeyarwady | Kan Gyi Chaung | 200 | 30 | R.C Bored Pile | R.C | R.C | 2006 | 9 | 2009 | 11 |
| 47 | Nyaung Chaung | PTN-Myaungmya | Ayeyarwady | Nyaung Chaung | 260 | 30 | R.C Bored Pile | R.C | R.C | 2006 | 9 | 2010 | 4 |
| 48 | Thon GWA Caung | Pantanaw-Einmel | Ayeyarwady | ThonGWA Chaung | $270{ }^{\prime}$ | 30' | R.C Bored Pile | R.C | R.C | 2006 | 9 | 2009 | 1 |
| 49 | Nankathu | HTT-Kwin Kauk | Ayeyarwady | Nankathu Chaung | 300 | 34 | R.C Bored Pile | R.C | R.C | 2007 | 10 | 2010 | 9 |
| 50 | Kyauk Chaung Gyi | PTN-Chaung- | Ayeyarwady | Kyauk Chaung | 360 | 36 | R.C Bored Pile | R.C | R.C | 2008 | 2 | 2011 | 2 |
| 51 | Kanyin Chaung | HTT-Myan Aung | Ayeyarwady | Kanyin Chaung | 240 | 34 | R.C Bord Pile | R.C | R.C | 2008 | 9 | 2011 | 1 |
| 52 | Ma Mya Chaung | HTT-Myanaung | Ayeyarwady | Ma Mya Chaung | 190 | 58 | Bored Pile | R.C.C | R.C.C | 2009 | 1 | 2011 | 4 |
| 53 | Yar Zu Daing No. (2) | MUB-Maw- <br> Lamyaing Gyun | Ayeyarwady | Myin Ka Kon | 540 | 24 | R.C Bored Pile | R.C | P.C+R.C | 2009 | 2 | 2010 | 1 |
| 54 | Htaw Paing | $\begin{array}{\|c\|} \hline \text { BGY-Satsan } \\ \text { Htaw Paing AMR } \\ \hline \end{array}$ | Ayeyarwady | Htaw Paing | 430 | 13'-6" | Bored Pile | R.C | Bailey | 2009 | 3 | 2012 | 4 |
| 55 | Yar Zu Daing No. (1) | MUB- <br> MawlamyaingGvun | Ayeyarwady | Yar Zu Daing | 1,956 | 24 | R.C Bored Pile | R.C | Steel Truss R.C | 2009 | 4 | 2010 | 7 |
| 56 | Ayeyarwaddy (Nyaung Don) | YGN-PTN | Ayeyarwady | Ayeyarwaddy | 10,814 | 48 | Bored Pile | R.C.C | $\begin{gathered} \hline \text { Steel Truss P.C } \\ \text { Girder } \end{gathered}$ | 2010 | 1 | 2011 | 11 |
| 57 | Out-Net Chaung | Bogale-Setsan-Htawpaing-AMR | Ayeyarwady | Out-Net Chaung | 466 | 13'-6" | Bored Pile | R.C.C | Bailey | 2010 | 1 | 2011 | 6 |
| 58 | Po Long Chaung | PTN-Mawtin | Ayeyarwady | Po Long Chaung | 240 | 22 | R.C Well | R.C | R.C | 2010 | 1 | 2010 | 10 |
| 59 | Pay Pin Bridge | PTN-Ngapudaw | Ayeyarwady | Paypin Chaung | 720 | 30 | Bored Pile | R.C.C | Steel Truss | 2011 | 1 | 2012 | 3 |
| 60 | Bago | YGN-MDY | BGO | Bago | 290 | 38' | R.C Preasat \& bored Pile | R.C | CH + RC | 1992 | 4 | 1994 | 3 |
| 61 | Wetpoke | YGN-PY | BGO | Wetpoke | 180 | 34' | R.C Pile | R.C | P.C | 1993 | 2 | 1994 | 7 |
| 62 | Myit-Ma-Kha | LPN-HTT | BGO | Myit-Ma-Kha | 1,520 | $17^{\prime}$ | R.C Precast \& bored Pile | R.C | P.C | 1994 | 1 | 1999 | 5 |
| 63 | Nawaday | PY-STE | BGO | Ayeyarwady | 4,183 | 38' | R.C bored Pile | R.C | Steel Truss | 1994 | 3 | 1997 | 9 |
| 64 | Pyay-Ye-Sin | - | BGO | Ayeyarwady | 183 | $20^{\prime}$ | R.C Pile | R.C | R.C | 1995 | - | 1997 | - |
| 65 | Bridge No.-2/83 | WAW-STN | BGO | - | 180 | 30' | R.C Pile | R.C | R.C | 1997 | 12 | 1999 | 4 |
| 66 | Kadoke-Chaung | YGN-MDY | BGO | Kadoke-Chaung | 196 | $56^{\prime}$ | R.C Well | R.C | R.C | 1999 | 3 | 2000 | 10 |
| 67 | Kha-Paung | YGN-MDY | BGO | Kha-Paung | 600 | 60' | R.C bored Pile | R.C | R.C | 1999 | 10 | 2000 | 9 |
| 68 | Kaw-Le-Ya | YGN-MDY | BGO | Kaw-Le-Ya | 196 | $56^{\prime}$ | R.C Well | R.C | R.C | 2000 | 1 | 2001 | 1 |
| 69 | Kwin Chaung | YGN-MDY | BGO | Kwin Chaung | 300 | 60' | R.C Pile | R.C | R.C | 2000 | 10 | 2003 | 9 |
| 70 | Phyu Chaung | YGN-MDY | BGO | Phyu Chaung | 468 | 60'-0" | R.C Bored Pile | R.C | PC | 2000 | 10 | 2002 | 1 |
| 71 | Sit Taung Shwe Kyin Ma Dauk | SKN - MDK | BGO | Sit Taung | 1,500 | 36 | R.C Bored Pile | R.C | R.C | 2000 | 12 | 2003 | 2 |
| 72 | Binder | YGN-MDY | BGO | Binder Chaung | 300 | 60 | R.C pile | R.C | R.C | 2001 | 5 | 2003 | 8 |
| 73 | Ye Nwe Chaung | YGN-MDY | BGO | Ye Nwe Chaung | 360 | 60 | R.C Pile | R.C | R.C | 2001 | 8 | 2003 | 2 |
| 74 | Kawa | Htone Gyi-Kawa | BGO | BGO | 560 | 12'-4" | R.C Bored Pile | R.C | Bailey | 2005 | 5 | 2009 | 3 |
| 75 | BGO | YGN-MDY | BGO | BGO | 360 | 72'-6" | R.C Bored Pile | R.C | PC | 2006 | 6 | 2010 | 3 |
| 76 | Swar Chaung | YGN-TGO-MDY | BGO | Swar Chaung | 270 | 54 | R.C Bored Pile | R.C | R.C | 2007 | 5 | 2009 | 5 |
| 77 | Naga PUK Chaung | Daik U-Sitto WN | BGO | Naga PUK | 240 | 30 | Bored Pile | R.C.C | R.C.C | 2008 | 6 | 2011 | 8 |

LIST OF COMPLETED BRIDGES, 180FT AND ABOVE IN LENGTH, SINCE 1988

| Sr |  |  |  | Name of | Length |  | Type |  |  | Date of |  | Date of Completion |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Bridge Name | Road Name | State/Division | River / Creek |  | (ft) | Foundation | Substructure | Superstructure | Year | Month | Year | Month |
| 78 | Myo Chaung | Minhla-Seinkant- <br> Lant-Myo <br> Chaung-Kyun | BGO | Myo Chaung | 270 | 30 | Bored Pile | R.C.C | Steel Truss | 2010 | 7 | 2011 | 7 |
| 79 | Sittown Canal | Daik U-Sittown | BGO | Sittown Canal | 240 | 28 | Bored Pile | R.C.C | R.C.C | 2010 | 7 | 2011 | 9 |
| 80 | Yenwe Chaung | MyochaungKyunKon | BGO | Yenwe Chaung | 360 | 30 | Bored Pile | R.C.C | Steel Truss Girder | 2011 | 5 | 2012 | 1 |
| 81 | Ba Maung | PY-TGU | BGO | Ba Maung | 226 | 34' | R.C Well | R.C | R.C | - | - | - | - |
| 82 | Theikchaung | PY-TGU | BGO | Theik Chaung | 198 | 34' | R.C Well | R.C | R.C | - | - | - | - |
| 83 | Kap Tal | TTN - RWR | Chin | Manipura | 400 | 9'-0" | Open Foundation | R.C | Timber Supension | 1996 | 4 | 2002 | 4 |
| 84 | Man Song | Teetain-Yi Lake | Chin | Mini Pura River | 460 | 11'-3" | Open Foundation | R.C | Bailey Supension | 2002 | 12 | 2005 | 3 |
| 85 | Tar-Pein | BMW-MKN | Kachin | Tar-pein | 320 | 18' | R.C Pile | R.C | Bailey Suspension | 1994 | 1 | 1994 | 11 |
| 86 | Balaminhtin | MKN-BMW | Kachin | Ayeyarwady | 2,688 | $40^{\prime}$ | R.C Well | R.C | Steel Truss | 1994 | 3 | 1998 | 11 |
| 87 | Tabet | BMW-MKN | Kachin | Tabet | 500 | 12'-4" | Open Fdn | R.C | Baily | 1995 | - | 1996 | - |
| 88 | Namtmyikha | MN-YMW | Kachin | Namtmyitkha | 260 | 12'-4" | R.C Pile | R.C | Bailey | 1997 | 11 | 1999 | 6 |
| 89 | Ma-Le-Yan | BNW-MKN | Kachin | Ma-Le | 320 | 12'-4" | R.C Precast \& bored Pile | R.C | Bailey | 1999 | 2 | 1999 | 8 |
| 90 | Nan-San-Yan | BMW-MKN | Kachin | Nan-San-Yan | 400 | 12'-4" | R.C Well | R.C | Bailey | 1999 | 10 | 2000 | 5 |
| 91 | Moe-Le' | BMW-MKN | Kachin | Moe-Le' | 325 | 12'-4" | R.C Well | R.C | Bailey | 1999 | 12 | 2000 | 5 |
| 92 | Tanaing | Namtee-Tanaing Nanyoon | Kachin | Tanaing Chaung | 942 | 12'-0" | $\begin{gathered} \hline \text { R.C Pile + R.C } \\ \text { Well } \\ \hline \end{gathered}$ | R.C | R.P.T +H-20 Steel Truss | 2001 | 2 | 2002 | 2 |
| 93 | Ho Pin | MDY-SBO-MKA | Kachin | Thayet Chaung | 200 | 42 | R.C Bored pile | R.C | C. $\mathrm{H}+\mathrm{R} . \mathrm{C}$ | 2002 | 2 | 2003 | 6 |
| 94 | Mogaung | MDY-SBO-MKA | Kachin | Namg Kong Chaung | 945 | 32 | R.C Bored Pile | R.C | R.P.T + R.C | 2002 | 6 | 2004 | 2 |
| 95 | Mohnyin | SBO-MKA | Kachin | Namg Ying Chaung | 200 | 42 | R.C Well | R.C | C. $\mathrm{H}+\mathrm{R} . \mathrm{C}$ | 2002 | 8 | 2004 | 2 |
| 96 | Sin Khan | MDY-TGG-BMW-MKA | Kachin | Sin Khan Chaung | 460 | 36 | R.C Bored Pile | R.C | P.C + R.C | 2003 | 2 | 2005 | 1 |
| 97 | Kaung Hmu Lon | Putao-Kaung- Hmu Lon-Naung- | Kachin | Malikha | 700 | 9' | R.C Well | R.C | Bailey Suspension | 2004 | 8 | 2010 | 11 |
| 98 | Namtee (Kan Hla) | SBO-MKA | Kachin | Namtee Chaung | 280 | 30 | R.C wall | R.C | R.C | 2005 | 3 | 2006 | 8 |
| 99 | Don Ban | Namtee-Tanai | Kachin | Namg Ying Chaung | 216 | 15'.6" | R.C Well | R.C | R.P.T Steel Truss | 2005 | 5 | 2007 | 7 |
| 100 | Phon In | MKA-PUTAO | Kachin | Phon In Chaung | 235 | 10'-6" | R.C Bored Pile | R.C | H20+Bailey R.C | 2005 | 12 | 2006 | 11 |
| 101 | Nan Kway (Shwe Ite) | Pamtee-G.T.C | Kachin | Nam Kway Chaung | 273 | 12 | Timber Pile | Timber | H20+R.S.J | 2006 | 9 | 2006 | 12 |
| 102 | Wayar Zut Bridge No <br> (2) | MKA-Namtee- Tanai | Kachin | Wayar Zut Chaung | 354 | 28 | Open Foundation | R.C | R.C | 2008 | 1 | 2009 | 5 |
| 103 | Nantkhwin | $\begin{gathered} \hline \text { Shwebo-Myit-Gyi } \\ \text { Nar } \\ \hline \end{gathered}$ | Kachin | Nantkhwin Chaung | 350 | 30 | R.C Well | R.C.C | P.C Girder | 2008 | 5 | 2011 | 5 |
| 104 | Nan Kway Chaung | Myitkyimar- | Kachin | Nan Kway Chaung | 262 | 30 | M.A.T Foundation | R.C | R.C | 2009 | 3 | 2010 | 1 |
| 105 | Ayeyarwaddy (Sinkhan) | Kathar-Bhamo Railway | Kachin | Ayeyarwaddy | 4,630 | 48 | Bored Pile | R.C.C | Steel Truss P.C (Girder) R.C.C | 2009 | 6 | 2012 | 2 |
| 106 | Kyun Taw | SBO-MKA | Kachin | Namg Ying Chaung | 366 | 42 | R.C Bored pile | R.C | $\mathrm{CH}+\mathrm{R} . \mathrm{C}$ | 2004 | 3 | 2005 | 4 |
| 107 | Htee Se Khar | Taungoo-Loikaw | Kayah | Thabat Chaung | 240 | 30 | R.C Well | R.C | R.C | 2005 | 5 | 2009 | 6 |
| 108 | Htu Chaung | Taungoo-Loikaw | Kayah | Htu Chaung | 228 | 30 | R.C Well | R.C | R.P.T + R.C | 2007 | 10 | 2011 | 3 |
| 109 | Pa-An | TAN-PAN | Kayin | Thanlwin | 2,252 | 38' | R.C bored Pile | R.C | Steel Truss | 1994 | 3 | 1997 | 8 |
| 110 | Hlaing-Wa | MDN-MWD | Kayin | Hlaing-Wa | 240 | 32'-6" | R.C Pile | R.C | R.C | 1994 | 9 | 1996 | 7 |
| 111 | Zar-Tha-Pyin | MLM-PAN | Kayin | Gyine | 2,900 | 24'-6" | R.C bored Pile | R.C | Suspension | 1995 | 11 | 1999 | 3 |
| 112 | Kawkayeik | PAN-MWD | Kayin | Gyine | 1,200 | 24'-6" | R.C Precast \& bored Pile | R.C | Bailey Suspension | 1997 | 6 | 1999 | 5 |
| 113 | Me'Kane' | MDN-MWD | Kayin | Me'Kane' | 182 | 33'-6" | R.C Pile | R.C | R.C | 1998 | 2 | 1999 | 1 |
| 114 | Paing Kyon | Hline Bwe-Pine Kyon | Kayin | Pine Kyon Chaung | 1,170 | 12'-4" | Timber Pile | Timber | Bailey | 2004 | 4 | 2007 | 6 |


