University of Surrey
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TSUNAMI

Project on

The Uninsured Elements of Natural Catastrophic Losses

THE GREAT HANSHIN EARTHQUAKE, KOBE JAPAN

Case Study Report

December 1999

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The author would like to express her thanks to Miyuki Ebisaki for her assistance in preparing this report. The views, however, are those of the author.

1. EXECUTIVE SUMMARY

Note: Conversion rate of yen taken as rate for 17.5.95, which is 1¥=0.01011 US$

The Kobe earthquake was extreme in terms of fatalities (over 5,000), injuries and damages, caused by a direct hit on a dense urban conurbation. The earthquake affected Hyogo, Kyoto and Osaka prefectures, but damage in the Hyogo prefecture, especially Kobe, was most severe. Kobe is Japan's sixth largest city, and it is the location of Japan's largest port. The densely populated Kobe region accounts for a fifth of the Japanese economy.

Kobe was one of the so-called "quiet sites" in Japan because it had experienced little or no seismic activity over the previous 30 years. Earthquake building codes, somewhat less stringent than for higher-risk Tokyo, were in force. Current building codes do not make allowance for stronger ground motion, in the form of pulse-like motions, which exceeded original design values by up to 400%. This has subsequently been revised in the USA, but there is no indication that it has happened in Japan.

Estimates on direct losses vary in the range of about US$ 85 billion to US$ 147. Taking the figure of US$ 115 billion, over half of these are business/industrial losses (US$ 63 billion), and about a fourth are losses to public infrastructure including public facilities at the Kobe port (US$ 32.8 billion). Residential losses have been estimated at US$ 15.2 billion, and agricultural losses at US$ 4 billion. Indirect losses were acknowledged to be high, and one estimate (probably low) put them at US$ 50 billion. Estimates on insured losses range from a low of a few million dollars to US$ 6 billion (EQE), and even an estimate of between US$ 8-12billion. This does not coincide with Japanese information on insured losses, and an assumption has been made that the conservative estimate of US$ 3billion is the most realistic benchmark. Delays in national government response contributed to the large number of fatalities and the economic losses, and the government was severely criticised.

Information on the public expenditures and compensation after the Kobe earthquake is not easily available, but we have found some in Japanese publications. Only about 38 per cent of the total estimated losses from the Kobe quake were reimbursed, and only about 3 per cent was reimbursed from private insurers. The main form of compensation was from the state. Local governments' compensation to victims amounted to about $ 2 billion, and private donations were only slightly less, at about $ 1.8 billion. The national government announced plans to subsidise 90 per cent of the cost of repairing public infrastructure, and subsequently invested approximately $34 billion. In addition, the Hyogo prefecture decided to invest $17.4 million to repair the city.

Insurance cover in Japan is high. Japan's premium per capita is $ 5088, of which 1012.5 is non-life and 4075.8 is life. Earthquake insurance levels in Japan are very low, particularly in Kobe, where the probability was perceived to be low and the premiums perceived to be high. Insurance density in the Kobe area was 3 %, compared to the national average of 7.2 % and the Tokyo area cover of 12 %. The present average density has subsequently increased to 10 %.

Earthquake Insurance cover is expensive, and not widespread. It is usually an addition to normal fire insurance policies. Commercial and industrial property indemnity provides proportional coverage depending on the location of the building, classified into regional risk zones. Rates for earthquake cover depend on the structure of the building insured. Residential earthquake cover is backed by a Government scheme. The insured amount is limited to the range between 30-50% of the sum insured in the main fire insurance policy, with the maximum amount of US$ 118,000 on building and US$ 59,000 on contents for total post earthquake or tsunami destruction, up to a ceiling of US$ 18.2 billion. If the total value of the scheme is exceeded, the average will be applied. The scheme is covered by the Governments' Japan Earthquake Reinsurance Company, which groups all Japanese non-life insurers, TOA

Re and the state. All earthquake risks written by direct insurers are reinsured with JER, which cedes part of the portfolio back to the original direct insurers, and part to Toa Marine and Fire.

Kobe raised the issue of insufficiency of residential cover protection. Subsequently, the earthquake building damage cover has increased to US$ 200,000. There have been policy discussions on further increases in insurance limits, on improvement of coverage, on compulsory insurance and on the automatic inclusion of earthquake risks in some type of fire policies. However, there seems to be little likelihood of greater earthquake cover of commercial earthquake risks from either Japanese government or insurers.

As of 1994, there were 30 foreign non-life insurers in Japan, of which 3 covered only reinsurance and 3 were marine protection and indemnity clubs. Eight of these companies were from the UK. Overall, foreign companies had a 2.9% share of the Japanese market.

The market for earthquake risk cover in Japan is complex. In high-risk regions, the premiums are very high, and demand is consequently low. Moreover, the potential losses are enormous, and earthquake risk estimates are difficult to make. The area to focus on would be the commercial and industrial risks, which include utilities, railways and motorways. Business interruption cover could provide opportunities, but insurers should be aware that the *kanban* (just-in-time) system carries enormous loss potential. More use can and is being made of catastrophe modelling to determine feasible insurance portfolios. Catastrophe bonds can make more capital available, and one of the few such bonds was issued by Tokyo Marine and Fire (?). Like in other cases, there may also be a market for insurance covering public infrastructure damage.

2. INTRODUCTION AND DESCRIPTION OF DISASTER

2.1 General Description

Date:
Thursday, January 17th, 1995 , 5.46 a.m.
Estimated Magnitude:
Moderate-sized earthquake, M7, in a highly developed industrialised region, 7.2 on the Richter scale.
6.9 (Mw) Moment Magnitude
Duration:
20 Seconds (8-12 seconds - RMS, 1995)
Epicentre:
North end of Awaji-Shima island, across a strait from Kobe, 23km from Kobe city centre (south-west). Depth of hypocentre was very shallow, only 20km below surface level, contributing to the high level of ground shaking which occurred.

Description:
A strike-slip fault-rupture was responsible for Kobe earthquake, with a fault-length of about 60km and a fault displacement of 1-2 m. The earthquake was a direct hit on an urban area. The earthquake spread to the edge of the city along the Arima-Takatsuki Line fault system. Due to the shallow depth ground shaking was extreme, reaching velocities of 100cm/sec with unusually high amplitudes. Ground shaking was amplified by a factor of 2 in soft soil and artificial sites, which covered a large proportion of the central city and port. (Muir-Wood, 1995; Kagawa, 1995)

Most of the damage took place in a narrow band along the central axis of the city, which also serves as the transportation corridor. Destruction of the two highways and three main rail lines, generally on elevated embankments and crossing a number of navigable waterways,

created land access by city streets only. This hampered relief efforts and increased indirect losses from business disruption. The earthquake affected Hyogo, Kyoto and Osaka prefectures, but damage in the Hyogo prefecture, especially Kobe, was most severe.

Fires:
Over 300 fires ignited within minutes of the earthquake. Response was severely hampered by the failure of the water supply and the disruption caused to the transportation system. 142 fires razed a total area of $1km^{2.}$, and 7,500 building units were destroyed by the conflagrations. Had there been wind, the level of devastation would have been much higher.

Most of Kobe is equipped with automatic fuel cut-out valves, yet the gas in the system caused or exacerbated approximately 30% of the fires, whilst 70% were caused by electrical short-circuits.

Kobe city:
Kobe is Japan's sixth largest city. It is situated in the Hyogo prefecture in central Japan, near Kyoto and Osaka, on a narrow strip of land between Osaka Bay to the south-east and the Rokko Mountains to the south-west. It forms a 2-4 km wide urban corridor between Osaka and the main transportation route between western and north-eastern Japan. Kobe is the largest port in Japan, and before the earthquake was the sixth largest world wide in annual cargo. Many foreign multinational corporations had bases in Kobe.

Due to its situation the city has been extended by extensive reclamation of the land close to the sea. The amount of reclaimed land in Kobe is approximately 23 km^2. Two manmade islands, Port Island and Rokko Island, were built to form part of Kobe port. The ground type of these reclaimed and manmade areas proved to be extremely vulnerable to seismic activity. Kobe earthquake raised awareness of the effect of ground conditions, which make a larger difference to the level of seismic ground motion than the distance from the hypocentre. (Kakimi, 1998)

There had never been a major earthquake centred on the faults close to Kobe, and the probability was considered lower than other areas of Japan. The fact that Kobe was not predicted as a serious earthquake zone and the low level of preparedness raised many issues in Japan. Some authorities have countered the criticism with the fact that certain publications described the Rokko-Awaji fault zone as a 'precaution' fault requiring special attention.

