Preparation of Anti-Disaster Manual and Information Systems

The earthquake will lead home disaster in the case of the absence of effective anti- disaster manuals. Thus, to improve mobilization and communication systems we prepared an "emergency water supply manual" and an "infrastructure restoration manual (waterworks)" in 1997. For better organization of information in the disaster, Kobe city whole anti-disaster communication network started operation in 1998. This is a computer system that quickly collects and shares information in an emergency to support the precise actions required. It links an anti-disaster center with city's branch offices, ward offices and the like, and offers information to citizens on the internet.

Private Well Registration

It is very difficult to do enough emergency water supplying whatever system organized. Therefore, in the disaster, it is necessary that a lot of the source of water exists near the citizen. In these sense, the wells that the citizen possesses in Kobe city are registered and, in case of the disaster, habitants around the registered well are able to use it. At present, a total of 536 wells were registered.

It is impossible to support all of the citizen's life in the disaster, since number of the staff of the administration and water supply utility is about 10% of the population. Also, citizen is to easy to obtain the information about the citizen of being in the neighborhood and the information is correct and up-to-date. Therefore, in Kobe city, a new autonomy disaster protection organization was established along with the welfare support organization which were formed separately in the past. In the area where there was not such an organization so far, the new organization is forming here and there. This organization will be able to do a fire fighting activity and an emergency water supplying activity in the early stages, too.

Drill to enable to practice Firefighting and Water Supplying

This picture shows the members of autonomous organization drilling to set up the equipment for emergency water supply taps in the park buried large capacity water tank connecting with distribution mains. If not training from time to time, even excellent organization and manual were established it is supposed that they will not function effectively in case of the disaster. As for my emphasizing to all of you, to attempt improving the risk management," the drill is essential".

2. LESSONS AND PLANNING FOR EARTHQUAKE RESISTANT WATER SYSTEM IN KOBE

2.1 General

Each part of water supply facilities must be designed to retain its respective capacity even after an earthquake with the design intensity of seismic ground motion. The more important the facility, the more the need for such consideration. For anti-seismic design of facilities, a design method, that is suitable to the characteristics of respective facilities and the nature of their founding and surrounding ground, must be employed. The facilities in a water works system include a variety of different structures. These structures can be classified in the following.

Classification of Water Works Facilities

Water works structures can be classified into four types, according to how they respond to an earthquake.

- The first are Rigid structures, such as dams, Raw Water Intakes, Underground Water Storage Tanks or Reservoirs.
- The second are Pipeline structures, such as Underground Pipelines, Closed Conduits, Common ducts, and others such as shield tunnel shafts.
- The third are Facilities which characteristically respond to an earthquake, such as Elevated Tanks, Water Intake Towers, Water Reservoir Towers, Aqueduct Bridges.
- The forth are structures which have different characteristics or special purposes, such as water works utility's buildings, and main purification and distribution stations.

2.2 Seismic Motion Level for Design

For an anti-seismic design, two different magnitudes of intensity must be employed. Seismic Motion Level 1(L1) may occur once or twice in the service period of a structure. L1 is equivalent to the conventional seismic motion level set by many civil engineering construction guidelines. Seismic Motion Level 2(L2) is equivalent to the seismic ground motion generated in areas with faults or with big plates bordering inland areas. The probability of a water works system experiencing Seismic Motion Level 2 is very low, but, the influence of L2 is considered enormously great.

2.3 Importance Ranking of Facilities

In principle, for planning anti-seismic design of water supply facilities, they must be categorized into two:

a) Facilities at a high level of importance (we call them Rank A)
b) Other facilities (call them Rank B)

A water supply system begins at the reservoir facility and continues on with water intake, conveyance, purification, transmission, and distribution facilities. Throughout various service devices are included, but these facilities function as a single system. Therefore, if one of these facilities is taken out of service, a stable water supply system can't function.

It's not realistic to demand the highest level of earthquake durability in every component of a water supply system, because maintaining and managing the construction of a water supply system must be done with limited budgets. When implementing anti-seismic planning for a facility, the degree of significance should be categorized into either **Rank A** or **Rank B**. In addition, the degree of importance should be combined with two Seismic Motion Levels, **Level 1 and Level 2.**

The significant degrees are decided by individual work groups, based on their own judgment, experience, local specialized reasoning, and consideration of local disaster prevention programs. Factors affecting a facility's degree of significance are grouped in two categories: those factors which, during an earthquake may influence non-water works facilities, and those factors which may affect the conventional functions of water works facilities.

Facilities Ranked A

1. Facilities ranked A are:
   - Facilities which posses the potential to generate serious secondary disasters.
   - Facilities located up-stream of water supply system.
   - Main facilities which don't have backup facilities.
   - Pipelines for social important institutions and facilities.
   - Main facilities which are difficult to restore if damaged.
   - Facilities which will become the center for gathering information during a disaster.

