DAMAGE TO SOLID WASTE MANAGEMENT SYSTEMS AND THEIR RECONSTRUCTION IN THE EARTHQUAKE-STRICKEN AREA

by Mr Hiroki Hashizume, Director, Japan Waste Research Foundation
Iidabashi KS Bldg., 2-14 Shimomiyabi-cho, Shinjuku-ku, Tokyo 162, JAPAN
Tel: +81-3-5261-9391 Fax: +81-3-5261-9393

1. Introduction

In an instant, one of the most densely populated areas in Japan became a disaster area on January 17. The predawn Hyogo Nanbu Earthquake killed more than 5,200 people and injured 27,000. More than 107,000 houses and buildings were destroyed or badly damaged and have therefore generated a huge amount of waste, estimated at 18.5 million tons. Fortunately, waste management facilities such as incinerators were not badly damaged. Still, it is anticipated that the amount is so large that its management will be extremely difficult.

2. Waste Generation

Various kinds of waste are being generated in the disaster area; 1) waste discharged from daily life, 2) waste laying on roads, 3) demolition waste of damaged houses and buildings, 4) bulky waste generated because of the earthquake, 5) human excreta and sludge from private sewers (Jokaso), and 6) waste generated from reconstruction activities. According to Hyogo Prefecture, the amount of 2), 3) and 4) (hereinafter the 'earthquake waste') is estimated to be as shown in Table 1.

The total amount, 18.5 million tons, is more than a third of the national annual generation of non-industrial waste in Japan.

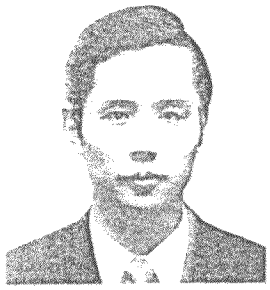
Table 1 Amount of Earthquake Waste (Source: Hyogo Prefecture)

kind of waste	10^3 tons (10^3 m^3)
houses and buildings	13,000 (12,000)
public facilities	
-roads and railroads	4,800 (3,000)
-houses & apt. houses managed by local gov. or public corp.	700 (500)
total	18,500 (15,500)

3. Management and Disposal of Earthquake Waste

Because the amount of earthquake waste is so large, its disposal must be effective and well planned. Thus, the earthquake waste is being managed in a somewhat different manner than that of ordinary waste. The earthquake waste is to be managed in the following ways: 1) Damaged public facilities are removed and disposed of by the administrators of the facilities; 2) Damaged buildings such as offices of big enterprises are managed by the enterprises themselves; and 3) Damaged houses and buildings are managed by municipalities.

A new policy is being applied to management of damaged houses and buildings this time. In past earthquakes, half of the cost for waste transportation and disposal has been subsidized by the Ministry of Health and Welfare. This time, half of the cost of demolishing houses and buildings is also being subsidized. The remaining half is covered by municipality loans, and 95% of their amortization is being granted by the national government.



Mr H. Hashizume

While all the waste from damaged railroads and half of the damaged national highways had been removed by the end of March, only 27.0% of the damaged houses and buildings (3,580 thousand tons) have been demolished and only 5.1% (671 thousand tons) have been transported. It is estimated that all of the houses and buildings will be demolished and transported for disposal by the end of fiscal 1995 and treatment and disposal will be finished by the end of fiscal 1996.

Because the earthquake waste mainly consists of concrete, metal and wood chips, recycling should be promoted as one of the treatment methods. Table 2 shows the earthquake waste treatment plan.

Table 2 Recycling Targets for the Earthquake Waste (Source: Hyogo Prefecture)

	generation (10^6 tons)	recycling (10^6 tons)	use and recycling targets (10^6 tons)
incombustibles (*1)	16	concrete 11.02	-houses, buildings 6.88 (reclamation 6.33, construction material 0.19) -public facilities 4.44 (reclamation 3.82, construction material 0.62)
		metals 0.45	-houses, buildings 0.28 (materials for iron manufacturing) -public facilities 0.18 (materials for iron manufacturing)
combustibles (*2)	3.5	wood chips 0.08	-houses, buildings 0.08 (materials for pulp, fuel, fertilizer after chipping)
total	18.5	11.55	recycling rate : 62.5%

(*1) Remaining incombustibles are being disposed of at the Osaka Bay Phoenix Center.
(*2) Remaining combustibles are disposed of at inland landfill sites or at the Phoenix Center after incineration, etc.

