Construction of Overseas Mini Hydraulic Power Plant

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Abstract

Mini hydraulic power generating facilities can produce electricity without requiring dams and/or large-scale water reservoirs. Such features are the one of the best solution for electrification in overseas less-populated areas where potential water-power resources are available.

Recently, we delivered mini hydraulic power generating facility in the Lao People's Democratic Republic with Japan's grant aid. Construction work for this project was carried out in an isolated site in Lao where the project site conditions are vastly different from those in Japan.

In cooperation of EAML Engineering Co., LTD. who has supply records of mini hydraulic power plants in Japan, we undertook a contract for the supply and construction of complete set of a mini hydraulic power plant with outdoor substation facility. The contract include installation engineering design, preparations for on-site work, on-site installation work, and installation management.

1 Preface

The Lao People's Democratic Republic ("Laos" hereafter) has rich potential hydro-power resources. The construction site is situated in Phongsaly Province in the extreme north region of Laos. The household electrification rate in this area is 23%[(1)], the lowest of all 17 prefectures in Laos. [Household average electrification rate is 80.13% (as of August 2012)][(2)]. As such, electric power is purchased from the neighboring country, People's Republic of China.

As a part of projects by Japan's grant aid, we recently accomplished the supply and installation of a mini hydraulic power plant. This project was challenging to carry out because we had no commercial base in Laos like other local subsidiary firms and we had to procure construction materials and workers from neighboring countries. This paper introduces an outline of the construction work and management for this project.

2 Outline of the Construction

2.1 Outline of the Project

(1) Name of the project: Laos Mini Hydropower Development Project

(2) Place of construction: Ou Thai Gnot Ou District, Phongsaly Province, Laos

(3) Project owner: Ministry of Energy and Mining Industries (MEM), Laos

(4) Planning and designing: TOKYO ELECTRIC POWER SERVICES CO., LTD. (TEPSCO)

(5) Contractor: HAZAMA ANDO CORPORATION

(6) Construction period: 8 November 2013 to 28 February 2015 (16 months)

(7) Loaned amount: ¥1,775,000,000.–

(8) Funds: Cooperation with the Japanese Government Grant Aid

(9) Contents of the project:

(a) Construction of a 450kW mini hydraulic power plant (intake weir, water intake, grit chamber, penstock, water storage tank, power plant, discharge channel, etc.)

(b) Extension of 22kV and 400V distribution grid line

(c) Supply and installation of power plant equipment (3 sets of permanent magnet subwater turbine generators, control equipment, main transformer, and outdoor substation equipment)

We have achieved a contact for the scope (c) from HAZAMA ANDO CORPORATION.

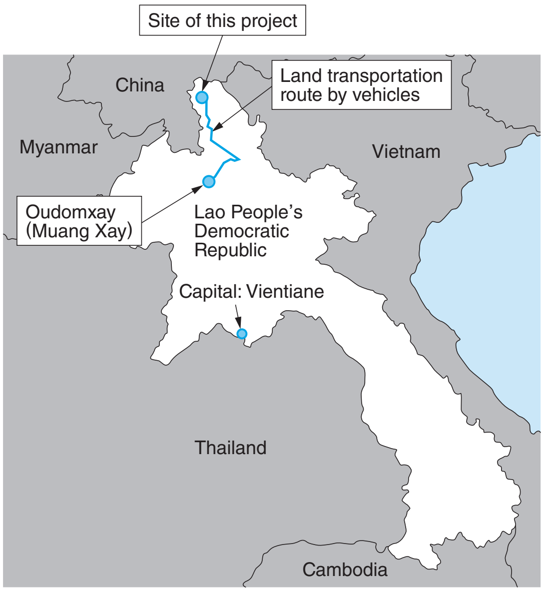

Fig. 1 **Lao People's Democratic Republic and Location of this Project Site**

Location of this project site in Laos is shown.

2.2 Location of Project Site

Fig. 1 shows the location of this project site. This project site is situated at the northernmost tip of Laos about 40km distance from the borderline with China. To reach the site, fly an hour from Vientiane, the capital of Laos, to Oudomxay, and then take an 8-hour drive to the project site. The last half of the road was predominately unpaved hills. During this project period, there was road improvement work to expand the road. As such, we often encountered temporary road blocks. In addition, clay soil based road would turn into a muddy when rain falls we anticipated difficulties with equipment transportation. Our construction period was in the dry season, there were few rain days and mostly had fine weather. However, once rains there was danger of slippage immediately after rain and crane trucks could not enter the project site. As a result, construction schedule has be delayed which we recovered later.

