THE KOBE EARTHQUAKE AND ITS IMPLICATION IN EARTHQUAKE INSURANCE IN JAPAN

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1. THE OCCURRENCE

When the Kobe earthquake occurred at 5:46 in the early morning of January 17, 1995, I happened to be sleeping in a hotel in Osaka, only about 40 km to the east of the epicenter. It was the strongest shaking I had ever experienced. Within a quarter of an hour, TV started to show the distribution of the seismic intensities reported by the Japan Meteorological Agency.

Within half an hour, the epicenter was known to be near the city of Kobe, the magnitude 7.2 and the focal depth about 20 km. I knew that the greater Kobe city has some 2 million people. With all this information at hand, I could not expect that a disaster which eventually claimed 6,300 lives was taking place.

"Buildings were toppled, houses were in rubbles, infernos swallowed entire towns, elevated highways and railways collapsed and crumbled cliffs buried houses. Everywhere people died," reported Asahi Evening News on the next day of the earthquake.

However, this was only a part of the damage of the 1995 Hyogoken-nambu earthquake which battered Kobe and nearby areas in the early morning of January 17. The death toll of 1,812 as reported by the same newspaper (as of 9:45 am. of January 18) continued to rise to finally reach 5,502 in May, 1995, making the earthquake the worst event since the 1923 Great Kanto earthquake that left 143,000 dead or missing. The number of the death toll further increased to some 6,300 including those who died because of indirect but earthquake-related causes.

It cannot be denied that both public and local authorities had taken it granted that a big earthquake would not happen in the Kansai region. The earthquake caught the residents of the Kansai region off guard. They had almost forgotten the major temblor of 1946 focused off Wakayama prefecture that claimed 1,330 lives.

The Japan Times Special Report quotes an aged housewife, 73, whose house completely collapsed saying, "I never imagined such terrible thing could happen to us at this age. We have to start from scratch again."

The head researcher at a disaster-related think tank says in Mainichi Daily News (January 18), "It was shocking to see the same kind of fires that broke out in the Great Kanto earthquake in a modern city. Until now, anti-earthquake policies have been directed toward the Kanto area, and now we see the blind spot in Kansai in that both officials and citizens were largely unprepared."

The director of a large construction company expresses his dismay, "I remain speechless in that although it was indeed a major earthquake, the expressway came down right in front of people's eyes."

Local governments fell into chaos with many officials themselves becoming victims. The nation was appalled by Tokyo's lack of leadership and absence of crisis management in the initial hours after the earthquake. Indicating the government was caught completely off guard, a high-ranking official says in The Japan Times Special Report that the government's main mistake was that it failed to grasp in the initial hours the full extent of the earthquake damage; "Nobody imagined that such a devastating earthquake could strike the Kansai region."

According to The Japan Times (January 19), fewer households in the region than in other parts of the country were insured for the earthquake damage because the area was considered a low risk region. Only 4.9 percent of households in Osaka prefecture had earthquake insurance, in comparison with 13 percent in Shizuoka prefecture where a big earthquake is expected. "It appears that almost nobody thought they would sustain damage in an earthquake." an insurance agent said.

The earthquake shattered the widely held belief that Japanese cities are built to withstand big temblors. Freeways and shinkansen railway tracks, which in a way symbolized highly urbanized towns and whose resistance to earthquakes had been said to be stronger than in any other country, were horribly destroyed.

The earthquake was a fresh reminder that big cities now are full of dangerous and disparate factors beyond comparison with those that existed at the time of the Great Kanto Earthquake. If the earthquake had taken place not at dawn but at other hours, the devastation would have been of a more horrible extent.

2. KOBE - A 1.4 MILLION CITY

Japan is divided into 47 prefectures. The general epicentral area of the Hyogoken-nambu earthquake or the Kobe earthquake was located in the

southern part of Hyogo prefecture (or Hyogo-ken). The earthquake mostly affected the Hanshin District, which occupies an area surrounded by the Rokko Mountains on the north, Osaka plain on the east, Seto Inland Sea on the south, and Akashi Strait on the west, which separates Kobe and Awaji island.

Although the earthquake affected Hyogo, Kyoto, and Osaka prefectures, damage in Hyogo prefecture, especially in Kobe, the prefectural capital of Hyogo and Japan's sixth largest city (see the following statistics), was by far the largest.

Kobe consists of nine wards (or "ku" in Japanese). Demographic characteristics differ very much between the seven wards along the coast and the two inland wards. The former seven wards have much higher population density, the highest being Nagata-ku with 12,000 persons/km^2 (livable), while those of the two inland wards are 2,000-2,300 persons/km^2 (livable).