Demand Surge:
Kobe was a 'non-linear' earthquake, defined as an event where the demand for resources greatly exceeds available capacity. Restoration times were stretched and delayed, because manpower and repair resources were so over-extended. Resources had to come from places some distance from the affected areas, and damage to local and regional transportation systems added an additional dimension to response times. Inflated material costs, due to increased demand for materials for reconstruction and repair after the disaster, had the effect of increasing costs by an average of 20%. This affected losses for all sectors. The repair cost from the earthquake has been estimated at $1500 per inhabitant. (Eguchi, 1997)

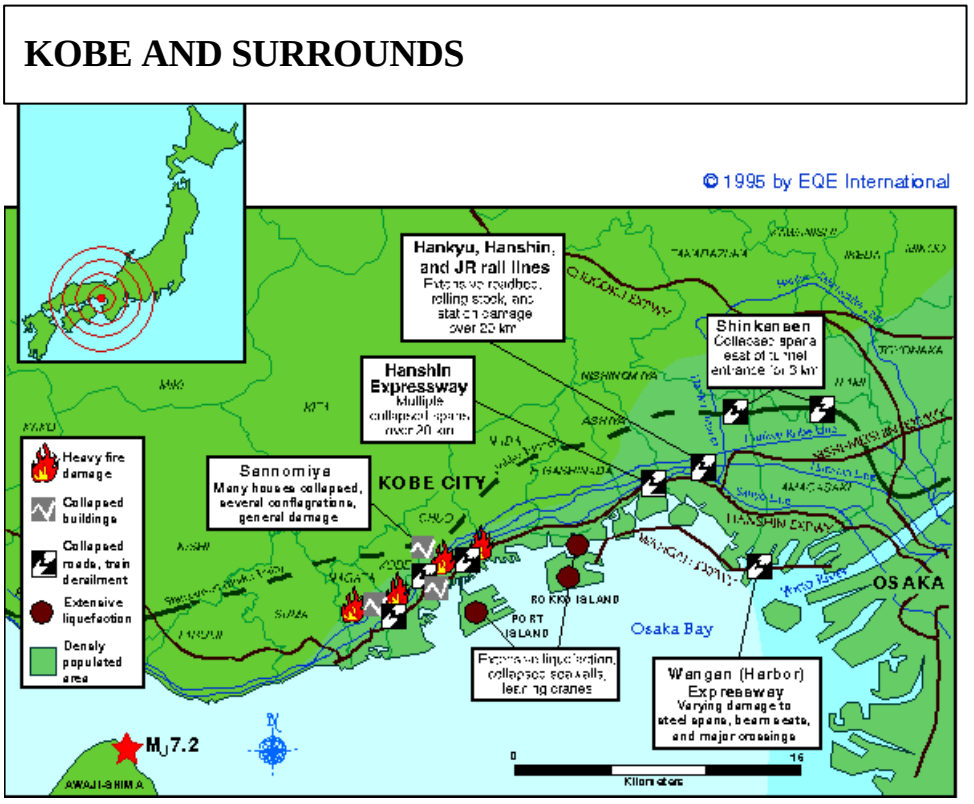
2.2 Total losses

Total losses are generally estimated as US$ 100 billion, but the estimated figure varies considerably. Later estimates have revised it upwards, as the extent of damage becomes clearer. This follows the pattern of estimation of the Northridge earthquake, California. Insured losses for Kobe were low, due to the lack of earthquake cover in Japan, and are generally estimated at US$ 3-4 billion, with some estimates as high as $ 6 billion, or even 8-12 billion. The conservative figure of US$ 3 billion appears to be the most accurate.

Human Losses:
First reports indicated that there were 1590 dead, 1017 missing, 6334 injured, 7876 homes destroyed, as at 11.45p.m. 900,000 homes were without electricity, and many without water and gas. 600-800 aftershocks were detected and the chance of an aftershock as big as the main earthquake was 30%.

Final reports indicated that the death toll had reached 6,310. People above 60 years of age contributed to more than 50% of fatalities, as the elderly slept mostly on the ground floor which was crushed when the houses collapsed. This was also due to the fact that many people were rescued by family and friends, and the elderly and children were not as agile or able to survive.

The total number of people injured and requiring medical inspection was 43,000. Over 300,000 people, 20% of the population, were made homeless. 432,000 residential buildings were destroyed, together with 865 public and 3,984 private buildings. (PCIRO, 1998) A further 156,537 buildings were damaged.

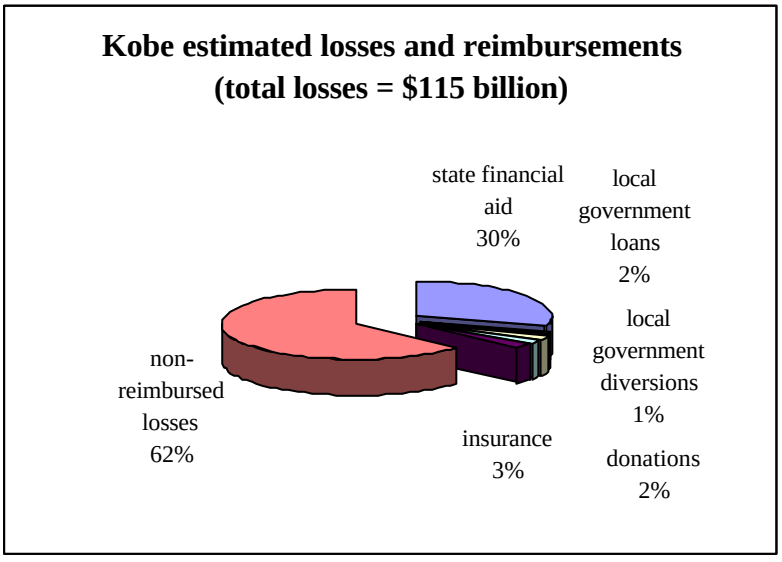


3. SUMMARY TABLES

DAMAGE BY SECTOR, TOTAL LOSSES AND PORTION INSURED

Sector	Share of total losses as a percentage	Total direct losses, in billion dollars	Amount insured, estimate ($bn)	Of which uninsured, estimate ($bn)
Commercial/ Industrial	**54.8**	**63.0**	**1**	**62.0**
Public sector losses	**28.5**	**32.8**	**No mention**	**32.8**
Residential losses	**13.2**	**15.2**	**1**	**14.2**
Agricultural losses	**3.5**	**4.0**	**1**	**3.0**
TOTAL	**100%**	**115.0 (85-147)**	**3 (max. 6 bn)**	**112.0**

Notes: 1)Insurance reimbursement taken as $3 billion, but it could be a maximum of $ 6 bn.
2)There is mention of $15 billion construction bonds and deficit-covering bonds. These have been assumed to be part of the £34.17 national government budget.



4. GENERAL ECONOMIC INDICATORS

4.1 Economic and demographic characteristics of Japan

ECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF JAPAN 1998

Population (millions)	126.3
GNP (US$ billions)	4,089.9
GNP per capita (US$)	32,380.0
% annual growth in GDP, 1988-98	1.8
% annual growth in GDP, 1998	-2.8
Current account balance /GDP	3.2
% population below poverty line	-
% urban population	79.0
Life expectancy	80.0
% GDP agriculture	2.8
% GDP services	56.8
% GDP industry	40.4

Source: http://worldbank.com 9/15/99

4.2 General indicators

Total value of property:
Hyogo prefecture: US$ 556 billion (4.3% of Japans total object assets).
Kobe: US$ 202 billion

The Kobe region accounts for a fifth of the Japanese economy. Kobe's regional economy was severely disrupted. It accounts for 1/5 of Japanese economy, and produces 19% of Japan's leather goods, 10% of rubber manufacturing, 9% steel. Manufacturing accounts for 1/3 of regional economy. 30% of Japan's commercial shipping passed through Kobe port, which has potential for 60,000 containers.

4.3 Population Density

Population of Japan: 126.3 million,
Population of Kobe: 1.5 million (2m including surrounding area)
Population density in Kobe: varies from 3,900 - 10,800 persons/$km^{2.}$
The earthquake hit the most densely populated areas of Kobe.

4.4 Level of insurance by coverage

Earthquake insurance levels in Japan are very low, particularly in areas such as Kobe where the probability was perceived to be low. Premiums for earthquake insurance are high, but fire premiums are low in Japan. (Kagawa, 1995). Overall, Japan has relatively high insurance cover. The premium per capita is US$ 5088, of which 1012.5 is non-life and 4075.8 is life. (Swiss Re,1997b).

