

TSS Tokyo Water's Efforts for Earthquake Disaster Measures

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Abstract

TSS Tokyo Water Co., Ltd. is taking responsibilities for important fundamental operations of waterworks management to conduct comprehensive operation and maintenance of overall waterworks facilities, taking advantage of its abundant experiences and high technical skills about waterworks and flexibility as a private entity.

Among the undertaking works from Tokyo Metropolitan Waterworks Bureau, TSS has recently expanded ones concerning reinforcement of earthquake-resistance, additionally concluding an agreement which enables TMWB and TSS to collaboratively and positively conduct necessary measures in the event of earthquake disasters.

This article reports introduction of some major examples of TSS's efforts including earthquake disaster measures. After "development of systems for entrusting works" is outlined, at "reinforcement of earthquake-resistance of pipelines," pipe network planning / designing and construction site supervision works as 10 Year Project for the Use of Earthquake-resistant Joints in Pipelines, and Adjustment Project of Service Pipes under Private Roads are explained, followed by "utilization of various pipe inspection data" with its examples such as pipeline diagnosis work and mobile mapping system. Lastly at "Collaboration with TMWB in earthquake disasters" efforts are introduced including reinforcement of collaborative system, practice of training against earthquake disasters, and development of circumstances concerning devices etc. for earthquake disasters.

INTRODUCTION

TSS Tokyo Water Co., Ltd. (hereinafter referred to "TSS") is playing a part as a partner company of Tokyo Metropolitan Waterworks Bureau (hereinafter referred to "TMWB"), in managing Tokyo Waterworks to support 13 million metropolitan residents' daily lives, urban activities, and central functions as the capital of Japan, collaboratively with TMWB. TSS has been undertaking a wide range of technical works such as O/M of facilities, pipe network planning / designing, and construction site supervision works "from water resources to taps," which were formerly conducted by TMWB.

In addition, TSS has another aspect as a Tokyo Metropolitan Government's supervised organization[†] (hereinafter referred to "Supervised Organization") which should contribute to efficient operation of waterworks by securing both publicness and efficiency. To accomplish these roles successfully, TSS is striving for showing comprehensive technical skills about waterworks operations which have been cultivated and making efforts for establishing an efficient business operation system which is characteristic of private companies.

Meanwhile, from both tangible and intangible viewpoints, TMWB has been dealing with various earthquake disaster measures against a local earthquake on metropolis which has been recently pointed out to occur, for establishing an earthquake-resistant waterworks which is

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desirable for the capital Tokyo. Among these leading measures, “reinforcement of earthquake-resistance of pipelines” is being implemented.

This article reports progress status of earthquake disaster measures including a leading project for reinforcement of earthquake-resistance of pipelines named “10 Year Project for the Use of Earthquake-resistant Joints in Pipelines” (hereinafter referred to “10 Year Project”) which TSS involves in.

† Supervised Organization of Tokyo Metropolitan Government: an organization which receives investment and continuous fiscal expenditure from Tokyo Metropolitan Government, as well as supervision and guidance from all bureaus of Metropolitan Government

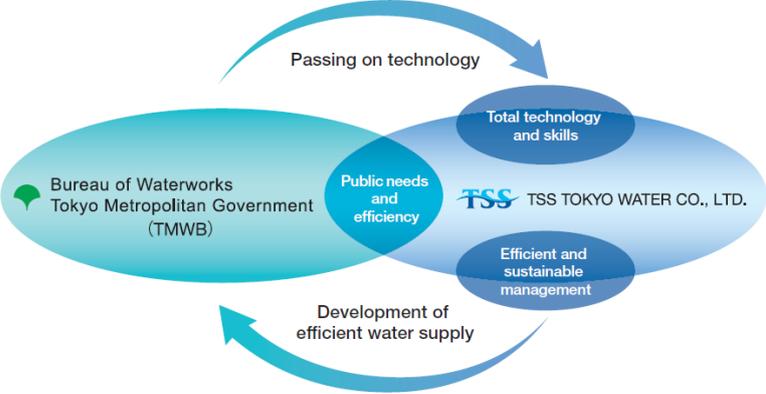


Figure-1: Partnership between TMWB and TSS

DEVELOPMENT OF SYSTEMS FOR ENTRUSTING WORKS

In 1987 TSS was established as “Waterworks Comprehensive Services Co., Ltd.” before changing its company name to “TSS Tokyo Water Co., Ltd.” in 2001. In 2006, “Integrated Operation System” was decided to establish, which specifies that fundamental waterworks operations should be conducted by TMWB and Supervised Organizations in order to be responsible for stably supplying Metropolitan residents with safe and drinkable water for the long future, securing both publicness and efficiency in administration.