4. Damage to Waste Treatment Facilities

Kobe City has five incineration plants for municipal solid waste. Damage to the facilities themselves is light. In the Nishi (West) Plant a crane has some problems, and in the Ochiai Plant steam leakage was detected. In other areas affected by the earthquake, damage to incineration plants, bulky waste crushing plants and night soil treatment plants is also very limited.

It seems that the biggest problem with waste management plants was the stoppage of the supply of water, electricity and gas.

For example, in Kobe's Higashi (East) Plant, right after the earthquake, the power, gas and water supplies all stopped. An emergency generator started and combustion was safely stopped. Equipment in the plant was inspected and deemed to be all right. On January 20 power was re-established. On January 25, the plant resumed receiving waste. On January 31 when the pits became full of 1,500 tons of waste, the plant again suspended receiving waste. On February 20, the water supply was reconnected and the plants started to burn waste again. Still, one incinerator out of two, remained out of operation due to stoppage of the industrial water supply needed for cooling purposes.

5. Other Problems Related to Earthquake Waste Management

Such a huge amount of waste was generated at once that waste treatment facilities for each municipality, such as incineration plants and final disposal sites, have been unable to handle the waste in proper order. Some problems are;

1) Temporary storage yards are necessary. Parks, athletic fields, beaches, etc. have been turned to be temporary storage yards.
2) Traffic jams are inevitable in the disaster area. Roads to landfill sites are extremely crowded with very many trucks. For example, 4,500 trucks per day are entering Kobe's Fusehata landfill site, where only 1,000 trucks disposed of waste before the earthquake. This situation has made transportation and disposal inefficient.
3) Although the law requires waste to be burned only in incineration facilities, lots of waste is being burned in open yards.
4) A lot of buildings and houses which contained asbestos were damaged. In order to prevent air dispersion, due consideration has been necessary during demolition, collection, transportation and disposal.
5) A lot of portable gas cylinders are being used and discharged. Accidents during collection, crushing and incineration are anticipated.
6) Sewage systems also suffered severe damage similar to the water and gas supply systems. For example, in Kobe, 99% of the houses are connected to public sewage systems. Thus, alternative systems of night soil treatment during an emergency had to be taken into consideration.

6. Issues for Proper Management of Waste in Emergency

1) Waste management should be included in disaster prevention plans. Further, local governments' waste management plans should incorporate plans for waste management during emergencies.
2) Waste treatment facilities should be built in places where damage to roads and bridges will not affect their operation.
3) Multi-purpose open spaces should be maintained so that huge amounts of waste can be stocked temporarily.
4) Landfill sites should be designed to receive a certain volume of earthquake waste.
5) In order to estimate the amount of waste generation, data bases should be established regarding housing, asbestos use, and the storage of chemicals.
6) Support systems should be established among local governments.
7) Incineration facilities that require a minimum amount of water to start up should be developed.
8) Earthquake-proof design of waste management facilities should be promoted.
9) Waste transportation using ships and railroads during emergencies should be studied.
10) New waste management technology should be promoted. For example, on-site recycling equipment for destroyed houses and emergency incinerators.