DIRECT PREMIUMS WRITTEN ABROAD BY JAPANESE INSURERS

	PREMIUM US$ billion
FIRE	137.0
AUTOMOBILE	123.4
MARINE HULL	6.9
MARINE CARGO	62.8
OTHER	281.6

Source: dyp, 1995a

Commercial: US$3bn,
Coinsurance in this sector amounts to 70%. Marine and non-marine commercial insurance is reported to have a 30% take-up. (dyp, 1995)
Residential: Only 3% of households in the Hyogo prefecture had earthquake insurance, compared with the national average of 7.2 %. This average increased to 10% after Kobe.
Government/public property: No mention of insurance.
Life: Japan has the highest take-up of life cover world-wide.
Automobile insurance: Earthquake insurance is generally excluded from auto coverages but it is included in Marine Cargo.
Non-Japanese insurance coverage: 30 foreign companies, including the British Insurance Group (Japan) are licensed to underwrite business and have about 3% of the market premiums. 11% of the market comes from fire cover, which usually includes earthquake.

5. INSTITUTIONAL ASPECTS

5.1 Emergency services

Kobe was the first major earthquake to occur in a densely populated metropolitan area. There was little open space, making it vulnerable to a secondary disaster. Access through the narrow streets, some 3m wide, not only caused considerable bottlenecks in the supply of emergency relief, but also failed to act as fire breaks.

Absence of crisis management, lack of information and the government failure to grasp the extent of the damage increased both human and material losses. Local governments fell into chaos with many officials victims themselves. The Hyogo Police Department, Kobe Fire Department and members from the Hyogo Prefectural government all participated in the emergency services. Their efforts were hampered by the minimum staffing levels employed at the time, because the previous day had been a holiday. There was no initial system in place to co-ordinate their responses, and response centres all operated independently.

The law requires that a request of the prefectural governor is required before the national Japan's Ground Self-Defence Forces (JGSDF) troops, based primarily in Tokyo, can be dispatched to search and rescue. This caused a delay of approximately 36 hours from the time of the event, leading to greater losses. The Government was severely criticised, and their responsibility was subsequently acknowledged. (Katayama, 1996)

5.2 Regulatory framework

After WWII the legal system was restructured and various laws were integrated into the 1950 Building Standard Law. Early Japanese earthquake design codes specified the minimum horizontal ground acceleration that must be resisted. For Kobe the codes were set out at 0.2, higher than the 0.1 codes used elsewhere, yet not at the 0.3 levels specified in Tokyo. The Building Standard Law was amended in 1963, 1971, 1977 and 1981.

Construction standards were revised in 1971 to incorporate requirements for ductility, the capacity to deform without significant loss even though over-stressed. This improved the resistance of a building to earthquakes. The 1978 Izu-Oshima earthquake proved the value of ductility and the design codes were amended again in 1981. The latest Seismic Design codes have incorporated the effects of soft soils on the behaviour of buildings, and buildings complying with these codes are of a similar standard to those in Tokyo. Kobe area port facilities were constructed under Ministry of Transportation's Construction Standard B, rather than the more stringent A or Super A. Importance of the facility was not a consideration in the current seismic codes. (Shinozuka, 1995)

Current building codes do not make allowance for stronger ground motion, in the form of pulse-like motions, which exceeded original design values by up to 400%. This has subsequently been revised in the USA, but not yet in Japan. A study is underway investigating the earthquake-resistant design standards for civil engineering structures, but no amendments have been issued yet. (PCIRO,1998)

The Kobe earthquake led to the enactment of the "Special Measure Law on Earthquake Disaster Prevention" in 1996. The result of this law was the establishment of the Headquarters of Earthquake Research Promotion, which is responsible directly to the Prime Minister and promotes the survey and research of earthquakes, and the comprehensive evaluation of results. The policy committee of the Headquarters is responsible for dissemination of information to the public.

5.3 Insurance aspects

Japan has low earthquake insurance density and strict limits on the scope of this cover. The lack of cover makes accurate quantification of losses difficult.

5.3.1 Earthquake Insurance background:

In 1923 the Great Tokyo Earthquake created such losses that the Government gave an 'Instruction' to the insurance companies of the day. "Insurance business being, by its very nature, primarily for the purpose of safeguarding the stability of public welfare, all those engaged in it should take into full consideration the real significance of the occurrence, and be prepared to evince a self-sacrificing spirit, to the end that they may be worthy of the great trust reposed in them by the unfortunate sufferers." Although the 38 fire insurance companies had excluded fire following earthquake from all policies and not covered earthquakes, their assets were analysed and they paid out grants to all their policy makers. (Muir-Wood, 1995) There were unfounded concerns after Kobe that this situation could occur again.

5.3.2 Current Earthquake Insurance:

Chastened by the above-mentioned events, earthquake insurance was only reintroduced after WWII. There are 3 types of earthquake cover, all additions to normal fire insurance policies:

Commercial and industrial property cover:

This cover is an endorsement of Fire Policy, and has been operational since 1956. Cover is provided on conditions adopted by the whole industry. The scope of the cover is for damage caused by the shock itself and subsequent fires. Damage caused by water leaks and explosions due to an earthquake may be covered by a policy extension, for an extra premium. Only direct losses are taken into account, loss of profit or business interruption insurance is not provided by any Japanese insurers, but may be provided by some foreign insurance companies. Industries have not been encouraged to buy earthquake insurance, "solely due to the tremendous shortage of capacity with continuity in the world market for the accumulation of high severity earthquake risks". (Kagawa)

Commercial and industrial cover is limited by statute. Limits vary according to risk location, and 12 zones are designated. These zones reflect risk exposure and asset concentration. Indemnity allows proportional coverage of up to 30% of the value of the fire insurance cover in zone 8, 15% in zone 5. Kobe is in zone 8 while Tokyo is in zone 5. Rates depend on the structure of the building insured (five classes A - E) and risk exposure (seven zones). Two types of cover may be bought: Reduced percentage indemnity clause, where the amount of compensation is equal to the cost of the damage, multiplied by the risk location percentage, and First loss policy, where compensation is

limited to the amount of the first loss mentioned in the policy. Deductibles are 2% of the value, with a minimum of US$ 100 and a maximum of US$ 1,000.
In 1992 government allowed first loss coverage to these percentages to be offered to oil refineries, and admitted that coverage of privileged customers took place.
Reinsurance: 85-90% of industrial earthquake insurance is reinsured overseas.
Insurance density (earthquakes): industry 2.4% (Swiss Re, 1997c)
Business Interruption clauses:
There are two types of business interruption covers, one for the lost earnings of the business and another which covers only the expenses necessary to continue the business. Business Interruption insurance is an attachment to the fire policy and it has a strict earthquake exclusion. There is an endorsement to waive the exclusion for the main fire policy but it never works for the business interruption part.
See Appendix A for a rough scale of business interruption in Japan.

Residential cover:

The Law concerning Earthquake Insurance was introduced after the Nigata earthquake in 1966. It provides residential cover by a reinsurance scheme backed by Government. The purpose of the law on dwelling risks is not to give full indemnity of the loss, but "to contribute to the stabilisation of livelihood of victims of earthquake". (Kagawa)
The insured amount is limited to the range between 30-50% of the sum insured in the main fire insurance policy, with the maximum amount of US$118,000 on building and US$59,000 on contents for total post earthquake or tsunami destruction. The value of the scheme extends up to US$18.2bn and if the total value of the scheme is exceeded, the average is applied.
From 1966-80 the system only indemnified in cases of total loss, and from 1980 it was modified to extend to half losses. Partial loss policies were introduced in 1991. The definitions of the terms 'total loss', 'half loss' and 'partial loss' are strict and are defined below:

SCOPE OF COVER FOR HOUSEHOLD RISKS

	BUILDINGS		**CONTENTS**	
	Structural Damage	**Indemnity % of insured value[1)]**	**Property Damage**	**Indemnity % of insured value[2)]**
TOTAL LOSS	>50 %	100 %	> 80 %	100 %
HALF LOSS	20-50 %	50 %	30-80 %	50 %
PARTIAL LOSS	3-20 %	5 %	10-30 %	5 %

1. Insured value is limited to the value of the asset at the time of the loss, with a maximum of US$500,000
2. With a maximum of US$100,000 Source: SCOR Tech.