As for entrusting works from TMWB, they are divided and separately contracted in two respective areas called Tama area and 23 Ward area, while TSS provides appropriate manpower to deal with work volume of each area. Tama area has 3.9 million population

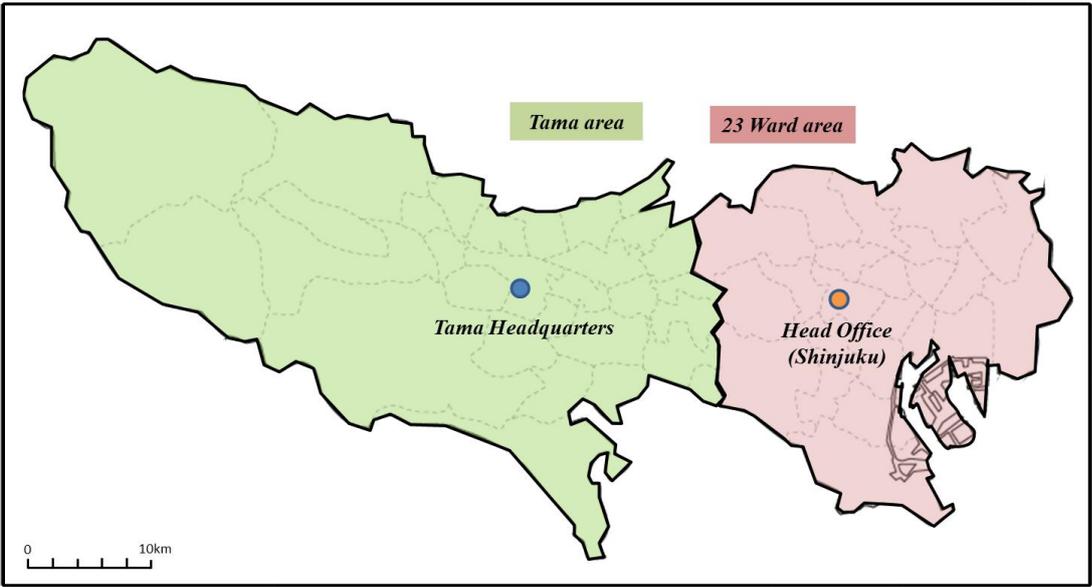


Figure-2: Operation system of TSS in Tokyo Metropolitan Government

served, which is almost equivalent to those of Yokohama, the second largest city in Japan.

In Tama area each waterworks was formerly individually administrated by municipality. But after 1955 as the rapid urbanization progressed, waterworks utilities of 26 municipalities have joined TMWB to secure stable water supply. For a period of time even after the unification into TMWB, based on Local Autonomy Law, entrustment of business affairs to each municipality has been applied to works including O/M of waterworks facilities, water charge collection which needs close relationship with customers, and approval of new installation of service connections.

After that, based on “Master Plan for Improving Waterworks Management of Tama Area” which was established in 2003 for further satisfactory customer services and more efficient waterworks management, all entrustment of business affairs has resolved at the end of 2011 FY so that technical works can be entrusted from TMWB to its TSS as a Supervised Organization. To follow this, Tama Headquarters of TSS made a lot of efforts for arranging branch offices and procuring necessary staff to overcome difficulties together such as drastic increase of work volume, developing planned reinforcement of earthquake-resistance of pipelines.

On the other hand, as recruiting of necessary staff is difficult because of recent shortage of civil workers in Japan, flexible and efficient work performance are being carried out; valve operation works during water suspension etc. with much work force are undertaken by TSS’s partner companies with reliable work records, and routine works in planning / designing such as close figure examinations of paving area and materials are charged by temporary-hired part-timers.

As undertaken works have expanded, TSS has as many as about 1,500 staff, including part-timers (as of the end of 2014 FY) in the whole company.

REINFORCEMENT OF EARTHQUAKE-RESISTANCE OF PIPELINES

Transition of Ductile Cast Iron Pipes in Tokyo Waterworks

Pipe bodies of ductile cast iron pipes have much more strength for earthquake-resistance than those of conventional cast iron pipes, while on pipelines without the slipping-off preventing function at their fittings, much damage by slipping-off occurred in Great Hanshin-Awaji Earthquake Disaster in 1995.