|  |  |  |  |  | Length | Width | Type |  |  | Date of |  | Date of Completion |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Bridge Name | Road Name | State/Division | River / Creek | $(\mathbf{f t})$ | (ft) | Foundation | Substructure | Superstructure | Year | Month | Year | Month |
| 115 | Pata | Nabu-YepuPinekyon | Kayin | Pata Chaung | 330 | 12'-4" | R.C Pipe Timber Pile | R.C + Timber | Bailey Timber | 2009 | 4 | 2010 | 9 |
| 116 | Dar Li | Kyar In Seik Gyi <br> - Chaung-Hna | Kayin | Dar Li Chaung | 188 | 16'-6" | R.C Bored Pile | R.C | R.P.T + R.C | 2008 | 1 | 2009 | 12 |
| 117 | Na-Thoe-Chaung | PUK-KTU | Magwe | Natoe | 180 | 33' | R.C Well | R.C | P.C | 1990 | 10 | 1992 | 3 |
| 118 | Yaw-Chaung | SPU-PKK | Magwe | Yaw-Chaung | 530 | 12'-4" | R.C Well | R.C | Bailey | 1992 | - | 1997 | 1 |
| 119 | Saing-du | GGW-HKA | Magwe | Myint-Thar | 600 | 12'-4" | R.C Pile | R.C | Bailey | 1993 | 6 | 1995 | 6 |
| 120 | New-Ta-Me | MHA-TNG | Magwe | Salin | 1,200 | 12'-4" | R.C Well | R.C | Bailey | 1995 | 1 | 1997 | 3 |
| 121 | Anawyathar | CHK-SPU | Magwe | Ayeyarwady | 5,192 | 40' | R.C Precast \& bored Pile | R.C | Steel Truss+PC | 1996 | 7 | 2001 | 4 |
| 122 | Mann-Chaung | MHA-TNG | Magwe | Mann-Chaung | 900 | 12'-4" | R.C Well | R.C | Bailey | 1996 | - | 1997 | 3 |
| 123 | Mone-Chaung | SLN-PPU | Magwe | Mone-Chaung | 1,300 | 12'-4" | R.C Pile + Well | R.C | Bailey | 1997 | 1 | 1998 | 4 |
| 124 | Ayeyarwaddy | MaGWAy-MBU | Magwe | Ayeyarwaddy | 8,989 | 40'-0' | R.C Bored pile | R.C | Steel Truss RC | 2000 | 1 | 2002 | 11 |
| 125 | Laung Gat | Kalay-Gangaw | Magwe | Laung Gat Chaung | 300' | 36'-0" | R.C Well | R.C | R.C | 2000 | 1 | 2001 | 12 |
| 126 | Man Chaung | PTN-MYA | Magwe | Man Chaung | 420 | 12'-4" | R.C Well | R.C | Bailey | 2001 | 9 | 2002 | 5 |
| 127 | Shwe Chaung | PTN-MYA | Magwe | Shwe Chaung | 500 | 34 | R.C Well | R.C | PC | 2002 | 11 | 2004 | 8 |
| 128 | Taw Win | Kalay-Gangaw | Magwe | Taw Win Chaung | 408 | 16'-6" | R.C Well | R.C | R.P.T+R.C | 2003 | 5 | 2004 | 9 |
| 129 | Bwet Gyi | YGN-PY | Magwe | Bwet Gyi Chaung | 1770' | 34' | R.C Bored Pile | R.C | PC + R.C | 2004 | 6 | 2008 | 5 |
| 130 | Maezali | PTN-MYA | Magwe | Mon Chaung | 940' | 14'-6" | R.C Bored Pile | R.C | Bailey Supension+ <br> R.C | 2004 | 8 | 2008 | 1 |
| 131 | No(2) PUK | $\begin{array}{\|c\|} \hline \text { PKK-PUK TLN- } \\ \text { GGW } \end{array}$ | Magwe | Yaw Chaung | 940 | 12'-4" | Timber\&R.C Pile | Timber+ R.C | Bailey | 2005 | 1 | 2005 | 7 |
| 132 | $\begin{gathered} \text { No.(1) PUK (Ohn } \\ \text { Taw) } \\ \hline \end{gathered}$ | $\begin{gathered} \hline \text { PKK-PUK-TLN- } \\ \text { GGW } \\ \hline \end{gathered}$ | Magwe | Yaw Chaung | 960 | 12'-4" | Timbers \& R.C Pile | Timber + R.C | Bailey | 2005 | 2 | 2005 | 7 |
| 133 | Min Don Chaung | Thayet Kanma | Magwe | Min Don Chaung | 700 | 12'.4" | R.C Pile | R.C | Bailey | 2005 | 3 | 2009 | 9 |
| 134 | SLN Chaung | PTN-MYA | Magwe | SLN Chaung | 230 | 12'-4" | R.C Bored Pile | R.C | Steel Truss+ Bailey | 2006 | 3 | 2007 | 6 |
| 135 | Wat Khote | PTN-MYA | Magwe | YAMR Chaung | 300 | 12'-4" | R.C Well | R.C | Bailey + | 2006 | 4 | 2009 | 4 |
| 136 | Yin Chaung | Taung Dwin GyiNat Mauk | Magwe | Yin Chaung | 320 | 12'-4" | Timber Pile | Timber | Bailey Timber | 2008 | 3 | 2010 | 6 |
| 137 | Daung Nay Chaung | YGN-PY-MDY | Magwe | Daung Nay Chaung | 1,785 | 24 | R.C Bored Pile | R.C | PC | 2008 | 4 | 2011 | 2 |
| 138 | Tha Yu Chaung | PTN-MYA | Magwe | Tha Yu Chaung | 260 | 12'4' | R.C Bored Pile | R.C | Bailey | 2008 | 12 | 2011 | 2 |
| 139 | Ayeyarwaddy (PKK) | PKK-Letpanchay Paw | Magwe | Ayeyarwaddy | 13,537 | 48 | Bored Pile | R.C.C | Steel Truss | 2009 | 12 | 2011 | 12 |
| 140 | Kyar Ku Bridge | Magway-Pyaw | Magwe | Kyarku Chaung | 480 | 24 | Bored Pile | R.C.C | R.C.C | 2010 | 8 | 2011 | 10 |
| 141 | Yin Chaung | Nay Pyi Daw- <br> Magway | Magwe | Yin Chaung | 250 | 28 | R.C Bored Pile | R.C | R.C | 2010 | 9 | 2011 | 3 |
| 142 | Zawgyi | YGN-MDY | MDY | Zawgyi | 210 | $24{ }^{\prime}$ | R.C Pile | R.C | Steel Truss | 1991 | 7 | 1991 | 9 |
| 143 | Doke-Htwady | MDY-TTU | MDY | Doke-Htawady | 700 | 84' | R.C Precast \& bored Pile | R.C | R.C | 1996 | 3 | 1999 | 1 |
| 144 | Pan Sae | IAP | MDY | Pan Sae | 200 | 84 | R.C Pile | R.C | P.C + R.C | 1996 | 10 | 2004 | 1 |
| 145 | Pan-Laung | MDY-IAP | MDY | Pan-Laung | 300 | 88' | R.C Precast \& bored Pile | R.C | R.C | 1998 | 4 | 2000 | 4 |
| 146 | Sa-Mone-Pauk | MC-YWN | MDY | Sa-Mone-Pauk | 300 | 34' | R.C Pile | R.C | R.C | 1998 | 6 | 2000 | 6 |
| 147 | Zawgi | YGN-MDY | MDY | Zawgi | 210 | 77'-0' | R.C Pile | R.C | R.C | 1999 | 12 | 2002 | 4 |
| 148 | Tangar | MDY-MKK | MDY | Ma Gyi Chaung | 360 | 34'-0' | R.C pile | R.C | R.C | 2000 | 1 | 2002 | 7 |
| 149 | Pan Laung | Paleik-Tadau | MDY | Pan Laung Chaung | 400 | 30 | R.C Pile | R.C | P.C+R.C | 2000 | 12 | 2005 | 12 |
| 150 | Ayeyarwady (Yadanarpon) | MDY-Saging | MDY | Ayeyarwady | 5614' | 32' | R.C Bored Pile | R.C | Steel Truss(Arch) | 2001 | 10 | 2008 | 4 |
| 151 | Myit Nge | YGN-MDY | MDY | Myit Nge | 840 | 80 | R.C Bored Pile | R.C | P.C + R.C | 2003 | 3 | 2005 | 9 |
| 152 | Lat Pan Hla | MDY-MMK | MDY | Lat Pan Hla Chaung | 240 | 30 | R.C Well | R.C | R.C | 2007 | 2 | 2009 | 7 |