	Kobe	Tokyo
(a) Total Area (km^2)	545	616
(b) Livable Area (km^2)	305	621
(c) Population	1,440,000	7,890,000
(d) Population Density (c)/(b)	4,725	12,703
(e) No. of Houses/Buildings	540,000	3,300,000

About 5% of the houses/buildings in the affected region were built before 1945, 10% between 1946 and 1960, 18% between 1961 and 1970, 31% between 1971 and 1980, and 36% after 1980.

Sandwiched between the mountains to the north and the sea to the south, the business district of Kobe developed along the narrow east-west area of about 190 km^2. Since early this century, Kobe has increased its city area by reclaiming land in the sea, and the amount of reclaimed land today is about 23 km^2, including two major man-made islands, Port Island and Rokko Island with a total area of 14 km^2.

Kobe is a port city. Ranked as the sixth largest cargo port in the world, Kobe handled about 40 million tons of international container cargo in 1993, with sea links to about 500 ports in 135 countries (The Japan Times Special Report). About 12 percent of Japan's exports pass through Kobe port.

The annual revenue of the city for the fiscal year 1992 was 907 billion yen. The Survey and Research Division of Tokai Research and Consulting Incorporation estimates that the total value of property in Hyogo prefecture was about 55 trillion yen, approximately 4.3 percent of the total object asset of Japan. The total value of property in the earthquake-stricken area was estimated as about 20 trillion yen.

3. THE CASUALTY AND DAMAGE

The Kobe earthquake completely destroyed about 100,000 houses and buildings. The majority of them were the older-style wooden Japanese residential houses, which killed most of the 5,502 persons in the immediate hours after the earthquake.

Although there was slight concern that some of the Japanese structures might be less earthquake-resistant than the others, many engineers believed that Japanese bridges, for example, would not collapse in such a way that some US bridges did during the recent earthquakes.

It is true that ground motion was strong, much stronger than what had been experienced before. However, this should not be surprising. Strong ground motions had not simply been recorded. For almost 50 years a seismically quiescent period had continued in Japan's urbanized areas, and this period was the golden time for the advancement in earthquake engineering research and technology in Japan. These two independent facts were misused to establish the safety myth, a myth that the time had come when Japanese structures would not collapse even subjected to strong earthquakes.

However, old structures were not designed to be ductile. If a reinforced concrete column is so designed that it eventually fails in shear, and if the column is subjected to seismic force which causes stresses exceeding the yield stress, catastrophic failure cannot be evaded irrelevant to the level of the design force. There should not be any difference in the degrees of misery when they were to fail.

Almost all completely destroyed houses/buildings concentrated in Hyogo prefecture, and about 60% of them were located in Kobe where about 10% of the houses/buildings were completely destroyed. The death casualty reported as of November 18, 1996 is 6,310 with two missing. The number of earthquake-related death is still increasing. 6,279 or 99.5% of the death casualty occurred in Hyogo prefecture, and 4,484 or 71% of the total death in Kobe.

In Kobe alone, 109 fires are reported to have occurred during the day of the earthquake. It is reported that 60 fires broke out by 6 am., or within 15 minutes following the earthquake, 10 between 6 and 7 am., seven between 7 and 8 am., and eight between 8 and 9 am., making the total number 85 within three and a quarter hours after the earthquake. In Hyogo prefecture, about 7,000 houses/buildings were completely burnt down, killing 559 people.

Immediate responses in the heavily hit areas were concentrated to search and rescue, and fire fighting. Hyogo Police Department established disaster guard headquarters at 6:15 am., Hyogo prefectural government and Kobe city independently established their emergency response offices at 7:00 am.

National government decided to establish major emergency response headquarters. The first meeting of the headquarters was held in the afternoon and agreed to help municipal governments in the heavily affected area with respect to rescue operations and earliest possible recovery.

However, during the immediate hours after the earthquake, nobody seemed to have understood the real gravity of the disaster. Because of the size of the disaster and the lack of information, it took several days before emergency responses became organized. This can be easily understood by observing how the number of the confirmed death increased in the week following the earthquake.

January	17	noon	203
		evening	1,407
	18	noon	1,885
		evening	2,679
	19	noon	3,109
		evening	4,015
	20	evening	4,438
	21	evening	4,706
	22	evening	4,936
	23	evening	5,028

The Kobe earthquake has clearly indicated that there are thousands of old/weak/substandard structures in large urbanized areas in Japan. Some of them do not look substandard during the ordinary times. However, when they are subjected to strong ground shaking, hidden flaws become visible.

