Construction of Medium Voltage Power Receiving and Distribution Facilities

Kiyoshi Watanabe,
Chikahiko Morikawa,
Masahiko Yokoyama

Keywords Medium voltage power receiving and distribution facilities, Water supply facilities, Portal steel tower, Piling work

Abstract

Medium voltage power receiving and distribution facilities cover 20kV, over 2000kW user facilities delivered in the 1970s and thereafter are facing renewal times and renewal work is now underway. To execute renewal construction work in a limited period while maintaining plant functions, it is necessary to conduct a sufficient project site study and to realize the best method of facility management and grasp on-site conditions. It is also essential to draw up an implementation schedule to allow the work in a safe manner without a challenging schedule. In addition, it is important to adopt new construction methods, technologies, and labor-saving techniques so that the project schedule can be minimized and the worker's work load can be reduced. This will lead to a safe project site and will support achieving no accidents and no injuries on the project site.

1 Preface

Recent tendencies suggest that medium voltage power receiving and distribution facilities cover 20kV, over 2000kW user facility delivered in the 1970s and thereafter are facing construction renewal times.

Renewal work for these facilities is generally carried out two ways: (1) it is conducted while the currently operating facilities are used on the same premises or (2) new facilities are constructed at a different site.

This paper introduces a case study of a renewal project for medium voltage power receiving and distribution facilities at the Hokuso Water Purification Plant managed by the Chiba Prefectural Waterworks Bureau, Japan. The renewal work was carried out while existing facilities remained operating.

2 A Case Study of a Renewal Work (Hokuso Water Purification Plant of the Chiba Prefectural Waterworks Bureau)

2.1 Outline of the Facilities

Fig. 1 shows the water supply area of the Hokuso Water Purification Plant and Fig. 2 shows the site layout of the premises. The Hokuso Water Purification Plant is situated in Inzai City of Chiba Prefecture. It was constructed for the purposes of water supply to Chiba New Town, Narita New Town, and Narita International Airport. In June 1975, water supply began by collecting surface water of the Tonegawa River as its water resource. The current capacity of water supply is 126,700 m³/day.

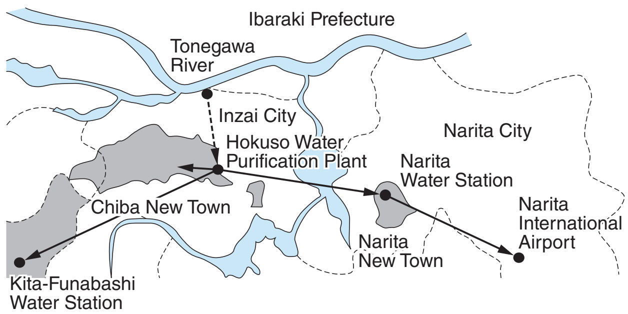


Fig. 1 Water Supply Area of the Hokuso Water Purification Plant

The water supply area of the Hokuso Water Purification Plant is shown.

2.2 Outline of the Substation Facilities

Since it has been 38 years since starting operation in 1975, the existing medium voltage power receiving and distribution facilities were suffering from system deterioration and had a high probability of failure. For stable drinking water supply from this plant, we conducted the renewal work for the pur-