LIST OF COMPLETED BRIDGES, 180FT AND ABOVE IN LENGTH, SINCE 1988

| Sr |  |  |  | Name of | Length | Width | Type |  |  | Date of |  | Date of Completion |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Bridge Name | Road Name | State/Division | River / Creek | (ft) | (ft) | Foundation | Substructure | Superstructure | Year | Month | Year | Month |
| 153 | Kyauk Oe | MDY-MKK | MDY | Kyauk Oe Chaung | 200 | 30 | R.C Bored Pile | R.C | R.C | 2008 | 11 | 2010 | 5 |
| 154 | Ayeyarwaddy (Yadanarpon) Approach bridge |  | MDY |  | 612 | 34 | R.C Bored Pile | R.C | R.C | 2009 | 6 | 2010 | 10 |
| 155 | Pyi Nyaung | $\begin{aligned} & \hline \text { MTLA-TGI- } \\ & \text { KTG-TCL } \\ & \hline \end{aligned}$ | MDY | Pyi Nyaung Chaung | 200 | 30 | R.C Bored Pile | R.C | R.C | 2010 | 1 | 2011 | 2 |
| 156 | Kywe Shin | PMA-TNO-TTG | MDY | Ngalite Chaung | 180 | 58 | R.C Bored Pile | R.C | Steel Truss | 2010 | 3 | 2011 | 1 |
| 157 | Wel Laung | YGN-PY-MDY | MDY | Wel Laung Chaung | 300 | 30 | R.C Bored Pile | R.C | R.C | 2010 | 3 | 2011 | 3 |
| 158 | The'-Phyu | YGN-DWI | Mon | The'-Phyu | 180 | 34' | R.C Pile+Well | R.C | P.C | 1991 | 11 | 1992 | 9 |
| 159 | Than Lwin (Mawlamyaing) | YGN-MLM | Mon | Than Lwin | 11,575 | 63'-8" | $\begin{gathered} \hline \text { R.C Bored Pile\& } \\ \text { Well } \end{gathered}$ | R.C | Steel Truss | 2000 | 3 | 2005 | 2 |
| 160 | STN (Moatpalin) | YGN- <br> Mawlamyine | Mon | STN | 2392.7 | 40' | R.C Bored Pile | R.C | Steel Truss+Steel Girder+RC | 2005 | 1 | 2008 | 7 |
| 161 | Tha-Yu | MBU-ANN | Rakhine | Tha-Yu | 320 | $18 '$ | R.C Pile | R.C | Bailey Suspension | 1987 | 11 | 1989 | 7 |
| 162 | Ann-Chaung | MBU-ANN | Rakhine | Ann-Chaung | 540 | $18^{\prime}$ | R.C. Pile | R.C | Bailey Suspension | 1989 | 2 | 1990 | 3 |
| 163 | Shwe-Hlay | TTE-TGK | Rakhine | Tha-Htay | 600 | 30'-6" | R.C Pile+Well | R.C | P.C | 1989 | 12 | 1993 | 9 |
| 164 | Tain-Nyo | MBA-KTW | Rakhine | Tain-Nyo | 300 | $20^{\prime}$ | R.C Pile | R.C | Steel Truss | 1991 | - | 1993 | 10 |
| 165 | Kyain-Ta-Li | TWE-GWA | Rakhine | Kyain-Ta-Li | 700 | 30'-6" | R.C Well | R.C | R.C | 1992 | 2 | 1995 | 1 |
| 166 | Bar | KL-HKA | Rakhine | Mini-Pura | 340 | 12'-4" | R.C Well | R.C | Bailey | 1992 | 12 | 1998 | 3 |
| 167 | Pazunpyay | TTW-GWA | Rakhine | Sa-Lu | 300 | 38'-6" | R.C Pile | R.C | P.C | 1995 | 2 | 1996 | 9 |
| 168 | Dwar-Ya-Wady | TGR-TWE | Rakhine | Tantwe | 540 | 38' | R.C Pile | R.C | R.C + P.C | 1995 | 4 | 1998 | 6 |
| 169 | Ah-Ta-Yan | MLM-PAN | Rakhine | Ah-Ta-Yan | 1,420 | 24'-6" | R.C Precast \& bored Pile | R.C | Stayed Bable | 1995 | 11 | 1998 | 3 |
| 170 | Myaung-Bwe | YGN-STW | Rakhine | Myaung-Bwe | 740 | 12'-4" | R.C Pile | R.C | Baily | 1996 | 9 | 1997 | 10 |
| 171 | Kin-Chaung | STW-KTW | Rakhine | Kin-Chaung | 440 | 12'-4" | R.C Pile | R.C | Bailey | 1996 | 11 | 1998 | 4 |
| 172 | Kispandy | YGN-STW | Rakhine | Kalatan | 2,513 | 40' | R.C Precast \& bored Pile | R.C | Steel Truss | 1996 | 11 | 2000 | 1 |
| 173 | Ohn-Ti | YGN-STW | Rakhine | Ohn-Ti | 270 | 12'-4" | R.C Pile | R.C | Bailey | 1996 | 11 | 1997 | 8 |
| 174 | Yoe-Chaung | YGN-STW | Rakhine | Yoe-Chaung | 420 | 12'-4" | R.C Pile | R.C | Bailey | 1996 | 11 | 1998 | 3 |
| 175 | Delet-Chaung | YGN-STW | Rakhine | Dalet-Chaung | 990 | 12'-4" | R.C Precast \& bored Pile | R.C | Bailey | 1997 | 8 | 1999 | 6 |
| 176 | Min-Chaung | YGN-STW | Rakhine | Min-Chaung | 2,003 | 40' | R.C Precast \& bored Pile | R.C | Steel Truss | 1997 | 8 | 2000 | 2 |
| 177 | Yar-Maung | YGN-STW | Rakhine | Yar-Maung | 1,300 | 24'-6" | R.C Precast \& bored Pile | R.C | Bailey Suspension | 1997 | 8 | 1999 | 12 |
| 178 | Yaw-Chaung | YGN-STW | Rakhine | Yaw-Chaung | 1,100 | 12'-4" | R.C Precast \& bored Pile | R.C | Bailey | 1997 | 8 | 1999 | 7 |
| 179 | Pe-Kauk | YGN-STW | Rakhine | Pe-Kauk | 360 | 12'-4" | R.C Precast \& bored Pile | R.C | Bailey | 1998 | 11 | 1999 | 7 |
| 180 | Kin-Shay | TGR-ANN | Rakhine | Taung-Koke | 540 | 12'-4" | R.C Precast \& bored Pile | R.C | Bailey | 1999 | 2 | 2000 | 3 |
| 181 | Ma-Ei Chaung | YGN-Kyaukphyu | Rakhine | Ma-ei Chaung | 940' | 30'-0" | $\begin{gathered} \hline \text { R.C Pile + R.C } \\ \text { Bored Pile } \\ \hline \end{gathered}$ | R.C | PC+RC | 1999 | 3 | 2001 | 11 |
| 182 | Sat-twa | TTW-GWA | Rakhine | Sat Twa | 660 | 30' | R.C Pile \& Well | R.C | PC+R.C | 1999 | 11 | 2001 | 3 |
| 183 | Tanlwe Chaung | Toungup-Am | Rakhine | Tanlwe Chaung | 600 | 12'-4" | R.C Well | R.C | Bailey | 2000 | 1 | 2001 | 10 |
| 184 | Kyauk Kyi PUK | YGN-KPU | Rakhine | Kyauk Kyi PUK Chaung | 300 | 30'-0" | R.C Well | R.C | Steel Truss+RC | 2000 | 2 | 2002 | 6 |
| 185 | La Mu | ToungupKyaukphyu | Rakhine | La Mu Chaung | 500 | 12'-4" | R.C Well | R.C | Bailey PC | 2000 | 8 | 2001 | 7 |
| 186 | Pyae Chaung | Toungup- | Rakhine | Pyae Chaung | 440 | 12'-4" | R.C Pile | R.C | Bailey+ R.C | 2000 | 9 | 2001 | 9 |
| 187 | Sa Nell PUK | YGN - KPU | Rakhine | Sa Nell PUK | 789 | 28 | R.C Well | R.C | Steel Truss + R.C | 2001 | 3 | 2003 | 11 |
| 188 | Min Kyaung | YGN-KPU | Rakhine | Min Kyaung | 2,704 | 30 | R.C Bored Pile | R.C | Steel Truss + R.C | 2001 | 4 | 2006 | 4 |
| 189 | Paung Tote | YGN - STE | Rakhine | Paung-Tote Chaung | 240 | 30 | R.C Bored pile | R.C | R.C | 2001 | 6 | 2003 | 5 |
| 190 | Nar Yi Kan | YGN-STE | Rakhine | Nar Yi Kan Chaung | 300 | 30 | R.C | R.C | R.C | 2001 | 11 | 2004 | 4 |
| 191 | King Pon | Thandure-GWA | Rakhine | King Pon Chaung | 420 | 30 | R.C Well+ R.C | R.C | Steel Truss+ R.C | 2002 | 1 | 2003 | 12 |