The greatest lesson learnt from this earthquake was that we realized there still is a possibility of such a damaging earthquake occurring in our country, which we used to believe one of the most technically advanced countries in the world. Behind the tragedy of Kobe, is the over-confidence among engineers, researchers, municipal and national officials, and the laymen. We should have realized that when economy gets better, some of the things get worse.

4. LIFELINE DISRUPTIONS

The earthquake was the first in modern Japanese history to seriously hit a heavily populated urban district. The region's civil infrastructure, including water and gas networks, telephone lines, power cables, highways and railways, were crippled, paralyzing business and financial operations.

Immediately following the earthquake, power outage affected about 2.6 million customers. Since major power generating stations and major transmission lines were not damaged, the number of customers without power decreased to 1 million by 7:30 am., and 0.5 million by 8:00 pm. Although about a dozen of distribution transformer stations were affected,

the most heavily damaged were poles and wires. It took six days to resume supply for the whole service area.

As to the telecommunications systems, it had been believed that systemic as well as structural damage would be minimum even during a large seismic disaster. This proved to be partially true because the system did not completely collapse. Although there was extremely heavy traffic congestion during the days following the earthquake, the overall system remained intact.

Water supply systems were severely damaged. Supply stopped to almost all people in the heavily affected area. The number of households without water was about 1.36 million in all stricken areas. About 1.2 million households or 56% of the total households in Hyogo prefecture, and 253,000 households or 39% of the total households in Kobe were without water. Supply was resumed to essentially all households by the end of February, some six weeks after the earthquake. Emergency water supply was performed by mostly using tank trucks. Help by the Japanese Ground Self-defense Force and many municipalities all over Japan was essential in delivering water to the affected people.

Emergency shut-off valves were installed at reservoirs to secure drinking water for the affected people. General understanding among water and fire fighting professionals was that water lines were not reliable and that most probably they would not survive a strong earthquake. Most emergency shut-off valves functioned well, and in addition water pipes broke in many places. There was almost no water from hydrants for fire fighting in all the city over.

City gas systems took about three months before the supply was restored. Neither production facilities nor high pressure transmission lines were damaged. Damage concentrated to small-sized pipes in low pressure distribution lines. On the day of the earthquake, five isolation blocks, each with 100,000 to 220,000 customers, had to be isolated. Shutting off relevant valves to isolate these blocks started six hours after the earthquake and the last block was isolated fifteen hours after the earthquake. The isolation left about 860,000 customers without gas supply.

In the heavily hit, isolated area, a total of about 26,000 repairs were made for low-pressure distribution lines and service pipes. A total of 10,000 people per day were engaged in the repair work at the busiest period, of which about 4,000 came from the other parts of Japan.

It has been reconfirmed that lifelines are vulnerable to earthquakes. This is true for a weaker ground shaking compared with the one experienced in Kobe. The periods of disruptions of lifelines may be several months for gas systems, several weeks for water systems, and from a week to ten days for power systems Telecommunications systems may not completely collapse but heavy traffic will certainly take place and will make ordinary communications extremely difficult.

Maintenance is important. Lifelines are lifelines during the ordinary times. Unless a system is well maintained during the ordinary times, the system cannot be made resistive to disasters. Do not hesitate to spend enough resource, both money and manpower, to maintain lifelines. It will eventually pay at the time of a disaster.

Since a lifeline is laid in a large area, it is critical to know, immediately following an earthquake, which part of the service area has been most badly damaged. For this purpose, real-time monitoring of ground motions within the service area is important, and the corresponding on-line control of the system seems to be promising.

5. ECONOMIC LOSS

Asahi Evening News reports on the next day of the earthquake, "Japan's economic network is already feeling the wallop of the huge earthquake that struck the heart of the Kansai region."

The newspaper describes responses of several large companies in detail: Computer maker Fujitsu Ltd. temporally shut its display and peripheral plant in Akashi, near Kobe, because the earthquake had damaged one of the buildings; Mitsubishi Electric Corp. suspended operations at all of its plants in the Kansai region; Kobe Steel Ltd. stopped all operations at its two main steelworks; Automaker Daihatsu Motor Co. halted production at two Kansai plants; Mazda Motor Corp. would halt operations at its plant in Hiroshima because it could not secure parts from factories in the Kansai and Tokai regions; Hyogo Bank Ltd. and Hanshin Bank Ltd. had to shut down some of their branches because of problems with their computer centers; Two Kobe offices of Nomura Securities Co. were wreaked havoc by the earthquake, "The power is out, the computer is down, and the internal telephone network is not working"; Tokyo share prices ended lower, share prices of insurance companies fell, some construction firms' share prices rose, and Japanese government bond prices closed sharply lower on worries that extra bonds might be issued to fund government emergency aid for the stricken region.

