University of Surrey
IIASA

TSUNAMI

Project on

The Uninsured Elements of Natural Catastrophic Losses

NORTHRIDGE EARTHQUAKE

Case Study Report

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1. EXECUTIVE SUMMARY

Northridge earthquake was an earthquake of moderate size, which struck a densely populated residential area. Yet, in terms of financial losses, Northridge is one of the worst natural disasters in US history, comparable to the Hurricane Andrew in 1992. In terms of economic damages, initial estimates were revised many times before the final figure of $44 billion in financial losses was reached.

The earthquake occurred on an undetected 'blind thrust', in a densely populated residential area. It occurred in the early morning and on a holiday, which dramatically reduced the effects of what otherwise could have been. Potential business losses were also reduced due to the timing of the earthquake, since most manufacturing and service industries were closed down. Northridge was subjected to thousands of aftershocks , many quite substantial, over several weeks after the initial quake, further damaging structures which had already been weakened. Most damage was caused by shaking, but ground failure and several dozen fires also caused substantial losses.

Northridge is situated in the northern suburbs of Los Angeles, California. This is an area that is active seismically and has been repeatedly rocked by earthquakes throughout recorded history. California is one of the most well prepared regions of the United States, yet the scale of damage and disruption were unprecedented. Damage to buildings, even those built to conform to building standards, was immense, and thousands of people were left homeless temporarily. Disruption of lifelines and damage to the transportation network of freeways had repercussions on a vast area of the metropolis. This has resulted in the prioritization of mitigation measures and studies of lifeline vulnerability at both state and federal level. California state had already commenced a retrofitting programme, and structures already retrofitted appeared to remain functional.

Initial estimates of damage are critical, as they are demanded under federal law under the Stafford Act as part of the request for a Presidential Disaster Declaration. This figure was $25 billion, and subsequent estimates have increased the direct and (partial) indirect losses to $44 billion. This has led to concerns about the likelihood of a Kobe-type disaster in the United States, causing more than $100 billion damage.

The market penetration of earthquake cover in California is still only 25-30%. High losses over recent years have made it more difficult and expensive to find insurance for natural disasters. This is in partly due to the enormous potential loss exposure and the high percentage of the population living in areas which can be classified as high risk.

In 1996 the California Earthquake Authority was set up to deal with the problem of insurance availability, under a mandatory earthquake insurance law.' This law was introduced in 1985 with the stipulation that insurers offering 'homeowners policies' are required to provide earthquake coverage, with the effect that 90% of insurers stopped selling new homeowners policies or placed restrictions on selling them. In addition, many policyholders did not renew their policies because premiums were too high and the deductible had been increased to 15%. Subsequently, the California State legislature passed a bill that would exempt private insurance industry funding for an initial tax-exempt one-shot payment of $1billion relieving them of future earthquake losses.

2. INTRODUCTION AND DESCRIPTION OF DISASTER

2.1 General Description

Date:
Monday, January 17, 1994, 4:31 a.m. Pacific Standard Time
Estimated Magnitude:
Moderate-sized earthquake, moment magnitude (Mw) 6.7, in a densely populated area of northern Los Angeles.
Duration: 15 seconds
Epicentre:
20 miles north-west of Los Angeles, 1 mile south of Northridge, beneath the San Fernando Valley, at a depth of approximately 11 miles (18km). Near-record ground shaking was recorded and peak horizontal accelerations at the ground surface ranged between 0.3g and 1.2g. There had been a previous earthquake in San Fernando in 1971.
Aftershocks:
14,000 reported aftershocks, many in the magnitude 4.0 - 5.0 range occurred during the few weeks after the earthquake, further weakening already damaged structures.

2.2 Total Losses

Human Losses:
57 people were killed, and 11,500 people received hospital treatment for injuries. 22,000 people were left homeless. The majority of deaths and injuries from earthquakes are caused by the damage or collapse of buildings and other structures. (USGS)

There were countless fires following the earthquake, of which a large proportion were structural fires. This led to the loss of many mobile homes at several locations, loss of several commercial structures in Northridge, Tarzana and Sherman Oaks, and a major hazardous materials fire in the science complex of the California State University, Northridge.

Economic Losses:
There appears to be much more consolidated information on **insured losses** than on total economic losses. Figures for insured losses were continuously being updated from an initial amount of US$ 2.5 billion in February 1994 to an amount of US$ 12.5 billion in July 1995. This appears to be the final figure.

Estimates for total **economic losses** stand at between US$ 26 billion, the initial estimated figure and US$ 44 billion, the final figure quoted by the California Governor's Office of Emergency Services.(Eguchi et al, 1998)

This large differential has encouraged both Government and the insurance industry why the losses have been so difficult to estimate. Eguchi states that the discrepancies are between projected losses based on building inspector information and data received from insurance companies, the continuous upward adjustment of insured losses with time, and the lengthy period during which losses accumulate.

2.3 Detailed Description of Earthquake

Northridge occurred on an undetected 'blind thrust', meaning that the rupture never spread to the earth's surface, but stopped some way below it. The location of the focus was a complete surprise to seismologists, and several hidden fault zones have now been identified which have changed the perception of earthquake risk in the greater Los Angeles area. (Smolka, 1995)

The earthquake occurred in the densely populated San Fernando Valley, in northern Los Angeles, which has been repeatedly struck by moderate to large earthquakes throughout recorded history. This is a predominantly residential area in one of the most well-prepared regions of the United States. Most of the structures in the affected area were built within the last three decades and the relevant building standards were considered to be reasonably earthquake resistant. The percentage of buildings destroyed by the ground motions was small, and the greatest damage occurred within about 16 km of the epicentre. The area reporting damage area covered 2,192 square miles in Los Angeles, Ventura and Orange counties. Approximately 114,000 residential and commercial structures were damaged.