2. Factors affecting a facility's degree of significance are grouped in two categories: those factors which, during an earthquake, may influence non-water works facilities and those factors which may affect the conventional functions of water works facilities.

3. For facility structures described in 2 through 6, these functions are very important during a disaster, especially from perspective of swift and effective restoration work to priority water supply works.

4. Damage to social activity from non-functioning up-stream facilities of water supply system is usually greater in extent and severity. Main facilities that don't have any substitute back-ups, than have multiple functions, or that have large capacity, are more significant in degree.

5. Facilities to be centers for information gathering, such government or municipal office buildings that serve as centers for emergency communication, joint activities, and water conveyance, must be insured the highest level of anti-seismic design.

2.4 Anti-Seismic Level to be maintained

		Seismic Motion Level	
		Level 1	**Level 2**
Rank of Significance	A	No damage	No severe impact on human life. Individual facility may receive light damage, but will still function.
	B	Individual facility may receive light damage and may be able to function.	Individual facility may receive some damage. The system retains its total ability to function. Early restoration possible.

Water supply facilities should maintain either one of the anti-seismic standards shown in this table, which are set by combining the Seismic Motion Level(L1 and L2) and the significant ranking of the facilities (Rank A and Rank B). In the case of that rank of significance is B and Seismic Motion Level is Level 2, the facility is to be **"Individual facility may receive some damage. The system retains its total ability to function. Early restoration is possible".**

The basic anti-seismic standard is arrived at by combining the appropriate seismic motion level with the appropriate degree of significance rank. Each water works utility **must exercise** their own judgment, in accordance with their own standard and evaluations for better anti-seismic construction designs.

2.5 Earthquake Effects on Anti-Seismic Designs

For anti-seismic design, following effects of earthquake must be taken into consideration:

a) Displacement and distortion of the foundation soil during an earthquake.
b) Inertial force owing to the weight of structures.
c) Soil pressure during an earthquake.
d) Dynamic water pressure during an earthquake.
e) Water surface sloshing.
f) Lateral soil movements due to liquefaction.
g) Soil distortion on a slope of reclaimed land.

During an earthquake, the behavior characteristics of underground pipe structures, such as pipelines, ducts, closed conduits, and common ducts or shield tunnel's shafts, are controlled by the surrounding ground. On the other hand, stiff structures must also receive sufficient consideration, especially with regards to their weighted and un-weighted loads. It's necessary to determine the inertial force characteristically related to each facility, because the effects are dependant on the structural characteristics of each facility.

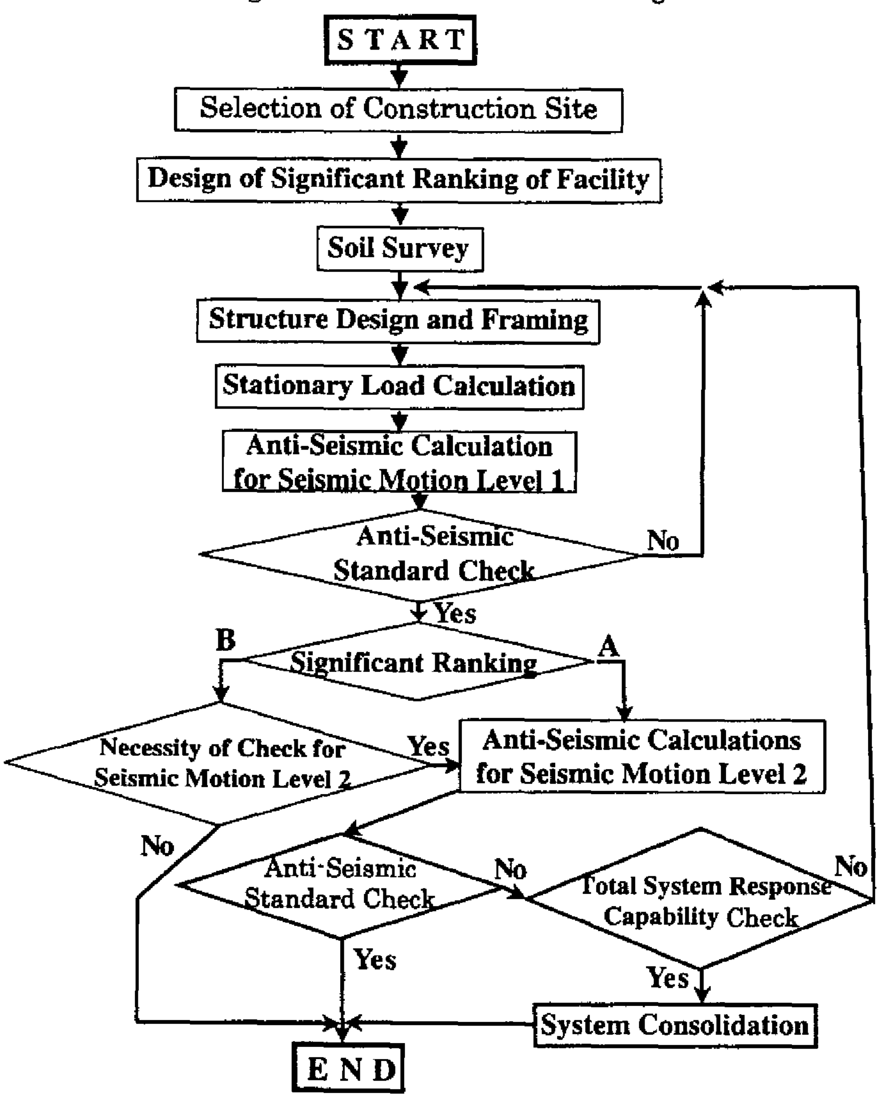
2.6 Sequence of Anti-Seismic Design Works