TMWB has adopted “pipes with NS type earthquake-proof joint” which has the slipping-off

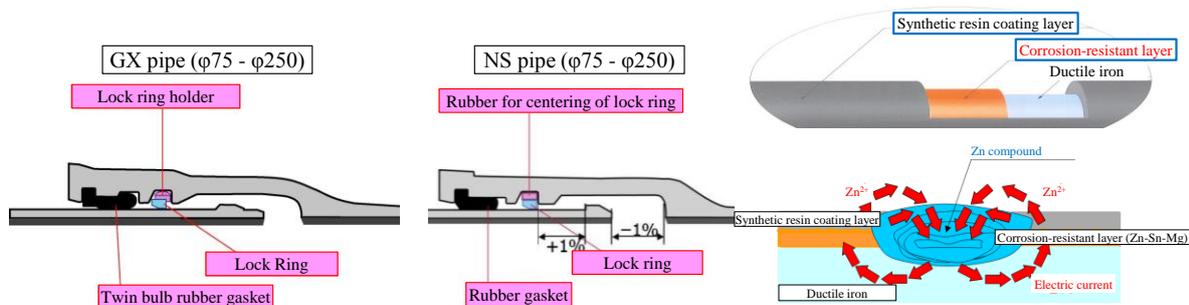


Figure-3: Structure of pipe fittings

Figure-4: Mechanism of corrosion-resistance of GX pipes

preventing function at their fittings gradually from pipes of smaller diameter since 1996.

Afterwards in October 2010, Japan Ductile Iron Pipe Association standardized GX type ductile iron pipes (hereinafter referred to “GX pipes”) which has as much earthquake-resistance as NS pipes and excellent in work efficiency, economic efficiency, and long duration. Then in order to verify such efficiency etc., TMWB conducted a trial construction of GX pipes from December 2010 in Tama area. According to this verification results, after Tama Headquarters of TSS started planning / designing and construction site supervision works of GX pipes gradually from the next fiscal year, in 2014 FY GX pipes (φ250 mm and smaller) became fully adopted in the whole Tokyo Metropolitan area. By the way, the verification results of the trial construction was reported in public by TMWB.

The following reported activities are mainly conducted in Tama area.

10 Year Project for the Use of Earthquake-resistant Joints in Pipelines

Great East Japan Earthquake Disaster revealed the importance of water supply at evacuation centers and major stations which accommodate many people in disasters, and hospitals as bases for first-aid medical care.

In addition, as the updated projection by Tokyo Government Disaster Prevention Council showed that seismic intensity of upper 6 may be recorded in a large number of areas with high liquefaction risks, more preparation of earthquake-resistance activities against a local earthquake on metropolis, which is pointed out to occur, is found to be necessary.

Based on such situations, for more efficient reduction of damage by water suspension, considering liquefaction risks and progress of reinforcement works of earthquake-resistance of pipelines, TMWB is promoting 10 Year Project (from 2013FY to 2022FY) in which evacuation centers, major stations, and so on have been newly positioned to be preferentially reinforced as earthquake-resistant facilities, in addition to conventionally positioned capital’s central agencies.

Table-1: Actual record of planning / designing and construction site supervision works (as for distribution sub-main)

| | Designing / Planning (km) | Construction Site Supervision (km) |
|---------|---------------------------|------------------------------------|
| 2014 FY | 224 | <u>230</u> |
| 2013 FY | 202 | <u>239</u> |
| 2012 FY | 257 | 226 |
| 2011 FY | 358* | 163 |
| 2010 FY | 235 | 63 |
| 2009 FY | 84 | 39 |

This project sets the target that the rate of pipes with earthquake-resistant joints (on φ350mm and smaller) in Tama area should increase from 35% in 2013 FY to 51.8% in 2022 FY with installation of about 2,100 km for 10 years or about 210 km per year. The status of progress is shown in Table-1. The both lengths of construction site supervision in 2013 and 2014 which are placed as 10 Year Project exceed 210 km as the target figure.

* The pipeline length of planning / designing of 2011 FY includes estimated increase in the next fiscal year because works in all of municipalities were succeeded to Tokyo Waterworks at the end of 2011 FY.

