Turkish Catastrophe Insurance Pool and Building Loss Estimation for Istanbul

E. Durukal, M. Erdik, K. Sesetyan

Bogazici University
Kandilli Observatory and Earthquake Research Institute
Department of Earthquake Engineering, Istanbul

June 2006, Lillehammer
Independence and diversifiability of risk are the basic tenets of any insurance program. Catastrophic natural events, such as earthquakes, severe storms, bushfires and floods cause huge, localized losses, breaking these two rules. As such, for an insurance company a catastrophic event may present a huge risk. However, from the reinsurance point of view it represents a random, independent, diversifiable event.

In terms of national economy, the insurance system is an essential element for the economic recovery of businesses and of families.
The insurance sector in Turkey felt the need to change their paradigm. In this context:

- **Turkish government** established the National Earthquake Insurance program (TCIP- became effective as of 2001)

- **Reinsurance companies** reduced their risks by increasing their premiums or even leaving the market

- **Private sector companies** decided to re-assess the risks associated with their portfolio in order to shape their future market strategies.
National Programs for Catastrophe Insurance

Pools with earthquake coverage

- California, USA (California Earthquake Authority, CEA, 1996),
- France (Catastrophes Naturelles, against natural disasters, includes earthquakes, 1982),
- Iceland (Icelandic Catastrophe Fund, for catastrophes, includes earthquakes, 1975),
- Japan (Japanese Earthquake Reinsurance Company, JER, 1966),
- New Zealand (Earthquake Commission, EQC, 1994),
- Norway (Norsk Naturskadepool, against natural disasters, includes earthquakes, 1980),
- Spain (Consortium of Compensation de Seguros, against abnormal occurrences, includes earthquakes, 1954),
- Taiwan (Taiwan Residential Earthquake Insurance Pool, TREIP, 2002)
- Turkey (Turkey Catastrophe Insurance Pool, TCIP, 2000)

(from Guy Carpenter, 2004)
Catastrophe Insurance Penetration in Developing Countries

- India – under 0.5%
- the Philippines – under 0.3%
- Iran – under 0.05%
- Romania – under 5%
- Bulgaria – under 3%
- China – under 0.5%
- Turkey – 19%
There is a two-level earthquake insurance system in Turkey:

**Level 1:** National compulsory earthquake insurance (TCIP), structural losses

**Level 2:** Private earthquake insurance, structural, non-structural and business interruption losses

To buy private earthquake insurance one has to be covered by the national earthquake insurance system, which has limited coverage (about 60,000 USD max).

The private insurance covers risks in excess of the TCIP limit. The premiums of both systems are fixed by the government.

All companies in the market regardless of their size can sell catastrophe insurance.
PARTICULARS OF THE TCIP SCHEME

COVERAGE

• Coverage for residential buildings and the commercial units located in residential buildings.

• Only losses due to earthquake and fire, explosion and landslide following earthquake are covered.

• Excludes business interruption losses, loss of market, loss of use and all similar indirect losses, damages to the contents, human losses and injuries; and liabilities.

• Does not cover governmental buildings, buildings in rural areas, buildings for only commercial and industrial use, and post-1999 buildings without a legal construction permit.

*General Regulations for the Compulsory Earthquake Insurance Scheme, 2000*
PREMIUMS

- The insured value of a property is calculated by multiplying the net area of a home by pre-determined monetary square-meter values.

- The deductible is 2%. If the claims exceed the funds in the pool after a large earthquake, TCIP pays the damage by prorating the claims and the sum of existing funds plus reinsurance coverage.
### Rates of Compulsory Earthquake Insurance Scheme

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Zone I %</th>
<th>Zone II %</th>
<th>Zone III %</th>
<th>Zone IV %</th>
<th>Zone V %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - steel and reinforced concrete frames</td>
<td>2.20</td>
<td>1.55</td>
<td>0.83</td>
<td>0.55</td>
<td>0.44</td>
</tr>
<tr>
<td>B - masonry</td>
<td>3.85</td>
<td>2.75</td>
<td>1.43</td>
<td>0.60</td>
<td>0.50</td>
</tr>
<tr>
<td>C - other</td>
<td>5.50</td>
<td>3.53</td>
<td>1.76</td>
<td>0.78</td>
<td>0.58</td>
</tr>
</tbody>
</table>

For a 120 m² home:

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Value Insured (USD)</th>
<th>Risk Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Steel / RC</td>
<td>43,000</td>
<td>95</td>
</tr>
<tr>
<td>Masonry</td>
<td>30,000</td>
<td>116</td>
</tr>
<tr>
<td>Other</td>
<td>15,000</td>
<td>83</td>
</tr>
</tbody>
</table>
In Turkey:

- 4 million buildings in metropolitan municipal areas; about 800,000 buildings in Istanbul

- As of May 2006 about 2.5 million compulsory earthquake insurance policies sold Turkey-wide, whereas the total number of house-holds is about 13 million. The penetration nationwide is about 19%.