Order of Anti-seismic design to be carried out is shown following:

1. After selection of the construction site, detailed consideration of ground conditions is undertaken. Next, the appropriate structural type and form is chosen.
2. The basic anti-seismic design is chosen after an evaluation of ground conditions. Constructing water works facilities on solid, even ground is always ideal.

However, the most of water transmission and distribution facilities in service areas are built without regard to whether the ground is good or bad. In many instances, these facilities must be built on ground with weak strata. In these cases, sufficient research and assessment of the ground, including soil surveys, must be done. In addition, implementation of countermeasures, such as substructure work to improve the ground or the use of flexible joints in the facility structure, should be undertaken.

Fig. Anti-seismic Structure Design Order



3. BASIC PRINCIPLE FOR ANTI-SEISMIC DESIGN OF JWWA'S GUIDELINES

3.1 Anti-Seismic Calculation Methods

Anti-seismic calculation methods for water supply facilities can be classified into three major categories:

a) Seismic intensity method
b) Response displacement method
c) Reference to the results by dynamic analysis.

Their selection are based on the structural nature of the objective structures and other factors.

The seismic intensity method mentioned here includes the traditional, modified seismic method. For the ground structures, an anti-seismic design must be implemented using the seismic intensity method. Because the effects of inertial force and dynamic water pressure, in the case water levels are full, can't be neglected, verification of the safety, using the dynamic analysis method, is recommended after the seismic intensity method is applied.

Buried structures must be designed using the seismic intensity method or response displacement method. For the anti-seismic design of a structure whose movements are complex at the Seismic Motion Level 2, to verity the results, calculation using the seismic intensity method or the response displacement method, the dynamic analysis method must be applied when required.

For an anti-seismic design of a massive. partially buried structure(such as a settling basin), the seismic intensity method may be used. By the way, during an earthquake, the vibrations in a structure differ according to the characteristics of the structure and the ground conditions at the site where the structure is located. This is true even when the structures are identical. The behavior of underground structures differ from the behavior of the structures on the ground. The characteristic of a seismic motion affects the structure's behavior to a considerable degree. As above mentioned, many factors affect the vibration patterns and the force to a structure. These factors are classified as follows.

3.2 Factors of the vibration pattern and the force to a structure

Many factors effect the vibration patterns and the force to a structure. These factors are classified into three:

a) The characteristics of the ground supporting the structure.
b) The structure's mass, natural oscillation period, damping characteristics and flexibility.
c) The strength of seismic motion and vibration characteristics which affect the structure.

During an earthquake, the vibration in a structure differ according to the characteristics of the structure and the ground conditions at the site where the structure is located. The behavior of underground structures differ from the behavior of structures on the ground. For design purposes, the appropriate anti-seismic design method/ must be selected after taking into account these factors.

A water supply system usually consists of a variety of different structure types. Furthermore, these facilities are also built on many different types of subsoil. Therefore, a single, fixed seismic calculation method for each facility's design cannot be applied. However, the method shown in the following Table is of general help.

Calculation Method		Water Supply Facilty
S.M. Level 1	**S.M.: Level 2**	
Seismic Intensity Method (S.I.M.)	S.I M.	Machinery & electric, Building structure
	S.I.M. or D.A.M.	Water intake
S.I. M. or R.D.M.	S.I.M. or D.M. If necessary D.A.M. check	Shield tunnel and shoft Pond-type reservoir
Response Displacement Method (R.D.M.)	R.D.M.	Well, Pipeline and tunnel (cross direction)
	R.D.M. or D.A.M.	Pipeline, tunnel (axis)
S.I.M. or Dynamic Analysis Method (D.A.M.)	S.I.M. If necessary: D.A.M. check	Water service tower Elevated water tank

For example, for **Water Intake Tower,** in the case of seismic-motion **Level 1,** the **Seismic Intensity Method** is generally adopted. In the case of seismic-motion **level 2,** the **Seismic Intensity Method** is adopted, and if necessary, such as in the case of a facility ranked **Significant A,** it's recommended to check with **Dynamic Analysis Method.** For pipeline's and tunnel's axis direction, in the case of seismic-motion **level 1, Response Displacement Method** should be adopted.