Planning / designing works: The planning / designing and construction site supervision works for distribution sub-main (φ350 mm and smaller) in Tama area have been gradually undertaken by TSS since 2004 as the entrustment of business affairs was succeeded from each

municipality to TMWB. After the entrustment completely resolved at the end of 2011 FY, TSS has been undertaking all of such works. TSS has been also undertaking the similar works for distribution main ($\phi 400$ mm and larger) by about 50% since 2010 FY, sharing all works with TMWB.

When TSS began to undertake planning / designing works, about only 5 staff were in charge of them. Young career staff have gradually improved their technical skills under the guidance for the work by experienced staff who were formerly working for TMWB.



Picture-1: designing room

The standard number of planning / designing works in charge per staff is set; at the first year from new employment, 1 or 2 works of relatively short length; at the second year, 2 to 4 works considering each learning level; and at fourth year or further, 10 to 15 as the goal, with guidance mainly by intermediately experienced staff. Consequently, after 2011 FY when the work volume has fully increased, they are not only capable of designing targeted length at 10 Year Project, but also have even advanced planning / designing knowledge including difficult excavation works with complicated underground facilities and pipe jacking method without excavation, so that they have acquired ability for planning / designing works which is almost equivalent to that of TMWB staff.

In 2011 the transition of earthquake-resistant pipes from NS pipes to GX pipes started as a trial in Tama Area prior to 23 Ward area. TMWB held briefings of the designing procedure of GX pipes and others about how to connect cut pipes and revised items of specifications from those for NS pipes. It took some terms to learn them, but eventually the transition was successfully done.

Construction site supervision work: Construction site supervision work by TSS staff needs the viewpoints from an ordering party because besides securing of both publicness and efficiency, a fair and strict stance is indispensable in the amount settlement works on the basis of contract articles and specifications, and securing of safety for construction works. In addition, deliberate management according to individual situations is required at communication with customers and instruction to many contractors with different amounts of experience.

Capacity development for young staff as construction site supervisors is conducted from long-term viewpoints, which consists of participation to in-house and outside training sessions, on-the-job training considering each participant’s characteristic by staff who were formerly working for TMWB. Consequently, nowadays many of them have grown into intermediately experienced staff who are acting in the forefront of construction site supervision works.



Picture-2: witnessing of pipe jacking work

By the way, TMWB is promoting “Image Improvement of Waterworks Construction” which helps local customers understand

waterworks more to safely and smoothly carry out constructions. Along the policy, annually “Image Improvement Competition of Waterworks Construction” is held, which awards imaginative and original activities such as method of waterworks management and construction, consideration for surroundings, and communication with local residents.

Every year several construction works which TSS supervised have been rewarded. Picture-3 shows a scene related to an awarded work; at the playground of an elementary school, where children had rare experiences to look inside or touch distribution main pipes actually to be installed under the ground. Besides, two representative children had another precious experience to try a connecting work of NS pipes which enabled them to understand that, the work is available even for children, while once the connection is done, the function of earthquake-resistance acts, preventing pipes from slipping off.



Picture-3: scene at practical study of earthquake-resistant pipes in an elementary school

In this manner, establishing good communication with local customers makes understandings about waterworks constructions which involves noises and traffic obstacles, and contributes to progress of 10 Year Project.

Promotion of Adjustment Project of Service Pipes under Private Roads

In Tokyo metropolitan area, many of service pipes under private roads which were made of polyvinyl chloride or lead were not shock-proof and could result in leakage until stainless steel was applied to service pipes.

In 23 Ward area, prior to Tama area, Adjustment Project of Service Pipes under Private Roads (hereinafter referred to “Adjustment Project”) has contributed to improvement of earthquake-resistance and leakage prevention by newly installing distribution sub-mains and replacing branched service pipes with stainless ones which are excellent in shock- and corrosion-resistance as shown in Figure-5.