- In the Marmara region, where the total number of households is about 4 million, the penetration is about 28%.
Concerns Regarding the Performance of TCIP in the event of a large earthquake

- The government was legally obliged to provide housing after a catastrophic event. The idea with TCIP was to release the government from this. However although the TCIP is operational it is still not a law. Hence the government still has ground to interfere due to political concerns.

- Prorating will be a big problem in the event of a large earthquake for example in Istanbul. It is unlikely that there will ever be funds to cover losses in Istanbul.

- Even with the current penetration rates the number of claims to be processed will be huge

- Lack of experts and sources to handle them
  - Northridge Eq. Example, CEA

- Cases to be handled by courts will take years to complete.

- Multiple ownership housing (not all the owners are insured) will hinder the repair-reconstruction period.

- The private insurance will wait for the compulsory insurance to process their own claims.
**INGREDIENTS OF EARTHQUAKE LOSS ASSESSMENT METHODOLOGY FOR FINDING PROBABLE MAXIMUM LOSSES FOR EARTHQUAKE INSURANCE**

*Insurance point of view*

- Probabilistic (poissonnian or time-dependent) and deterministic regional site dependent earthquake hazard parameters
- Regional building inventory (and/or portfolio)
- Building vulnerabilities associated with typical construction systems in Turkey (intensity and spectral-displacement based fragility curves, i.e. estimations of damage ratios for building types under different earthquake hazard levels)
- Estimations of building replacement costs for different levels of damage.

The probable maximum losses (PML) and average annualized losses (AAL) are estimated as a result of analysis.
1. Earthquake Hazard

Both time-dependent probabilistic and deterministic methods utilized.

**Ingredients:** Compilation and interpretation of seismotectonic features, propagation path characteristics, topographical, geological and geotechnical data, and the identification of the proper attenuation and site response analysis models.

**Attenuation relationships:** MSK Intensities, peak ground acceleration (PGA), spectral acceleration (SA).

**Site-specific modification of ground motion:**
Intensity change degrees empirically correlated with the geological ground conditions. For spectral accelerations “Average Horizontal Spectral Amplification” factors as stipulated in NEHRP recommendations.

*Earthquake hazard data are aggregated in 0.005 x 0.005 degree geo-cells. The same geo-cells are also used for aggregation of the geotechnical data and the building portfolio.*
Deterministic Earthquake Hazard

Scenario Earthquake, Mw=7.5

2000 - 20?
Site dependent PGA’s

For a repeat of the 1906 eq. (Borcherdt et al., 1995)
Site dependent earthquake intensities

Boatwright et al, 2006
Probabilistic Time-dependent Earthquake Hazard

PGA contour map at NEHRP B site class for 10% probability of exceedence in 50 years
Ratio of Poissonian to time dependent model
Site dependent PGA distribution for 10% probability of exceedance in 50 years
2. Building Stock

*Cell based earthquake vulnerability assessment*

- Type of structure
- Number of stories
- Construction date
Classification of damage

D1: Negligible to slight Structural Damage (SD), Slight Non-Structural Damage (N-SD);
D2: Moderate damage (Slight SD, Moderate N-SD);
D3: Substantial to heavy damage (Moderate SD, Heavy N-SD);
D4: Very heavy damage (Heavy SD, very heavy N-SD) and
D5: Destruction.

The existing intensity-based vulnerability curves for the general building types in Turkey have been reevaluated and revised on the basis of available empirical data, compilations from post earthquake damage reports and engineering interpretations. The vulnerability curves for the mid-rise (4-8 stories) reinforced concrete frame type buildings are provided. Considering the damage level relations between low, medium and high rise R/C frame structures, the vulnerability curves for low-rise (1-4 stories) and high-rise (9 stories) R/C frame type buildings are obtained by left shifting of the intensity scale in the horizontal axis of the vulnerability curves of the medium rise R/C frame buildings by half a intensity unit.

Intensity-based vulnerability curves are based on observational data which are known to be deficient for low intensity and lighter damage cases. As such, for slight and medium damages, the damage ratios provided by the intensity-based damage assessments are underestimated compared to the spectral displacement-based damage estimates.
Revised Intensity Based Vulnerability Curves for Midrise RC Buildings

**REVISED INTENSITY VULNERABILITY CURVES FOR MIDRISE RC BUILDINGS IN TURKEY**

- 1976 Denizli eq. (ERD)
- 1971 Bingöl eq. (ERD)
- 1992 Erzincan eq. (ERD)
- 1998 Adana eq. (Wenk, 1998)
- 1999 Kocaeli eq. (AL, 2000)

% of buildings damaged vs. MSK intensity:

- D1
- D2
- D3
- D4
- D5

Intensity levels:

- VII
- VIII
- IX
- X

Intensities:

- 6
- 6.5
- 7
- 7.5
- 8
- 8.5
- 9
- 9.5
- 10
- 10.5
- 11
REVISED INTENSITY VULNERABILITY RELATIONSHIPS FOR LOWRISE RC BUILDINGS IN TURKEY

Intensity based

Vulnerability Curves for Mid-Rise Pre-1980 R/C Buildings

Spectral displacement based
Distribution of buildings with complete damage
Replacement Cost Ratio (or Repair-Cost Ratio):
The ratio of the cost of repair of the damage to the cost of reconstruction

Insurance experts were asked to give their estimations of damage levels and corresponding replacement cost ratios for 19 cases of earthquake damage.