There are four zones applied for rating, and fire policies allow fire-following to be covered up to US$ 30,330. This provides a maximum limit of US$ 100,000 for building damage, US$ 50,000 for contents damage per policy. The present scheme is based on a no loss, no profit principle, which has enabled Japanese insurers to accept earthquake risks. The reserves are untaxed and the scheme is supported by the Government.
Fire policy holders can buy earthquake insurance at any time during the policy period. Cover is separate from the fire policy, with its own general conditions. The residential scheme is voluntary, but there is a legal requirement to ask the homeowner whether earthquake insurance is included, and specifically mark when it is not. Earthquake insurance will increase premiums by two or three-fold. (Ebisaki, 1999)
Insurance density (earthquakes):
National average at the time of Kobe: 7.2%
Kobe area cover: 3%
Tokyo area cover: 12%
Present average density: 10% (Swiss Re, 1997c)

Reinsurance:
Maximum compensation is fixed each year by the Diet (parliament) in order to limit the total commitment. The scheme is covered by the Governments' Japan Earthquake Reinsurance Company, which groups all Japanese non-life insurers, TOA Re and the state.
All earthquake risks written by direct insurers are reinsured with JER, which cedes part of the portfolio back to the original direct insurers, and part to Toa Marine and Fire.
Under the scheme insurers are responsible for the whole of the first US$ 0.66bn losses, for 50% of the layer up to US$ 3.36bn, and for 5% of further losses to a maximum of US$ 18bn, with the Government responsible for the remainder. The scheme effectively limits the industry pay-out to a maximum of US$ 2.74bn, irrespective of the magnitude of the total insured loss. (dyp,1995a)

DIAGRAM OF COMPENSATION SHARING - 1996 FIGURES

In US$ millions

<table>
<tr><td rowspan="2">JER (606)</td><td rowspan="2">ASS (324)</td><td>50%GVT (1900)</td><td rowspan="2">95% GVT (25279)</td></tr>
<tr><td>50%ASS/JER (1698/200)</td></tr>
<tr><td colspan="3"></td><td>5% JER (1330)</td></tr>
</table>

Note: Private insurers shaded.

JER: Japan Earthquake Reinsurance Company
ASS: Direct insurers TOA Re
GVT: Government
Source: SCOR Tech, 1996; Kagawa, 1995

Cover for fire following earthquake.
This is an automatic addition to normal homeowners fire policy. Maximum pay-outs per policy of 5% of fire policy, to a limit of US$ 200,000 (Industrial risks) and US$ 30,000 (Household risks). Losses are paid from the Japanese Earthquake Fire Expense Pool (EFEI) formed by the insurers and managed by TOA Fire and Marine Reinsurance Co..
Reinsurance: Since 1984 this cover is reinsured into the international market for a cover limit of US$ 606 million excess of a US$ 2.billion pooled market retention [dyp,1995]

Zenkyoren.
This mutual aid scheme was founded in 1951 and is supervised by the Agriculture, Forests and Fisheries Ministry. It is provided as an alternative insurance by the National Mutual Insurance Federation of Agricultural Co-operatives for farmers, as an extension of fire policies. It operates independently of the other systems described above. Earthquake cover of 50% of the fire coverage up to a limit of US$ 500,000 is provided.
Reinsurance: Zenkyoren bought US$ 1billion reinsurance in excess of US$1.9 billion.

Personal Accident.
Some reports mention that this commonly excludes death or injury by earthquake, although this can be waived by an endorsement. Estimates on Kobe insured losses mention a figure for life insurance, but it has not been possible to ascertain whether this is due to the high number of endorsements or some other factor. (SCOR Tech,1996; dyp 1995a)

Automobile Coverage:
Earthquake cover is generally excluded.

Marine Cargo:
Earthquake cover is generally included for this.

6. TOTAL LOSSES

TOTAL DIRECT AND INDIRECT LOSSES

	US$
Restoration of basic functions	115bn*
Indirect losses, economic dislocation and business interruption	50bn
Private property	50bn
Total losses (4% of Japan's GDP)	**215bn**

Source: DIS, Inc, although figure for restoration of basic functions is indicated as US$100bn.

Estimations of the impact of the disaster on GNP and growth have varied considerably, from 1% to 4.5%. This is clear from other sources, as the quote below indicates. "Taking into account the losses wrought by the disruption of economic activity, the quake will end up costing **$400 billion**. (*The Nikkei Weekly*, 30 January 1995, p6, in Cochrane, 1997)

6.1 Direct Losses:

DIRECT LOSSES:	US$ billion
CORPORATE LOSSES	63
PUBLIC LOSSES	32.8
HOUSING LOSSES	15.2
AGRICULTURE LOSSES	4
TOTAL DIRECT LOSSES	**115**

The economic losses of the earthquake have been estimated at wildly fluctuating levels. These range from US$ 82.4bn (Swiss Re sigma 2/1996), the generally accepted figure of US$ 100bn (Munich Re, 1995; Alexander Howden, 1995; Scor tech, 1996) and the higher levels of US$120bn (Kagawa) and US$ 95-147bn (EQE).

Initial estimates for total losses were varied. Alexander Howden gave an estimate of US$ 100bn one week after the earthquake, whilst Choji Ashio, deputy governor of Hyogo estimated total losses at US$ 85.5bn one month after earthquake. This figure was revised by his department to US$ 99bn one month later, as the extent of the damage became clear. Later sources seem to have pinned the losses to amounts greater than US$ 100bn. (Dr Smolka, Munich Re, 1995; Collins, Sun Alliance, 1998) Experience from Northridge indicates that losses tend to increase over time, due to additional damage being discovered, particularly structural damage which is often difficult to detect.

Corporate/Business Losses

Total	**US$ 63 bn**
Commercial and industrial buildings	US$ 14.1bn
Other construction	US$ 25.3bn
Machinery & Equipment	US$ 10.1bn*
Transport equipment	US$ 2.0bn
Consumer durables	US$ 5.1bn
Investments in process	US$ 4.0bn
Port: private facilities	US$ 2.4bn

*Another estimate puts this figure at US$ 6.37bn (Katayama 1996)

Insured Losses*:	**US$ 1bn**
Commercial and industrial:	US$ 0.5bn
Marine and aviation:	US$ 0.5bn

(Marine and Fire Insurance Association of Japan, preliminary figures)
Uninsured losses: US$ 62bn

AMOUNT OF JAPANESE ASSETS AND DAMAGE (US$billions)
ESTIMATIONS MADE 1 WEEK AFTER DISASTER

ITEM	OBJECT ASSETS (billion US$)			DAMAGE BILL (billion US$)
	JAPAN	HYOGO	QUAKE-STRICKEN AREA	GREAT HANSHIN EARTHQUAKE
NET FIXED ASSETS	*11188,7*	*482.2*	*181.0*	*66*
Commercial & industrial buildings	2510	103.0	38.4	14.1
Other construction	4163.3	183	68.7	25.3
Transport & machinery	400.4	16.2	6.1	2.0
Machinery & equipment	1720.7	74.8	28.3	10.1
Consumer Durables	819.9	36.4	14.2	5.1
Inventory Assets	801.7	33.4	12.1	4
SUBTOTAL	**10416.4**	**446.9**	**167.9**	**60.6 billion**
Harbour (private losses)				2.4
TOTAL with harbour				**63.0 billion**

Source: Tokai Research and Consulting Inc. in Katayama, 1996.**

Public Sector Losses

Note: The division between commercial/industrial and the public sector is somewhat blurred, and it has been assumed that infrastructure and lifelines, such as the Shinkansen bullet trains, general railways, highways, ports, airports, gas, water, electricity and telephone fall under public losses, except where specified as private.

Total Direct Losses US$ 32.8bn
Insured Direct Losses no mention
Uninsured Direct Losses US$ 32.8

DAMAGE EVALUATED BY HYOGO PREFECTURE (billion US$)
ESTIMATIONS MADE 2 MONTHS AFTER DISASTER

ITEM	AMOUNT (billion US$)	OUTLINE
Railways	3.48	West Japan Railway Company, Hankyu Corporation, Hanshin Electric Railway, Kobe Electric Railway, Sanyo Electric Railway etc.
Highways	5.56	Hanshin expressway, Chugoku driveway, Meishin expressway, etc.
Public works facilities, except for highways	2.81	Roads 1.1, Rivers 0.3, Seashores .004, Sand flow detention .007, Drains 0.7, Streets 0.04, Parks 0.14, etc.
Harbour facilities (public)	7.7	
Reclamation Land	0.06	Sano and Shichiku district 0.007, South Ashiyahama and Ashiyahama district 0.04, Nishinomiya and Koshien district 0.017.
Educational Affairs facilities	3.45	School, Social education facilities, Physical training facilities, Cultural assets.
Agriculture, Forestry and Fisheries facilities	1.19	Wholesale markets, Fishing ports, Facilities for agriculture etc.
Health, Medical and Welfare facilities	1.75	Hospitals, Clinics, Experiment research facilities, etc.
Industrial & Human Waste Disposal facilities	0.04	
Waterworks facilities	0.55	Waterworks 0.5; Water for industrial use 0.05
Gas and Electricity	4.25	Gas 1.92, Electricity 2.33
Communication and Broadcasting facilities	1.22	Nippon Telegraph & Telephone Corporation 0.8, CATV 0.18, etc.
Public facilities	0.76	Prefectural office building 0.14, City and town office buildings 0.52, Police office building 0.1 etc.
TOTAL	**32.8billion**	