Photo 1 At Hokudan Village, Awaji Island

Photo 2 Depot of Demolition Waste, Kobe City

HYOGO NANBU EARTHQUAKE – DAMAGE TO SEWERAGE SYSTEMS

by Mr Katsuhisa Shioji, Deputy Director, Sewerage Planning Division,
Sewerage and Sewage Purification Department, City Bureau, Ministry of Construction
2–1–3 Kasumigaseki, Chiyoda–ku, Tokyo 100, JAPAN
Tel: +81–3–5251–1863 Fax: +81–3–5251–1940

1. Introduction

In the early morning of January 17 1995, a devastating earthquake (the Hyogo Nanbu Earthquake) hit the southern part of Hyogo Prefecture. As of March 23 the earthquake's toll stands at 5,504 persons dead or missing, 41,648 persons injured, 208,502 buildings destroyed and 294 incidents of fire. The total damage is estimated to be more than 9,000 billion yen.

2. Assessment of Earthquake Damage to Sewage Systems

Sewage systems were severely damaged by the earthquake. The "Guidelines on measures for protecting sewage systems against earthquakes –1981 edition–" indicates the strength of an earthquake and applicable measures for the protection of sewage facilities against earthquakes as follows;

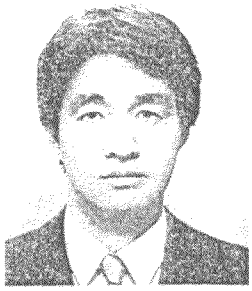
a. The Tokyo area during the Kanto Earthquake
b. The City of Niigata during the Niigata Earthquake
c. The City of Sendai during the Miyagi-oki Earthquake

Table 1 shows that the Hyogo Nanbu Earthquake generated seismic motion which exceeded the motion considered in the guidelines. This fact is considered to be the main reason that sewage systems sustained such heavy damage.

It also should be noted that the earthquake is the first one to hit a metropolitan area with a high ratio of sewered population. For example, the ratio of sewered population in Kobe City was about 97% as of March 1993; in Nishinomiya City 78%; and in Ashiya City 99%.

3. Outline of Damage to Wastewater Treatment Plants

Forty three wastewater treatment plants out of one hundred and two which are now operating in Hyogo, Osaka and Kyoto prefectures were damaged. At eight of the plants, secondary treatment function were lost. Some plants discharged wastewater with primary treatment, the others with no treatment. Most plants, however, recovered full scale operation in a short time. Because of water supply suspension, the flow rate of waste water in these plants was low for a while after the quake, and there was probably no adverse effect on any bodies of water. It is also consoling to note that it was in the dry season.



Mr K. Shioji

The Higashinada Wastewater Treatment Plant in Kobe city was severely damaged. The plant is located on reclaimed land next to a canal. Because of liquefaction and lateral ground deformation, the buildings and facilities, as well as pressure pipes which connect the treatment plant and the pumping station on the other side of the canal, were damaged and lost of treatment functions. Because it was expected that repair work would take a long time, authorities partitioned the canal so that the canal serves as a sedimentation tank. From February 6 to the end of April, wastewater was treated in this temporary sedimentation tank. On March 19, partitions were added to prevent a short-circuit. A facility for coagulation was added on March 28 in order to improve effluent quality. On the first of May, the plant recovered secondary treatment functions (activated sludge treatment) through temporary repair work.

An intensive investigation has been done on Higashinada Wastewater Treatment Plant. It has been found that pile foundations are broken under several

Table 1 Comparison of "Hyogo Nanbu Earthquake" and Other Earthquakes in the Guidelines

Name of Earthquake	Magnitude / Depth of seismic centre	Seismic motion by seismograph: Peak acceleration	Max. velocity	Max. displacement	Intensity scale by Meteorological Agency
KANTO Earthquake (1st September, 1923)	M = 7.9 Sea bed in SAGAMI				Level VI Disastrous Earthquake
NIGATA Earthquake (16th June, 1964)	M = 7.5 ± 0.2 Approx. 40 km	Approx. 190 gal (Underground in Niigata City)			Level V Very Strong Earthquake
MIYAGI Earthquake (12th June 1978)	M = 7.4 Approx. 70 km	Approx. 320 gal (Soft ground in Sendai City)	Approx. 36 kine (Hill of Sendai City)	Approx. 15 cm (Hill of Sendai City)	Level V Very Strong Earthquake
HYOGO NANBU Earthquake (17th January 1995)	M = 7.2 approx. 14 km	818 gal (KOBE Ocean Meteorological Observatory in KOBE)	Approx. 91 kine (KOBE Ocean Meteorological Observatory in KOBE)	2 cm (KOBE Ocean Meteorological Observatory in KOBE)	Level VII Ruinous Earthquake
		727 gal (Higashi Kobe Bridge)	Approx. 91 kine (Higashi Kobe Bridge)	49 cm (Higashi Kobe Bridge)	