The timing meant that losses were substantially lower than they could have been on a normal weekday at a different time of day. Even so, everyone was shocked by the extent and severity of the damage. It had not been understood that there are no legal requirements to ensure that privately owned buildings are retrofitted to current standards, or that the current building standards ensured that loss of life was minimised, but did not protect the structure or its contents.

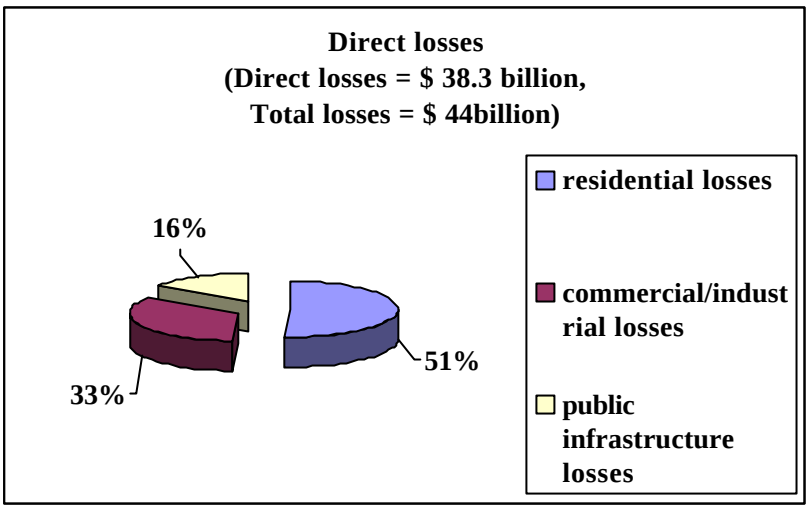
3. SUMMARY TABLES

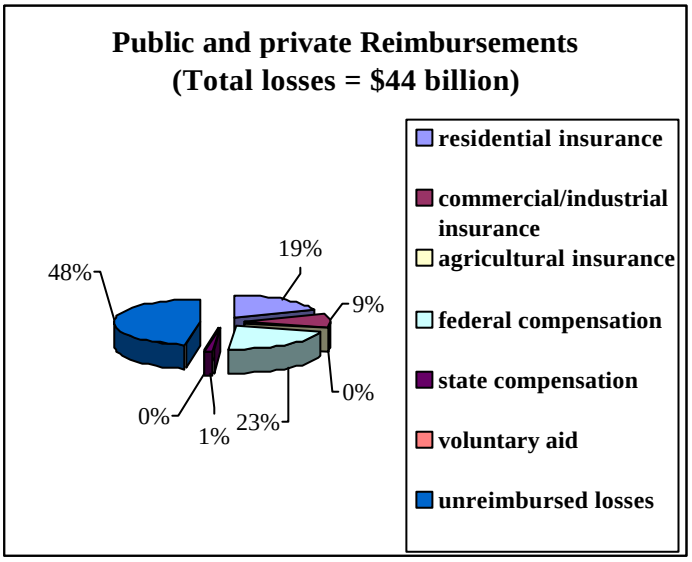
DAMAGE BY SECTOR, TOTAL LOSSES AND PORTION INSURED

Sector	Share of total losses as a percentage	Total direct losses, in billion dollars	Amount insured, in billion dollars
Residential losses	**51.0**	**19.5**	**8.4**
Commercial/ Industrial losses	**33.4**	**12.8**	**4.1**
Public infrastructure losses	**15.6**	**6.00**	**No mention**
Agricultural losses		**No mention**	**0.004**
TOTAL	**100**	**38.3**	**12.5**

PUBLIC AND PRIVATE REIMBURSEMENTS

Sector	Share of total losses as a percentage	Costs in billion dollars
Residential insurance	**36.14**	**8.4**
Commercial/Industrial insurance	**17.64**	**4.1**
Agricultural insurance	**0.02**	**0.004**
Federal compensation	**43.46**	**10.1**
State compensation	**2.58**	**0.6**
Voluntary aid	**0.16**	**0.037**
TOTAL	**100**	**23.24**





4. GENERAL ECONOMIC INDICATORS

4.1 Economic and demographic characteristics of the US

ECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF UNITED STATES 1998

Population (millions)	270.0
GNP (US$ billions)	7,922.7
GNP per capita (US$)	29,340
% inflation 1998	1.6
% annual growth in GDP, 1998	3.9
Current account balance /GDP	-2.8

% population below poverty line	---
% urban population	77
Life expectancy	76
% GDP agriculture	2.0
% GDP services	68.3
% GDP manufacturing	19.8
% GDP industry	29.7

Source: http://www.worldbank.org/data/countrydata 1999

DEMOGRAPHIC INDICATORS

	Population/km^2 (1998)	**Per capita income at current prices (1998)**	**Total population (millions, 1998)**
United States	29.5	USD 26,482	270.3
California	80.0	USD 27,579	32.7