2.3 Outline of Our Work (Construction Work of Electrical Machinery)

(1) Generator facilities
- (a) 150kW permanent magnet sub-water turbine generators: 3 sets (see Fig. 2.)
- (b) Penstock and inlet valves: 3 sets
- (c) Inverter units for sub-water turbines: 3 sets
- (d) Generator control panel: 1 set
- (e) Operation controller: 1 set

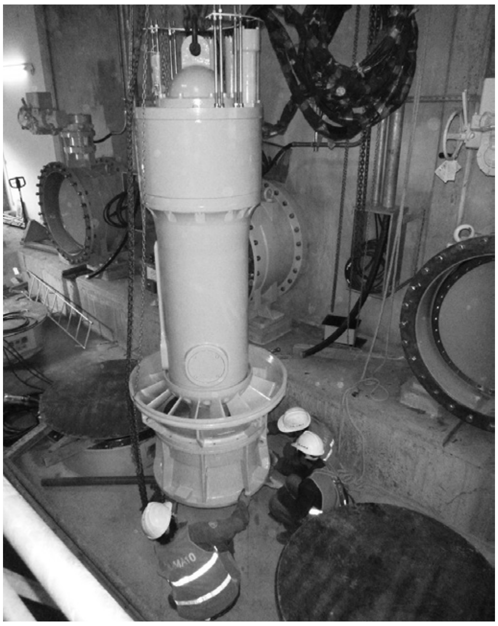

Fig. 2 **150kW Permanent Magnet Sub-Water Turbine Generator**

The water turbine and the generator come in a joint construction. The water turbine is produced by EAML Engineering Co., Ltd. and the Permanent Magnet Generator (PMG) is manufactured by us.

- (f) DC power unit: 1 set

(2) 22kV outdoor substation facilities
- (a) 500kVA step-up main transformer: 1 set
- (b) Vacuum circuit breaker: 1 set
- (c) Others: Disconnecting Switch (DS), Current Transformer (CT), Voltage Transformer (VT), Lightning Arrester (LA), Neutral Current Transformer (ZCT), and other affiliated products

3 Concern Points in On-Site Construction Work for this Project

3.1 Pre-Construction Issues

The key challenge for this project was to meet the taking-over date February 28. 2015, which is short lead time. We worked with subcontractor first time with covering construction material procurement, safety, quality and schedule management.

3.1.1 Change Penstock Installation Sequence to Meet Short Installation Lead Time

Typical penstock installation procedure is to start from down stream and go upward. In this project, this typical installation sequence could not meet the allowable construction date on head tank of the power station. Therefore, we had to adopt with irregular installation sequence which install intake pipe (uppermost stream) embed into the head tank starting first, then install draft tubes (lowermost

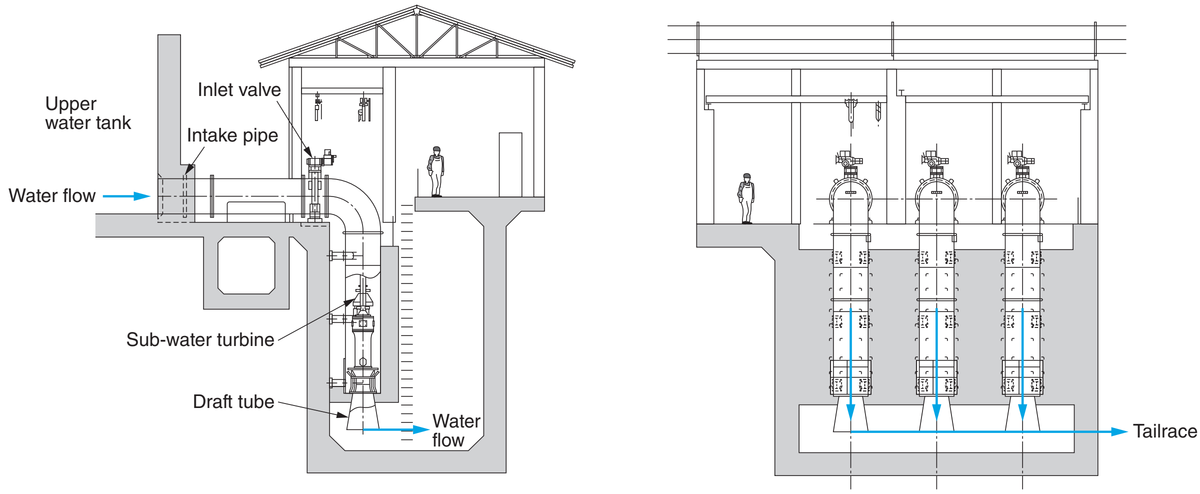

Fig. 3 **Penstock Installation Configuration for Sub-Water Turbine Generator**

The penstock installation configuration for the power plant is shown.

stream), and joint both penstocks at the mid-point. Fig. 3 shows the penstock installation configuration for the sub-water turbine generator.

