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**Rational, Organized, and Successful Emergency
Operation against Disaster
– Case of the Historic Earthquake in Japan –**

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ABSTRACT:

On March 11, 2011, historic earthquake with magnitude 9.0 hit Japan. To manage necessary response to serious earthquake disaster, the head office of Japan Water Agency (JWA) and each branch offices set up Emergency Operation Centers (EOCs) based on "Emergency Operation Plan" immediately after the earthquake, and JWA's President declared emergency. And, based on the detailed rules of Emergency Operation Plan, JWA started emergency facility inspection and information collection just after the earthquake. At the dam sites where the quake exceeded certain standard which was defined beforehand, primary emergency inspection was carried out within 3 hours after the earthquake, and secondary inspection was carried out within 24 hours. Through the emergency inspections, JWA confirmed that there were no problems on safety in all JWA's dams. On the other hand, damages occurred to some facilities at the project sites of barrage, bank, and canal in Tone River downstream area and Lake Kasumigaura area. Therefore, with an organization's overall effort, JWA conducted emergency operation, such as prevention of further damage, emergency rehabilitation works at damaged sites, information release to related organizations, prompt administrative procedure for rehabilitation works, etc. In addition, regular meetings in headquarters EOC were organized with the participation of all board members and all Director Generals to share information and instruction on emergency responses. Through sharing accurate and necessary information and making right decision on time, JWA successfully managed emergency rehabilitation works started right after the earthquake and necessary preparation of coming full-scale rehabilitation, which finally completed in March 2013.

Keywords: *emergency operation, preparedness, organizational governance, disaster management*

1. OUTLINE OF DISASTER BY THE EARTHQUAKE AND TSUNAMI FOR JWA FACILITIES

Magnitude 9.0 (maximum seismic intensity 7) "The 2011 off the Pacific coast of Tohoku Earthquake" (The 2011 Tohoku Earthquake) occurred at 14:46 on March 11, 2011. At 18 project sites located in Tone, Ara and Kiso River Basin, more than 500 km away from epicenter, of Japan Water Agency (JWA) which is in charge of water resources management in major river basins in Japan, the earthquakes recorded more than seismic intensity 4 on the Japanese scale of 7 that requires urgent check of facilities in JWA's internal regulation. Especially, at the facilities in Ibaraki Prefecture in Tone River Basin that is close to the epicenter, the quake of seismic intensity upper six was observed at

maximum. In addition, the warning about the tsunami was announced in the seacoast area (see fig 1).

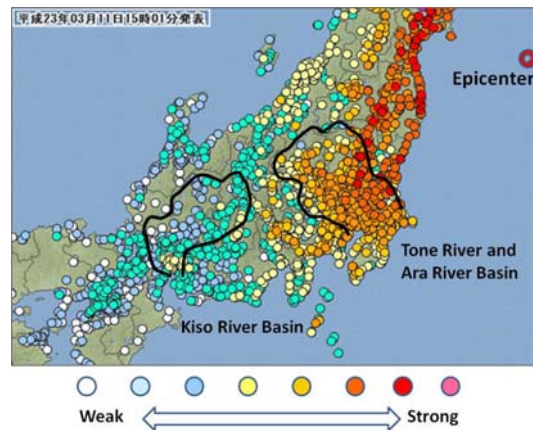


Figure1.Seismic intensity distribution map

Finally, facility damages by the quake were observed at 8 projects located in Ibaraki and Chiba Prefecture of the Tone River and Ara River Basin. Most of the damages were subsidence caused by the liquefaction and water leakage of pipeline system in canal project sites. However, damage by the tsunami and the human damage did not occur. And also there was no damage in dam facilities. Followings are major damages observed at the damaged project sites.

- a) Damage of the air valve(see photo 1)
- b) Water leakage from pipeline systems(see photo 2)
- c) Subsidence around the pumping station caused by liquefaction(see photo 3)
- d) Damaged bank protection(see photo 4)



Photo 1. Damage of the air valve



Photo 2. Water leakage from pipeline systems



Photo 3. Subsidence caused by liquefaction



Photo 4. Damaged bank protection

2. THE OFFICIAL ANNOUNCEMENT OF EMERGENCY SITUATION AND IMPLEMENTATION OF EMERGENCY RESPONSE

At the JWA's project site where seismic intensity information of monitoring point recorded more than seismic intensity 4 or more than 25 gal with a seismometer, emergency operation alert was announced promptly, and, based on Emergency Operation Plan, started the patrol and inspection to check the condition of facilities. Moreover, the emergency situation over tsunami was issued at five project sites located in the place where the emergency alerts about tsunami were announced, and JWA urgently checked the facility condition and watched the data carefully to implement necessary operation under tsunami condition.