Source: Katayama, 1996
** Reconstruction estimated to increase by 50% with inducement effects on production

ALTERNATIVE INFRASTRUCTURE REPLACEMENT COSTS (US$ BILLIONS)
ESTIMATIONS MADE 3-4 WEEKS AFTER DISASTER

AGENCY	BUILDINGS	HARBOURS	ROADS	RAILWAYS	UTILITIES	OTHER
Hyogo Prefectural Gvt.	65.7 (58)	11.8 (10.4)	6.8 (6)	4.6 (4.07)	--- (-)	--- (-)
National Land Agency	71.3 (63)		24.9 (22)		6.8 (6)	5.7 (5)
Ministry of Transportation		8.4 (7.4)		4.7 (4.14)		

Source: EQE International, 1995
*Figures in brackets from Tiong 1995

Private Residential Sector Losses

Total direct losses housing **US$ 15.2bn**
Insured residential losses: **US$ 1-2bn**

Damage to buildings:
The traditional wooden buildings were susceptible to loss of strength due to rotting and termite damage. They have heavy tiled roofs, few walls and large rooms, unlike the residential buildings in Northridge which had much lighter roofs. This led to greater losses.

The overall losses to buildings were estimated at US$58.6bn, and the residential sector appears to account for 26% of this figure. Commercial buildings account for 24%, other construction for 43%, public buildings for 7%.

Agriculture

Total direct losses to agriculture **US$ 4bn**
Total insured losses **US$ 1bn**

The damage to agricultural and educational buildings and river defences evaluated by the Hyogo Prefecture two months after the earthquake was US$5.1m but these figures appear to conflict with the figures in table 6 above. Although no actual figure of US$4bn is given, descriptions and reports appear to indicate that the correct figure is in the region. The Zenkyoren (National Mutual Federation of Farming Co-operatives) posted a loss of around US$ 1-1,150bn. The local association said that the Zenkyoren had 462,000 policies totalling US$46bn for earthquake risks under building endowment.

Life

Life Cover:
Japan has the highest take-up of life cover world-wide. (Swiss Re, 1998)
The Life Insurance Association of Japan first estimated insured losses to members as US$0.4bn. There was a large spread of life insurance, and the adjusted estimated life insurance loss burden was revised to US$500-750 million. (Munich Re, 1995) The figure obtained from the Life Insurance Association of Japan was US$ 490m, on 5,798 policies, for the life insurance claim paid up to December 1995, including any payments for hospitalisation. (Ebisaki, 1999) This figure would have been much higher had more breadwinners, or males in the working population, perished.

AGE OF DEATHS

	Male	%	Female	%
Above working age	803	15	1596	29
Working population	898	16	1143	21
Below working age	500	9	530	10
TOTAL	**2201**	**40**	**3269**	**60**

Insured life losses **US$ 490 m**

6.2 INDIRECT LOSSES

Corporate/Business Losses

TOTAL Indirect economic losses **US$ 50bn** (DIS, 1996)

Some losses mentioned:
Kobe Steel industrial loss quoted as US$748m
Mitsubishi Heavy Industries (10s of billions Yen)
Proctor and Gamble - US$ 50m charge made (Muir-Wood, 1995)

Industrial losses:
No definitive assessment has been possible for Kobe or Northridge. The impression gained is that industrial risks, in spite of their higher average loss, were less severely affected than residential buildings and the services sector. There were some specific large losses, indicating a large loss variance. (Smolka, 1995)

Examples of Indirect Losses: (These were all uninsured.)

Demand surge losses (20%)	US$ 12.6bn
Discount retailer estimated losses	US$ 500m,
60 supermarkets estimated losses	US$ 3.3bn,
10 department stores estimated losses	US$ 1.1bn on stocks and sales.
Japanese car makers	US$ 350m

(production losses of 40,000 units during the month after the disaster. Kunreuther, 1997)
Kobe Steel US$ 552m business interruption costs. (The material damage was US$ 748m - Smolka, 1995)
Losses of small/medium firms US$ 0 5bn Ministry of International Trade & Industry estimated losses (Tiedemann, 1996b)

Consumer spending was reported to have dropped by 20% to 30% in Osaka after the disaster, due to a sense of self-restraint in consumers due to the widespread suffering. Kyoto, which was hardly damaged, reported a sudden drop in tourism.

Public Sector Indirect Losses

Government Losses:
Finance Ministry anticipated a drop of US $6-7bn* drop in tax revenue for the fiscal year 1994. (EQE) (*Tiong put these figures at US$ 5-6bn in tax revenues) There were already considerations about tax increases underway, and the consumption tax increase scheduled for 1997 was adopted sooner. This proved to be very unpopular with the public.

Utilities:

Water:
Failure of water supplies affected 2.5 million people. About 70% of the water system was inoperable, due to over 2000 breaks in the water piping.
There were more than 1000 cisterns for the backup water supply to Kobe, yet they only provided a fire fighting water supply which lasted for ten minutes. (EQE)
The Department of Water Supply and Sewerage of Kobe was situated on the 6th floor of the City Hall, and totally collapsed, making all essential documents inaccessible. This hindered the repair of utilities. (Katayama, 1996)

Electricity and Gas:
Nearly I million households were without power, the same number without gas. Both telephone and power supplies were reconnected within 2 weeks, but the gas and water supplies took between few weeks and several months. This caused major disruptions to business.

One week after earthquake:	Electricity: 100 % restored
	Water: 68 % restored
	Gas: 15 % restored

One month after the disaster only 34% of the gas distribution system had been restored.

Osaka Gas utility revenue losses	US$ 68m.

Major transport links:

Railways:
The (Shinkansen) Bullet train was out of operation for almost five months, resulting in huge restoration costs and revenue losses to Japan Rail. The Shinkansen high speed rail route between Tokyo and all of western Japan was closed by the collapse of bridge spans, as were the other two rail lines. Damage to the Shinkansen bullet train railway tracks was relatively small, but there was substantial damage to the railway stations.

Estimated damage to Shinkansen system	US$ 6bn. (Shinozuka)

Train services to Port and Rokko Islands stopped, due to damage to bridges and overhead sections. Services to port islands were interrupted for eight months.

Port connection repair	US$ 135m
Rokko line repair	US$ 100m
Hanshin Railway revenue losses	US$ 51m

There was a complete breakdown in the local transport system for several days. Reconnection of commuter trains with the damaged city centre took several weeks. One company stated that it was losing more than US$2m daily.

Highways:
The elevated Great Hanshin expressway, the main vehicular traffic artery through Kobe, was closed by collapses at several locations. Many spans of structures and bridges collapsed, built under the older design codes. The highway collapsed over a length of more than 20km, causing chaos until it had been repaired. This took several years to complete. (Scawthorn, 1997)

Kobe Port:

Estimated damage to the port	US$10-11bn. (Katayama)
Estimated decrease in Japan's trade surplus due to damage to Kobe port.	US$5-8bn

90% of the berths and cranes at Kobe Port were destroyed. The port was shut down to international shipping, due to major damage to containing loader piers and the blocked access to Kobe via highway and railway. The port is a semi-public corporation and was unlikely to be entitled to full government compensation. Full reconstruction was estimated to take 2-3 years.

Kobe port and related businesses were estimated to support over 100,000 jobs and generate approximately 40% of Kobe's revenue. There was concern that the alternative arrangements made during reconstruction would ensure that the port was unlikely to regain the commercial success it had had. By October 1996, when significant repair had been relaxed, the total container cargo handled had only returned to 73% of its pre-earthquake volumes. The rate of recovery was not only affected by the damage to the port itself, but also to the adjacent

highway infrastructure which slowed trucking traffic to and from the port, thereby raising user costs. (Werner et al, 1997)

Airports:
Both Kansai International airport, situated on an island 5km from the south-east shore in 18m depth of water, and Itami, the domestic airport for Osaka, 10km east of the damaged area, sustained no significant damage.

Household Losses

DIS Inc. mentions US$ 50bn losses to private property, but this cannot be substantiated. There are numerous reports stating that the indirect losses are approximately 100-200% those of the direct losses. This is presumably spread over all sectors, with the demand surge costs of 20%, design costs of approximately 15% etc.