Hyogo prefecture estimated the damage (as of May 15, 1995) in the prefecture as shown below.

1. Buildings/Houses	5,800.00 *
2. Railways	343.90
3. Expressways	550.00
4. Civil Infrastructures	283.30
5. Ports and Harbours	1,000.00
6. Reclaimed Islands	6.40
7. Educational Facilities	335.20
8. Agriculture and Fishery	118.10
9. Health and Welfare	173.30
10. Solid Waste Treatment	4.40
11. Water Supply	54.10
12. Gas and Electricity	420.00
13. Telecommunications	120.20
14. Commerce and Industry	630.00
15. Other Public Buildings	75.10
Total	9,914.00

* all in billion yen

The total damage of 9.9 trillion yen in Hyogo prefecture corresponds to 2.1% of the gross domestic product (GDP) for the fiscal year 1994 (about 468 trillion yen), and to about 18% and 50% of the total value of property in Hyogo prefecture (55 trillion yen or about 4.3% of the total object asset of Japan) and of the total value of property in the earthquake-stricken area (about 20 trillion yen), respectively. It may be also stated that approximately 0.8% of the nation's total object asset was lost in the earthquake. The scale of this amount may be more easily comprehended by comparing it with 37.5 percent of GDP which was perished by the 1923 Great Kanto Earthquake which killed about 140,000 people mostly due to the fires that followed the earthquake.

According to an estimate by the Ministry of International Trade and Industry, the damage sustained by big corporations was 1,040 billion yen, while that by small enterprises amounted to 1,920 billion yen. Because the estimate was made only a month after the earthquake, the numbers cannot be complete. However, it seems to indicate that a large number of small enterprises were heavily affected by the earthquake.

As far as the earthquake impact on wholesale prices is concerned, consumer prices seem to have been stable. The net addition to the housing market seems to be spread out over longer years than initially expected, and positive effects on construction industry and labor market seem to be much smaller than expected. Generally speaking, structural problems of Japanese economy seem to be overriding some of the expected positive effects arising from reconstruction.

It should be mentioned, however, that the total loss is difficult to estimate even three years after the earthquake, and that one of the estimates is as high as 30 trillion yen.

6. EARTHQUAKE INSURANCE AT THE TIME OF THE KOBE EARTHQUAKE

Earthquake insurance has been available in Japan since 1966 following the 1964 Niigata earthquake. The original system has been changed several times since then to solve certain problems disclosed following damaging earthquakes over the 30 years period.

The earthquake insurance policy at the time of the Kobe earthquake may be summarized as follows.

Earthquake insurance was separately purchased for the house and the properties in it. The maximum policies to be purchased by homeowners were 10 million yen*1 for the house and 5 million*2 for the properties in it. Earthquake damage was classified into three grades; (1) Complete collapse for which the full amount of insurance both on the house and the properties may be collected, (2) Partial collapse for which 50% of the insurance on the house and 10%*3 of the insurance on the properties may be collected, and (3) Slight damage for which 5% of the insurance both for the house and the properties may be collected.

Assessment and authorization of damage is difficult. In the case of damage to houses, complete collapse is defined as the loss sustained by the major structural members of a house exceeding 50% of its current price, partial collapse between 20% and 50% of its current price, and slight damage between 3% and 20% of its current price.

Earthquake insurance was purchased as an addendum to fire insurance policies, and the minimum and the maximum earthquake insurance are 30% and 50% of the fire insurance, respectively. The premium greatly differed in four rate zones, the highest being 4,750 yen*4 per one million yen of coverage for wooden houses (1,800 yen*5 for non-wooden houses) and the lowest being 1,600 yen*6 for wooden houses (500 yen for non-wooden houses).

The total amount of insurance to be paid for one event is limited to 1,800 billion yen*7. When this maximum amount were to be paid, about 15% *8 is paid by insurance companies, and the rest by the government.

7. WHAT HAPPENED TO EARTHQUAKE INSURANCE AFTER THE KOBE EARTHQUAKE

Following the earthquake, it was immediately realized how low the subscription rate of earthquake insurance was in the affected area, and for the country as a whole. Only 3.7% of the homeowners in the Kinki region, which includes Hyogo, Osaka and Kyoto prefectures among other four less affected prefectures, had their homes insured for earthquake loss. The average subscription rate in Japan was 7.2%, with the highest being 12.5% in the Kanto region where the greater Tokyo area is located.