3.1.2 Securing and Procurement of Construction Materials and Tools

For the procurement of construction materials, we placed an order to LILAMA10 Corporation ("LILAMA10" hereafter) in the Socialist Republic of Vietnam evaluate the companie's rich supply record in hydropower plant construction. Since materials were limited to those which were available in Vietnam, we first engineered work drawings based on the material sizes available in Japan and then LILAMA10 selected and proposed the equivalent materials that could be procured in Vietnam. Based on their proposals, we updated the drawings for work.

For construction work in an isolated place, it is difficult to take prompt reactions countermeasure against construction material and working tools shortage which potentially cause delay in installation schedule. To avoid this, we had to be extremely cautious to any potential defect in material procurement, logistics and onsite installation schedule compare to other projects.

3.1.3 Safety Management

Since it was difficult to expect sufficient medical support in this remote project site, work environment safety management was one of principal task and conscious to eliminate occupational injury from this project.

Workers' safety ethic and safety apparatus quality were low compare to identical work industry in Japan. If the workers were not instructed, they would do "dangerous work procedure" defined in Japanese safety standard, the workers in this project makes personal decisions based on the personal experience with wreckless or braveness without knowledge of legitimate safety training. Therefore our engineers have done preliminary risk assessment prior to scheduled work. Compared with construction management work in Japan, more time and is required for the construction engineers to verify materials and work methods assessment.

3.2 On-Site Installation Management

3.2.1 Installation of penstock

As described in previous clause, the sub-water turbine and penstock was installed in an unordinary sequence compared from standard procedure due to meet civil construction milestone date considered as top priority in this project. Based on the installation manual issued by EAML Engineering Co., Ltd.; manufacturer of penstock, installation work was completed with instruction of EAML's installation supervisor and on-site supervisor of LILAMA10. Fig. 4 shows a view of the installation work of the intake penstock and Fig. 5 shows that of the installation work of inlet valve.

Adhesive type anchors were used for the installation of penstock. Work was carried out carefully not to cause adhesive failure. For the anchor holes, we instructed thorough cleaning after holes had been bored. In cooperation with HAZAMA ANDO CORPORATION and under the guidance by TEPSCO, in order to proof the quality of materials and working methods, we made an adhesion type of anchor test piece installed into the concrete piece

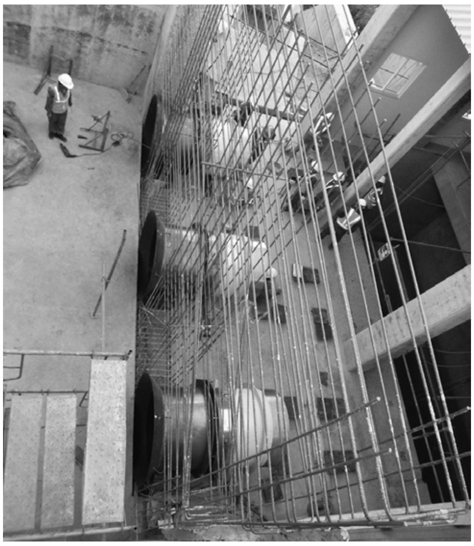

Fig. 4 Installation Work of Intake Penstock

A view of installation work is shown. Intake penstock (manufactured by EAML Engineering Co., Ltd.) under our scope of supply were embedded in the head wall structure. This is the most important milestone task for this project.

Fig. 5 Installation Work of the Inlet Valve

Succeeding the installation of horizontal penstock, this picture shows an inlet valve is carried into final position and under assembly. Such inlet valves are typically installed, after downstream penstock has been installed. For this project, penstock installation started from the upstream side.

at the strength equivalent to the pull-out strength. The concrete piece was lifted from the anchor bolt by crane. Result, the working quality for adhesive anchor bolt has been proofed the performance in this pull-out strength test.

3.2.2 Procurement of Construction Materials and Tools

We assessed working tools brought to the site by LILAMA10 and verify using the “required tool list” issued for this project from us. Working materials were also checked and immediately noticed to

Fig. 6 A View of TBM and Hazard Prediction Activity (Kiken Yochi Katudo “KYK” in Japanese)

A view of daily routine safety activities with our-related workers is shown. This was conducted every morning after the morning brief meeting for all project members.