| LIST OF COMPLETED BRIDGES, 180FT AND |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \hline \text { Sr } \\ \text { No. } \\ \hline \end{gathered}$ | Bridge Name | Road Name | State/Division | Name of River / Creek | Length (ft) | Width <br> (ft) | Type |  |  | Date of |  | Date of Completion |  |
|  |  |  |  |  |  |  | Foundation | Substructure | Superstructure | Year | Month | Year | Month |
| 192 | Lone Taw PUK | YGN-KPU | Rakhine | Lone Taw PUK <br> Chaung | 1,155 | 30 | R.C Bored Pile | R.C | Steel Truss RC | 2002 | 1 | 2004 | 10 |
| 193 | Di Dote PUK | YGN - KPU | Rakhine | Di Dote PUK | 592 | 30 | R.C Well | R.C | Steel Truss+ R.C | 2002 | 3 | 2004 | 3 |
| 194 | Than Thama Gyi | YGN - KPU | Rakhine | Than Thama Gyi <br> Chaung | 552 | 30 | R.C Bored Pile | R.C | Steel Truss+RC | 2002 | 9 | 2004 | 12 |
| 195 | Thazin Tan PUK | YGN-KPU | Rakhine | Thazin Tan PUK Chaung | 592 | 30 | R.C Well | R.C | Steel Truss R.C | 2003 | 7 | 2006 | 2 |
| 196 | Than Thama Chay | YGN-KPU | Rakhine | Than Thama Chay Chaung | 707 | 30 | R.C Well | R.C | Steel Truss RC | 2003 | 11 | 2005 | 11 |
| 197 | Kyauk Tan | YGN-STW. | Rakhine | Kyauktan Chaung | 452'-5" | 32' | R.C Bored Pile | R.C | R.C | 2004 | 9 | 2008 | 3 |
| 198 | Won Phite | YGN-KPU | Rakhine | Won Phite Chaung | 827 | 30 | R.C | R.C | Steel Truss + R.C | 2004 | 12 | 2006 | 10 |
| 199 | Tha Yu (Pepadon) | YGN-STE | Rakhine | Tha Yu Chaung | 400 | 24 | Open Foundation | R.C | Bailey Suspension | 2008 | 4 | 2010 | 8 |
| 200 | Chaung | KLW-MYA | Sagaing | Bon-Chaung | 300 | 31'-9" | R.C Pile + Well | R.C | R.C | 1984 | 12 | 1989 | 11 |
| 201 | Nyaung-Pinwun | MDY-MYA | Sagaing | Mu | 600 | 34'-6" | R.C bored Pile | R.C | R.C | 1990 | 12 | 1994 | 1 |
| 202 | Tha-Ma-Yoe | SBO-MYA | Sagaing | Mu | 748 | 12'-4" | R.C Pile | R.C | R.C | 1992 | 2 | 1996 | 8 |
| 203 | Sin-Phyu-Shin | PKK-CU | Sagaing | Chindwin | 4,957 | 66'-6" | R.C Precast \& bored Pile | R.C | Steel Truss | 1994 | 3 | 1999 | 9 |
| 204 | Ka-Bar-Ni | GGW-KL | Sagaing | Ma-Ni-Pura | 595 | 14'-7" | R.C Well | R.C | R.C | 1995 | - | 1995 | 6 |
| 205 | File-Lin | TM-ST | Sagaing | Nan-A-Yar | 250 | 12'-4" | R.C Pile | R.C | Bailey + Timber | 1996 | - | 1996 | 5 |
| 206 | Yu-Chaung | TM-ST | Sagaing | Yu-Chaung | 320 | 12'-4" | R.C Pile | R.C | Bailey + Timber | 1996 | - | 1996 | 5 |
| 207 | Mezar | SBO-MKN | Sagaing | Mezar | 465 | $24^{\prime}$ | Open Fdn | R.C | R.C | 1999 | 8 | 2001 | 6 |
| 208 | Shwe Li | Tagaung-Shweku- Bamaw | Sagaing | Shwe Li | 2,330 | 34 | R.C Bored Pile | R.C | $\begin{gathered} \hline \text { Precast Concrete + } \\ \text { R.C } \\ \hline \end{gathered}$ | 2000 | 5 | 2003 | 3 |
| 209 | Chindwin | MYA-KLW | Sagaing | Chindwin | 4,730 | 40 | R.C Bored pile | R.C | Steel Truss RC | 2000 | 12 | 2003 | 4 |
| 210 | Myit Thar | MYA-KLW | Sagaing | Myit Thar | 1,320 | 28 | R.C Bored Pile | R.C | Steel Truss <br> Suspension | 2002 | 7 | 2004 | 6 |
| 211 | Pan Mon Chaung | Kalay-Gangaw | Sagaing | Pan Mon Chaung | 220 | 24 | R.C Well | R.C | R.P.T+R.C | 2003 | 8 | 2004 | 5 |
| 212 | URU Bridge | Teetke KyinPhaung PyinKhanti | Sagaing | URU Chaung | 1090' | 16'-6" | R.C Bored Pile | R.C | Bailey Suspension | 2004 | 5 | 2008 | 2 |
| 213 | Kan Gyi Wa | TM-Zayti | Sagaing | Mahuyar Chaung | 360 | 30 | R.C Well | R.C | R.C | 2005 | 3 | 2007 | 1 |
| 214 | Nantsalain | Khantee Lahel | Sagaing | Nantsalain Chaung | 250' | 10' | R.C Well | R.C | Suspension | 2006 | 4 | 2009 | 1 |
| 215 | Myaung Chaung | Kalay-Gantgaw | Sagaing | Myaung Chaung | 186' | 12' | R.C Well | R.C | R.PT+Bailey | 2007 | 7 | 2008 | 8 |
| 216 | Zaw Chaung | SBO-MKA | Sagaing | Zaw Chaung | 180 | 32 | R.C Well | R.C | R.C | 2007 | 8 | 2011 | 1 |
| 217 | Myauk YAMR | PTN-MYA | Sagaing | YAMR Chaung | 1,280 | 12'-4" | R.C Bored Pile | R.C | Bailey | 2008 | 3 | 2010 | 9 |
| 218 | Nay Yin Zayar | Kalay-Kyi Kon | Sagaing | Nay Yin Zayar Chaung | 270 | 28 | R.C Bored Pile | R.C | $\mathrm{PC}+\mathrm{RC}$ | 2008 | 5 | 2010 | 10 |
| 219 | Thiri Mingalar | Yadanarbon | Sagaing |  | 485 | 56 | R.C Bored Pile | R.C | R.C | 2008 | 12 | 2010 | 2 |
| 220 | Nanthalet | TM-Zaydi | Sagaing | Nantha Let Chaung | 240 | 12'-4" | R.C Well | R.C | Bailey | 2009 | 1 | 2010 | 12 |
| 221 | Le-lu | TPW-NSN | Shan | - | 300 | 12'4' | Plain Conc: | R.C | Bailey Suspension | 1992 | - | 1994 | 7 |
| 222 | 2-Mile | TKW-KTG | Shan | 2-Mile | 220 | $14^{\prime}$ | R.C Pile + Well | R.C | Bailey | 1994 | 9 | 1995 | 1 |
| 223 | Tar-Kaw-Ett | TYN-PSN | Shan | Thanlwin | 600 | 16'-5" | Plain-Cone | R.C | Bailey Suspension | 1995 | 4 | 1997 | 2 |
| 224 | Pun-Chaung | SSN-KDG | Shan | Pun-Chaung | 220 | 12'-4" | Plain-Conc | Masonry | Bailey | 1996 | 5 | 1998 | 9 |
| 225 | Tarsan | MPN-MTN | Shan | Thanlwin | 900 | 16'-6" | R.C | R.C | Bailey | 1997 | 4 | 1999 | 2 |
| 226 | Tone-Hone | NTY-KTL | Shan | Be-Lu-Chaung | 240 | 15' | Timber Pile | Timber | Timber | 1998 | 10 | 1999 | 3 |
| 227 | Nant-Tein-Chaung | TNE-MMW | Shan | Nant-Tein-Chaung | 432 | 16'-6" | R.C Well | R.C | RPT | 1999 | 4 | 2000 | 11 |
| 228 | Mat Lan | Lecha-Mineshu <br> Mine Naung | Shan | Namtein Chaung | 240 | 30'-0' | Steel Casing | R.C | R.C | 2000 | 2 | 2000 | 2 |


|  |  |  |  | Name of |  |  | Type |  |  | Date of |  | Date of Completion |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Bridge Name | Road Name | State/Division | River / Creek | (ft) | (ft) | Foundation | Substructure | Superstructure | Year | Month | Year | Month |
| 229 | Lin Khay | NSM-MTN-MST | Shan | Namg Tein Chaung | 290 | 30 | R.C well+ R.C Pile | R.C | R.C | 2001 | 8 | 2003 | 9 |
| 230 | Nam Mway | Tale-Pasho- | Shan | Nam Mway Chaung | 300 | 12'-4" | R.C Well | R.C | Bailey | 2002 | 2 | 2003 | 9 |
| 231 | Sar Taw | Loilim-Thibaw | Shan | Nam Laung Chaung | 360 | 30 | R.C Well | R.C | R.C | 2003 | 11 | 2011 | 3 |
| 232 | Than Lwin (Tapah) | Mai Sie-Tapah-Tar-Shwe Htan | Shan | Than Lwin | 600 | 16'-4" | R.C Well | R.C | Steel Truss+ Suspension | 2003 | 11 | 2005 | 5 |
| 233 | Dote Hta Waddy | Naung Cho-Yat Sauk | Shan | Dote Hta Waddy | 465 | 30 | R.C Bored pile | R.C | CH + R.C | 2004 | 2 | 2005 | 6 |
| 234 | Shwe Li (Nam Kham) | Lashio-MuseBamaw | Shan | Shwe Li | 600 | 24 | R.C Bored Pile | R.C | Bailey Suspension | 2004 | 11 | 2009 | 4 |
| 235 | Wantarkhet | Minepyin- | Shan | Nankha Chaung | 440 | 12'-4" | R.C Well | R.C | Bailey | 2005 | 5 | 2009 | 2 |
| 236 | Mai Pon | Meiktila- | Shan | Namg Pon Chaung | 208 | 30' | R.C Well | R.C | R.C | 2006 | 3 | 2007 | 11 |
| 237 | Nam Pong | Lashio-Kyay | Shan | Nam Pong Chaung | 180 | 30 | R.C Well | R.C | R.C | 2006 | 4 | 2009 | 8 |
| 238 | Lein Li | $\begin{aligned} & \text { Pyinmanar- } \\ & \text { Pinlong } \\ & \hline \end{aligned}$ | Shan | Paung Long Chaung | 1,760 | 34 | R.C Well | R.C | Steel Truss <br> Suspension | 2006 | 9 | 2010 | 11 |
| 239 | Thibaw | MDY-Lashio | Shan | Doatta Wady | 569 | 38 | R.C Bored Pile | R.C | Steel Truss R.C | 2008 | 5 | 2011 | 3 |
| 240 | Win-Wa | DWI-KTH | Tanintharyi | Win-Wa | 500 | 12'-4" | R.C Pile+Well | R.C | Bailey | 1995 | 7 | 1998 | 4 |
| 241 | Pulaw | DWI-KTH | Tanintharyi | Pulaw | 600 | 12'-4" | R.C Precast \& bored Pile | R.C | Bailey | 1997 | 1 | 1998 | 12 |
| 242 | Pulauk | DWI-KTH | Tanintharyi | Pulauk | 500 | 12'-4" | R.C Well | R.C | Bailey | 1997 | 9 | 1998 | 12 |
| 243 | Tanintharye | DWI-MYK-KtG | Tanintharyi | Tanintharye | 1,360 | 12'-4" | R.C bored Pile | R.C | Bailey | 1999 | 6 | 2000 | 11 |
| 244 | Lay Nyar Mun Dai | DWI - KTH | Tanintharyi | Lay Nyar | 860 | 30 | R.C Well\& Bored | R.C | PC | 2000 | 6 | 2003 | 10 |
| 245 | Kywe Ku Kyauk Phyar | DWI - KTH | Tanintharyi | Kyauk Phyar | 3,612 | 40 | R.C Bored Pile | R.C | Steel Truss PC+Steel Girder | 2000 | 11 | 2003 | 10 |
| 246 | Yay Pone | MLM-YE-DWI | Tanintharyi | Yay Pone Chaung | 200 | 32 | R.C Well Open Foundation | R.C | R.C | 2005 | 7 | 2009 | 4 |
| 247 | Thone-Khwa | TNL-PGO | YGN | - | 224 | 38'-6" | R.C Well | R.C | P.C | 1985 | 10 | 1991 | 12 |
| 248 | Thone-Khwa | TNL-PGO | YGN | - | 224 | 38'-6" | R.C Well | R.C | P.C | 1985 | 12 | 1989 | 3 |
| 249 | Thanlyin | YGN-YLN | YGN | Bago | 5,977 | 67'-24" | R.C Well | R.C | Steel Truss | 1985 | - | 1993 | 7 |
| 250 | Dagon | N/OKL-DGN | YGN | Nga-Moe-Yeik | 600 | 40' | R.C Pile | R.C | P.C | 1989 | 6 | 1992 | 3 |
| 251 | Tha-Khut | DLA-KMU | YGN | Tha-Khut | 495 | $17^{\prime}$ | R.C Pile | R.C | P.C | 1990 | 10 | 1992 | 12 |
| 252 | Bayintnaung | BYN | YGN | Hlaing | 1,640 | 42' | R.C bored Pile | R.C | Steel Truss | 1991 | 4 | 1994 | 7 |
| 253 | Dayebo | YGN-MDY | YGN | Da-Ye-Bo | 220 | - | R.C Well | R.C | P.C | 1992 | 11 | 1993 | 4 |
| 254 | U-Do | UTO-CTW | YGN | Hlaing | 780 | 12'-4" | R.C Precast \& bored Pile | R.C | Bailey | 1993 | 3 | 1995 | 4 |
| 255 | Tawpele | DLA-DDY | YGN | Tawpele | 186 | 38' | R.C Pile | R.C | P.C | 1994 | 4 | 1996 | 2 |
| 256 | Parame | SOKL-STW | YGN | Nga-Moe-Yeik | 664 | 40' | R.C Pile | R.C | R.C | 1994 | 6 | 1997 | 9 |
| 257 | Kad-Da-Pa-Na | KDP-PTA | YGN | Mhaw-Wun | 188 | 13' | Timber | Timber | Timber | 1995 | 4 | 1995 | 12 |
| 258 | Kha-Naung | KDP-PTA | YGN | Maw-Wun | 180 | $13 '$ | Timber Pile | Timber | Timber | 1995 | 4 | 1995 | 12 |
| 259 | Bar-Lar | No(7)hw | YGN | Bar-Lar | 211 | 86' | R.C Well | R.C | R.C | 1995 | 11 | 2001 | 2 |
| 260 | Aung-Ze-Ya | ISN-HTY | YGN | Hlaing | 3,780 | 52'-6" | R.C Precast \& bored Pile | R.C | Stayed Cable | 1997 | 4 | 2000 | 8 |
| 261 | Mahabandoola | YGN-DBN | YGN | Pazaundaung | 3,643 | 84' | R.C Precast \& bored Pile | R.C | Stayed Cable | 1998 | 1 | 2000 | 7 |
| 262 | Shwe-Pye-Thar | SPT-HTR | YGN | Hlaing | 3,415 | 64'-6" | R.C Precast \& bored Pile | R.C | Steel Truss | 1998 | 1 | 2001 | 1 |
| 263 | Thin-Gan-Gyun | TGK-DGN | YGN | Nga-Moe-Yeik | 700 | 84' | R.C Precast \& bored Pile | R.C | R.C | 1998 | 1 | 1999 | 3 |
| 264 | Don-Byike-Inn | TKI-TKA | YGN | Don-Byike-Inn | 200 | 12'-4" | Timber Pile | Timber | Bailey | 1998 | 5 | 1999 | - |
| 265 | Inn-Lan | TKI-TKA | YGN | Inn-Lan | 205 | 12'-4" | Timber Pile | Timber | Bailey+Timber | 1998 | 5 | 1999 | - |
| 266 | Myo-Chaung | GGN-MCN | YGN | Hlaing | 1,940 | 34' | R.C Precast \& bored Pile | R.C | R.C | 1999 | 1 | 2000 | 3 |
| 267 | Ye-Paw-Taung | MHW-YPT | YGN | Bawle' | 1,940 | 34' | R.C Precast \& bored Pile | R.C | R.C | 1999 | 2 | 2000 | 10 |
| 268 | Ta-Man-Yoe | No(7)hw | YGN | Ta-Man-Yoe | 180 | 36' | R.C bored Pile | R.C | R.C | 1999 | 12 | 2001 | 2 |
| 269 | DGN | YGN-Thanwlyin | YGN | BGO | 4,540 | 84' | R.C Bored Pile | R.C | P.C+R.C | 2000 | 5 | 2007 | 10 |