Source: www.bea.gov in various pages

4.2 Level of insurance by coverage

According to Swiss Re, the US property and casualty market appears to be characterised by overcapacity, intense rate competition and correspondingly low premium growth for years. (Sigma 1/97)

Premiums per capita (US$)	(Source: Sigma 03/99)
Total business	2570.6
Non-Life	1403.7
Life	1167.0
Non proportional catastrophe covers:	34.5% of total market US$52.9bn

5. INSTITUTIONAL ASPECTS

5.1 Regulatory/legal framework

FEMA (Federal Emergency Management Agency) was given responsibility for leadership and co-ordination of the National Earthquake loss reduction Program, (NEP) a new interagency effort directed at earthquake mitigation. It is intended to strengthen and expand the National Earthquake Hazards Reduction Program (NEHRP), established by Congress in 1977, in order to involve the following agencies: FEMA, U.S. Geological Survey, the National Science Foundation, and the National Institute of Standards and Technology. (http://www.fema.gov/NWZ96/nateqp.htm)

FEMA has adopted a National Mitigation Strategy, aimed at reducing loss of life and property damage caused by natural hazards. There are five main elements:

- Public Awareness and Training: this includes architects, engineers, building and local officials.
- Leadership and Co-ordination: all twenty nine affected federal agencies have issued regulations to implement Executive Order 12699, Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction. Executive Order 12941, of 1.12.1994, was

established to protect lives and lessen damage to existing federally owned or leased buildings in the case of earthquakes.

- Hazard Identification and Risk Assessment: FEMA has commissioned the National Institute of Building Sciences to develop a nationally applicable standardised method for estimating potential earthquake losses.
- Applied Research and Technology Transfer: 'Yellow-Covered' reports, which recommend NEHRP provisions for new buildings, have been distributed, and a comprehensive set of nationally applicable consensus-backed guidelines are being produced.
- Incentives and Resources: The 1993 Volkmer Amendment to the Stafford Act following the Midwest floods incorporated a new formula for post-disaster mitigation funding. This increased the Northridge mitigation funds to nearly $1billion instead of the $200 million under the old formula. (Moore, 1997)

Building Codes:

These codes are the primary form of protection against losses from earthquakes. The first local building code to incorporate earthquake design requirements was established in 1933. Besides some municipal requirements to improve the earthquake resistance of older reinforced masonry buildings, there are no requirements for privately owned buildings to be retrofitted to current standards. A very important lesson from Northridge was the value of the seismic strengthening and risk reduction programmes. In some cases substantial losses of hundreds of millions of dollars were avoided. (EQE)

The Uniform Building Code, a set of design standards used in many states, which control the design of new structures in California required revisions to incorporate greater levels of resistance. The issue of levels of resistance was discussed as an issue that should be codified. The Code was revised in 1991 after the Morgan Hill earthquake. This required a 50% increase in the strength of the wall-to-roof connection design forces of buildings.

After Northridge it became apparent that some of the ground motions were twice those designed for in the building codes, and the code was revised again in 1994. The Structural Engineers' Association of California have quoted in their codes that "these recommendations primarily are intended to safeguard against major failures and loss of life, not to limit damage, maintain functions or provide for easy repair." (DIS)

Retrofitting ordinances:

Local government can sometimes undertake risk reduction programmes, as a function of local political demands and community resources. The California Senate Bill 547 of 1987 targeted unreinforced masonry (URM) buildings requiring that they be strengthened. The City of Los Angeles has been actively enforcing the upgrade of these structures, and their 10-year programme was almost complete by the time of the Northridge Earthquake. Some retrofitted URMs experienced significant damage. There is concern that in order to keep the cost of retrofitting to an acceptable level the criteria for these programmes are risk reduction rather than complete protection. Overall though, there was more failure among the unstrengthened buildings than the retrofitted ones. In many communities, the codes are not well enforced due to inadequate staffing levels and lack of trained building inspectors.

Land-Use Planning:

The Alquist-Priolo Act of 1972 is the principal form of land use planning for earthquakes, passed by the California State Legislature. It was designed to prevent location of developments along active fault lines, but the legislation permits evaluation of the site by an engineering geologist who can make recommendations for 'safe' construction. The act requires real estate agents or

sellers to inform prospective home buyers if the property lies within 1/8 mile of a trace of an active earthquake fault. Studies indicate that the legislation has not been implemented.

5.2 Emergency measures

California was well prepared for an earthquake, and there are no mentions of lack of coordination, etc.

5.3 Earthquake insurance in the US

Earthquake insurance can be purchased as a supplement to standard coverage, but the take-up is low except in high-risk areas such as California, where market penetration is still only 25-30%. High losses over recent years have made it more difficult and expensive to find insurance for natural disasters. This is in part due to the enormous potential loss exposure and the high percentage of Americans living in areas which can be classified as high risk.

Insurance rates are regulated differently in each of the 50 states, ensuring that state insurance departments can find insurance on the political agenda. This has led to a situation where premiums are considered inadequate at present and the potential losses far exceed the private sector's capacity.

This has led to problems of insurance availability, and several federal approaches have been considered. These range from a national pool to a new layer of catastrophe reinsurance to the industry. Various financial products have been launched to make up for these inadequacies in the private sector market, ranging from PCS Cat. at the Chicago Board of Trade, the Contract Auction System (CAS) and the Catastrophe Risk Exchange (CATEX) in New York.

