Earthquakes and Risk Management

Some Defintions

- Tectonic Plates (about 15) -Segments of the Earth Crust
- Lithosphere, Asthenosphere
- The lithosphere moves differentially on the weaker asthenosphere which starts at the Low-Velocity Layer in the Upper Mantle at a depth of about 50 km.

- Boundaries of plates are of four principal types;

(1) Divergent zones, where new plate material is added from the interior of the earth.

(2) Subduction zones, where plates converge and the under-thrusting one is consumed.

(3) Collision zones, former subduction zones where continents riding on plates are colliding.

(4) Transform faults, where two plates are simply gliding past one another, with no addition or destruction of plate material.

The Strength of Earthquakes—Magnitude and Intensity

- During earthquakes the release of crustal stresses is believed generally to involve

  -the fracturing of the rock along a plane which passes through the point of origin(the *hypocentre or focus) of the event.*

  -*Sometimes, especially in larger* shallower earthquakes, this rupture plane, called a *fault, breaks through to the ground* surface, where it is known as a *fault trace*

- The *strength of an earthquake-used in the* normal language sense of ‘How strong was that earthquake?’
- Earthquake strength is defined in two ways: *first* the strength of shaking at any given place (called the *intensity) and*

  second, the total strength (or size) of the event itself (called magnitude, seismic *moment, or moment magnitude). These entities are described below.*

- *Intensity is a qualitative or quantitative measure of the severity of seismic ground motion at a specific site.*

  Example: the Modified Mercalli scale (commonly denoted MM), which has twelve grades denoted by Roman numerals I–XII

- *Magnitude is a quantitative measure of the size of an earthquake, related indirectly* to the energy released, which is independent of the place of observation.

  -- calculated from amplitude measurements on seismograms, and is on a logarithmic scale expressed in ordinary numbers and decimals.

  -- Unfortunately several magnitude scales exist, of which the four most common ones are described here (*ML, MS, Mb and MW).*

- The most commonly used magnitude scale (after Richter)is denoted *M or ML. It is defined as:*

$$M_L = \log A - \log A_0$$

where *A is the maximum recorded trace amplitude for a given earthquake at a given* distance as written by a Wood–Anderson instrument, and A_0 *is that for a particular* earthquake selected as standard.

- more precisely called *local magnitude* (M_L)
- magnitudes are measured from surface wave impulses they are denoted by M_S.
- Gutenburg proposed what he called ‘unified magnitude’, denoted *m or* m_b *, which is dependent on body waves, and is now generally named body wave magnitude (*m_b*).* This magnitude scale is particularly appropriate for events with a focal depth greater than *45km.*
- All three scales M_L*,* m_b *and* M_S *suffer from saturation at higher values.*

Moment magnitude, M_W

- The most reliable and generally preferred magnitude scale is moment magnitude (M_w)
- This is derived from seismic moment, M_0*, which measures the size of an* earthquake directly from the energy released(Wyss and Brune,1968);

seismic moment, $M_0 = \mu AD$

Where, μ is the shear modulus of the medium (and is usually taken as 3 × 1010 Nm), A is the area of the dislocation or fault surface, and *D is the average displacement or slip* on that surface.

Moment magnitude is a relatively recent magnitude scale from Kanamori (1977) and Hanks and Kanamori (1979),

$$M_w = \frac{2}{3}\log M_0 - 6.03 \quad (M_0 \ in \ Nm)$$

Relation between M_s and M_w (after Ekstrom and Dziewonski, 1988), with depth <50km.

$$M_w = \begin{cases} 2.13 + \frac{2}{3}M_s & \ldots M_s < 5.3 \\ 9.40 - \sqrt{41.09 - 5.07M_s} & \ldots 5.3 \le M_s \le 6.8 \\ 0.03 + M_s & \ldots M_s > 6.8 \end{cases}$$

Consequences of Earthquake

Different Geo-hazards a consequences of Earthquakes:

- fault displacement;
- subsidence (flooding and/or differential settlement);
- liquefaction of cohesionless soils;
- failure of sensitive or quick clays;
- landslides;
- mudflows;
- dam failures;
- water waves (tsunamis, seiches);
- groundwater discharge changes.