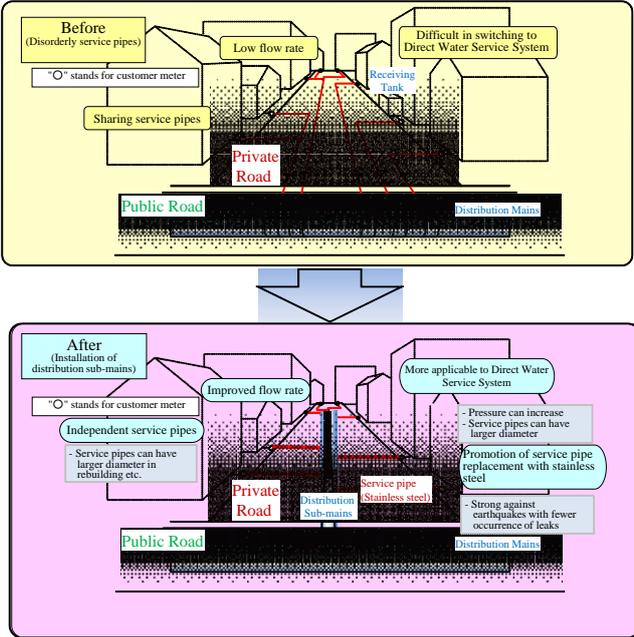


Figure-5: abstract of “Adjustment Project of Service Pipes under Private Roads”

In Tama area, on the other hand, the project began on a large scale around 2011 when entrustment of business affairs to municipalities had been almost resolved.

Adjustment Project, placed as one of the important projects to promote reinforcement of earthquake-resistance of pipelines, is financially wholly under the responsibility of TMWB and its achievement ratio for all the targeted distribution lines in Tokyo metropolitan area is

set as 79 % as of the end of 2023 FY. Besides, for further implementation of the project, in 2012 FY the application criteria was revised to be relaxed from the original so that the project can be conducted in case of more than 3 service connections (customer meters). At the end of distribution sub-mains which are installed under private roads, drainage valves with the same structure as hydrants are installed; they are also available for emergency water supply in earthquake disasters or first-aid firefighting.

For implementation of the project, basically a signature and a seal on the “letter of approval for installing distribution sub-mains under private roads” are necessary. Though such approval works in Tama should be conducted by the consulting company as a contractor of designing work for the concerned pipeline, there are some difficult cases to be given approvals because of refusal of construction works, difficulty in contact, or other reasons. In such cases TSS staff who are responsible for designing works work together for approval, but repeated occurrence often results in delay of designing works.

To improve these situations, TSS formed a team to compile business affairs about letter of approval, which consists of part-timers. Consequently the delay of designing work solved and 10 Year Project is smoothly advancing. By the way, part-timers become able to make appropriate explanations about this project through short-term in-house training by understanding the leaflet which is prepared by TSS, even if they have no knowledge about Adjustment Project. Anyway, the project is running more successfully than the initial expectation.

UTILIZATION OF VARIOUS PIPE INSPECTION DATA

Pipeline Diagnosis Work

TSS has been consistently entrusted “Pipeline Diagnosis Work” by TMWB since its establishment in 1987. “Attached facilities of pipeline investigation,” which is one of the main businesses in Pipeline Diagnosis Work, becomes the basic materials for the pipeline replacement plan developed by TMWB.

This inspection sets the object that leakage accidents and traffic accidents, which are caused by unevenness of road surface on attached facilities, can be prevented and that the results of investigation can be reflected on sound maintenance of attached facilities by investigation of current situation of maintenance, aging deterioration on attached facilities of pipeline, and function of gate valves. Among them, the inspection of function is utilized as criteria for priority of the maintenance and repairs by ranking its results as shown in Table-2 below.

Table-2 : assessment standard table for judgment

| | Rank A | Rank B | Rank C |
|-----------------|---|--|---|
| Rank | Failed facilities which are dangerous and necessary to repair immediately | Failed facilities which seem to be necessary to repair and improve | Facilities which have slight failure and seem to be necessary to repair and improve sooner or later |
| Inspection item | Chamber or its iron cover of valve, hydrant, etc.: paving / capability of opening and closing / rattling / difference in level / error in sign / damage of iron cover / crack of pavement / insufficient drainage of water and mud / damage of chamber / condition of pipeline / leakage / condition of valve / body of vertical shaft and tunnel / pipe in vertical shaft and tunnel / operational problem / water quality problem / crossing pipeline | | |

Photo-4 shows inspection of difference in level which is 24 mm between road surface and a cover of gate valve. As this facility is “failed facility which is necessary to repair immediately” according to Table-2, it should be carried out repair work immediately by the maintenance department.

10 Year Project is promoting reinforcement works of earthquake resistance of pipelines by giving priority to pipelines for evacuation center and major station and so on. While the attached facilities of pipelines that need emergency treatment will be repaired and replaced as soon as possible according to the results of this inspection.