LILAMA10 when shortage has identified. Regarding the installation configuration for cable junction/ terminal boxes adjacent to, our construction engineers issued preliminary draft plan at site and design engineers in Japan finalized to shop drawings. With this support of design engineers and material logistics controllers supporting in Japan, the installation work has been able complete on assigned handover date.

3.2.3 Safety Management

Injured workers were carried to the Laos People’s Army Hospital (located in the closest township Oh Thai). For non-life threatening injuries or workers feeling sick, they were sent to a clinic (medical volunteer group arranged by the specified emergency nonprofit corporation, by the name of Japan Heart) with the aid of HAZAMA ANDO CORPORATION. Leaning on this support, we could able to concentrate in on-site safety management during the period of construction and site-test activities.

After morning brief meeting for all on-site workers including Civil workers, all of our project-related workers moved to our workplace and continue our own daily meeting. For the safety management, our engineer display and notice the work schedule for the day on signboard with safety and quality instruction and shared to all workers. Especially tried to make practical and clear instructions to the workers “What should be done” and ” What should not be done.” Fig. 6 shows a view of a Toolbox Meeting (TBM) and hazard prediction activity (“Kiken Yochi Katsudo,” “KYK” in Japanese).

For rigging heavy and large items, rigging work plan was issued in advance with the crane position and lifting capacity table. visualize and share the work procedure concept and weight load perimeter with work foreman and crane operator. When the work starts, our engineer monitor the work procedure and instruct further improvement action to work procedure in safety aspect if necessary. Particularly, during dangerous work, such as Rigging work or high-place work Meiden installation engineer attend and supervise in the work seene. And instruct work procedures to finish the work safely. Instructions in such a case are, (1) Strictly follow workprocedures for heavy / large rigging work, (2) Use safety harness during high-place work and/ or work around opening, and (3) Strictly prohibit going underneath the lifted cargo. As gaining the schedule, workers began to self perform following safe working procedures to the instructions given in the past. And safety awareness and understanding level of each worker has been improved.

3.2.4 Arrangement of On-Site Installation Engineers

At the time plan and estimating project man power and its configuration was done referring common practice in Japan. However most projects in Japan are subcontracted to the contractors well known our corporate products with rich supply record and skills, but these work resources are difficult to expect outside of Japan. Therefore, we reinforced our Japanese domestic internal management system to control from installation material to manpower.

This project had to be undertaken in adverse working conditions itemized below. As such, far more detail site management was required.

(1) The construction office and the working site were separated through a 6km road with very poor conditions.

(2) The road traffic was frequently blocked due to:

(a) Blasting in a quarry located between project office and construction site

(b) Cliff undercutting work in order to expand the road width

(3) No safe material storage place on site (exposed to public access).

3.2.5 Project Schedule Management

On this project, a civil general contractor (HAZAMA ANDO CORPORATION) and a water turbine and generator system integrator (MEIDEN) worked closely cooperate and each work was done in a sequential and reciprocal work schedule. The sequence for this project was: construction of power house building (civil general contractor) → installation of penstock (MEIDEN) → completion of head tank (civil general contractor) → installation of vertical penstock and inlet valve (MEIDEN) → penstock root wrapping concrete and wall construction for electric room (civil engineering and building construction). Since this was short lead time project, we made the work progress management in half a day scale, based on the installation schedule where work tasks were subdivided in small tasks not to allow any delay in our scope of work. The work was sorted in three category: "Work must be finished on the very day," "Work must be started on the very day," and "Work that is executed whenever extra work hand are available." Also We have estimated appropriate man power required for each work, and make efficient arrangement of workers challenge to eliminate unnecessary man power seek work productivity improvement.

4 Postscript

For the mini hydraulic power plant delivered in this project, we have proofed to deliver small-scale civil-construction in a short installation lead time which is very effective in an isolated place with rich water resources.

We will continue to deliver infrastructure construction service to deliver enrich life with electricity in irrespective of electrified or non-electrified areas, isolated locations, or urban or local areas.

In last, we express our deepest gratitude to the associated persons of TOKYO ELECTRIC POWER SERVICES CO., LTD. (TEPSCO), HAZAMA ANDO CORPORATION, Japan Heart (medical volunteer group arranged by the specified emergency non-profit corporation), and LILAMA10 Corporation for their dedicated support and cooperation throughout the construction time until successful completion.

《**References**》

(1) Japan International Cooperation Agency: Southeast Asia Section 4, Southeast Asia and Pacific Division. (Ex-ante Project Evaluation Sheet)

(2) Japan External Trade Organization (JETRO): Outline of Laos