JWA is usually preparing for emergency cases by the earthquake as Emergency Operation Plan which regulates, and decides staff formation in case of emergency in advance. And when large earthquake occurs, JWA announces emergency operation alert and conducts emergency inspection to check the facility condition and to inform it to related organization promptly. It is basic outline of emergency response by JWA which is always prepared and trained. Therefore, in case of the huge earthquake in 2011, all JWA offices smoothly started its emergency operation based on its emergency operation plan. Through the emergency inspection of facilities, JWA found that water supply was stopped due to serious facility damage in some areas. In addition, various damages occurred in many places, and emergency response and rehabilitation works were needed.

From the next chapter, this report introduces how JWA implemented emergency response against the greatest earthquake on record under leadership of JWA headquarters (HQ) and lessons learned.

3. THE TASKS IMPLEMENTED BY EMERGENCY OPERATION CENTER IN HQ

3.1. Leadership of Emergency Operation Center

Just after the earthquake occurrence, Emergency Operation Center (EOC) was established in JWA HQ immediately, and gathered information of the disaster situation of all the JWA project sites. Considering the whole situation, Emergency Declaration of JWA HQ was announced at 19:30 on March 12 to enhance governance of emergency operation. At the EOC in JWA HQ, EOC meetings, led by the JWA President, were held every some hours just after the earthquake and once or twice a day from then on. The meeting was held 19 times until March 22 when EOC confirm certain progress in emergency rehabilitation from damaged project sites. At the EOC meeting, information was regularly shared among core members of JWA HQ, and also, important discussion and decision was made there. With the consultation and instruction by Board members, JWA continuously carried out quick and precise disaster recovery and risk management tasks for 24 hours a day (see photo 5).

The information and record which were shared at the meetings in HQ were reported at other meetings by the heads of JWA Regional Bureaus or the heads of projects. Also, the information is disseminated internally to JWA staffs. For the emergency rehabilitation on damaged facilities, at first, JWA confirmed situation and health condition of all JWA staffs and their families in Kanto area, and then, preparing logistics support, JWA gave highest priority to the early restart of the water supply which are seriously damaged by the

earthquake. For example, human resources, materials and equipment were additionally supplied from other JWA projects in less damaged area to the Kasumigaura Canal Project where the facilities were seriously damaged, to achieve expected goal, resuming domestic water supply in a week, which is set by the JWA president. Also, JWA dispatched an executive director to the damaged project office as the general director of emergency response on site instead of the President in HQ. And after the restart of domestic water supply, JWA worked on urgent rehabilitation of irrigation water supply system which is expected to be recovered by middle of April.

EOC in JWA HQ managed field survey, planning, designing, and administrative procedure for full recovery of damaged facilities, in addition to management of emergency response and urgent recovery which was started from just after the earthquake.



Photo 5. Emergency Operation Center in JWA HQ

4. EMERGENCY RESPONSE BY DAM MANAGEMENT OFFICE

4.1. Reporting result of emergency inspection of dams after earthquakes

The notice from the Director of River Environmental Division, Water and Disaster Management Bureau of Ministry of Land, Infrastructure, Transport and Tourism of Japan, says that dam management offices should conduct emergency check of their dams immediately after the earthquake and report the result to river administrator of dam location when seismograph in dam foundation or bottom of dam body records more than 25gal in maximum acceleration of seismic movement, or dam area registers an intensity 4 on the Japanese scale of 7 through the observation by meteorological observatory of Japan Meteorological Agency. Specifically, the flash report on facility damage should be submitted within one hour after the earthquake which includes all abnormalities confirmed, even if emergency check has not completed. After the flash report, primary inspection result should be reported within about 3 hours through appearance check by visual confirmation, and secondary inspection result should be reported within about 24 hours through detailed appearance check and measurement after the primary check. When abnormalities are observed, the result of the extraordinary inspection should be prepared and reported immediately.

In the case of this earthquake, at all the dams of JWA which recorded earthquake motion beyond the standard value mentioned above, the emergency inspections were implemented as described, and safety of the dams were confirmed. As an example, the outline and result of emergency inspection at Yagisawa Dam, one of representative arch dams in Japan, and Naramata Dam, one of representative rock-fill dams, are introduced from following section.