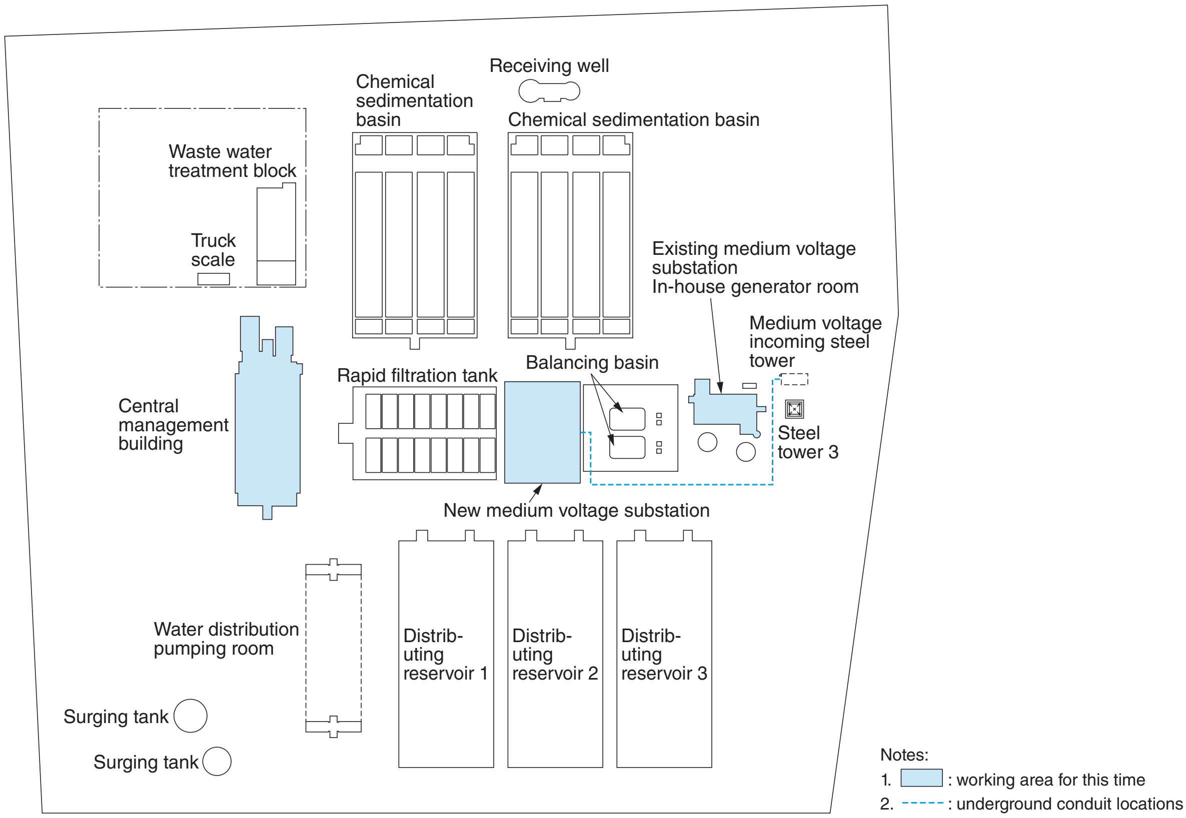


Fig. 2 Site Layout

The site layout of the Hokuso Water Purification Plant is shown.

Table 1 Outline of Renewed Facilities

Renewed facilities are outlined in this table.

Facility name	Before renewal	After renewal
GIS	Indoor open type	Cubicle type
Transformer	1 unit (6000kVA)	2 units (3000kVA/unit)
High/low voltage panel	13 panels	16 panels

poses of “Improving Safety and Maintainability” and “Improving Reliability.” **Table 1** shows an outline of renewed facilities.

2.3 Switchover Plan

The condition for this system’s migration was that the renewal work had to be carried out while the water purification plant remained running because water supply is an essential lifeline for the covered community. In addition, there are many restrictions against the power consumer from the power company in terms of grid power outage at the power receiving point facility. As such, we consulted with the power company for one year prior and drew up the renovation work schedule based on the scheduled power outage of the grid.

As the system relocation plan, we adopted a method where system relocation was made while both old and new medium voltage facilities remained in operation. In order to secure the power receiving grid for both the new and old power facilities, we installed a gate-shaped lead-line steel tower and an medium voltage substation so that each new and old facilities could receive separate grid power from a steel tower on the premises owned by the utility power company. In this manner, system relocation work could be finished without causing a power outage. **Fig. 3** shows the system relocation procedures for medium voltage overhead lines and **Fig. 4** shows a view of the gate-shaped lead-line steel tower.

2.3.1 Work Procedures

The existing medium voltage facilities were connected from a steel tower (on the premises owned by the power company) to an indoor open type medium voltage substation through overhead lines. For the newly installed medium voltage facilities, power was received from a newly installed lead-line steel tower via newly installed underground conduit tubes.

