Damage and Restoration of Drinking Water Systems Caused by 0206 Tainan Earthquake and Future Mitigation Measures

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1. Overview of 0206 Earthquake's

At 03:57 local time (19:57 UTC) on 6 February 2016, an earthquake with a moment magnitude of 6.4 struck 28 km (17 mi) northeast of Pingtung City in southern Taiwan[1], in the Meinong District of Kaohsiung, Caoling of Yunlin County magnitude of 6, Tainan City, and Chiayi City areas of the earthquake level of 5. The earthquake struck at a depth of around 23 km (14 mi). Its comparatively shallow depth caused more intense reverberations on the surface[2]. The earthquake had a maximum intensity of VII (Very strong) on the Mercalli intensity scale, causing widespread damage and 117 deaths. Almost all of the deaths were caused by a collapsed residential building, named Weiguan Jinlong in Yongkang District, except two others, who were killed in Guiren District[3][4], both Districts are in Tainan City. Sixty-eight aftershocks have occurred[5]. The earthquake was the deadliest earthquake in Taiwan since the 921 earthquake in 1999.

The 6th branch office of Taiwan Water Corporation (TWC) immediately set up an emergency response team at 05:00 am, and recalled employees to inspect damage to water system infrastructure due to the earthquake. TWC found some transmission lines (1 meter or greater in diameter) were seriously damaged, thousands of distribution pipelines were damage due to shifting ground and soil liquefaction, resulting in water loss, water service interruptions, low pressure, contamination and sinkholes and/or large pools of water throughout the service area in the city.

The disaster has left 400,000 homes without water service. TWC dispatched several emergency repairing teams corporate with outsourcing contractors to repair leaky pipeline and buried new pipes, gradually reduced the number of households affected by the water-supply outage due to the earthquake until on the February 25th morning to restore water supply. Fig.1 shows restoration of water supply system in 0206 Earthquake in 2016.

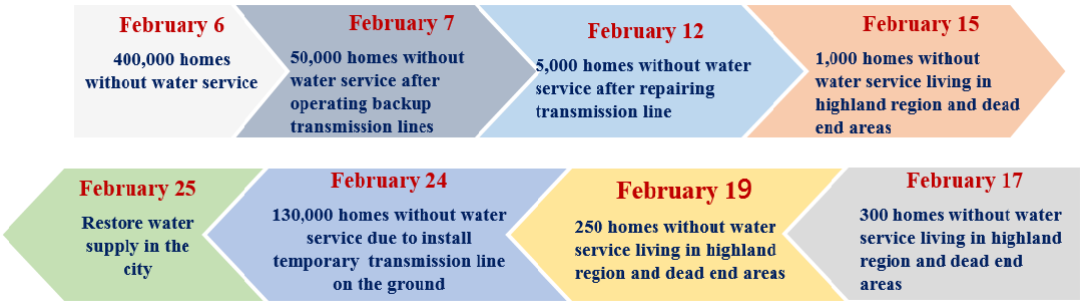

Fig.1 Restoration of water supply system in 0206 Earthque in 2016

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2. Emergency operation of Water Supply Systems in 0206 Earthquake

2.1 Emergency Water Supply Stations (Vehicle Transportation)

1. Emergency Water Supply Station (Water Supply Point):
   There are 142 Emergency Water Supply Station, generally one of these stations located within a 2km radius of consumer's home . Consumer can check the location of nearest Emergency Water Supply Station (Water Supply Point) from Public Notice or website of TWC and Tainan City Government.
2. Tour water supply: TWC uses water trucks to transport water to Emergency Water Supply Station (Water Supply Point). In accordance with the 22 vehicle route/stop for solid waste collection truck to send water tankers for providing patrol service.
3. Water tanker or Fire-fighting truck injected water into pipeline for supplying water to consumer's water tank.

2.2 Emergency Water Supply Operation

1. Due to the earthquake, Tainan Water Supply System had been seriously damaged, it needed time to restore water supply system gradually after repairing damaged water infracture , especially the damaged 2,000mm(in diameter) transmission line which was located under the collapsed 17-story Weiguan Jinlong Building (see Fig.2). TWC used backup 1,750 mm transmission line to transfer water and laying 1,350 mm emergency temporary transmission pipe on the ground (see Fig.3 and Fig.5) by reducing pressure to supply water. Owing that the total volume of water is insufficient and water pressure is low, the consumers living in highland region and dead end areas are still suffering water shortage problem.
2. Highland region : By operating the valves during night time to supply water .
3. Dead end areas : By using Water tanker or Fire-fighting truck injected water into pipeline for supplying water to consumer's water tank(see Fig.4).

Fig.2 The collapsed 17-story Weiguan Jinlong residential building

Fig.3 1,350 mm emergency temporary transmission pipe on the ground

Fig.4 Water tanker injected water into pipeline for supplying water to consumer's water tank

2.3. Repairing Pipelines

1. After inspection, there were about 7,948 cases of reporting water interruption, and about 4,710 leaky pipes (72 cases are larger than 300mm in diameter). The repairing teams cooperated with outsourcing contractors were dispatched immediately to fix leaky pipes.
2. Yongda Road damaged 2,000mm (in diameter) pipe:
   After the Tainan City Government has cleaned up the collapsed Weiguan Jinlong Building, Repairing teams of TWC rushed to repair the pipe and completed at 24:00 on February 24th then restore water supply.
3. Xinhua Zhongxiao Road damaged 2,000mm (in diameter) pipe :
   The damaged pipe was constructed by pipe jacking method and was under 8 meters from the ground, total length of 1,200 meters. After inspection it was found there were 7 cracks in the pipe. It was repaired at 00 : 30 on February 24th.
   Location of damaged 2,000mm pipe and

Fig.5 Location of damaged 2,000mm pipe and 1,350 mm temporary pipe

2.4 Communicating with the Public during the earthquake

Effective communication with employees, customers, and reporters is a key element of emergency response. When the crisis hits, our communication measures are following:

- Daily regular press releases are available on TWC website for information on water and water supply stations.
- Provide free Mobile Water Housekeeper APP for query service (see Fig.6).
- Established FB to provide user for consultation platform.
- Toll-free hotline at 1910.

Fig.6 Mobile Water Housekeeper APP

3. Lessons Learned from the 0206 earthquake

3.1 Establishing Forward Command Post:

Forward Command Posts shall be established on the spot of serious disaster areas. The post shall be headed by President of Taiwan Water Corporation and operated by TWC HQ to integrate TWC's all kind of resource to relief the disaster as soon as possible.

3.2 Water service message:

- Establish Line or Messages Group for government officials, elected representatives to inform emergency message at the first time.
- Set up the news media center to provide complete, accurate, and timely information.
- Tell the truth and express empathy.
- Acknowledge uncertainty and offer to get back with more information later.

3.3 Continuously strengthen the supply system and take aseismic measures.

3.4 Improve the restoration time needed for highland region and dead end areas.

4. What To Do Next

- Constructing Nan-hua dual transmission line system
- Improving plans for water supply in Highland region
- Developing smart water networks across the system
- Surveying seismic and geologic hazards across the system
- Replacing aging pipe remains a big source for work
- Seismic vulnerability and condition assessment for large diameter pipeline
- Capacity building and institutional strengthening for water loss control
- Enhance training for emergency management capacity

5. Conclusion

- Location on the seismic area that we cannot predict, but we can do our best to strengthen the water system and do well prepared to face the coming hazards.
- In response to the challenges, we need to improve the old facilities, establish supporting and backup system.
- Different environments face different disasters, we suggest focusing on the most critical threats and engaging in the proper solutions.

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