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| Sr |  |  |  | Name of | Length |  | Type |  |  | Date of |  | Date of Completion |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. | Bridge Name | Road Name | State/Division | River / Creek |  | (ft) | Foundation | Substructure | Superstructure | Year | Month | Year | Month |
| 270 | Phaung Gyi | Hlegu-Phaung | YGN | Nga Moe Yeik | 240 | 36'-0" | R.C Casing + R.C | R.C | R.C | 2001 | 1 | 2002 | 8 |
| 271 | Shwe Linban | Tapin Shwe Htee | YGN | Shwe Lin Ban | 208 | 50 | R.C Pile | R.C | R.C | 2002 | 8 | 2006 | 7 |
| 272 | Pan Hlaing | Hlaing Thar Yar - Twante | YGN | Pan Hlaing | 1,940 | 36 | R.C Bored Pile | R.C | P.C + R.C | 2002 | 11 | 2005 | 10 |
| 273 | Twante | $\begin{array}{c\|} \hline \text { Hlaing Thar Yar- } \\ \text { Twante } \end{array}$ | YGN | Twante Canal | 3,570 | 36 | R.C Bored Pile | R.C | Steel Truss Supension | 2003 | 12 | 2006 | 5 |
| 274 | Rakhine Chaung | DLA-Let Kokkon | YGN | Rakhine Chaung | 250 | 30 | R.C Bored Pile | R.C | R.C | 2004 | 3 | 2006 | 1 |
| 275 | Nga Moe Yeik (KAMR Kyi) | Thuwana-Thaketa | YGN | $\begin{gathered} \text { Nga Moe Yeik } \\ \text { Chaung } \end{gathered}$ | 970 | 60 | R.C Bored Pile | R.C | P.C+R.C | 2004 | 5 | 2007 | 4 |
| 276 | Kayan Chaung | BGO-Tanatpin- Kayan- ThonGWA-TLN | YGN | Kayan Chaung | 220 | 34 | R.C Bored Pile | R.C | R.C | 2005 | 3 | 2006 | 6 |

Appendix-1

| 1 | YGN | Yangon | 28 | STE | Sin-Te | 54 | STN | Sittaung |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | PTN | Pa-Thein | 29 | MMA | Myaung-Mya | 55 | LPN | Letpadan |
| 3 | TLN | Thanlyin | 30 | LPT | Laputta | 56 | HTT | Hinthada |
| 4 | BGO | Bago | 31 | GWA | Gwa | 57 | SSN | Se-Sine |
| 5 | ANN | Ann | 32 | SPU | Seik-Phyu | 58 | KDG | Ga-Du-Gyi |
| 6 | KLW | Kalaywa | 33 | PKK | Pakokku | 59 | SML | Sar-Ma-Gyi |
| 7 | MYA | Monywa | 34 | PPN | Phyapon | 60 | MK | Mawkyun |
| 8 | NDN | Nyaung-Don | 35 | BGY | Bogalay | 61 | SLN | Sa-Lin |
| 9 | OKA | Oak-Ka-Lar | 36 | TYN | Tant-Yan | 62 | PPU | Pwint-Phyu |
| 10 | DGN | Dagon | 37 | PSN | Pan-San | 63 | TKI | Tike-Kyi |
| 11 | PUK | Pauk | 38 | KDN | Kyonkadon | 64 | TKA | Thone-Khwa |
| 12 | KTU | Kyaukhtu | 39 | AMR | Amar | 65 | CU | Chaung-U |
| 13 | DWI | Dawei | 40 | MHA | Min-Hla | 66 | CTR | Chaung-Thar |
| 14 | DLA | Dala | 41 | TNG | Ta-Nyaung | 67 | GGN | Gyogone |
| 15 | KMU | Kaut-Mu | 42 | KDP | Kadapana | 68 | MCN | Myo-Chaung |
| 16 | MDY | Mandalay | 43 | PTA | Pan-Taw | 69 | MC | Myinchan |
| 17 | TWE | Than-Dwe | 44 | BMW | Bhamaw | 70 | YWN | Ye-Wun |
| 18 | TGP | Taungup | 45 | MKN | Myitkyina | 71 | KTW | Kyauk-Taw |
| 19 | MBA | Minbya | 46 | MPN | Mongpan | 72 | MYK | Myeik |
| 20 | KLT | Kyite-Latt | 47 | MTN | Mongton | 73 | HTY | Hlaing-Thar-Yar |
| 21 | MUB | Maubin | 48 | DDY | Dedaye | 74 | PNK | Pe-New-Kone |
| 22 | TTY | Tun-Tay | 49 | TM | Tamu | 75 | KK | Kyaukgyi |
| 23 | THN | Thahton | 50 | STE | Sayti | 76 | MPT | Mong-Phyat |
| 24 | PAN | Pa-An | 51 | NTY | Naung-Taya | 77 | MST | Mong-Sat |
| 25 | PY | Pyay | 52 | KTL | Kyauk-Talone | 78 | MBU | Minbu |
| 26 | STW | Sittwe | 53 | WAW | Waw | 79 |  |  |

## Appendix-2 Bridge Diagnosis (Field Survey)

This work was a field survey intended to figure out about the present state of design, execution, and other technologies in order to transfer technology by confirming the results of the BETC project.
The results are categorized by bridges surveyed for each survey, because individual road technologies were not surveyed.

## 1. Survey procedure

The field survey was performed divided into two halves: the first half and last half of the period that the survey team was in Myanmar. The survey examined bridges on ordinary roads (major trunk roads, etc.) and bridges. And the team also surveyed expressway bridges in order to clarify the present state of the most advanced technologies.
The following report outlines the survey procedure and the major objects of the survey.

|  | period | Location |
| :---: | :---: | :---: |
|  | The First half <br> $12-14,16-17$ <br> May 2012 | Eastern Yangon to Mawlamyaing route <br> Sittanung Bridge, Thanlwin Bridge etc. 4 points <br> Road <br> Weston Mandalay Route <br> Ayaewawady Bridge (Pakokku, Yadanabon etc. 5 points |
|  | The Second half <br> $13-14,20 ~ 26-29$ <br> May 2012 | At the periphery of Yangon <br> Anungzaya Bridge, Thuwunna Bridge etc. 4 points <br> At the periphery of Pathein <br> Nagwun Bridge, Pathein Bridge etc. 5 pints <br> At the periphery of Mandaley <br> Yadanabon Bridge, Malun Bridge etc. 4 points |
| Exp-Way | 14-15, 18 <br> May 2012 | Yangon Mandalay Expressway 18 points |

## 2. Field survey Ordinary roads (major trunk roads etc.: first half)

## 2-1. Range of the survey

The survey locations were set in the eastern part of Yangon and western part of Mandalay: on a route designated as the Asian Highway, a proposed route of the Asian Highway in Myanmar, and in the range of the India-Myanmar-Thailand Tripartite Highway Road.

Western Mandalay is a region crossed by the Tripartite National Highway. The bridge surveyed in this region was the Ayeyarwady Bridge (Pakkoku Bridge), the longest bridge in Myanmar (about 3.5 kilometers (11,431 feet) over the river). Its construction began in December 2009, and was completed two years later in December 2011.
In Eastern Yangon, the bridge surveyed was the Thanlwin Bridge (Mawlamyaing, about 2.4km (7,699 feet) over the river) which is Myanmar's second longest bridge, completed in April 2005 (construction started in March 2000).