The California Earthquake Authority

In 1992, the California legislature introduced the California Residential Earthquake Recovery Fund (CRERF). 90 % of homeowners bought the product offered which covered up to USD 15,000 in damage to homes. This was meant to cover the 10% deductible which homeowners were obliged to pay in the case of damage as stipulated by the private insurance contracts. The program only lasted for the year of 1992, since it became administratively too costly and was seen to be unsustainable.

At the end of 1996 the California Earthquake Authority was set up to deal with the problem of insurance availability. It was initiated in order to 'relieve insurers of the risk of providing protection against earthquakes in compliance with the mandatory earthquake insurance law.'(Roth,1998) This law introduced in 1985 stipulates that insurers offering 'homeowners policies' are required to provide earthquake coverage too. The effect of the law was that 90% of insurers stopped selling new homeowners policies or placed restrictions on selling them, as they found they were too exposed in this sector. The CEA initiative included securing reinsurance and tapping the capital markets.

Many policyholders did not renew coverages under the CEA scheme because premiums were too high and because the deductible was increased to 15%. On the insurers' side, those who participate are subject to a post-earthquake assessment in the layer USD 3 billion in excess of USD 1 billion, based on the individual insurer's market share of earthquake policies. To reduce the potential assessment exposure, the insurer must thus sell less CEA policies, which means selling less homeowner policies (as discussed above).

Expanded protection to insurers against catastrophic losses have been explored in California. The California State legislature passed a bill that would exempt private insurance industry funding for an initial tax-exempt one-shot payment of $1billion relieving them of future earthquake losses. There would be a $3 billion assessment on insurance companies after an earthquake, $2 billion to be raised from insurers as normal premiums and another $4.5 billion on line from credit from banks, Act of God bonds assessment of policy holders and the insurance industry. Earthquake losses are capped at $10.5 billion, after which claims are prorated. (Kunreuther, 1997, p11)

Earthquake insurance outside California

There appears to be agreement that California faces the likelihood of more powerful earthquakes in the future, but less well recognised is the seismic prediction that other parts of the United States do as well. Seismologists believe that major earthquakes could occur at several locations east of the Rocky Mountains within the next several decades.

Unlike California, these states are not well prepared for these events, and as a consequence are potentially likely to face higher human and physical losses than a comparable earthquake in California. This has led to the current federal policy of mitigation, and several insurance proposals have been introduced into the House of Representatives. (Litan et al, 1992)

Risk modelling:

There are sophisticated models to estimate the risks from earthquakes which enable insurers to vary earthquake rates by zip codes to reflect the varying geological conditions. The US insurance industry appears to be more concerned about coverage than they ever have been. There are two reasons for this - the insured losses of Northridge cost more than three times the total earthquake premiums California insurers collected in the 25 year period prior to the disaster (Insurance Information Institute, in Kunreuther, 1997) and the fear of a future catastrophic earthquake where insured damage is in excess of $100 billion.

6. TOTAL LOSSES

6.1 Direct losses

Estimates of total losses and rebuilding costs ran at about $26billion (with approx $6bn in FEMA assistance) and are still climbing (James Witt, director of FEMA, January 17, 1997 http://www.fema.gov/library/wittspch5.htm). Initial reported damage totalled $25 billion, but this has proved to be too low. Later estimates for total damage are $39.6 billion (Scawthorn, 1997) and $44 billion (DIS). Eguchi et al confirms this final figure of $44 billion, and their breakdown has been used as the basis of the summary tables.

Total damage from non-residential exposure was estimated as $20.1 billion, 51% of the total $39.6 billion estimated damage. (Scawthorn, 1997)

Collins (1998) mentions that had the incident occurred at noon, just 5 miles away in a more commercial centre, the insurance and economic loss would have been $100billion.

Corporate/Business Losses

57% of Los Angeles businesses reported experiencing some type of direct physical damage due to the earthquake, of which the most common type was non-structural (68% of those with reported damage) damage to furnishings (56%) damage to equipment (52%) damage to inventory or stock (50%) structural damage to building (39%) and buildings declared unsafe (15%)(Tierney, 1997).

Damage to buildings

25,000 buildings were left uninhabitable. EQE made the point that widespread cracking, even when it does not pose an immediate safety concern, causes enough concern among the occupants to make repair necessary to instill confidence in the occupants. In many cases, hidden structural damage in modern steel structures was found, hidden by finishes and fireproofing. Structural damage to steel buildings was found as far as 25 km from the epicentre. Poor building construction was believed to be partly responsible for the damage. One of the most striking indications of earthquakes on high-rise glass systems is the failure of the rubber gaskets around the windows, causing substantial cumulative costs in terms of repair.

BUSINESSES REPORTING EARTHQUAKE DAMAGE BY SECTOR AND SIZE

Sector and Size of business	% reporting damage	Median USD losses for businesses reporting damage
Small Wholesale and retail trade	64.4	5,750
Large Wholesale and retail trade	48.1	27,500
Small Manufacturing and Construction	54.3	4,000
Large Manufacturing and Construction	43.1	30,000
Small Business and Professional Services	62.0	3,500
Large Business and Professional Services	63.9	10,000
Small Finance, Insurance and Real Estate	57.5	10,000
Large Finance, Insurance and Real Estate	63.3	50,000
Small Other businesses	43.5	2,000
Large Other businesses	50.7	5,000
ALL BUSINESSES	**57.2 %**	**$5,000**

Source: Tierney, 1997

Industry:

FEMA provides additional federal assistance by the U.S. Small Business Administration, (SBA)

Public Sector Losses

Total damage to infrastructure and production centres **$6bn**
Damage to lifelines **$2bn**

Losses resulting from damage to infrastructure (power, gas, water) and direct damage to production centres amounted to $6bn, equivalent to 15 -30% of actual property losses, of which lifeline damage is estimated at $2 billion.