Picture-4: condition of difference in level

In addition, the abundant information that has been accumulated by the Pipeline Diagnosis Work is not only reflected on maintenance of attached facilities of pipelines, but also used as an effective data for judgment of priorities to develop earthquake-resistant routes and areas.

Mobile Mapping system

Traditionally, Tokyo Waterworks stores its pipeline information in the “Water Mapping System” and it has been useful for specifying position and grasping the attribute information of pipeline in earthquake disasters.

However, speaking about the damage in Great East Japan Earthquake, searching for information was difficult because a fatal situation occurred; for example, collapse of government buildings, disconnection of communication network, and suspension of power supply which was required for operation of communication system. Therefore, serious trouble broke out in understanding of local conditions and subsequent restoration activities. In addition, even in the event of earthquake disasters, currently “paper-based” documents which are output from the mapping system terminals are dealt with. That means, it is impossible to output paper-based data in power failures. As there are problems that it is hard to see at night and it can get wet in the rain, obstacles for recovery efforts have been supposed.

In order to solve these problems, TSS has innovated "Mobile Mapping System" since 2014, to provide rapid and reliable temporary restoration in emergency. This terminal is a tablet type which has cooperative functions with GPS. Staff can receive support for fast recovery response



Figure-6: mobile mapping system terminal



Picture-5: use of terminal

from it by bringing it to site and exactly getting the location and pipeline information in earthquake disasters. Moreover, the terminal is highly waterproof, not influenced by night and weather, easily displays pipeline information, and enables appropriate works on site. At the same time, the terminal enables an office to accurately grasp situations with utilization of functions such as work reports and telephotography for sharing of site conditions with the office.

Mobile Mapping System is in a trial stage in Tama area at this time for its introduction. In the future, investigations for excellent functions towards the full-scale adoption and subsequent consultation with stakeholders should be conducted.

COLLABORATION WITH TMWB IN EARTHQUAKE DISASTERS

Reinforcement of Collaborative System

TMWB decided to work on the basis of “the Tokyo Water Works Bureau Earthquake Disaster Emergency Plan” in the event of earthquake disasters. Therefore, each division of TMWB achieves emergency recovery activities smoothly by developing an action manual.

When disasters occur, not only clear policy of TMWB but also collaborative system among waterworks stakeholders is extremely important. TMWB and TSS concluded “Agreement of Emergency Response Operations against Disasters (31st March, 2009)” to secure collaboration. In addition, for the similar purpose, support system is secured by being specified measures during emergency in the specification of the project which TSS is ordered. Moreover, TMWB concluded agreements with related organizations and secures collaboration by describing contractors’ gathering and command system in disasters on the specification.

TSS should quickly deploy specific activities by reflecting this policy in “Earthquake Disaster Emergency Plan” and “Earthquake Disasters Action Manual” established by TSS, because damage investigation, emergency recovery, and emergency water supply are the main activities as the part of TSS in earthquake disasters.

Practice of Training against Earthquake Disasters

In order to practically learn the behavior in earthquake disasters, TSS is periodically conducting training such as “disaster prevention training (emergency recovery training)”, “information contact training”, and “gathering training” together with TMWB to prepare for activities in case of occurrence of disasters.



Picture 6: information contact training



Picture 7: emergency recovery training

Development of Circumstances Concerning Devices etc. for Earthquake Disasters

When earthquake disasters occur, it is necessary for waterworks stakeholders to conduct recovery activities cooperatively. TSS has experienced communication panic, planned blackouts, fuel shortage, and so on in the Great East Japan Earthquake. So, it is necessary to promote development of circumstances as far as possible for forecasted situations.

Not only stock of disaster prevention equipment but also securing of communication means for contact with TMWB and formation of internal structure is essential. TSS has installed satellite-based mobile phones and non-utility power generation facilities for power failure as well as wireless communication prepared by TMWB.

CONCLUSION

Tokyo Waterworks has set the target to improve the rate of earthquake-resistant joints on pipeline in the whole Tokyo area up to 54% as 10 Years Project until 2022 FY. The achievement of this target depends on if TSS, in charge of pipe network planning / designing, construction site supervision works, and so on, can enough play a role for which Supervised Organization is responsible by fully using extensive knowledge and experience that has been accumulated in waterworks operation.

TSS, as a partner company of TMWB, hopes to contribute to development and optimization of waterworks operation, eagerly tackling reinforcement of earthquake-resistance of waterworks facilities with its rich experience and high technical skills in the future.

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