Note) The data in the comparison table are obtained in the following references

1. MIYAGI Earthquake Disaster investigation report (1978, The Architects Institute of JAPAN 1980)
2. Guidelines on measures for the sewage system against earthquake - 1981 edition
3. Document of aseismatic design for structures (The Architects Institute of JAPAN 1981)
4. Latest report on damage of Earthquakes in Japan (Tsuda Osami 1994)
5. The Japan Society of Civil Engineers Hanshin Earthquake Disaster Investigation Committee (The Japan Society of Civil Engineers 1995)
6. The Hanshin Expressway Public Corporation, Ministry of Construction

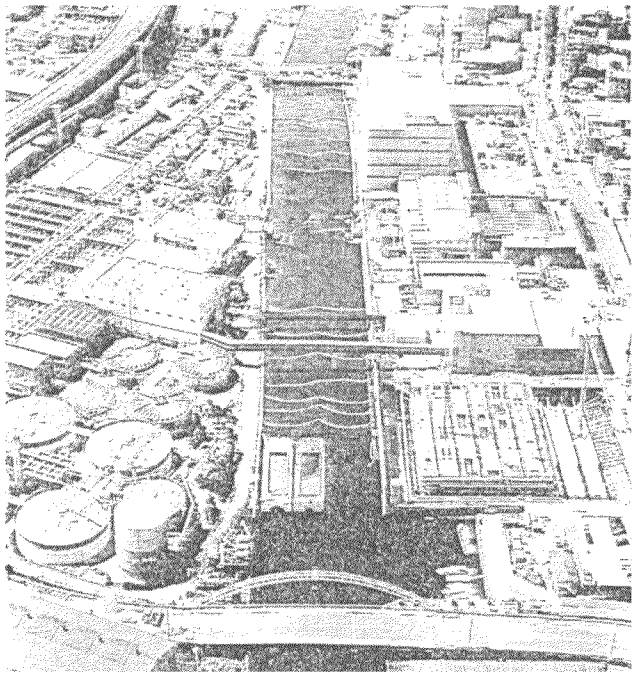


Photo 1 Higashinada Wastewater Treatment Plant and Adjacent Canal Which Is Partitioned to Serve as a Temporary Sedimentation Tank

buildings including the administration building and part of the wastewater treatment facilities. In one part of the treatment facility in particular, 40% of the pile foundations are estimated to be broken. These structures are scheduled to be rebuilt. It will take four or five years to complete.

The characteristics of damage in the wastewater treatment plants are;

- irregular settlement of the channel that seemed to be caused by liquefaction of the ground
- rupture of the pipeline and floating of the pipeline base
- damage in the foundation pile that seemed to be caused by lateral ground deformation
- rupture and cracking of joints of conduit and tanks that seemed to be caused by lateral ground deformation
- rupture of tanks and the piping gallery caused by the lack of elasticity in the joints.

On the other hand, there was only slight damage in wastewater treatment plants which had prepared against liquefaction, even though other buildings in the area were more severely affected by liquefaction.