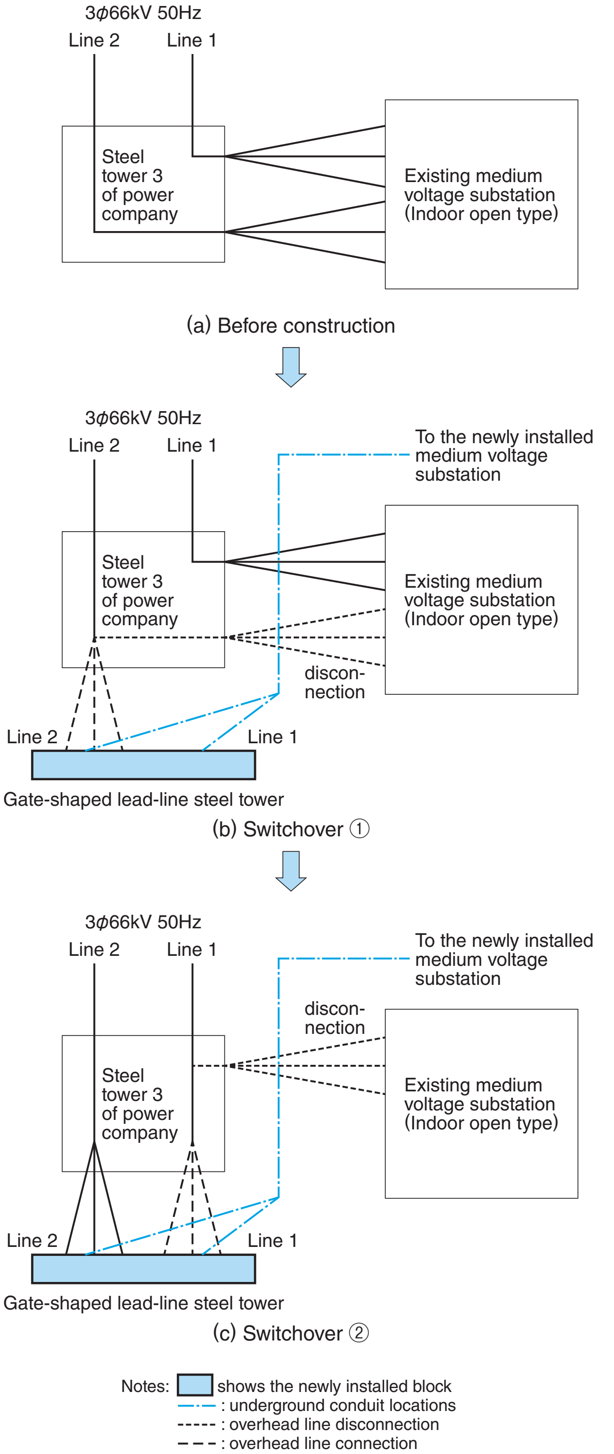


Fig. 3 System Relocation Procedures for Medium Voltage Overhead Lines

Switchover procedures for medium voltage overhead lines are shown.

2.3.2 Line 2 Switchover

Since switchover action was taken while facilities were in operation, we first studied separation distances from respective overhead lines at the time of switchover from Line 2. After Line 2 had been shut down, the power company separated the over-

Fig. 4 View of Gate-Shaped Lead-Line Steel Tower

A view of the newly installed gate-shaped lead-line steel tower is shown.

head lines from the existing medium voltage substation and connected them to the medium voltage cable heads on the gate-shaped lead-line steel tower side. After this, single-circuit power receiving began at the new medium voltage substation [see Fig. 3 (b)].

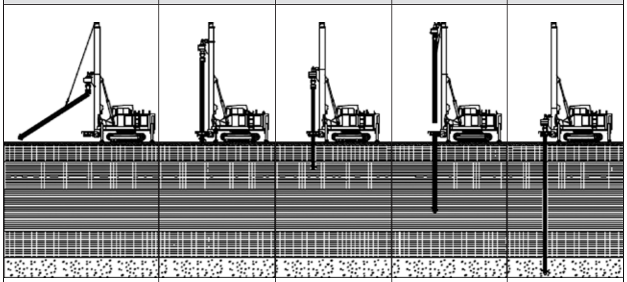
2.3.3 Line 1 Switchover

After power of Line 2 had been received at the newly installed medium voltage substation, high voltage systems in the premise was switched over. After the switchover was complete, Line 1 was shut down and power was switched over to the newly installed medium voltage substation. In this fashion, two-circuit power receiving was realized. Both Lines 1 and 2 were switched over to the newly installed medium tension substation without causing any power outage on the premises. [See Fig. 3 (c).]

2.4 Construction of Gate-Shaped Lead-Line Steel Tower

Since September 2014, prior consultations with the power company were conducted to discuss configuration (height) of the gate-shaped lead-line steel tower, phase layout (phase-to-phase distance), voltage of the overhead anchor wires, and steel tower construction. To define the steel tube pile diameter and the number of piles and their lengths, we examined ground survey data in the installation location (by way of boring) and other factors such as site situation position and designed supporting force.

Piling	Pile fixing	Rotary piling	Pile joint welding	Completion of piling work



Piles are lifted and set in the piling center.	After the pile tip has been set in the piling center, the pile body is fixed with the use of steady braces.	After pile's verticality has been confirmed, forward rotation (clockwise rotation) is given and piles are buried by the effect of propelling force of the vanes.	After the first pile has been embedded, the second and latter piles are in turn joined together and buried by rotation.	After embedding by rotation has been completed to the scheduled depth, the driving motor is turned reversely (counter-clockwise rotation) and caps are removed to complete the piling process.

Fig. 5 Construction Procedures for Steel Tube Piles (Rotary Piling System)

Construction procedures for steel tube piles (rotary piling system) are shown.

2.4.1 Selection of Piling Method

Since the installation location was very narrow, it was necessary to carry out work near the face of the slope. As a result, steel tube piles (rotary piling system) were adopted. The advantages of steel tube piles are that the piling machine can be small and work can be carried out in a small space. Compared with other methods, noise level is low, vibration is minimal, and there is no surplus soil. Since no cement milk is used, this method is environmentally friendly.