Example: 2008 Sichuan Earthquake

- 8.0 magnitude
- Over 87 thousand+ deaths
- Felt in Beijing & Shanghai
- Over 26 thousand aftershocks
  - Heavy damage to infrastructure
  - Quake lakes
  - Massive economic loss

Earthquakes are Worldwide Problem

- 5 July 1201 Eastern Mediterranean
  - 1.1 million deaths
  - Syria to Upper Egypt
- 1755 Lisbon, Portugal
  - Over 60 thousand deaths
  - Triggered tsunamis
  - **Led to Voltaire's view: "A just God wouldn't let this happen"**
- May 1970 Peru
  - Over 50 thousand deaths, 7.9 magnitude
- 23 December 1972 Managua, Nicaragua
  - 5 to 20 thousand deaths
  - **Government mishandling cited as leading to Sandinista revolution**
- 2007 Kashiwazaki-Kariwa Nuclear Power Plant
  - **Radioactive water leak into ocean**

Chinese Red Cross & Red Crescent Report (RCSC)

- Sichuan provincial government – 12 Aug 2008
  - All displaced people in transitional housing
  - 4.5 million lost homes
    - 978,000 urban households in transitional housing
    - 3,400 resettlement areas built
    - 3.5 million rural families rebuilt housing themselves, with government subsidies
      - 20,000 rural permanent homes completed
      - 175,000 under construction

RCSC Food & Basic Non-food Items

- Objective 1 (0-3 months)
  - Ensure up to 100,000 families receive food, water, sanitation
- Objective 2 (1-12 months)
  - Ensure up to 100,000 families receive food enabling move to transitional shelter
- Progress

150,000 tents

>120,000 quilts

250,000 clothing items

1.7 million mosquito nets

6,480 tons of food

RCSC Shelter

- Objective 1 (0-3 months)
  - Ensure 100,000 families receive emergency shelter
- Objective 2 (1-12 months)
  - Provide technical support for 1,000 health centers, 1,500 schools
- Objective 3 (3-36 months)
  - Provide earthquake-resistant houses for 2,000 rural families
- Progress
  - 53 planes chartered to deliver tents from Iran, elsewhere
  - 102,210 international tents received by end of July

RCSC Health

- Objective 1 (0-3 months)
  - Deploy medical, first aid, psychological support teams
- Objective 2 (1-12 months)
  - Provide technical assistance & training – health clinics
- Objective 3 (3-36 months)
  - Provide technical assistance & training – preparedness & service
- Progress
  - 10 medical teams deployed by end of May

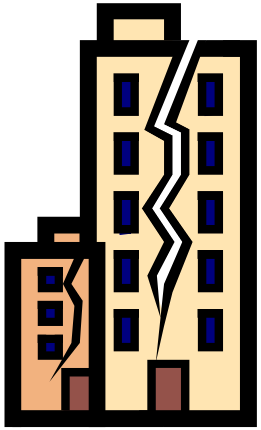
RCSC Water, Sanitation, Hygiene

- Objective 1 (0-3 months)
  - Provide drinking water, sanitation, hygiene promotion
- Objective 2 (1-12 months)
  - Provide technical assistance & training – service Emergency Response Units
- Objective 3 (3-36 months)
  - Provide technical assistance & training – water & sanitation emergencies, provide facilities
- Progress
  - 2 M15 water emergency response units (Austria, Spain) served 30,000
  - 1.3 million Water purification tablets (PRC)
  - 1,000 household purification sets
  - others

RSCS Rural Livelihood

- Objective 1 (0-3 months)
  - Training & technical advice on livelihood substitution
  - Cash & voucher transfer programming
- Objective 2 (3-36 months)
  - Provide livelihoods to 2,000 families in permanent shelter program
- Progress
  - Awaiting area stabilization

