DAMAGES IN THE KOBE EARTHQUAKE AND JAPANESE SEISMIC DESIGN GUIDELINES OF DRINKING WATER SUPPLY FACILITIES

Ing Hiroshige Fukuda(1)

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The "Seismic Design Guidelines for Water Supply Facilities" published by Japan Water Works Association in 1997, are based on the damages of Kobe Great Earthquake, which have drastically changed from the prior edition.

Damages Caused by the Kobe Earthquake in 1995

Epicenter		far from 20 km to the Kobe city hall
Scale		Mg 7.2
Damages	Fatality	6,430 persons
	Injury	43,793 persons
	Building	250 thousand buildings
	Fire	198 cases

(1) Kobe Municipal Waterworks Bureau, Japan.

Outline of the Kobe Earthquake damage:

- The Kobe earthquake occurred at 5:46 a,m January 17, 1995
- The epicenter was located at the northern Awaji Island, far from about 20km to the Kobe city hall.
- The earthquake magnitude was 7 2 in the JMA scale
- The earthquake caused a lot of terrible damage to the citizens in Kobe city and around cities.
- The number of dead persons in the earthquake was 6,430.
- The number of injured persons was about 44 thousand.
- The number of destroyed buildings, completely and partially, was about 250,000, and about 200 cases fire have occurred.
- The earthquake had significant impact on lifelines, in addition to railroad, highway and so on.
- The water supply was cut off in 10 cities and 7towns

Damage Overview

Facilites	Damages (damaged/total)	Expense
Dams	1/ 3 dams	(billion) Yen)
Purification Plant	2/ 7 plants	
Raw water conduit	2 lines/ 43 km	
Transmission Main	6 lines/ 260 km	7.0
Distribution Reservoir	1/ 119 stations	1.9
Distribution Pipe	1,757 failures/4,002 km	13.5
Service Pipe	89,584 repairs/650,000 lines	2.5
Others (inc. Building)	Head office, one branch, etc	4.1
Total		**29.0**

- This table shows the damage summary of the drinking water supply facilities only in Kobe city suffered from the earthquake.
- The total estimated damage reached 29 billion yen. Equals to 242 million US dollars.
- Furthermore, including indirect damage, the sum went up to 35 billion yen
- Especially, the most significant damages were distribution pipes and water service connection. These repair cost was 16 billion yen, over the half of the total cost.

1. GENERAL OF JWWA'S GUIDELINES FOR SEISMIC DESIGN

1.1 General

For developing anti-seismic measures in water supply, the following basic plans must be drawn beforehand:

(1) Proper damage estimates before the occurrence of an earthquake, and preventive measures based on such estimates.
(2) Plans on emergency relief measures to be undertaken immediately after an earthquake, and disaster prevention measures including effective emergency repair works.

(3) Detailed plans on the organization for the implementation of permanent restoration works in the period from temporary works in the above (2) to the completion of the permanent works.

Some other considerations that must be taking into account are·

- If water supply restoration was not done early, corporations in the damaged city would go out to the non-damaged city and this matter would lead the city to decline, further.
- A plan should be established to provide well balanced, comprehensive measures to be standing with related organizations, during the pre-earthquake period; the immediate post-earthquake period and the re-construction period.
- In the immediate post-earthquake period, it's essential to collect quick and accurate information, and establish a communication-network. A plan should be drawn before-hand for calling out personnel for their deployment for initial response activities, which are considered the most important fact.
- All the above-mentioned measures must be planned in adequate coordination with the regional emergency preparedness plan. Moreover, education and training programs must regularly be practiced at all appropriate opportunities.

1.2 Planning, Design and Implementation

Planing:

a) To give sufficient consideration to earthquakes in accordance with various conditions.
b) To rationally design the structures with adequate consideration for important facilities.
c) To retain the water supply system as a whole as much capability to do water service.

Design:

a) For preparation of plans and designs of water supply facilities and their implementation, sufficient consideration should be given to earthquakes in accordance with various conditions in which the water utility is actually situated.
b) For important facilities, their structures must be rationally designed with adequate consideration to the effects from earthquakes.
c) The construction of water supply facilities must be so implemented that the water supply system as a whole retain as much capability to do water service even though the system has sustained certain damage.

Implementation:

a) Since a water supply system consists of a variety of different facilities (which extend from an individual spigot to a local facility) and is spread over a wide area, addressing one part of the system will not prevent damage to the entire system when a strong earthquake occurs.
b) The entire water supply system should be protected as much as possible. In order to achieve this goal, decentralization and separation of main facilities and back-up facilities must be implemented, including pipeline connections, electric facilities, and power distribution networks. If possible, facilities with gravity flow systems should be used instead of pump systems. In addition, it's advantageous to correlate the different anti-seismic strengths of the facility's buildings with their relative importance.

c) Anyway, temporary failure of water supply systems can't be avoided. Therefore, it's very important to design an entire system that can be quickly repaired to supply water, at least, for drinking and domestic use. This is one of the points that I would like to emphasize.