The data were analyzed wrt
(1) known damage levels
(2) damage levels as they are assigned by the experts to the damage cases.
D1  Slight Damage, (Negligible to slight SD, Slight N-SD)

D2  Moderate damage (Slight SD, Moderate N-SD)

D3  Substantial to heavy damage ( Moderate SD, Heavy N-SD)

D4  Very heavy damage (Heavy SD, very heavy N-SD)
Statistical Evaluation of Replacement Cost for Damage Levels

Predetermined Damage Levels  Damage levels assigned by experts

The results of the two approaches compare favorably indicating that the results of portfolio analysis can be expected to yield reliable loss estimations for a post-earthquake situation where the claims will be processed.
5. Uncertainty in Loss Estimations

Uncertainty in building loss estimations associated with:

1. vulnerability relationships
2. replacement cost ratios
Probable maximum losses in Istanbul using spectral displacement based vulnerabilities
Probable maximum losses in Istanbul using intensity based vulnerabilities
Probabilistic Building Loss Curve

Using median replacement cost ratios
Using SD+1 replacement cost ratios
Using SD-1 replacement cost ratios
Deterministic loss, median
Deterministic loss, SD+1
Deterministic loss, SD-1
Log. (Using median replacement cost ratios)
Log. (Using SD+1 replacement cost ratios)
Log. (Using SD-1 replacement cost ratios)
### Intensity Approach

<table>
<thead>
<tr>
<th>Scenario</th>
<th>SD-1</th>
<th>Median Loss</th>
<th>SD+1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean vulnerability,</td>
<td>0.09</td>
<td><strong>0.14</strong></td>
<td>0.23</td>
</tr>
<tr>
<td>Mean damage ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max vulnerability,</td>
<td>0.17</td>
<td>0.26</td>
<td><strong>0.36</strong></td>
</tr>
<tr>
<td>Max damage ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min vulnerability,</td>
<td>0.04</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td>Min damage ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Spectral Displacement Approach

<table>
<thead>
<tr>
<th>Scenario</th>
<th>72 Yrs Return Prd</th>
<th>100 Yrs Return Prd</th>
<th>224 Yrs Return Prd</th>
<th>475 Yrs Return Prd</th>
<th>2475 Yrs Return Prd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean vulnerability,</td>
<td>0.16</td>
<td><strong>0.28</strong></td>
<td>0.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean damage ratio</td>
<td>0.15</td>
<td><strong>0.25</strong></td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max vulnerability,</td>
<td>0.17</td>
<td><strong>0.30</strong></td>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max damage ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min vulnerability,</td>
<td>0.23</td>
<td>0.37</td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min damage ratio</td>
<td>0.27</td>
<td><strong>0.43</strong></td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.68</strong></td>
</tr>
</tbody>
</table>
Average annualized loss associated with the Istanbul building stock is estimated as \textbf{0.47\%}. It may vary between \textbf{0.28\% and 0.61\%} representing SD-1 and SD+1 replacement cost estimations.

\textit{In California, the state average of AAL is 0.18\%, county AAL's change between 0.05\% and 0.26\%.}

For RC structures, the compulsory earthquake insurance premiums in Istanbul vary btw 0.22-0.83\%. The comparatively higher AAL of Istanbul is the result of two important agents: the very high expectations for a significant earthquake (upto 65\% in 30 years for a M7+ earthquake on Main Marmara Fault) and the existence of a building stock with poor earthquake performance.

\textbf{Rates of Compulsory Earthquake Insurance Scheme}

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Zone I</th>
<th>Zone II</th>
<th>Zone III</th>
<th>Zone IV</th>
<th>Zone V</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-steel and reinforced concrete frames</td>
<td>2.20</td>
<td>1.55</td>
<td>0.83</td>
<td>0.55</td>
<td>0.44</td>
</tr>
<tr>
<td>B- masonry</td>
<td>3.85</td>
<td>2.75</td>
<td>1.43</td>
<td>0.60</td>
<td>0.50</td>
</tr>
<tr>
<td>C-other</td>
<td>5.50</td>
<td>3.53</td>
<td>1.76</td>
<td>0.78</td>
<td>0.58</td>
</tr>
</tbody>
</table>
Thank you!