In this working system, the tip of the pile body was attached with excavation bits and spiral vanes, and the steel tube pile was rotated and buried. Thus, excavation was forwarded by digging into the ground. Sand and soil amounting to the volume of pile body was automatically pushed toward the pile side surface. As a result, the pile body was installed in the supporting ground without generating soil dug out of the site. Fig. 5 shows the construction procedures for steel tube piles (rotary piling system). Actual working time was 3 days and installation was finished quickly.

2.4.2 Procedures

Table 2 shows actual construction procedures for the gate-shaped leas-line steel tower.

2.4.3 Work Management

In this working approach, the confirmation of pile hitting a solid ground was confirmed by the following three methods:

(1) Confirmation based on the drilling log

(2) Confirmation according to motor torque value of the rotary pile drive machine

(3) Confirmation according to the amount of penetration per turn of the rotating pile at the time of pile installing by rotation

When the pile length was 25 meters (5m × 5 piles), joints were welded on the site considering the tensile stress exerted on the piles. Non-weld joints were not used. All welding operators had licenses conforming to JIS Z3801 or JIS Z3841. Color check (penetrant test) was carried out on the welded parts in the presence of site foremen.

Table 2 Actual Construction Procedures for Gate-Shaped Leas-Line Steel Tower

Actual construction procedures for gate-shaped leas-line steel tower are shown. Construction work was completed in a short time of only 3 days.

Year, month / Item	Fiscal 2014				Fiscal 2015		
	September	October	November	December	January	February	March
Gate-shaped steel tower design	■	■	■				
Design and consultation with power company			■	■	■		
Field survey	■	■	■	■	■		
Field work						■ 2015.2.17 ~ 2015.2.19	

2.5 Construction of Conduits for Medium Voltage Cables

For conduit tubes where 66kV medium voltage cables are accommodated, PFP tubes (reinforced plastic composite tubes) were adopted for the improvement of reliability. These tubes have the same specifications as those adopted by power companies. Since PFP tubes cannot be fabricated on the site, we made a preliminary field survey for one month to examine practical cable bends and rising points so that pre-fabricated tubes could be available. Fig. 6 shows the cross section of the PFP Tube and Fig. 7 shows situation of PPF tube installation.

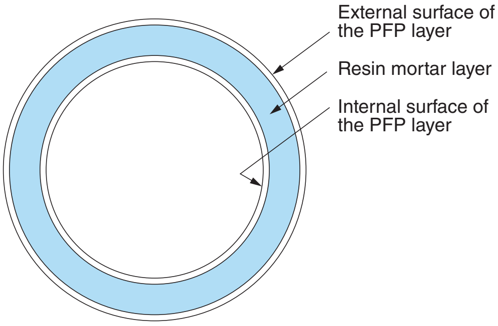


Fig. 6 **Cross Section of PFP Tube**

Cross section of the PFP tube is shown.

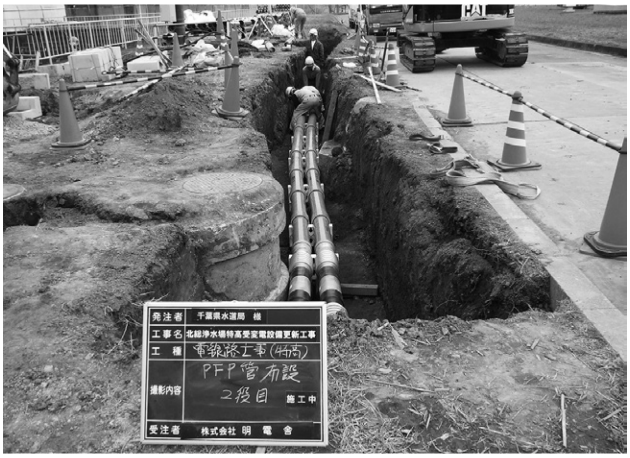


Fig. 7 **Situation of PFP Tube Installation**

Situation of PFP tube installation is shown.

3 Postscript

This paper introduced a case study on the supply of medium voltage power receiving and distribution facilities. After a sufficient field study, we understood the facility management method and the site conditions. Based on our knowledge obtained from the project site study, we drew up a construction schedule in a safe manner and without a challenging schedule. The application of labor saving techniques was a key to realize not only a shorter project schedule, but also safe work by reduced workload on project site workers. Such an approach was indeed indispensable to realize a no accident and no injury conditions. Going forward, we will positively work on introducing new labor-saving techniques.

Finally, we would like to express our deepest gratitude to the related individuals at the Chiba Prefectural Waterworks Bureau for their kind cooperation and suggestions during the execution of the project construction work.