4.2. The outline of Yagisawa dam and Naramata dam

The Numata Comprehensive Operation and Maintenance Office (Numata Office) is located at Numata City in Gumma Prefecture, and in charge of management of Yagisawa Dam and Naramata dam.

4.2.1. Yagisawa dam

Yagisawa Dam is located in the uppermost stream of the Tone River and is a 131m high arch type concrete dam. Purposes of the dam are; flood control, maintenance of normal function of river, agricultural water, domestic water, power generation.

4.2.2. Naramata dam

Naramata Dam is located in the tributary stream of the Tone River and is a 158m high rockfill dam. Purposes of the dam are; flood control, maintenance of normal function of river, agricultural water, domestic water, industrial water, power generation.

4.3. Outline and result of the emergency inspection of the dams after the earthquake

Since seismic intensity 4 is recorded at control point, Numata Office, based on the Emergency Operation Plan, issued emergency operation alert immediately, and started emergency inspection of dam facilities. By “The 2011 Tohoku Earthquake”, besides the main shock which occurred at 14:46 on March 11, major three aftershocks occurred at 0:24, 3:59, and 4:32 on March 12, and registered seismic intensity 4 once and 5-lower twice at the control point. In each case, Numata Office implemented emergency inspections. According to the inspection results, there were no abnormalities in the dam facilities such as dam body, ground surface and formation around the reservoir, discharge equipment, backup power system, dam operation building, etc. Also after that, Numata Office continued the emergency operation until April 1 when aftershocks settled down.

5. THE SUPPORT TO THE DAMAGED AREA

5.1. Dispatching staff to the damaged project office

In the office of damaged project, there are various kinds of things to do such as field investigation, emergency rehabilitation planning, management of emergency rehabilitation works, communication and coordination with related agencies, contract arrangement, compensation, application management for full recovery works, etc. To implement these tasks in short period, JWA dispatched staffs from less damaged area in Japan, which counted a cumulative total of 1,101 persons by the end of May 2011.

The dispatched staffs were devoted to work on emergency recovery under unusual condition after the earthquake. In the damaged area, it was difficult to find an open restaurant, and also difficult to buy food or drinks at shops. In addition, Hotels there could provide limited service, such as a bed without meal, even if they were available. They slept in the office at the sofa or on some pieces of cardboard placed on the floor. As it is mentioned above, because of the rational, reasonable, and flexible input of human resources, and their dedicated actions, the emergency response after the earthquake disaster and other necessary procedures to implement full recovery works were conducted properly.

5.2. Stocked materials, machineries, and pumper trucks

JWA have stocks of various materials and machineries as a part of preparedness activities against disaster. At The 2011 Tohoku Earthquake, the materials for water leakage repair which were stored at Tone Canal office beforehand were sent to Hokusou Canal project site where the pipelines were damaged and contributed to facilitate urgent recovery. In addition, a pumper truck (1m³/s class) was sent to a pump station in Tousou Canal System to help deliver water to purification plant in case of electricity failure which was planned by electricity company because emergency generator was broken by the earthquake and there is no energy to send water to the plant if electricity stopped (see photo 6.7).



Photo 6. Conveying materials of stocked



Photo 7. Pumper truck

5.3. Logistics support

EOC in JWA HQ worked on preparation and delivery of necessary material for each damaged project site because information has been received that there is not enough number of cars for patrol and other necessary transportation, fuels, drinking water, food, etc. and that it was very difficult to secure those necessary materials by themselves on site. Therefore, EOC communicated each damaged site office to know necessary material one by one every day, and managed logistics support to let damaged site have more workable environment. In addition, after EOC received the information which mentions that the emergency recovery at lakeshore embankment of Lake Kasumigaura and Lake Inbanuma needs more blue plastic sheets, EOC prepared the list of stockpiled materials in all JWA offices and also the list of possible suppliers of the materials, and then, sent them to the offices in emergency recovery.

5.4. Portable seawater desalination equipment

Since Kasumigaura Canal facilities suffered damage from the earthquake and the water supply to the water purification plant of Ibaraki Prefecture stopped, JWA staffs worked on water supply using portable desalination equipment, operated by them, at Sakuragawa City where domestic water supply stopped. JWA provided 115m³ of desalinated water for 9 days, equivalent amount in water use for 38,000 people, which is made of the water of the pond for agriculture, to the houses and hospitals with the support of Sakuragawa City municipal government.