Schools: almost half of Los Angeles schools were unscathed, but damage costs exceeded $100million.

California State University, Northridge (CSUN): the university was badly damaged due to its close proximity to the epicentre, and FEMA announced that the CSUN had accepted a final settlement offer of nearly $63 million in federal and state disaster aid, which was made under FEMA's new Grant Acceleration Programme (GAP) for public facilities damaged during the earthquake. The total FEMA funding represents the 90% federal share for eligible public assistance projects as authorised under President Clinton's major disaster declaration of January 17, 1994. The university anticipates earthquake repair, restoration and preparation costs of $320million. (http://www.fema.gov/nwz97/97291.htm)

Hospitals: FEMA created the Seismic Hazard Mitigation Program for Hospitals (SHMPH) which will make $1.7 billion in Federal Grants available to participating hospitals. These grants account for almost 25% of the total estimated cost of the earthquake. (http://www.fema.gov/IG/shmp_bk.htm

Residential Losses

Residential losses were estimated as $19.5billion (Scawthorn et al, 1997). Building inspectors estimated that 82% of all structures declared uninhabitable by the earthquake were residential, 77% being apartments and 23% single family dwellings. Approximately 14,600 dwelling units were deemed uninhabitable. The most widespread damage to mobile homes was caused by the building being shaken off its foundations, increasing the risk of conflagrations from gas and propane lines.

Agriculture

For this sector there is no data readily available, although insured losses can be perceived in the table below.

6.2 Indirect Losses

Corporate/Business Losses

More than 50,000 businesses have applied to the Small Business Administration for loans to cover earthquake-related losses. 57% of Los Angeles businesses reported experiencing some type of direct physical damage(Tierney, 1997)

PERCENTAGE OF BUSINESSES CLOSED OR MADE INACTIVE DUE TO THE EARTHQUAKE BY SECTOR AND SIZE

Sector and size of business	% reporting closure	Median USD losses due to business closure
Small Wholesale and retail trade	63.7	7,500
Large Wholesale and retail trade	40.7	16,000
Small Manufacturing and Construction	69.4	3,800
Large Manufacturing and Construction	46.6	40,000
Small Business and Professional Services	60.7	4,000
Large Business and Professional Services	47.5	10,000
Small Finance, Insurance and Real Estate	56.8	8,000
Large Finance, Insurance and Real Estate	63.3	20,000
Small Other businesses	47.7	2,550
Large Other businesses	39.2	17,500
ALL BUSINESSES	**56.1 %**	**$5,000***

*The range to this question was quite broad. Many businesses lost only a few thousand dollars, but there were businesses that reported business interruption losses in excess of $1million.

REASONS FOR BUSINESS CLOSURE

Reason	percent
Need to clean up damage	65.2
Loss of electricity	58.7
Employees unable to get to work	56.4
Loss of telephone	49.8
Damage to Owner or Manager's home	44.4
Few or no customers	39.9
Building needed structural assessment	31.5
Could not deliver products or services	24.0
Loss of machinery or office equipment	23.7
Building needed repair	23.4
Loss of inventory or stock	21.9
Loss of water	18.2
Could not get supplies or materials	14.9
Building declared unsafe	10.1
Could not afford to pay employees	9.5
Loss of natural gas	8.7
Loss of sewer or waste water	5.3
Other	15.8
NUMBER OF BUSINESSES THAT CLOSED	**N=617**

Source: Tierney, 1997

A sample studied after the Northridge earthquake found that 80% of the businesses sampled experienced some degree of business interruption, and the estimated aggregate business interruption losses (job losses, reductions in dollar outputs) amounted to $6.5 billion. By this estimate, approximately 23% of the total losses resulting from the earthquake were business interruption losses (Gordon et al, 1996, in NAP,1999) RMS (1995) suggests that the mean business interruption loss is anticipated to be 45% of the mean commercial building loss and nearly three times the mean lifeline damages.

The timing of the earthquake moderated business losses, as most manufacturing and service industries were closed down. The day of the earthquake was a holiday. Collins (1998) cites a study which revealed that the region had lost the equivalent of more than 460,000 working days, based on complete loss of operation and reduced levels of output and trading.

Some of the most dramatic damage was to large shopping centres in the valley. Damage ranged from near total collapse of a major Northridge department store to damage to interiors. Many sprinkler systems were inadvertently activated, soaking the interiors of some stores. Structural damage exposed asbestos (insulation and fireproofing) in some buildings, which delayed construction due to the specialist removal requirements. This in turn affected the ability of some stores to reopen, exacerbating the indirect losses.

Public Sector Losses

Transportation:
Traffic disruptions were a major problem after the earthquake, as the area is almost entirely dependent on automobiles. Portions of 11 major arteries into Los Angeles had to close and 9 bridges on major interchanges or freeways collapsed. All of these structures had already been scheduled for retrofitting after the 1989 Loma Prieta earthquake, when 860 structures were identified. (average cost per structure, excluding bridges: $0.5m) None of the 122 structures which had already been strengthened failed in the Northridge earthquake.
There was no significant damage to any of the airports in the vicinity.