7. COMPENSATION

7.1 Donations

In the immediate aftermath many corporations and other non-governmental organisations donated goods and transport. Kirin Beer filled thousands of quart-sized bottles with drinking water and shipped them into the area.

Donations from the public and private corporations poured in through the Red Cross, the government and local government collections. The Hyogo prefecture South District Earthquake Disaster Charity Committee was established to administer the fund. This comprised of 26 organisations, including the Hyogo prefecture, Osaka prefecture, Kobe city, Hyogo Mayor's Committee, various local government and Red Cross organisations and several smaller organisations. The fund made the decisions regarding the distribution of the donations, and apportioned aid according to the schedule set out below:

Donations given: **$ 1,810 million** (at 31/12/97)

ALLOCATION OF DONATIONS
(31/12/97)

	Per person/unit $	number	Total $ million
Dead/missing people	1,000	5791	5.9
Housing (totally destroyed, half destroyed, totally burned, half burned)	1,000	448322	453.3
Severely injured (more than one month)	500	11058	5.6
Families needing help (relating to housing damage)	3,000	48947	148.5
Affected children	100-500	52946	17.6
Rebuilding domestic dwellings (repair and rent)	3,000	142092	430.3
Orphan children	10,000	466	3.6
Subsidies for living (totally destroyed, half destroyed, totally burned, half burned and less than $ 69,000 income per year)	1,000	367823	371.9
(Additional payment to the above)	500	366969	185.5
Subsidies to the local governments (mainly improvement of housing)		25	151.7
Balance			36.1
TOTAL			**1810.0**

Source: http://www1.odn.ne.jp/fukkou/gienkin/gienkin.html (Japanese text only)

7.2 National Government

The government announced plans to subsidise 90% of the cost of repairing public facilities by issuing some US$ 7-8 billion construction bonds, and US$ 6-7 billion deficit-covering bonds in anticipation of tax revenue drops. (Tiong, EQE, 1995) It has been assumed that this forms part of the government diversions set out below.

The government took $34.17 billion out of its budget over two years, which was administered as set out below. Money taken from government budget:

1995:	2nd amendment, budget related only to earthquake:	$ 10.34 billion
1996:	1st amendment, budget related only to earthquake:	$ 14.45 billion
1996:	2nd amendment, budget related only to earthquake:	$ 7.87 billion
1995:	exceptional items budget:	$ 0.20 billion
1996:	exceptional items budget:	$ 1.31 billion
TOTAL		**$ 34.17 billion**

(PCIRO, 1997)

GOVERNMENT EXPENDITURE
In $ billions

	1994 - 2nd amendment	**1995 - 1st amendment.**	**1995 - 2nd amendment**
To normalise life in area	1.31	0.47	4.71
Debris removal	0.35	1.37	
Prevention of secondary disaster	0.10	0.13	
Rebuilding of port	1.21	3.71	
Rebuilding of infrastructure	4.41	3.77	2.35
Strengthening of roads and building structures	0.20	0.47	
Housing	0.91	0.98	
City areas and park facilities	0.15	0.24	
Employment	--	0.11	
Health/medical	0.17	0.44	
Education	0.15	0.97	
Agriculture, fishing and forestry	0.17	0.25	
Rebuilding of economy	0.61	1.20	0.80
Reorganisation		0.02	
Safety and transport	0.07	0.02	
Security	0.07	0.23	
Other	0.46	0.07	0.01
TOTAL	**10.34**	**14.45**	**7.87**

Source: Earthquake Insurance Survey Report 26, 1998

7.3 Local Government

Hyogo prefecture decided to invest US$ 17.4 million over 10 years to rebuild the city. This was decided on 4.8.95. The Hyogo prefecture also amended their budget to allow US$ 858.4 million for rebuilding works. They provided loans and grants, details of which are set out under section 8.1.

Private Insurance

ESTIMATED INSURED LOSSES

INSURED LOSSES	**US$**		
Sources	Munich Re	Marine and Fire Insurance Association*	Tiong.* EQE*
Homeowners' comprehensive	750m	1bn	
Buildings in the agricultural sector	1,150m	1bn	
Industrial insurance	450m	0.5bn	
Life insurance	750m		
Marine insurance	50m	0.5bn	
TOTAL	**3,150m**	**3,000m**	**6,000m****

Sources: Munich Re, 1995; *Alexander Howden, 1995 (initial estimates); Tiong, EQE, 1995
**This amount could rise due to two factors: 1) additional damage discovered, and
2) unreported claims.

Insured losses were initially estimated at US$ 3-4m, but later reports suggested that this was too conservative. EQE estimated US$3-6bn, and Standard and Poor estimated insured losses between US$8-12bn, on aggregate losses of US$100bn. (dyp, 1995a) They questioned whether Japanese insurers would come under political and public pressure to ease payment thresholds, increasing the total value of the claims paid. (refer to section 3.3.1) This does not appear to have happened.

Total aggregate earthquake insurance in force for industrial and commercial property was less than US$ 3bn at the time of the earthquake, ensuring that total insured losses were unlikely to exceed 5% of the total loss. (Smolka, 1995)

Total insurance payments: US$ 3.0 billion

There were concerns that this figure could rise because of additional damage yet to be discovered, similar to the situation at Northridge, and as yet unreported claims against offshore insurers for property damage covered under multinational corporate policies or for business interruption claims resulting from the Kobe port disruption. There are no indications that this has been the case.

Total figure of Japanese non-life insurance companies: (on 21.4.95)

Earthquake insurance on dwelling risks	US$ 882m
Cargo, etc	US$ 529m
Total insured losses:	**US$ 1.4bn**

(Kagawa states that 97.45% of those claims had already been paid.

Kobe port had independent insurance cover.	No mention
Marine & Fire Association estimated insured losses	US$2.76bn insured (excluding liability) at 1998 prices
AIG (the largest foreign insurer in Japan) estimated nett losses	US$50m, after reinsurance.
GIO (Australian reinsurer) estimated reinsurance losses (estimate)	US$58m maximum

Households

Residential losses were estimated to be US$ 760m (Muir-Wood). This figure coincides with the data set out below from the PCIRO, but it is clear that there is an industrial element within this amount. It cannot be ascertained whether this amount has been calculated twice.

INSURANCE CLAIMS PAID
up to July 1996

	No. of policies	% of policies	Amount paid	% paid
Household Fire	4,207	6.6	49.0	6.3
Household Combined	30,850	48.0	422.7	54.6
Medium/small factory with industrial element	614	1.0	9.7	1.3
Small store /comprehensive policy	9,070	14.1	142.1	18.3
Pre-cast concrete building structure	4,676	7.3	31.1	4.0
Long-term policies for fire with maturity fund	10,021	15.6	73.6	9.5
Special fire policy with public building society	4,778	7.4	46.4	6.0
TOTAL	**64,216**	**100.0**	**774.6**	**100.0**

Source: Earthquake Insurance Survey Report 26, 1998

Agriculture:
Zenkyoren losses* **US$ 1bn**
(*this level is below the US$2bn deductible)

Loss assessment:
Marine and Fire Insurance Association of Japan had prepared for emergency by holding drills and seminars, but the industry, with only 550 loss assessors was not prepared for the scale of the catastrophe. Discrepancies arose as to what constituted earthquake damage, particularly as there is a widespread belief in Japan that repair is not a suitable form of reinstatement. No attempt was made to estimate the cost of repair, which was reflected in the losses incurred by the insurers. (Windsor, 1995)

Insurance payments for indirect losses

The main coverage for foreign insurers appears to be on foreign owned property, foreign marine and business interruption risks. These are spread throughout the industry so losses have been difficult to assess. For details of business interruption cover refer to Appendix B.

8. EX POST MEASURES

8.1 Public Policy

Victim compensations
Earthquake victims are eligible for relief grants, low cost loans and tax breaks. In June 1996 a Law concerning Special Measures for Protecting the Rights and Benefits of Victims of Specific Emergency Disasters was passed, setting out clear legal guidelines for compensation. There is no mention whether this money was channelled from national or local government coffers, and it is not clear whether the Kobe victims were retrospectively compensated.