6. DISSEMINATION OF THE INFORMATION

6.1. Information release through website

JWA posted the Information related to facility condition and JWA's emergency status on risk management on the website of JWA HQ after the earthquake occurrence on March 11 and updated "disaster information" regularly to inform latest situation of the damages and the condition of the facilities. (29 times updated by the end of March, 2011) And from April 1, JWA changed the name of information release as "disaster recovery information" and sent information about the emergency recovery of each facility.-11 reports by May 10, 2011.

6.2. Information release through JWA public relations magazines

The JWA public relations magazine "together with Water" reported the outline of damages briefly in April, and then, the issue of "the damage of JWA facilities in the East Japan great earthquake disaster and the latest progress of rehabilitation" in May, and also, an article entitled "The review of emergency response against earthquake disaster and restart of water supply service " in July, 2011. In addition, the article about the facility damage and its rehabilitation are published in JWA's brochure "business summary (2011)" as TOPICS and also, JWA released related information through "water supply industry newspaper" on June 20, 2011.

6.3. Information release to the water users

The JWA branch office whose facilities are damaged, together with JWA HQ, worked on updating information to water user organizations appropriately about the damages to each facility and the progress of emergency recovery while carrying out the recovery works.

6.4. Reporting to the competent ministries

After an earthquake occurrence, JWA reported the situation of major damages of each facility and the progress of emergency recovery to the competent ministries. (Water and Disaster Management Bureau of Ministry of Land, Infrastructure and Transport, Rural Development Bureau of Ministry of Agriculture, Forestry and Fisheries, Health Service Bureau of Ministry of Health, Labor and Welfare, and Economic and Industrial Policy Bureau of Ministry of Economy, Trade and Industry)

7. THE PROGRESS OF THE DISASTER RECOVERY WORKS

7.1. Problems of the disaster recovery works

At damaged area by the earthquake, construction works increased drastically because of the disaster recovery in the same time. Therefore, there were fear of the shortage of labors, construction materials and construction machineries. As same as others, the disaster recovery works that JWA placed an order needed time for the procurement of material and construction machineries. Also, some of the disaster recovery works is not allowed to be implemented in flood season, from June to October, because the damage took place in river area. In addition, sometimes JWA had to redo because of some additional damage by the aftershock during recovery works. Further, restoration to its original form is the principle of recovery work. Therefore, additional function such as earthquake resistant function could not be added in the scheme of recovery works.

Finally, JWA completed the disaster recovery works, in full scale, by the end of March, 2013 (see photo 8).



Photo 8. Disaster recovery (left) damaged bank protection (right) after recovery

8. CAPACITY DEVELOPMENT AND RAISING AWARENESS ON RISK MANAGEMENT

8.1. The preparation to earthquakes

During the last 100 years, massive earthquake which brought serious disaster hit Japan 3 times, on September 1, 1923, the Great Kanto Earthquake around Tokyo, on January 17, 1995, the 1995 Kobe Earthquake, before the 2011 Tohoku earthquake. Actual disasters by earthquakes have some differences by place, season, time, weather, etc. Therefore, JWA implements disaster drills several times every year.

The disaster drills have two types, the one is the drill led by JWA HQ involving all JWA offices, and the other is the drill organized by each individual JWA office. In the whole JWA drill, assuming same disaster in each river basin, training on information transmission and distribution between branch office and JWA HQ etc., and also training on emergency recovery at the assumed damaged sites are conducted. On the other hand, in the individual training by each branch office, relevant organizations are involved in the training focusing specific trouble in each project. The accumulated experience through the disaster drill resulted in smooth operation in the first action just after the 2011 Tohoku Earthquake.

8.2. Unique effort of Numata Office in snow area

Numata Office makes unique effort to implement first action smoothly in case of earthquake. The northern Gumma prefecture area, in which Yagisawa Dam and Naramata Dam are located, is one of the heaviest snowfall areas in Japan.

The distance from Numata Office to each dam management place is almost 45 km, and, especially under snow covering condition, it takes about 2 hours in maximum to reach to Yagisawa Dam, including some necessary time to gather JWA staff from their home. Therefore, Numata Office installed distant monitoring facilities which enable observation of the situation of dam facilities from Numata Office.