Hospitals:
31 Los Angeles area hospitals were damaged, and 9 forced to evacuate. Content damage was in the billions of dollars. The first 'seismically isolated' hospital, USC University Hospital, suffered no damage, but the L.A. County USC Medical Hospital one km away suffered $389m damage. The cost of the seismic isolation at the time of construction had added approximately 2% on to the initial construction cost of the hospital (DIS), thus representing a very worthwhile investment.

Residential Losses

There is no mention of indirect losses.

7. COMPENSATION

7.1 Government

Repairs of Transportation, structures and roadways	**$ 0.327 billion**
Utilities	**$ 0.3 billion**
Public Assistance	**$ 4.05 billion**

Small Business Administration	**$ 4.03 billion**
Individual/Family Grant programmes	**$ 0.19 billion**
Disaster Housing/Mortgage Assistance	**$ 1.2 billion**
Total federal aid	**$ 10.10 billion**

FEMA administers the President's Disaster Relief Fund and coordinates federal assistance when disasters and emergencies are declared. The aid supplements existing state and local resources and is authorized by the President only when those combined capabilities fall short of effective recovery.

"Many homeowners, renters and businesses paid thousands of dollars out of their own pockets to rebuild their own lives." James Witt, director of FEMA 17.1.97

***FEMA Disaster relief funds** **$2.7billion**

By the close of the year, the agency reported that some 667,801 Southern Californians had applied for federal aid, more than three times as many as following Hurricane Andrew in 1992. (Fema.gov/NW294/94_015.htm)

***Total FEMA assistance** **$ 5.6 million**

FEMA assistance provided direct assistance to more than half a million individuals and families and almost 12,000 public facilities, including schools, colleges and private non-profit hospitals. FEMA funds have been dispersed through the Individual Assistance programmes (IA), which provides residents affected by disasters with temporary housing, crisis counselling, unemployment assistance and may provide grants for unmet needs through the Individual and Family Grant (IFG) programme. FEMA provides additional federal assistance through the Housing and Urban Development Department (HUD), the Infrastructure (Public Assistance) programme, and Hazard Mitigation Grant Programme. (HMGP) (http://www.fema.gov/reg-iv/998/r4top10.htm).

* It has been assumed that the latest figures by Eguchi et al (1998) include these total figures from FEMA.

7.2 State Sector

State Board of control	**$ 0.55 billion**
California Employment Development Department	**$ 0.041 billion**
Individual/Family Grant programmes	**$ 0.06 billion**
Public Assistance	**$ 0.45 billion**
Total CA share	**$ 0.6 billion**

(Eguchi et al, 1998)

7.3 Private Insurance Sector

Insured losses rose to $12.5 billion in July 1995, the eighth time the Property Claim Services (PCS) updated its estimate. The first estimate dated February 1994 was for $2.5bn, but increased claims have come in for hidden damage and higher repair costs. PCS said that the following factors were contributing to higher estimates: previously closed claims with more discovered damage and higher living expenses resulting from longer repair periods.

The 1971 San Fernando earthquake caused substantial damage to homes, businesses and public buildings which were widely uninsured. Since then insurance coverage against earthquakes has increased considerably. 20 years ago, approximately 5% of the homeowners purchased earthquake insurance in California, by the end of 1994 approximately 25-30% of the residences in the state were covered. There is considerable variation, from 35-40% in cities around San Francisco and Los Angeles, to approximately 5% in cities north of San Francisco and the central

parts of California (Kunreuther, 1997). 'A typical earthquake policy insures for loss against structural damage, damage to contents, and loss of use (residential) or business income (commercial)…In the Northridge earthquake, for every USD 100 of insured residential damage, there was an average of USD 20 of content damage and USD 10 of loss of use.' (Roth, 1998)

In 1996, the property-casualty insurers in California possessed earthquake premiums totalling USD 1.5 billion. In total, for all types of insurance, USD 32.6 billion were available in 1996. It can thus be concluded that there was cross-subsidisation from other forms of business in the Northridge 1994 earthquake, and indeed also from other states. A problem mentioned is that since many insurers are mutual insurers they can only raise capital after a disaster by raising premia charged to policyholders. Stock insurers, on the other hand can raise capital by selling more stock which is in higher demand after an earthquake since stock market participants anticipate higher earnings due to the higher insurance premia to be charged (Roth, 1998).

The table on the following page shows data of insured losses broken down according to type of insurance as available in February-March 1995. Although final losses were expected to be around $12.5 billion, the distribution of the losses should not change.

Liability limits: the US makes widespread use of liability limits on individual risks, but contrary to theoretical expectations, the majority of individual losses were partial losses and generally below these limits.

Points to note

- Close attention should be paid to damage to non-structural elements and contents - these were underrated at the time of Northridge. Rough estimates indicate that in the worst affected area for every building with structural damage, there were at least 12, and up to 40 examples of non-structural damage. Structural losses, which building codes are designed to minimise, contributed to no more than 10-15% of the total building losses. Between 20-25% of residential building claims were for external structures such as garages, swimming pools, gates, walls etc. (Smolka, 1995)
- Damage caused by sprinkler systems was very large. Approximately 20-25% of insured losses fell into this category. (Smolka, 1995)
- Long-tail losses: months after the earthquake, the widespread problem of structural damage to moment-resisting steel frames without diagonal bracing emerged. This occurs close to weld joints and can lead to shearing of columns. Regional differences in welding technology may have lead to greater losses in Northridge than in Kobe.