PUBLIC COMPENSATION LOANS AND GRANTS
From local government coffers

	Amount per item	**Number of grants**	**Estimated TOTAL**
Breadwinners death	$ 50,500	5732	$ 183 million
Other family members death	$ 25,275		
Householders severely injured	$ 25,275	41	$ 620,000
Other family members severely injured	$ 12,640		
Injuries, homelessness.	Max. $ 35,000 loan over 10 years, 5 years no interest, 3 %interest rest of term. 55,613 loan contracts		$ 1,950 million
Compensation for lack of earnings	Max. $ 1,000 (in special cases 2x amount) over 5 years, 2 years no interest, 3 % interest rest of term. 55,020 loan contracts.		$ 55 million
Estimated TOTAL			**$ 2,188.6 million**

Source: Earthquake Insurance Survey Report 26, 1998

8.2 Private insurance sector

Subsequent changes to institutions:

Kobe raised the issue of insufficiency of residential cover protection. Separate damage certification for household property has been introduced, and the insured limit for earthquake building damage cover has increased from US$ 100,000 to US$ 200,000. Studies have been undertaken to examine issues such as the increase of the insured amount and the aggregate limit, improvement of coverage (perhaps compulsory) and the introduction of automatic inclusion of earthquake risks in some type of fire policies. There appears to be no likelihood that the government would become involved in industrial earthquake risks. (Kagawa)

No major changes to insurance were proposed subsequent to Kobe, partly due to the deregulation proposals already in place at the time. Japan introduced a new insurance law in April 1996, designed to stimulate competition, based on solvency controls. At the time of Kobe, Lloyds was not licensed to operate in Japan, but many of the other international insurers were established. Deregulation changed the situation.

Rates in mass-risk business, such as fire and voluntary motor insurance have been deregulated, but earthquake insurance for residential buildings is still state regulated and reinsured. (Swiss Re, 1997b) In April 1997, there was an unpopular consumption tax rise from 3% to 5%. This led to a decrease in public expenditure and a series of deregulation and stimulus measures.

Japanese insurers are lobbying the government to help increase the take-up of domestic household earthquake risks. Only 15% of households in Japan are insured against earthquakes and even in the most exposed areas, such as Tokyo, the take-up is only 24%. In a bid to attract more takers, the Marine and Fire Insurance Association is calling for a tax rebate on earthquake premiums for dwelling risks up to an annual limit of Y50,000 ($475). It also wants an increase in the non-taxable element of catastrophe reserves from 3% to 5% of net premiums on fire and other catastrophe-prone classes. (Ebisaki, 1999)

8.3 Hazard Mitigation

After the Kobe earthquake, Japan has increased its focus on earthquake disaster mitigation. The Disaster Countermeasures Basic Act was passed, as well as an amendment of the Basic Plan for Disaster Prevention. There are a number of disaster mitigation systems in place, and co-ordination of these differing systems could prove to be a problem.

Japan Railway has pioneered UrEDAS (Urgent Earthquake Detection and Alarm System),an information system that detects the arrival of P-waves near the source, estimated the location and magnitude of the earthquake and uses this information to stop high-speed trains before the arrival of S-waves. Japan Railway also developed HERAS (Hazards Estimation and Restoration Aid System) which uses the UrDAS information to estimate the degree of damage to railway systems caused by an earthquake.

Since 1994 the Tokyo Gas Company has operated SIGNAL (Seismic Information Gathering and Network Alert) which will automatically shut of the gas supply when microcomputer meters detect a seismic intensity of 5 (on the JMA scale). The system also estimates damage based on earthquake motion monitoring and provides warnings. Other large city gas companies have been installing seismometer networks since the Kobe earthquake.

In 1994 Kawasaki City has installed the most advanced earthquake disaster countermeasures support system at the city level, and its simulation functions are used for disaster prevention drills. The system consists of four modules; estimating the distribution of seismic intensity, predicting various hazards, structural damage and human casualties, suggesting policies for crisis management and disaster prevention education.

The JMA (Japan Meteorological Association) has more than doubled the number of its earthquake intensity observation stations to 574 sites in total, and the National Research Institute for Earth Science and Disaster Prevention has constructed a network of 1,000 observation points, named the *Kyoshin Net* (K-Net) throughout Japan. These points are connected to the municipalities and an observation centre from where information is transmitted by satellite. The strong motion data can be edited and distributed through the Internet in a few hours. The FDA (Fire Defence Agency) has developed a simplified earthquake damage estimation system, which has been offered to all municipalities and fire fighting organisations. It has also constructed a municipal earthquake intensity network, which deploys one accelerometer in each of Japan's 3,255 municipalities. Any information on an earthquake can be transmitted to the JDA through ISDN lines. There is also a link between the JMA and the FDA. (For more details on hazard mitigation systems refer to Yamazaki, 1998.)

9. CONCLUSIONS

Japan has a long history of earthquakes yet the fact that it was so ill prepared for Kobe and the scale of human and economic losses has led to a major evaluation of its hazard prevention and an increased interest in seismic research.

Japanese insurers are extremely wary of insuring against earthquake risks, and there appear to be many opportunities for the foreign insurers. It would not be a policy for the faint hearted, for the potential losses are extreme.

All types of earthquake insurance are in short demand, and there appears to be little commercial insurance on the market at present. A factor worth noting is the large percentage of buildings on reclaimed land, due to the land shortage. Liquefaction is more likely under

these soil conditions, which play a larger role in the level of seismic ground motion than the distance from the hypocentre.

Insurers should also be extremely wary of business interruption clauses. The Japanese manufacturing industry appears to be very lean, and operation of the *Kanban* system could have major repercussions.

10. BIBLIOGRAPHY

Alexander Howden Group Ltd. (1995) The Great Hanshin Earthquake, Japan. April 1995, Alexander Howden Non-marine Division, London & Sydney.

"Disaster of Kobe City." http://www.niksula.cs.hut.fi/~haa/kobe.html

Crewe, A. The Kobe Earthquake: A Personal Perspective. EERC (Earthquake Engineering Research Centre, University of Bristol) http://www.fen.bris.ac.uk/civil/eerc/research/kobe

Chang, S.E. (1995) Economic Impacts. in Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995. MCEER publications, New York.

Cochrane, H.C. (1997) Forecasting the Economic Impact of a Midwest Earthquake. p 223-247, in Jones, B.G. *Economic Consequences of Earthquakes: Preparing for the Unexpected*. NCEER-SP-0001, Buffalo, NY

Collins, CM (1998) Earthquake for Insurers: A Personal View to include Lessons arriving from the Kobe and North Ridge Earthquakes. *Journal of the Insurance Institute of London*, 1998. P42-54.

DIS, Inc. (Dynamic Isolation Systems, Inc.) Kobe Earthquake: History. http://www.dis-inc.com/kobe.htm

Doornkamp, J. (1995) A Hazard Too Hot To Handle. *The Review*, March 1995, p 27-29.
DSBB (1999) Economic and Financial Data for Japan. http://www.stat.go.jp/19.htm

dyp (1995a) Kobe Earthquake: Massive damage but not the Big One. *Catastrophe Reinsurance Newsletter*, Issue 23, January 1995, p1-4

dyp (1995b) State and Public Bear the Brunt of Kobe Earthquake. *Reinsurance Market Report*. Issue no 270, January 25, 1995. p49-52

Ebisaki, M. (1999) Personal conversation with Japanese insurer, currently with Royal & SunAlliance.

Eguchi, R.T. (1997) Economic Implications of Damage to Infrastructure and Mitigation Opportunities, p 111-123, in Jones, B.G. *Economic Consequences of Earthquakes: Preparing for the Unexpected.* NCEER-SP-0001, Buffalo, NY

EQE (1995) The January 17, 1995 Kobe Earthquake. An EQE Summary Report.
http://www.eqe.com/publications/kobe/kobe.htm

Europa World Year Book. Vol I, (1999) Europa Publications Ltd, London.

Goddard, S (1995) Japan: how deep are the cracks? *One Lime Street*, February 1995, p20-21

Goltz, J.D. (1995) Social Impacts. in Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995. MCEER publications, New York.

Jones, B. (1995) Preface of Conference. *Economic Consequences of Earthquakes: Preparing for the Unexpected.* September 12-13, 1995. National Center for Earthquake Engineering Research, Buffalo, New York.

Kagawa, T [Executive Director of The Non-Life Insurance Institute of Japan, Tokyo](1995) Great Hanshin Earthquake - A Japanese Insurer's View. *The Geneva Papers on Risk and Insurance*, 20. (No 77, October 1995) p 481-487.