Western Mandalay Route
(May 16, 17, 2012)

※A to I show the survey bridge point

2-2 Condition of the roads

## 2-2-1 Eastern Yangon to Mawlamyaing Route

The following is a description of the conditions of the roads (entered in the sequence: Yangon to Mawlamyaing)

- NH8 is a new route constructed as far as A (the old route is on the north side). It includes many two-lane (inbound/outbound lanes) sections, and in some parts, it is not sufficiently wide including the shoulders.
- In the $\mathrm{A} \rightarrow \mathrm{B}$ section, the shoulders have been widened. We presumed that when the main traffic lanes were repaved, the shoulders were also paved.
- The traffic volume in the $\mathrm{A} \rightarrow \mathrm{B}$ section is estimated as approximately 4,000 to 7,000 vehicles/day based on to observation of the traffic flow. The number of motorcycles traveling on the road tends to be higher on weekdays than on weekends. And on weekdays in particular, about half of all the vehicles traveling on the road are motorcycles.
- In the $B \rightarrow C$ section, the shoulders have been widened. We presume that when the traffic lanes were repaved, the shoulders were also paved.
- The traffic volume in the $B \rightarrow C$ section, is estimated as approximately 4,000 to 7,000 vehicles/day based on observation of the traffic flow. The number of motorcycles traveling on the road tends to be higher on weekdays than on weekends. And on weekdays in particular, about half of all the vehicles traveling on the road are motorcycles. The number of standard automobiles traveling on weekdays was higher than in the $A \rightarrow B$ section, but this is a primarily a result of counting compact special vehicles.

From Mawlamyaing to a road on the south end (to Mudon), widening work has progressed, with width sufficient for four lanes found in many sections. But because the lane marking work has not been done, the locations of the lanes are not clear.

- Overall, repair work seems to be progressing on the paved roads beginning with damaged locations. This includes partial repair work, and repairs seem to have been made several times, and there are level differences at execution boundaries but these are not very high. There are a number of medium and small sized bridges scattered along the road, and there is a danger of accidents caused by vehicles colliding with the bridge barriers.
- The route to D is a route which branches from NH8 at Bilin. A route which branches from NH8 towards the ocean, after it leaves NH8, it changes from a paved road to a dirt road. The earth work is severely rutted, but it has been repaired by local residents.

State of the surveyed road


| A West side (westbound lane) May 12 (Sat.) 2012 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Vehicle type | Survey time (a) <br> $12: 20 \sim 12: 30(10$ min.) | Converted to 1 hour(b) <br> (a) $\times 6 \mathrm{X}$ | Converted to daily section traffic <br> (b) $\times 10 \times 2$ directions |  |
| Ordinary vehicle | 12 | 72 | 1440 |  |
| Large vehicle | 8 | 42 | 840 |  |
| Bus | 4 | 24 | 480 |  |
| Motorcycle | 12 | 72 | 1440 |  |
| Total | 36 | 216 | 4320 |  |


| A West side (eastbound lane) May 14 (Mon.) 2012 |  |  |  |
| :---: | :---: | :---: | :---: |
| Vehicle type | Survey time (a) <br> $11: 40 \sim 11: 50(10$ min.) | Converted to 1 hour(b) <br> (a) $\times 6 \mathrm{X}$ | Converted to daily section traffic <br> (b) $\times 10 \times 2$ directions |
| Ordinary vehicle | 13 | 78 | 1560 |
| Large vehicle | 6 | 36 | 720 |
| Bus | 5 | 30 | 600 |
| Motorcycle | 38 | 228 | 4560 |
| Total | 62 | 372 | 7440 |


| B to C (southbound lane) May 13 (Sun.), 2012 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Vehicle type | Survey time (a) <br> $14: 10 \sim 14: 20(10$ min.) | Converted to 1 hour(b) <br> (a) $\times 6 \mathrm{X}$ | Converted to daily section traffic <br> (b) $\times 10 \times 2$ directions |  |
| Ordinary vehicle | 9 | 54 | 1080 |  |
| Large vehicle | 7 | 42 | 840 |  |
| Bus | 4 | 24 | 480 |  |
| Motorcycle | 16 | 96 | 1920 |  |
| Total | 36 | 216 | 4320 |  |


| B to C west side (northbound lane) May 14 (Mon.) 2012 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Vehicle type | Survey time (a) <br> $12: 20 \sim 12: 30(10$ min.) | Converted to 1 hour(b) <br> (a) $\times 6 \mathrm{X}$ | Converted to daily section traffic <br> (b) $\times 10 \times 2$ directions |  |
| Ordinary vehicle | 20 | 120 | 2400 |  |
| Large vehicle | 5 | 30 | 600 |  |
| Bus | 1 | 6 | 120 |  |
| Motorcycle | 32 | 192 | 3940 |  |
| Total | 58 | 348 | 6960 |  |

※The one day conversion was done tentatively using a conversion factor of 10 , because there were no grounds.

### 2.2.2 Western Mandalay Route

The following is the condition of the road. (Described in sequence to the south-west, or to the west from Mandalay)
(To the west from Mandalay)

- The route which passes through FG and continues towards H is the India Route of Asian Highway No. 1. The section the team traveled on had wide shoulders and two lanes, inbound and outbound, and its flatness was good so it was pleasant to drive in this section.
- There are almost no lane markings, but they are marked in curves. And at curves, columns are installed to prevent vehicles from leaving the road. It appears that such measures have been taken because it is a section with high priority on safety.
(Southwest from Mandalay)
- On NH 12 , there are many dirt road or gravel road sections. So it is extremely unpleasant to drive in this section, and traveling takes a long time. During the survey, we met only a few ordinary vehicles and a little more than 10 large vehicles each hour, showing that its traffic volume is low.
- Gradually, sections where partial paving work had been done appeared. But many places remain where there either is no bridge (overflow bridge) or places with simple wooden bridges.
- On NH2, many sections are still dirt or gravel covered, but paving work has been done in many sections. In the section from the expressway to the bridge at $E$, about $30 \%$ is still unpaved
- In paved sections, the road is wide enough for two lanes; one inbound and one outbound. It appears that initially, shoulders were built, but were damaged at many locations.
- The bridges on the route are also crossed by railway tracks (not side by side). Because these are placed like streetcar tracks, there are gates at opposite ends of each bridge to prevent cars from crossing the bridge at the same time as the railway cars.

State of the surveyed road


## 2-2-3. Paving Work

On the routes which were surveyed, the team saw sites of new construction work or improvement work on the paved roads. Among these, we report on the new road work being done near the Ayeyarwady Bridge (Pakkoku Bridge) on National Highway No. 2.
The work was permeable macadam pavement (asphalt macadam pavement). Permeable macadam pavement is pavement made by first spreading aggregate, then spreading bitumen (asphalt emulsifier), performing permeability processing, then roller compacting the surface. At this site, the hot penetration method was used.

The way the work is done is outlined below using photographs. Photo [1] shows crushed rock (about 10 cm ) already transported to the road side being placed on the road. It is a two lane road, so the work was done by alternately closing one lane to traffic and allowing traffic on the other lane. Photo [2] shows workers manually spreading the crushed rock. They are placing stakes to ensure that the material is spread to an equal thickness. This is manual work, but to a certain degree it ensures uniform thickness of the crushed rock. Photo [3] shows roller compaction of the crushed rock which was manually placed. Crushed rock at uneven places is broken, filling the spaces to some degree. Photo [4] shows sand spread on top of the crushed rock. This sand fills the gaps between the rock pieces. After this work has been completed, the surface is compacted again by roller. Photo [5] shows the bitumen material being superheated. And workers were also seen heating bitumen material in drums. The heated bitumen material is spread on the road and again roller compacted. Photo [6] shows the road after the work has been completed.


## 2-3 Bridge survey

2-3-1 Survey and challenges

## (1) Specifications of the bridges surveyed

The following are the principal specifications common to the bridges surveyed.
In order that differences between these and the above expressway bridges are easy to understand, (*) are attached to points of difference.

Bridge length: 15 m to $3,500 \mathrm{~m}$ (*) $^{*}$
Form: [1] and [2] are simple girder bridges, excluding [3] and [4].
Between abutments, many are [1] [2] independent or combined. Several bridges are prestressed concrete. [3] and [4] which also served as railway bridges were connected (not continuous bridges) in some cases (*).
[1] Reinforced concrete T* girders pan L = approx. 15m
※Girder are I-girders without top flanges. They differ from T girders, but below T* girder will be entered for convenience.
[2] Prestressed concrete I girders Span L = approx. 25m
[3] Steel continuous truss Span L = over 100m, shared with railway tracks (*)
[4] Steel arch Span L = over 100m, shared with railway tracks (*)
Bridge with spans from 25 to 100 m : we think there are no box girders, which are adopted in Japan.

Deck slabs: RC deck slabs are not linked above support points.
From a visual inspection, it is presumed that because there are precast joints on the bottom surface of the deck slabs, either concrete was poured after the precast form slabs were installed between the main girders or they are precast deck slabs (*).
Bearing and support point condition:
[1] Reinforced concrete $T^{*}$ girders, steel plates, ( movement unrestricted)
[2] Prestressed concrete I-girders (movement unrestricted)
[3] Steel continuous truss, BP bearing, pin bearing, roller bearing, FMM 1-point fixed (*)
[4] Steel arch cannot be confirmed. Thought to be the same as [4] (*)
Bridge piers: Reinforced concrete column type bridge piers (T-type, multi-column type) approx. 10 m or lower.

Bridge abutments: reverse T-type abutments approx. 5 m
Foundations: cast-in-place concrete piles, caisson foundations
Expansion devices:
[1] No reinforced concrete T$^{*}$ girders
[2] No prestressed concrete I-girders
[3] Steel continuous truss, product joints similar to finger joints (*)
[4] Steel arch, product joints similar to finger joints (*)
Handrail (Bridge railing) : Concrete

## (2) Typical damage

Main girders, cross beams:
[1] Reinforced concrete $T^{*}$ girders Coated.
On main girders, many rock pockets, and some are not compacted enough.
[2] Prestressed concrete I-girders Coated
On main girders, many rock pockets, and some are not compacted enough.
There is rusting of bearing plates and anchor nuts of transverse prestressing steel of cross beams. Steel may be corroded.
[3] Steel continuous trusses: There is rust thought to be caused by water leaking from expansion devices at truss panel points on the girder ends. (*)
[4] Steel arches: Cannot be confirmed by close-up visual inspection. (*)

## Deck slabs: Reinforced concrete deck slabs

[3] Steel continuous truss: deck slabs were poorly executed. On deck slabs between stiffening girders, there are traces of repair work done from below. (*)

On another bridge, there were many cracks in the deck slabs. Steel reinforcing bars are partly exposed. (*)

Bearings: [1] Reinforced concrete $T^{*}$ girders: steel plates and iron plates are rusted and there are traces of rust fluid on abutments and piers.
[2] Prestressed concrete I-girders: steel plates, same as [1]
[3] Steel continuous trusses: no damage. (*)
[4] Steel arches: unconfirmed. (*)
Bridge piers: Reinforced concrete column type piers (T-type, multi-column type)
Coated. No damage caused by leaking has been confirmed on intermediate bridge piers. External appearance is fine.
Abutments: reverse T-type abutments There are some with inclined abutment bodies. Abutment foundations are scoured by the flowing water of the river, and we think it is possible it was pushed by earth pressure behind the abutments, so action is necessary.
Revetment use block masonry around the abutment has partly caved in as a result of the inclination of the abutment.