NORTHRIDGE INSURED LOSSES,
AS ESTIMATED BY INSURANCE COMPANIES
February-March 1995. Thousands of USD.

Line of insurance	No.of claims	Earthquake losses Paid and Estimated	Loss adjustment expenses
Life	81	1,986	0
Accident and health	10,017	14,063	15
Fire, residential	424	12,238	570
Fire, commercial	211	141,602	2,216
Fire, undetermined	106	1,620	167
Allied lines (special)	3,278	118,654	5,750
Farm owners' multiple peril	537	3,040	208
Homeowners' multiple peril	74,471	929,312	40,512
Commercial multiple peril	9,374	1,096,237	26,797
Other liability	83	1,053	307
Misc. property, residential	3,570	40,292	466
Misc. property, commercial	1,321	528,630	11,273
Misc. property, undetermined	652	164,445	9,896
Earthquake, residential	185,180	5,521,489	186,478
Earthquake, commercial	3,939	1,059,014	33,355
Earthquake, undetermined	658	52,574	3,598
Workers' compensation	138	2,878	29
Automobile, personal	32,249	55,554	567
Automobile, commercial	846	1,717	40
Glass	295	524	5
Burglary and theft	3	5	0
Boiler machinery	17	5,135	19
Other, residential	5,041	43,743	2,118
Other, commercial	19	10,674	44
Other, undetermined	706	1,727	70
Late reported claims		405,254	57,897
Totals	333,216	10,213,459	382,397

Source: Roth (1998) p. 72 and California Insurance Department The final losses were estimated at $12.5 billion, but the distribution of losses in this table should be the same.

Insurance payments to:
Businesses
Commercial insured losses **$4.1 billion**
Commercial losses represent 16% of all claims (dyp, 1995). RMS estimated that of the commercial losses 71% were attributable to building damage, 10% to contents, and 19% to business interruption (Collins, 1998)

PERCENTAGE OF BUSINESSES WITH EARTHQUAKE INSURANCE BY SECTOR AND SIZE

Sector and size of business	% with earthquake insurance	% with business interruption insurance
Small Wholesale and retail trade	15.5	18.3
Large Wholesale and retail trade	26.4	56.3
Small Manufacturing and Construction	8.8	18.8
Large Manufacturing and Construction	30.1	50.7
Small Business and Professional Services	19.7	17.7
Large Business and Professional Services	27.6	29.7
Small Finance, Insurance and Real Estate	24.4	25.4
Large Finance, Insurance and Real Estate	35.4	32.5
Small Other businesses	13.3	10.5
Large Other businesses	24.7	28.6
ALL BUSINESSES	**20.5%**	**24.3%**

Source: Tierney, 1997

As noted in the table above, 20% of the businesses in the Tierney sample were insured for earthquake damage at the time of Northridge, and of those, 27% filed a claim. Of these, half had received full payment by the time of the survey. However, the median estimate on the proportion of the total earthquake-related losses covered by insurance was about 50%. 11% of the sample applied for SBA loan assistance for their business losses. Of this number, half had received loan amounts requested, 30% had their applications turned down and 10% of the loans were still pending. For the businesses that had received SBA loan assistance, the median percentage of business losses covered was about 50%.

Small businesses appear to be more vulnerable to disasters than large businesses. Large businesses are more likely to carry insurance than smaller ones. Following the earthquake, business owners generally used their personal savings to offset their losses. It appears that one of the short-term effects of disasters is to drain profits and divert resources which would otherwise fund business expansion.

Residential
Insured Residential losses **$ 8.4 billion**
(Scawthorne, 97, Eguchi et al,1998)

This amount is broken down as follows:
Coverage A (structures) $ 5.6 billion
Coverage B (appurtenant structures) $ 0.6 billion
Coverage C (contents) $ 2.0 billion
Coverage D (loss of use) $ 0.2 billion

The high peak-ground acceleration of the earthquake was the primary cause of damage to building contents, chimneys and garden walls.

Insurance coverage according to residential sector, in numbers (millions) and % at the end of 1994

	Dwellings		Condos		Renters	
Policy ®	**HO**	**Earthquake**	**HO**	**Earthquake**	**HO**	**Earthquake**
nos.	6.30	1.93	0.43	0.21	0.55	0.25
% insured	97.2	29.8	52.1	25.6	14.2	6.6

Source: Roth (1998) HO = Homeowner policy

Farms
Agricultural insured losses appear to be very small, in the order of $ 3,720.

Automobiles
From the table of insured losses, page 16, revised to current figures, losses appear to be in the order of $ 70,835, 0.007% of the total losses.

7.4 Aid from other sources

American Red Cross **$ 36 million**
Salvation Army **$ 1 million**
Volunteer assistance was received from volunteer organisations including the American Red Cross (ARC) and Salvation Army. The ARC sheltered 22,000 people, served 1.7million meals and operated various other programmes. The Salvation Army spent more than $1 million for displaced persons' housing and mass feeding.