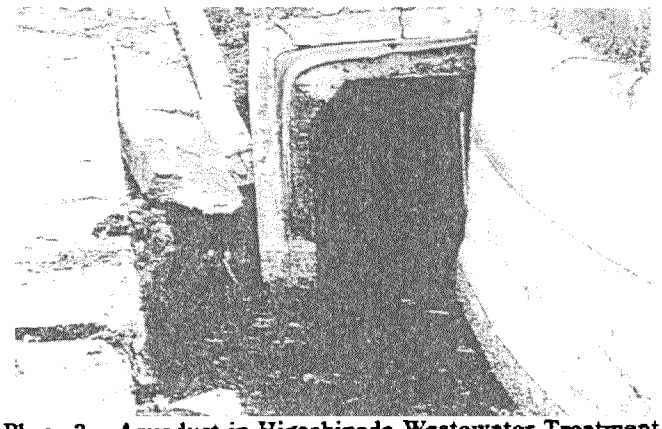


Photo 3 Aqueduct in Higashinada Wastewater Treatment Plant (Aqueduct is broken at a joint.)

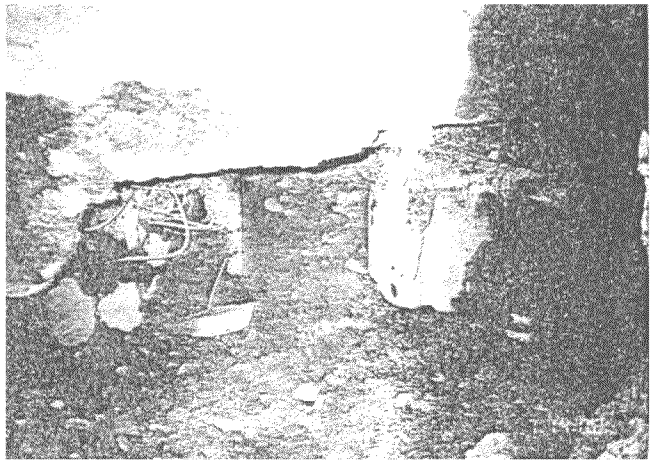


Photo 2 Pile Foundation at the Administration Building at Higashinada Wastewater Treatment Plant

4. Outline of the Damage to Sewer Pipes

Just after the quake, the authorities had their men check sewer pipes by opening manhole covers and observing the situation inside as the first stage of investigation. This stage was done in several days and it was reported that pipes were broken at about 1600 sites. Emergency countermeasures were taken in order to maintain sewer function where the pipes were jammed by debris, etc.

For the second stage of investigation, a TV camera was used to check the inside of pipes which are so small in diameter that investigators could not go inside. Table 2 shows the toll of damage to sewer pipes at each municipality as of April 21. The total length of damaged pipe is about 162km or 1866 sites. Investigation with a TV camera takes a long time, and where the pieces of destroyed buildings still cover the street, the investigation is impossible. Therefore, the investigation is not totally completed.

It is reported that most broken pipes are lateral pipes which generally have a shallow covering. Trunk sewers were only slightly damaged though some of them were broken resulting in temporary suspension of water transmission. Damage was found mainly at the connections of manholes and pipes, and the connections of lateral sewers and public inlets. Moreover, some damage in outlet bulkheads was also reported.

Table 2 Damage to Sewer Pipes

Prefecture	City	Pipe Length (km) Total	Investigation Need	Investigation Finish	Total Length of Broken Pipe	
Hyogo	RSS	64.3	64.3	64.3	0.2	
	Kobe	3800.0	1557.0	1395.0	59.3	*1
	Amagasaki	1081.6	66.0	66.0	39.0	
	Akashi	500.7	13.1	13.1	1.9	
	Nishinomiya	1247.0	890.0	890.0	20.3	
	Ashiya	217.0	22.3	22.3	23.9	*1
	Itami	511.7	6.3	6.3	1.7	
	Takarazuka	510.0	12.5	12.5	7.5	
	Kawanishi	343.8	0.3	0.3	0.3	
Osaka	RSS	873.0	326.3	317.0	-	*1
	Osaka	4514.9	12.5	12.5	1.8	
	Toyonaka	945.8	150.0	150.0	0.93	
	Suita	573.0	288.3	38.0	-	
Kyoto	Kameoka	150.4	-	-	-	*2
Total		15015.3	3773.2	3255.3	161.9	

RSS: Regional Sewage System

*1: Investigation is not finished because of destroyed buildings

*2: Damage on the wastewater treatment plant