Katayama, T. [Director of INCEDE, IIS, University of Tokyo] (1996) Lessons from the 1995 Great Hanshin Earthquake of Japan with emphasis on Urban Infrastructure Systems. Proceedings of Structural Engineering in consideration of Economy, Environment and Energy. 15th Congress, June 1996, Copenhagen, Denmark. p187-200.
http://incede.iis.u-tokyo.ac.jp/kobenet/report/publ/publ-l.html

Kunreuther, H (1997) New Strategies for the Earthquake Hazard. In Jones, B.G. *Economic Consequences of Earthquakes: Preparing for the Unexpected*. NCEER-SP-0001, Buffalo, NY

Muir-Wood, R. (1995) Do we know enough? Assessing the Risk: Kobe- Counting the Cost. Third International Reinsurance Conference, London Underwriting Centre, 7/8.6.95, p71-75

Munich Re. (1995) Catastrophe portrait of the year. The Great Hanshin Earthquake of 17th January 1995 in Kobe, Japan. *Annual review of catastrophes* 1995.

Nigg, J. (1995) Societal Impacts and Emergency Response. in *Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995*. MCEER publications, New York.

O'Rourke, T.D. (1995) Geotechnical Effects. in *Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995. MCEER publications*, New York.

Pantelic, J. (1995) Initial Reconnaissance Efforts. in *Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995*. MCEER publications, New York.

Property and Casualty Insurance Rating Organization of Japan (PCIRO) (1997) *Earthquake Insurance Survey Report 26. Hanshin-Awaji Great Earthquake data*.. March 1997

Property and Casualty Insurance Rating Organization of Japan (PCIRO) (1998) *Seismology and Earthquake Engineering in Japan.*

RMS (1999) Japan - the Great Hanshin Earthquake, excerpt.
http://www.riskinc.com/rms/publications/publications3.html

Scawthorn, C. Overview of Structural Damage. in *Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17*, 1995. MCEER publications, New York.

Science and Technology Agency. (1996) *Earthquakes in Japan*. March 1996. Tokyo 100, Japan.

Shinozuka, M. (1995) Summary of the Earthquake, in *Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995*. MCEER publications, New York.

Somerville, P (1995) Kobe Earthquake: An Urban Disaster. *Eos*, Vol. 76, no 6, February 1995, p49-51. American Geophysical Union. http://www.agu.org/sci_soc/kobe.html

Smolka, A. (1995) Comparing faults. *Reinsurance*, October 1995, p 29-34

Swiss Re, (1997a) Importance of the insurance markets: an international comparison. Sigma no 4, p14

Swiss Re, (1997b) Japan: Insurance industry virtually unaffected by fragile economy. Sigma no 6, p10

Swiss Re, (1997c) Too little reinsurance of natural disasters in many markets, Sigma no 7, 1997

Tiedemann, H. (1996) Kobe: Was this a foretaste for the world's greatest earthquake disaster - Part II. *Catastrophe Reinsurance Newsletter*, August 1996, Issue no 42, p155-160

Tiong, R. (1995) The Great Hanshin Earthquake: A Quick Look at Loss Estimates and Insurance Aspects. *Asia Insurance Review*, May-June 1995, p 59-60

World Bank (1998) World Bank Atlas, World Bank Indicators, Washington D.C.
WSSPC, Western States Seismic Policy Council, Kobe, Japan Earthquake. http://www.wsspc.org/resources/resources.html

Windsor, B. (1995) Shaken to the core. *Post Magazine.* 9 February 1995, p23.

Werner, S.D, Dickenson, S.E, Taylor, C. (1997) Seismic Performance of Ports: Lessons from Kobe. p125-153, in Jones, B.G. *Economic Consequences of Earthquakes: Preparing for the Unexpected*. NCEER-SP-0001, Buffalo, NY

Yamazaki, F (1998) Real-Time Earthquake Disaster Mitigation Systems in Japan, in *Seismology and Earthquake Engineering in Japan.* Property and Casualty Insurance Rating Organization of Japan (PCIRO) (1998)

Internet sources, mainly images:

http://tgl.geology.muohio.edu/Focus/TheKobeEarthquake.html
http://www.seismo.unr.edu/ftp/pub/louie/class/100/effects-kobe.html

APPENDIX A:
ENGINEERING CRITERIA FOR CONSIDERATION

Building performance criteria:

The building code is intended to protect a new building from collapse during an earthquake, but it is expected that it would be severely damaged. Higher design standards can be applied to reduce the risk of extreme damage, at an increase in cost. In Kobe many commercial buildings had extensive damage to their finishes and certain structural elements, losing more than 50% of their value, yet met the conditions of the code. (EQE,1995)

Building type criteria:

Engineered buildings, particularly concrete-frame, built in the late 1970's before the building codes were updated are very vulnerable, as no allowance was made for ductility. Steel buildings performed better, but there were exceptions, notably some innovative systems. Construction features were a factor in the scale of the losses, with modern structures conforming to the revised 1981 code proving to be earth-quake resistant in the most cases. Pre-1981 concrete frame buildings performed very poorly, with many collapses. Post-1981 buildings performed much better, but some were extensively damaged and most had light damage. Seismic isolation of bridges and other key structures is claimed to enable a structure to withstand an earthquake. There have been calls for a major strengthening programme to be undertaken. (Smolka, 1995; EQE, 1995; DIS, 1995)

Location Criteria:

Most of the serious damage to larger commercial buildings and infrastructure occurred in areas of soft soil and reclaimed land. Liquefaction (ground loses strength and structures sink or topple over) occurred over wide areas of artificial landfill, particularly the port area, with cracks up to six feet deep, but the extent of losses was minimised by suitable construction techniques, deep-pile foundations driven in to a subsoil depth of more than 20 metres. (Crewe, 1995; Smolka, 1995) Land shortage has ensured that these conditions occur throughout Japan.

Fires:

Fire following earthquake is potentially devastating, and Kobe was fortunate that there was no wind. Kobe had more than 1000 backup cisterns for fire water supply, but they provided only a 10-minute supply. There were over 150 fires which damaged an area of $1km^2$ of the city centre, plus areas of the port. (EQE,1995) Better control of gas and water systems is required to reduce the risk.

Seismicity:

Kobe occurred on a known fault line, but one that was not active. The particular section had been classified as higher risk in a 1983 publication, but the probability of an earthquake was considered much less compared with Tokyo. All of Japan is an earthquake region and lack of recent seismicity might be a sign of accumulating seismic stresses. (EQE, 1995) The possibility of earthquakes occurring on unknown or seldom active faults must be considered in the risk assessment. (Smolka, 1995) Major earthquake recurrence intervals in central Japan are typically in the range of 1000-5000 years, beyond the span of recorded history.

Time-of-day:

Had Kobe earthquake occurred later in the day, losses would have been in a different league. Kobe earthquake occurred 14 minutes before the first four Shinkansen trains scheduled departure for Kobe, at speeds of 230km/h with capacity of 1300 passengers. At full speed they require 3km to stop. Many reports confirm that the resultant effects of Kobe could have been far worse. (Tiedemann, 1996b)

APPENDIX B
BUSINESS INTERRUPTION

Business Interruption:
This is a major issue within the total damage claim. The integrity of a single building is inconsequential without integrated lifelines and infrastructure. Consequential loss of business interruption is not often covered in Japan, but is the rule with multinational risks. There was limited experience of the interpretation of 'time element' covers.

Business interruption covers were for foreign interests, but they are proved to be massive and to extend for beyond the boundaries of the loss area, proving that these covers carry a large loss potential. Disruptions to lifelines, staffing levels, materials supply as well as direct damage all affect the ability of an organisation to function normally.

***'Kanban'* (just-in-time) system:**
This poses major problems for the unwary insurer, particularly when the plant stops production due to lack of supply rather than damage. (Windsor, 1995) 'Just-in time' delivery system affected various industries, particularly the automotive industry because of losses at two steel producers. Loss of production of computer monitors by one company affected 5 major computer manufacturers around the world. (Smolka, 1995) Physical damage, problems of transport systems and utilities, effect on workforce all contributed to stoppage of production. (Tiedemann, 1996b) Interpretation of the time element can be difficult, when there is no physical damage to a particular plant, yet problems of delivery or staffing from elsewhere affect production.

Lifelines:
Failure of infrastructure (lifeline) systems, such as transportation facilities, water and sewage lines, gas and electricity supplies can cause the most disruption to the social and economic system. Mitigation measures can reduce risks at costs that are relatively modest. (Eguchi, 1997) Ports are particularly vulnerable. The congestion caused by lifeline disruption impeded the emergency response and recovery. (Somerville, 1995)

EXISTING BUSINESS INTERRUPTION BUSINESS IN JAPAN

	Policy number: Fire Total (000)	Policy number: Business Interruption (000)	Premium Written: Fire Total ($ million)	Premium Written: Business Interruption
1993	14,905	58	8,383	180
1994	15,514	53	9,173	170
1995	15,478	52	9,239	164
1996	15,860	54	9,731	155