8. EX POST MEASURES

8.1 Public policy

Hazard Mitigation **$ 0.92 billion** (Eguchi et al, 1998)
The California Office of Emergency Services retained EQE to help the state with its application and administration of disaster aid by producing an immediate estimate of the total damage. The day of the earthquake, EQE produced a projected map of the affected zip codes, as well as initial damage estimates for residential, commercial, industrial and public property. The $15bn total damage estimate was used as the basis for the Governor's appeal to the President and Congress for aid to California. The resulting map was used to allocate resources in the affected area. This was the first time that modelling had been used to assist disaster response. (EQE, 1994, personal discussions with Scawthorn, 1999)

FEMA loans **$ 4.1 bn** (124,245 loans)
(fema.gov/library/df_4.htm).
FEMA federal assistance provided 64% of loans, others provided 36% (http://www.fema.gov/NR/nr_0106.htm)

Cleanup operations

The Debris Collection Programme was a partnership initiative between local government, California Office of Emergency Services, and the private sector, using a secured site to prevent illegal dumping of hazardous materials.

Total cost of cleanup programme **$ 2.5 billion**

(http://www.fema.gov/pte/exp_20.htm)

8.2 Private insurance sector

No mention of subsequent changes.

8.3 Hazard Mitigation

FEMA was given $2 million and a further $6.7 million from the President's Northridge Earthquake Emergency Supplemental Fund to manage phases 1 and 2 of a project to develop better design criteria for steel moment resisting frame construction, a common building technique in the US, often thought to be seismically safe. (http://www.fema.gov/NWZ95/95_129.txt)

FEMA asked Congress for Fiscal Year 1999 budget authority of $3.1billion, including $2.3billion in emergency contingency funds for disasters. The request is made to reduce disaster costs. FEMA director James Witt said: "Dollars invested in community-based pre-disaster mitigation programs ultimately will help our citizens from becoming disaster victims and will help reduce the escalating costs of disaster assistance. That is why we are focussing on creating disaster-resistant communities through an initiative known as Project Impact." (http://www.fema.gov/nwz98/98017.htm)

FEMA funding of $ 6.312bn from the Presidents' Disaster Relief Fund has been earmarked for FEMA's assistance programmes, hazard mitigation grants, federal mission assignments, contractual services and administrative costs as of July 31,1998. The figure does not include funding provided by other participating federal agencies, such as the disaster loan programs of the Small Business administration and the Agriculture Departments Farm Service Agency. (http://www.fema.gov/library/df_2.htm) Since Northridge, Congress has required all disaster supplementals (for FEMA and other federal agencies) to be offset with cuts in expenditures elsewhere (NAP,1999)

Plans have been made to change building codes to introduce a 'near field factor' to make allowance for stronger ground motion. Subsoil plays an essential role contributing to losses, when liquefaction occurs. Los Angeles has also initiated a project to identify URM (unreinforced masonry) structures, in order to upgrade them. (Smolka, 1995) Many buildings had already been strengthened, reducing the potential losses.

9. CONCLUSIONS

Northridge earthquake marked a new era in catastrophic risk assessment. The scale of losses, both human and economic in an area that was relatively well prepared stunned many observers. The legislative changes that had been effected in the wake of the 1993 floods ensured that the federal government carried a large proportion of the losses.

The US has been heading the list of insurance loss tables. The numbers of catastrophic hazards have been rising, both in terms of hurricanes and the potential of further earthquakes is accepted to be a likely one. There have been subsequent discussions at federal levels about the lack of insurance availability, and there are potential openings for the intrepid insurer.

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APPENDIX A

COMPARISONS BETWEEN NORTHRIDGE AND KOBE EARTHQUAKES

Annex 1
COMPARISONS BETWEEN NORTHRIDGE AND KOBE

	Northridge	Kobe
Magnitude	6.7	6.9
Duration of main shock	Approx. 15 sec	Approx. 15 sec.
Max. intensity	IX	X
Max. acceleration	0.93g[2]	0.83g[3]
Deaths	61	6 055
Injured	10 500	27 000
Homeless	25 000	310 000
Damaged houses	15 000	159 000
Total loss ($billion)	40	>100
Insured loss ($billion)	12.5	Ca.3
Damage Index	7	9
Repair cost per customer	$100	$1500*
Affected area	Suburb	City centre, with industry and port
Business interruption	Little	Yes
Construction density	Low	High
Construction cost	Lower	High (2x California)
Ground motion	High	Normal
Directivity	Yes	Probable
Stress drop	High	High
Subsoil	Average	Bad, and very bad
Liquefaction	Little	Widespread
Fire	Little	Conflagrations
Management	FEMA is invested with powers and authority to respond quickly, helped by the prompt payment of substantial insurance benefits of $12.5bn, covering 30-40% of total losses.	Poor co-ordination of catastrophe aid measures in early stages due to responsibility being spread among range of authorities and organisations. Percentage of insured property losses was 3-5%.

Source: Smolka, 1995, Eguchi, 1997,

Annex 2

COMPARISON OF TOKYO AND LOS ANGELES
RESIDENTIAL INSURANCE COSTS (in USD)

	Tokyo	**Los Angeles**
Suburban neighborhood	Tachikawa	Northridge
Per capita income	$20,000	$22,000
Commute minutes to central business district	90	60
Typical house lot, square metres	80	500
Typical floor area, square metres	140	180
Typical sales price, (1995, estimate)	$750,000	$250,000
Typical replacement value	$250,000	$180,000
Ratio, structure replacement to total price	0.33	0.72
Total sum insured	$100,000	$180,000
Earthquake premium	$500	$360*

Source: EQE, 1995 All sums in 1995 US$
*premium prior to Northridge Earthquake