1.3 Geotechnical Survey of the Foundation

1. It's desirable that water supply facilities are founded on location where the foundation is firm and the landscape is stable. Prior to the construction of specially important facilities a careful and detailed geotechnical survey must be carried out.

2. From a study of past earthquake disasters and subsequent damage records, damage to buildings constructed on solid and stable ground has been found to be comparatively less. Therefore, for the construction of the water supply facilities, it's essential to that a good ground site be chosen.

3. When the ground conditions aren't the most desirable, improving the foundation through substructure work or additional slope stabilization work must be applied. Preventative measures, such as the use of flexible structures which respond to ground "floating" or displacement during an earthquake, must also be used.

1.4 The Employment of Highly Earthquake Resistant Materials and Joints

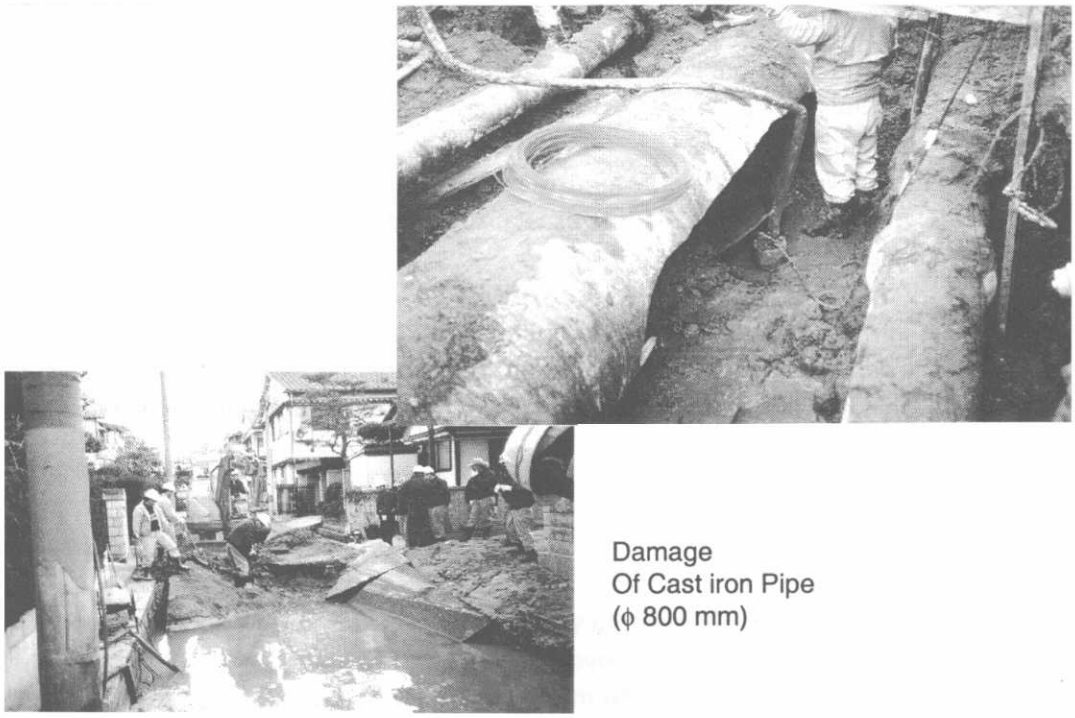
1. For construction of main water supply facilities, earthquake resistant materials should be employed in structurally important locations. For water-proof containing facilities and structures, it's necessary to design with the provision of earthquake resistant joints, which absorb expansion, contraction and distortion, and to be provided between interfacing structures which may move, when an earthquake occurs, and leave relative displacement.

2. Underground pipelines will deform as a result of the ground displacement produced by an earthquake. Such displacement tends to escalate in areas where the geography or topography is subject to sudden change.

3. This results in movement and distortion of structural damage. On such ground, flexible, anti-seismic joints capable of absorbing the displacement generated during an earthquake, must be used. In addition, flexible materials capable of absorbing earthquake displacement may also be used to avoid structural damage.

Deformed Flexible Pipe

- This picture shows that an expansion joint was sunk over expected.
- If flexible pipe was not installed, a large damage had suffered in this pipeline.
- For a place threatening to cause irregular subsidence such as a tie-in point with a structure, highly flexible expansion joints should be used.



Damage
Of Cast iron Pipe
(ϕ 800 mm)

- This is an example of the damage to Cast Iron Pipe.
- Because the material that was used is easily broken, 253 cases of such damage occurred to Cast Iron Pipe.