Approaches to Earthquake Risk Management



- US

1. Assess risk
   - Standards
   - Software
2. Identify alternative risk mitigation strategies
   - Engineering alternatives
   - Management practices
   - Financial mechanisms
3. Evaluate life-cycle economic economics of alternatives
   - Software

Phases

- **PREDICTION**
  - Scientific endeavor
    - Understand, predict
  - Earthquakes are rare events
    - Animal behavior; Unusual cloud patterns
    - Statistical analysis
- **PLANNING**
  - Standards
  - Software
  - Identify alternative risk mitigation
- **CONTROL**
  - Emergency reaction
- **POST-EARTHQUAKE RESPONSE**
  - **WHAT TO DO AFTER DISASTER OCCURS**
  - **REDUCE ADDITIONAL SYSTEM FAILURE BY HUMANS**

Risk Management Process

- Identification
  - Potential losses quantified for every significant risk source
  - Earthquake timing, magnitude, location
  - Loss modeling tools
    - Risk maps
    - Analyses of risk impact and likelihood
- Establish Acceptable Level of Loss
- Risk Control
  - Building codes
  - Emergency management agencies
    - Emergency food, water – deployment of construction equipment
- Risk Transfer (for firms, not governments)
  - Insurance
  - Catastrophe bonds

Earthquake Risk Management Tools

- FINANCIAL
  - Insurance pools
  - Conditional Value at Risk (CVaR)
- INFORMATION TECHNOLOGY
  - Geographic information systems (GIS)
    - Earth science data
    - Socioeconomic information by locality
  - Communications
    - Telephones, whiteboards, the Internet
    - Database systems, Data mining tools
    - Models in Decision Support Systems

Risk Management in Post-Earthquake Construction

- Can use information technology (earthquake disaster data systems)
- ERM
- Need to research value of prediction markets
- Recognition-primed decision approach a way to prepare

Disaster Information Management Systems

- Collect relevant data
- REQUIREMENTS
  - Recognize & handle diverse disaster data sources
    - Geographical, registry information, aid information
  - Handle disparate disaster data formats
    - E-mails, documents, pictures, movies, audio
- Some data gathered prior to disaster
  - Hazard information
  - Victim locators
  - Registries of families, medical needs

Emergency Management Support Systems (EMSS)

- Decision Support Systems focusing on emergency management
- US: National Incident Management System
- US: National Disaster Medical System
  - Information processing
  - Response planning
  - Inter-agency coordination
- Europe: Global Emergency Management Information Network Initiative
- Earthquake prediction (Aleskerov et al., 2005)

Earthquake Response Systems

- Damage assessment of structures
  - **POST-EARTHQUAKE RESPONSE**
    - **don’t compound disaster**
- Lessons of post-earthquake recovery
- Rehabilitation & recovery
- Public policy
- Land use options
- Urban planning & design

Emergencies

- Surprises
  - Asteroid strikes
  - Human-induced
- Repetitive
  - Hurricanes
  - **Earthquakes (tsunamis)**
- **Repetitive emergencies have data**
  - RISK – some predictability
  - Can prepare

Emergency Management Problem

- Tools exist to gather data
- Data mining tools might be able to make some sense of this data
- **HARD TO HAVE RIGHT DATA AT RIGHT PLACE AT RIGHT TIME**
  - Need filters to focus on crucial data

Loss Estimation models

- Required input for loss estimation-
  - 1. Hazard
  - 2. Vulnerability
  - 3. Exposure

Models:

1. Empirical model – needs

a. fatality rate

b. Uncertainity estimation

c. Regionalization

- 2. Semi-empirical model
  - Collapse ratio
  - Fatality rates given structural collapse

  3. Analytical Model

  4. Grid-based loss computation

  5. Second generation loss estimation tool (QLARM)- Earthquake Loss Assesement for Response and Mitigation.