A total of 76 billion yen was paid for about 64,000 earthquake insurance policies. Some of the statistics are shown below:

		Damage Grade	No. of Policies	Insurance Paid*	Average/ Policy**
Houses	Wooden	Total	4,750	18.8	3,950
		Partial	7,569	16.6	2,191
		Slight	14,443	3.4	235
	Non-wooden	Total	1,333	85	6,368
		Partial	2,457	9.1	3,688
		Slight	10,380	3.8	365
Properties	Wooden	Total	3,389	7.2	2,133
		Partial	7,713	1.8	239
		Slight	12,723	1.6	129
	Non-wooden	Total	1,082	3.1	2,870
		Partial	2,912	0.9	309
		Slight	11,526	1.8	157

*billion yen, **thousand yen

It was debated that the premium was too expensive, and that the maximum insurance of 10 million yen to be collected for the total collapse of a house was too small to rebuild an average residential house which was estimated to cost at least about 17 million yen. The premium of earthquake insurance tends to be expensive because more of the insured party live in higher seismic zones.

Earthquake insurance is an important economic measure that the household can adopt to prevent "some" of the devastating economic consequences of an earthquake. It is not supposed to pay sufficient money to completely rebuild or repair a damaged house but to help the earthquake victims to rehabilitate their lives.

Subscription rate greatly increased after the earthquake. It increased from 7.2% to 10.8% for the whole Japan, 12.5% to 16.4% for the Kanto region, and especially from 3.7% to 9.0% for the Kinki region where the most heavily affected prefectures are located.

To solve some of the problems encountered after the Kobe earthquake, some of the key numbers in the previous earthquake insurance system were changed and the new system has come into effect as of January, 1996. To avoid repetitions, only those numbers underlined with asterisks in the previous section are shown below:

*1 50 million yen
*2 10 million yen
*3 50%
*4 4,300 yen
*5 1,750 yen
*6 1,450 yen
*7 3,100 billion yen (3,700 billion yen as of April, 1997)
*8 13.3% (13.6% as of April, 1997)

Although the maximum insurance has been significantly increased, earthquake insurance is still expensive to purchase. To collect 17 million yen, which is an average cost to build a 100m^2 house, it is necessary to purchase at least 34 million yen fire insurance policy. The following example shows the premiums for fire and earthquake insurance for a 100m^2 wooden house in Tokyo which is located in the highest premium zone:

(a) Premium for fire insurance:
34 million yen x 1,700 yen/1 million yen = 57,800 yen
(b) Premium for earthquake insurance:
17 million yen x 4,300 yen/1 million yen = 73,100 yen
(c) Total = (a) + (b) = 130,900 yen (with no insurance on properties)

The premium of the present earthquake insurance distinguishes only two types of houses (wooden and non-wooden) in four rate zones. There have been discussions that more factors be considered to classify different types of houses and environments. They are, for example, age of building, local soil condition, demographic condition of the area where the building is located including population density, et al. Insurance should be purchased at a lower cost for better houses in better surrounding conditions.

People with the most to lose--those with a better home and more properties in it--purchase insurance. Although those with more resources have a greater propensity to purchase earthquake insurance, the present system does not stimulate the incentive of those who own better housing stock under favorable environment to purchase earthquake insurance.

The purpose of insurance is the mutual assistance among people at large. Therefore, the rationality of the system and the equality to all potential subscribers should be the key issues. However, the former is not always compatible with the latter.

If one pursues, on the individual basis, a scientific and rational system to an extreme, the premium for old and poor housing stock will become relatively more expensive in spite of the fact that the financial losses associated with an earthquake may result in collapse of the daily lives and long-term economic prospects for the less wealthy families.

Occurrence of a large earthquake is a very low-probability event even for a country like Japan. But once such an event occurs, the impact will be felt by a large number of people. Levels of objective risk are difficult to grasp, and vulnerability of individuals and households to earthquake hazards cannot be easily perceived. The financial benefits of insurance to the society as a whole are generally difficult to calculate.

Although a number of problems have been raised regarding to earthquake insurance after the Kobe earthquake, it seems difficult to reach any practical conclusion at this moment. Views differ in whether or not a policy goal is universal coverage, or whether or not nation-backed, mandatory insurance coverage is desirable.

The present understanding may be summarized that earthquake insurance is only "one" of the measures to mitigate burdens caused by earthquakes and that it should be considered as a very complex system which requires further study.

(This article is based on the speech made by the author at the 1997 Sunshine Seminar of the Australian Insurance Institute, Queensland, held in Novotel Twin Waters Resort during 14 to 16 September 1997. Minor changes have been made to the original manuscript submitted to the Seminar.)