In addition, after the Niigata Chuetsu earthquake in October, 2004, Numata Office prepared new manual for emergency inspection considering possibility of the occurrence of massive earthquake in winter, under bad condition for first response. The manual, called "Flash report and primary inspection manual in case of earthquake" aims at enabling all

Numata Office staff to carry out series of necessary first actions, until end of primary inspection, certainly and quickly. This manual was distributed to all staff member of the office, and explained in detail. Moreover, it is utilized not only in the case of earthquakes but also in emergency drills to confirm procedure of each inspections (see photo 9).



Photo 9. The primary check manual for earthquake (left: general, right: for winter)

9. LESSONS LEARNED THROUGH THE EARTHQUAKE DISASTER

It is the first time for JWA to experience such a large-scale disaster. Such a large-scale disaster brought not only lack of materials and construction machineries but also lack of manpower for recovery works because these are required for all urgent recovery works in the same time at everywhere in damaged area. Also it required additional time that the drawings of facilities and photo before the disaster had not been computerized, in the preparation of the application documents for urgent recovery works.

From the perspective of risk management, according to PDCA cycle, JWA is going to review existing plans and manuals for risk management and disaster prevention duties as follows to improve the capability on risk management, considering the lessons learned through the experience of the large scale disaster. (see Fig 2)

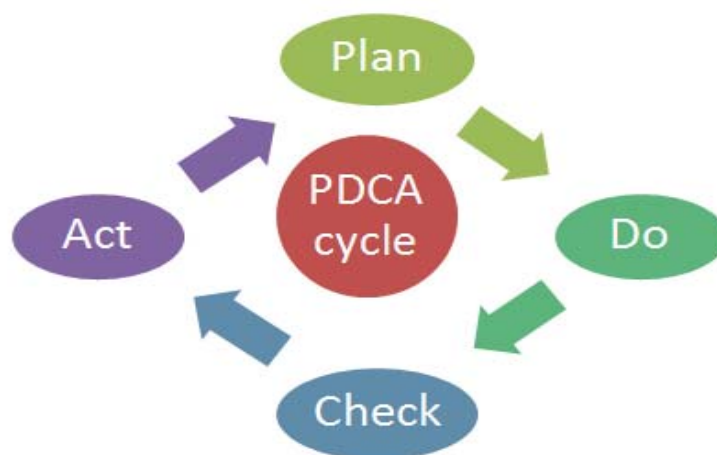


Figure2.The PDCA cycle

- a) The revision of detail rules of emergency operation plan.
- b) The database compilation of main facilities.
(computerization of the drawings and photos)

- c) Revision of draft “business continuity plan”, and authorization.
- d) Improvement of stockpiled materials and construction machineries, backup scheme for emergency case, and logistics.
- e) Promoting arrangement of cooperation agreement at the disaster with local firms.
- f) Standardization or review of specifications of equipment such as air valve.
- g) Accumulation and brushing up of technology on emergency recovery and temporary water supply.
- h) Implementation of more practical disaster drill.
- i) Further study on compensation for earthquake damages.

Through these improvements, to improve “preparedness” during normal situation, to review and restructure JWA’s organizational scheme, and to develop human resources, are key issues for JWA to accomplish its social mission, “steady supply of water”, under any kind of difficult situation.

In fact, many JWA offices, JWA staffs and their families suffered from the historic earthquake disaster. However, even though they are one of the large number of earthquake victims, they started emergency recovery works immediately after the earthquake. On the other hand, the earthquake let them think “unexpected matters” which have less possibility of occurrence as “the matters which will happen someday”, which brought opportunity for JWA staff to work from broader viewpoint.

In addition, JWA conducted a study on the institutional scheme to implement prompt support activities for emergency countermeasures against large scale natural disasters in Japan, utilizing JWA’s technology, human resources, materials, machineries, and experiences. Following the study, these activities were added in JWA’s Emergency Operation Plan. JWA commits social contribution through these activities and also accomplishment of assigned roles and tasks as a public organization.

10. CONCLUSION

Key for success on emergency operation is preparedness before the disaster and organizational governance on decision making and implementation after the disaster. In the case of JWA’s emergency operation against the earthquake in 2011, “Emergency Operation Plan” prepared beforehand and rational, organized performance of JWA staff led by strong leadership of HQ contributed toward success of urgent recovery on water resources management services. Even though it was serious disaster, Japan, including JWA, learned a lot to improve future risk management.

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