Foundation: cast-in-place concrete piles
Many piles of both bridge piers on rivers and of abutments have become elevated piles as a result of scouring. It is not confirmed that they were designed as
elevated piles. We think a response including the abutment bodies is necessary.
Expansion devices :
[1] Reinforced concrete $T^{*}$ girders: expansion devices could not be confirmed. There is constant leaking from the road surface above support points (*)
[2] Prestressed concrete I-girders: same as [1] (*)
[3] Steel continuous trusses: no damage (*)
[4] Steel arches: no damage (*)

Road surfaces: There are cracks and gaps in parts without expansion devices.

Drainage: drainage pipes are installed through the deck slabs, draining water into the river. With no plumbing work from the earth work around the abutment, the soil at the front surface of some abutments was eroded.

## (3) Challenges

## Scouring

- Leaning abutments caused by scouring
$\rightarrow$ We think it is necessary to build erosion barriers to prevent scouring and to fill the scoured parts to stop the leaning of the abutments.
For example, a wall foundation or an underground diaphragm can be built around the existing footing (is it difficult to deploy machines?)
- Scouring of bridge pier foundations
$\rightarrow$ Because it has become elevated piles, the design must be checked again.
- Planning the arrangement of bridge abutments or piers
$\rightarrow$ Scouring occurs because the bottom surface of the footing is above the riverbed or there is an abutment in the river.
$\rightarrow$ The river area or planned riverbed etc. must be appropriately set.
$\rightarrow$ A river plan by the river manager is necessary.
- Appropriate water plumbing treatment
$\rightarrow$ Road surface water flows into abutments from earth work part, forming a water path in front of the abutment, causing erosion.
$\rightarrow$ Appropriate water plumbing treatment is necessary.

Quality of concrete -main girder, deck slabs, wall rails-

- It can be concrete with high water content.
$\rightarrow$ When ready mix concrete is made, quality at pouring time is thoroughly controlled.
- There are many rock-pockets on the main girders.
$\rightarrow$ It is thoroughly compacted. It might not have been vibrated.


## Corrosion of steel bearing plate and anchor nut of prestressed concrete

$\rightarrow$ If a nut is out of place, the steel could be pulled out so rust prevention is necessary.
On a Japanese bridge, the anchor part is generally buried in mortar after blocking out and tension anchoring the concrete.
$\rightarrow$ Rusting must be watched for under present circumstances.

## Leaking from girder ends

$\rightarrow$ Regardless of whether there is or is not an expansion device, there is leaking, conveying road surface water to the abutments and piers. Because salt damage caused by freezing prevention chemicals does not occur as it does in on expressways in Japan, we assume this is a small problem, but we think it would be better for the ends of the girders of steel bridges to be rust-proofed and for bearings of RC bridges and PC bridges to be rust-proofed by iron plates and to have undrained structures.

## Cracking and gaps of road surface in parts without expansion devices

$\rightarrow$ There are problems driving, but we think there are no structural problems at this time. It will be handled according to the views of the government of Myanmar.

2-3-1 Conditions at the site
(A) Sittaung Bridge (Motpaline)

1) Outline

It is a bridge with length of about 730m (2,392.7 feet) crossing the Sittaung River on National Highway No. 8.


The Sittaung Bridge (Theinzayat: built 1942) is on the north side of this bridge. This bridge was deteriorated, so using it at night was then prohibited.
For this reason, on its downstream side, this bridge was provided for use on July 12, 2008.
Its form is: a RC simple girder +2@steel bridge +4@span trusses (above the river) +2@steel bridge + RC simple girder.
2) Condition

- Leakage from the joints have already soiled the girders and bridge piers. Above the RC, there is a bearing consisting only of an iron plate, so its functions might be lost because of corrosion deterioration caused by
 water.
- No shear connectors were installed on the girders at right angles in the bridge axis.
- The embankment is a front-filled bridge embankment, and the ends of the main girders are completely covered with block pitching. So it is a structure whose bearings etc. cannot be visually inspected and maintained. There is a
 weak point that settlement of the embankment near the girder ends might accumulate water.
(B) Bilin Bridge

1) Outline

This is a bridge on National Highway No. 8 crossing the Bilin River. It is a $7 @ P C$ simple girder bridge. The girders are larger over the high water channel than over the low water channel.

2) Condition

- The wall rail etc. is overall extremely soiled.
- The bearings of the abutments (fixed shoes) are corroded. We assume it was probably caused by leaking. Similarly, deterioration of the girder ends has progressed.
- The bearing plates of the transverse prestressing have bulged up. Steel bars are anchored in place only by the threading of the bearing plate, and an anchor (nut etc.) is not installed.
- On the pier, the ends of the girders are severely deteriorated by leaking water. On the road surface, there is a pavement
 overlay from above the existing joint (angle material), but there are gaps at the girder ends, and water blocking measures are not taken.

(C) Thanlwin Bridge (Mawlamyine)

1) Outline

This is a combined road-railway bridge across the Thanlwin River on National Highway No. 8. The road and railway tracks diverge in the approaches, so the lengths of the two bridges are different. The truss bridge above the river extends for about 2,350m (7,699 feet) (21@truss bridge:
 caisson foundation).
The road approach bridge ( $R C$ bridge) is about 1,180m (1,624+2,252 feet) on both banks, and its total length as a road bridge is about $3,530 \mathrm{~m}$. The railway approach bridge is about $4,250 \mathrm{~m}(6,442+7,498$ feet) on both banks, and its total length as a railway bridge is about $6,590 \mathrm{~m}$. The road bridge is about 9 m ( 28 feet) wide, and the railway bridge is about 5 m ( 14 feet) wide.
In 1998, the geological survey was done, and on March 18, 2000 the work began (date of groundbreaking ceremony). About four and a half years later on December 7, 2004, the work was completed and the bridge was officially opened in February 2005. Because the bridge is located at the point of convergence of the Gyanin River and the Attayan River, rapids made the work difficult to execute. But thanks to the technical prowess of Myanmar technologists, they were able to complete this difficult work, and their feat was described at the opening ceremony. When it was opened for service, it was the longest bridge in Myanmar. The team was told that Myanmar did not have the technology to build a long bridge, but by the time this bridge opened, it had obtained such know-how.

## 2) Condition

- The foundation was badly scoured. The piles were under the footing, and appeared to be cut. It is possible they were cut, because the scouring around the piles caused by the flowing water had reduced the horizontal resistance of the
 piles.
- Places where the bolts had fallen out were seen. It is concerned that the bridge is not adequately inspected and maintained.
- There was deterioration around the drainage pipes. Deck slab concrete around the drainage pipes had peeled off, exposing rebars.
- Panel points on the ends of girders were rusted.
- It was constructed so that road surface water fell from the drainage pipes onto the bridge piers.

- Water leaking from the expansion device on the bridge surface was severely soiling the bridge piers.
- The bridge piers were cracked. Because it is close to the ocean, a detailed inspection must be done.

- The concrete panels on the sidewalk are deteriorated. There is danger that they will fall out.

D) Branch from National Highway No. 8

1) Condition

When entered the branch from the national highway, the further traveled, the less pavement there was, until it became a dirt road. In this region, there are many small rivers and canals, so there are many small bridges, but two characteristic bridges are introduced.
The photos on the top right show an integrated concrete bridge.
 The center of the span of the main girders sags deeply. It is possible that the foundation settled, because there are no supporting piles.
The photos on the lower right show a simple cable-stayed bridge. It is a steel bridge with a truss structure as its principal structure. The roads at both ends of the bridge are dirt roads, but simple pavement is executed on the bridge surface.

(E) Ayeyawady Bridge (Pakokku)

1) Outline

This bridge which is a combined road and railway bridge across the Ayeyawady River, is the longest bridge in Myanmar. It is on the route of the India - Myanmar Thailand Tripartite Highway Road.
The work started on December 15, 2009, and was conducted by Bridge Construction Group 3 authorized by the Public Works (PW) Agency. The bridge is about 4 km in length, but it went into service on December 31, 2011, only about 2 years after the start of
 construction.

The road and railway tracks diverge on the approaches so their bridge lengths are different. The length of the truss bridge ( 30 spans) over the river is about $3,480 \mathrm{~m}$ ( 11,431 feet). The road's approach bridge ( RC bridge) is about 640 m ( $1,378+728$ feet) on both banks, so the total road bridge length is about 4,120m. The railway approach bridges are about 2,740m (5,420 $+3,746$ feet) on both banks, so the total length of the railway bridge is $6,220 \mathrm{~m}$. To let ships pass under this bridge, clearance from the water's surface is about 80 m ( 262 feet) for about 16 m ( 52 feet) wide. The road bridge is about 9 m ( 28 feet ) wide, and the width of the railway bridge is about 4 m ( 14 feet). Sidewalks about 1 m ( 3 feet 3 inches) wide are installed on both the left and right sides.
2) Condition

- It was just completed, so the expansion devices etc. are sound and the drivability of the bridge is good.

- There are no sufficient length of bolts on its nuts (bolts are not long enough). It is assumed that the delivery of the materials was not adequately controlled.

- A cable is passed under the railing, but one part only hung on a steel iron bar and a part with its height adjusted by a wooden panel remained, so it is still in temporarily installed state.

- Slope protection work executed by block pitching has been done. But the block pitching work is not sufficiently embedded so there is fear of damage to the block pitched foundations.

(F) Inwa Bridge

1) Outline

This bridge is a 13 span Warren truss combined road and railway bridge (approx. 1,200m (3,948 feet)) across the Ayeyawady River.

It was constructed by the British in 1934, but during the Second World War, two spans
 were destroyed to block the advance of the Japanese army. Following the end of the war, the bridge returned to normal use in 1954 after the damaged parts were repaired.

Beginning in 1992, the upstream Ayeyawady Bridge (Yadanabon) was constructed because it was difficult for vehicles heavier than 15 tons to cross this bridge, but it is still in use as a toll bridge. It was assumed that the Inwa Bridge, as a bridge constructed by occupiers, would have no more role to play after construction of the new bridge, but it has been preserved as a historical structure.
2) Condition

- Damage to the deck slabs could not only be confirmed visually, showing that they were severely damaged with large cracks accompanied by exposed steel reinforcing. Repair and reinforcing work must be executed.

(G) Ayeyawady Bridge (Yadanabon)

1) Outline

This bridge was planned in response to deterioration of the downstream Inwa Bridge, and went into service on April 11, 2008. Because the road and railway diverge on the approaches, the lengths of the two bridges differ. The truss bridge (30 spans) over the river is about $3,480 \mathrm{~m}(11,431$ feet) long. The bridge over the river (steel truss+3@steel arches) is 1,130m (3,694 feet) in length, and the approach bridges (RC bridges) are about 560 m (1,140 $=780$ feet) long on both banks, for a total length of about 1,690m.

To allow ships to pass under the bridge, clearance from the water surface is about 12 m ( 40 feet) for about 210 m wide ( 700 feet). The bridge is about 15 m ( 49 feet) wide, and sidewalks with width of about 2 m (6 feet) are built on the left and right sides.


In the front, the Ayeyawady Brige (Yadanabon) and in the background, the Inwa Bridge
2) Condition

- The bridge is in relatively good condition because only four years have passed since it was completed.
- An examination of the deck slabs from below revealed that they are extremely soiled. This was presumably caused by the execution method used to pour the concrete.

(H) Mu River Bridge, PC bridge west of Mynmu

1) Outline

This is 6@PC simple girder bridge crossing the Mur River on a route linking Sagain and Monywa on the Asian Highway Route. It is constructed parallel to a railway bridge.

2) Condition

- At B bridge discussed above, it was impossible to check the anchor bodies at the anchors, but these locations were tensioned with nuts. However the anchor bodies were not cured, so it is necessary to take measures to prevent rusting.
- Piles were exposed, but it is not clear that it was an elevated pile design.

- The river side of the abutments are scoured, and held in place by steel sheet piles.
- However, the crest concrete was already destroyed, so full-scale restoration should be done soon.

- Holes to pass PC cables through the girders were confirmed. It is not clear if the PC cables are now unnecessary because of a change of the shape of cross beams.
The design calculations of the cross beams should be checked.

(I) $\mathrm{NH} 2 / \mathrm{NH} 12$ bridges

1) Condition

Bridges built on NH2/NH12 are shown in photos


Truss Bridge with deck plate deck slabs


RC simple girder: Used as a railway and as a road bridge


There are locations without a bridge They have been improved as overflow bridges (concrete slabs).

## 3.Field survey Ordinary roads (major trunk road etc. ; Second half)

## 3-1. Range of the survey

The site survay was implemented to 13 bridges in the list shown in the table below this time. This includes two bridges of under construction.

The survey results concerning the bridge shown in the table below is wrapped up with photographes.

Table 1. Bridge list that executes one local investigation

| No. | Bridge Name | Type(Main Bridge) | Constructed Year |  |
| :---: | :--- | :--- | :--- | :--- |
| $(1)$ | Aungzaya(INSEIN)Br. | Cable Stayed | 2000 |  |
| $(2)$ | Bayinaung Br. | Truss | 1994 |  |
| $(3)$ | Twantay Br. | Suspension | 2006 |  |
| $(4)$ | Thuwunna Br. | PC Box | 1985 | designed and constructed in <br> the BETC project. |
| $(5)$ | Ngawun Br. | PC Box | 1991 | designed in the BETC project. |
| $(6)$ | Pathein Br. | Suspension | 2004 |  |
| $(7)$ | Myaungmya Br. | Suspension | 1996 |  |
| $(8)$ | Lapuda Br. | Suspension | 1998 |  |
| $(9)$ | Panmawaday Br. | Suspension | 2006 |  |
| $(10)$ | Yadanabon Br. | Truss,Arch | 2008 |  |
| $(11)$ | No.1Shwe Chaung <br> Br. | PC Girder | Under <br> Constructing |  |
| $(12)$ | Pakokku Br. | Truss | 2011 |  |
| $(13)$ | Malun Br. | Truss | Under <br> Constructing |  |

## 3-2. Bridge survey

## (1) Aungzaya(INSEIN)Br.

Bridge Type: Cable Stayed
Design and Making: China
Work : PW
Constructed year:2000


Situation of earthwork
-The earthwork part sunk and the guard concrete is floating.


## (2) Bayinaung Br.

Bridge Type: Truss
Design and Making: Italy
Work : PW
Constructed year:1994


Current situation


## (3) Twantay Br.

Bridge Type: Suspension (80.8+263.3+80.8=424.9m)
Design and Making: China (The approach girder is PW).
Work : PW
Constructed year:2006


Cover shot


Road surface condition


Wheel guard concrete

- Wheel guard concrete : gotten rid of concrete.
(There is a possibility of aimed at the decrease of the dead-weight load to recover the camber that hangs down.)
- The anchor reinforced concrete : as baring.
- Wreckage of scrapped concrete


Situation of slab


Expansion on the anchorage

- It opens by no engagement of joint device.


Situation of approach girder (1)

- An expansion gap of each piers has greatly width.

Situation of approach girder (2)

- Remarkable damage is not seen there.

Situation of approach girder (3)

- Web is soiled since the drainpipe does not have enough length.



## (4) Thuwunna bridge

Bridge Type: PC Box
Design and Making: Myanmar \& Japan (BETC)
Work: PW \& Japan (BETC training) and overhang mounted Dywidag method
-Bridge constructed as OJT of BETC training (1979-1985)

Cover shot


Situation of approach girder

- The remarkable damage of slab or girder is not observed this time..


Batting plant in the vicinity of Thuwunna bridge

(5) Ngawun Br.

Bridge Type: Continuous PC box girder of $(30+30+30 \mathrm{~m})+2$ simple PC I girder spans (77.5m+110m+77.5m)

Design: Myanmar \& Japan (BETC training)
Work: PW
Constructed year:1991 year

- Bridge designed by BETC training (1985)
- Construction; .after BETC. .under Japanese engineer guidance (Mr. Matsumoto)..
- Civil Engineering association Tanaka prize winning in 1991 fiscal year


Cover shot


## Approach girder (PC I girder)

- In the blueprint, pressetress has been introduced into a horizontal girder.
- Damage of girder or slab was not seen is not seen.


From the now Ann bridge

Bridge abutment

- The block pitching ware set up in front of the bridge abutment.

(6) Pathein Br.

Bridge Type:SUSPENSION
Design and Making: China
Work: PW
Constructed Year :2004


Situation of road amount

- The camber hangs down.


Situation of main tower

- A main tower has been displaced to the central span side by 107 mm (tower top).


Expansion apparatus on anchorage

- The expansion device on anchorage is open for the finger not to engage.



[^0]:    ${ }^{1}$ Detailed explanation of PDM is in Chapter-2.

[^1]:    ${ }^{2}$ New JICA Guidelines for Project Evaluation, First Edition, June 2010
    3 In academic terms this is referred to as a logical framework (logframe). The core of the theoretical composition of a logframe is a logic with the chain relationship of "activities - outputs - project purpose - overall goal". It is an if-then logic, as in: "If an activity is conducted, then an outcome was achieved. If the outcome is achieved, then the project purpose was fulfilled. If the project purpose was fulfilled, then it will help achieve the overall goal." Planning a project entails making a hypothesis.

[^2]:    4 This is a long-term effect that is expected as the result of a project. When a project is planned, how the overall goal contributes to the subject's development (or the development of the subject itself may be the overall goal, depending on the project) must be fully studied. In JICA technical cooperation projects, the overall goal is defined as "the outcome that takes place in the subject society about 3 to 5 years after completing the project." This is also called "final outcome".
    5 A direct effect on the target group (including people and organizations) or on the subject society that is expected as a result of implementing a project. "Project purpose" in the case of technical cooperation is generally achieved when the project is complete in principle. The level of achievement of this "project purpose" is an indicator of whether or not the project has produced results or of whether any meaningful result has been achieved from implementing the project.
    A project in which an output has been generated but no benefit has been produced for the target group will waste large inputs of resources. Such an outcome is also called an "intermediate outcome."
    6 Goods or services produced from a project in the process of fulfilling the "project purpose." The "project purpose" indicates positive changes for the target group and other beneficiaries, while the "output" is what is produced by the implementers of the project. For a project mainly consisting of training, for instance, "implementation of training" is an output, while "improvement of the trainees' knowledge" or "effective use of the learned skills at the work place" may be viewed in terms of project purpose level.
    7 A series of actions necessary to produce an "output" when using those "inputs" and a matter implemented by the project team at the project site. A logframe describes major activities that indicate the strategy of the project, but since it is a table of the outline plan, a detailed activity plan is prepared separately.

[^3]:    8 Resources necessary to produce an "output," which may include human resources, materials, equipment, running costs, and facilities). Inputs are described for the Japanese side and for the recipient country
    9 JICA (2010) p19

[^4]:    1041 is the number out of 59 trainees minus 13 untraceable trainees and five deceased.

[^5]:    ${ }^{11}$ A consultant firm formed by former employees of PW. It also receives study service contracts from PW.

[^6]:    ${ }^{12}$ The major viewpoints for the analysis of relevance are as follows:

    1) Necessity: does it meet the needs of the subject area or society or the needs of the target group?
    2) Priority: is it consistent with Japan's assistance policy or JICA's nation-specified project implementation plan? Is it consistent with the development policy of the recipient country?
    3) Relevance of the means: is the project appropriate as a practical strategy for the development task of the recipient country's subject field or sector? (Is the approach, subject, or area of the project appropriately selected? What synergy is expected from assistance cooperation with other donors? Is the selected target group appropriate (in terms of subject or scale)? Is Japanese technology predominant (is the know-how of the subject technology of Japan assimilated?))
    ${ }^{13}$ Japan provided yen loan for "Kyangin Cement Plant Expansion Project" in 1979.
[^7]:    ${ }^{14}$ The major viewpoints for analyzing effectiveness are as follows:

    - Is the Project purpose clearly established (are the indicators, target values, and acquisition means appropriate)?
    - Was the Project purpose achieved?
    - Was it generated from the output of the Project?
    - Was the Project affected by external conditions until it fulfilled its objectives?
    - What are the factors that promoted or impeded effectiveness?

[^8]:    ${ }^{15}$ Major viewpoints for analyzing impact are as follows: Has the overall goal been achieved (or will it be achieved)?

    - Did achieving the overall goal contribute to the recipient country's development plan?
    - Was achieving the overall goal a result of fulfilling the Project's purpose?
    - Did external conditions influence the Project until the overall goal was achieved?
    - Were there any unforeseen positive or negative influences (including repercussions)?
    - What factors promoted or impeded achieving the overall goal?
    - What factors caused unforeseen positive or negative influences?

[^9]:    ${ }^{16}$ Road improvement trends over the past decade are explained in detail in 3.1.2, Chapter 3.
    17 Data before 1990 could not be obtained.

[^10]:    18 Since there were cases where two people were involved in bridge construction the number of bridges is 102 although the total number of bridges constructed in 107.

[^11]:    ${ }^{19}$ The major viewpoints for analyzing efficiency are shown below:

    - Did or does the level of output achieved match the cost (input) (compared to similar projects of other donors or the recipient country)?
    - Was there any alternative way to achieve the goal at lower cost? Was it possible to achieve better results at the same cost?
    - What factors impeded or promoted efficient implementation of the Project?
    ${ }^{20}$ JICA Bridge Engineering Training Center (Burma): Series of Project System Technical Cooperation Activity Cases 10, pp6.

[^12]:    ${ }^{21}$ At this time, JICA has sole jurisdiction.

[^13]:    ${ }^{22}$ The major viewpoints for analyzing sustainability are shown below:

    - Will the effects aimed at by the Project, such as the Project purpose or overall goal, continue after assistance has ended?
    - What factors generated or impeded sustainability effects (is political support maintained, is there enough organizational capability to smoothly conduct activities, are personnel appropriately arranged, is the budget ensured, does the process of decision-making function properly, is the necessary technology maintained and diffused, are the materials and equipment properly maintained, and on.)?
    ${ }^{23}$ Figures calculated by year of start of construction

[^14]:    ${ }^{24}$ This is not a PC box girder bridge using the cantilever election method like Thuwunna Bridge or Ngawun Bridge.

[^15]:    ${ }^{25}$ The Tanaka Award was established in 1966.
    The Tanaka Award (Excellence in Bridge Design and Construction) recognizes a constructed or reconstructed bridge or a related structure that demonstrates excellent quality in planning, design, construction, maintenance, and management and exhibits technical and aesthetic excellence. Special or innovative techniques applied to a structure are also regarded as a subject of this award. 2011 award winners include the elevated bridge of the Metro in Dubai, the Ikina Bridge in Ehime prefecture, and the Tokyo Gate Bridge.

[^16]:    ${ }^{26}$ The abbreviations used refer to the following:

    Dy. Minister*: Deputy Minister (Union)
    MD (Managing Director)
    CE (Chief Engineer)
    SE (Superintending Engineer)
    EE (Executive Engineer)
    TE (Technical Engineer)

    Minister**: (Minister (Local))
    DMD (Deputy Managing Director)
    DCE (Deputy Chief Engineer)
    DSE (Deputy Superintending Engineer)
    AE (Assistant Engineer)

