Disaster Risk Reduction after Wenchuan

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Abstract

The Wenchuan earthquake continues the succession of disasters exacerbated by the absence of design and construction for seismic resilience. Damage and loss of life from this event are reviewed, and severity of losses in schools noted. Cases of survival indicate the kind of school retrofitting, education and commitment necessary to achieve such success.

Acceptable levels of risk for both voluntary and involuntary human activity are reviewed, providing one reason why activating disaster risk reduction (DRR) in communities at risk can be so difficult. The concept of a Disaster Limit State is introduced to achieve effective DRR for whole communities. The lack of cost effective, sustainable means of retrofitting typically non-engineered buildings is noted.

Introduction

The majority of natural disasters are of hydro-meteorological or geophysical origin. In the majority of places where they occur the popular attitude is that the losses from these hazardous events are inevitable. The notion is alien that one could redefine and defend the way people live and work so that, while the hazard remains, the risk does not. It is the building collapse, not the earthquake, that kills people.

Consider some major earthquakes of the last five years shown in Table 1. Generally, they are located on major tectonic plate boundaries. Generally, the communities affected had low socioeconomic standards or there were actual regions of poverty – perhaps because most of the human population of the world falls into this category.

Table 1 – Recent Major Earthquakes

Location	Date	Depth	M_W	Deaths	Tectonic drift
Sichuan, China	12/05/2008	10 km	7.9	~69000	15 mm/yr
240 km sth Java Is†	17/07/2006	49 km	7.2	668	69 mm/yr
Yogyakarta	26/05/2006	12 km	6.4	5749	69 mm/yr
Pakistan/Kashmir	08/10/2005	23 km	7.6	~87000	50 mm/yr
Nias Is., Indonesia	28/03/2005.	30 km	8.7	~1300	60 mm/yr
Aceh/Andaman Is†	26/12/2004	30 km	9.1	~297000	60 mm/yr
Niigata, Japan	23/10/2004	13 km	6.8	48	
Bam, Iran	26/12/2003	6 km	6.6	~31000	30 mm/yr

†involved tsunamis

The lowest death toll listed in the Table occurred in Japan, which stands out as the most affluent of the nations listed, with earthquake resistance standards in place and implemented. There were a significant number of foundation failures, in spite of which the structures generally held together and did not disintegrate into rubble.

However, it is not just because proper standards were in place and enforced that the death toll was relatively low. Japan has invested 1% of its annual GDP for fifty years in disaster risk reduction (DRR) to achieve a 95% reduction in losses, including loss of life, over that period. Such investment involves not just building standards, but education and drill in what to do when earthquakes, typhoons and tsunamis strike, together with special attention to critical infrastructure and emergency services.

Thus it would appear that the disastrous record shown in Table 1 need not be a blueprint for the future. The task is formidable. We must find ways of raising common awareness of risk and its management, of engaging communities in their own DRR, with the right technical support.

What can we learn from the Wenchuan earthquake in this regard?

The Wenchuan Earthquake 12/05/2008

The following observations are made with regard to damage and losses, rapid response, communications, and schools. (Some of this information was gained at a workshop with high level Chinese officials in Davos on 29/08/2008.)

The damage bill is of the order of US$100 billion, about 3% of China's GDP. The area of intense effect was 300km x 40 km. The total impact area was 500,000 km^2. The main shock was Richter magnitude 7.9. Six aftershocks exceeded R6.0, and 54 exceeded R5.0.

On 11/07/2008 human life loss estimates were: 69,197 dead, 18,341 missing, 96,445 hospitalised and 2.8 million treated. About 5.2 million were rendered homeless.

Hundreds, if not thousands, of dams were affected. China's largest earth-rock dam moved 30 cm. 5,000 km of major pipelines were destroyed. About 30 landslides caused barriers damming rivers, the one upstream from Wenchuan being the most critical.

There are 30 radioactive sources in the earthquake zone. All nuclear facilities were shut down, pending damage checks.

Mobile phone communication towers were not designed for seismic resistance, so that a critical post disaster communication system was lost. These should have exceptional standards of design and construction so that they remain effective after catastrophic events. Combined with the ruptured highways blocked by damage vehicles post disaster emergency response was severely hampered.

Emergency response to prevent further major disasters was rapid and effective, thanks to the rapid mobilisation of the army. A method of draining the lake generated by the landslide upstream of Wenchuan was devised and implemented in seven days.

However, the removal of mountains of rubble and the reconstruction of destroyed schools, hospitals and homes will require years to implement.

Buildings with proper structural design generally performed well. The design standard was effectively for a Modified Mercalli Intensity of VII, yet some 12% of these buildings survived in areas where the MMI was XI. (This says something about the value of robustness in detailing.)

Schools

More than 5,000 classrooms collapsed in the earthquake. About 12,000 students and teachers were killed. In many instances emergency exit doors were locked. It appears that seismic resilience was absent from schools built more than 10-15 years ago, and haphazard in more recent times. This earthquake occurred just after a UN sponsored 2-year program to "Make our schools safe." An OECD report (2004) stated

> "…schools built world-wide routinely collapse in earthquakes due to avoidable errors in design and construction…because existing technology is not applied and existing laws and regulations are not sufficiently enforced…Unless action is taken immediately to address this problem, much greater loss of life and property will occur."
>
> (extract from "*ad hoc* Experts' Group Report on Earthquake Safety in Schools", in this publication)

It is clear that an effective program of risk reduction must engage the school students. Raising awareness of the risk, safety and evacuation procedures and evacuation drill must become part of the curriculum. The structural engineer is a necessary but by no means sufficient condition for effective disaster risk reduction.

Equally it can be said that the engagement of the staff and students of schools in DRR is a necessary but not sufficient condition for DRR to succeed. Funding and willing NGOs are not enough. Top-down and bottom-up approaches must work together.

A number of schools survived against the odds. The remarkable case of the Sangzao Middle School was reported in the New York Times. The headmaster was acutely aware of the seismic risk and worked for more than a decade to achieve the necessary DRR. More than 1,200 students and staff all survived. The building was damaged, but it did not collapse.

Some essential aspects of the success and experience of Sangzao Middle School are as follows:

1. School buildings up to five storeys, one built 1983-85, were perceived to have columns with undersize area of cross-section and insufficient reinforcement, and hollow block reinforced concrete floors of dubious quality.
2. Prior construction was carried out without independent site inspections to ensure quality.
3. One person in authority – the headmaster, Mr Ye – recognised the serious seismic risk arising from deficient construction.
4. One person – Mr Ye – had the leadership to pursue county funding ($58,000) to strengthen the buildings.

5. Retrofitting took several years to complete. (Details of the retrofit beyond adding concrete and reinforcement to the columns are scant.) Lobbying the county took somewhat longer.
6. There was no NGO assistance or external input to the risk reduction process.
7. Earthquake emergency drill, practised twice a year, ensured that the buildings were safely evacuated within two minutes of the first shocks.
8. The buildings are considered unsafe since there is no means of knowing their residual seismic resistance after the earthquake. They remain unoccupied. They will be demolished and rebuilt.

From this report it would appear that the Sangzao Middle School is close to the ideal of disaster risk reduction. Risk was identified. A community based action for risk reduction was developed and implemented. Appropriate education in the process of risk reduction was provided. The outcome was feasible, affordable, sustainable and achievable.

Acceptable Risk

In a landmark paper Whitman (1984) presented a chart relating acceptable risk to consequences of failure (Figure 1). The chart was actually provided by a colleague (Baecher). The chart maps the historical risks associated with industrial activities associated mainly with energy, resources and transportation. Operations at sea are clearly the most risky.

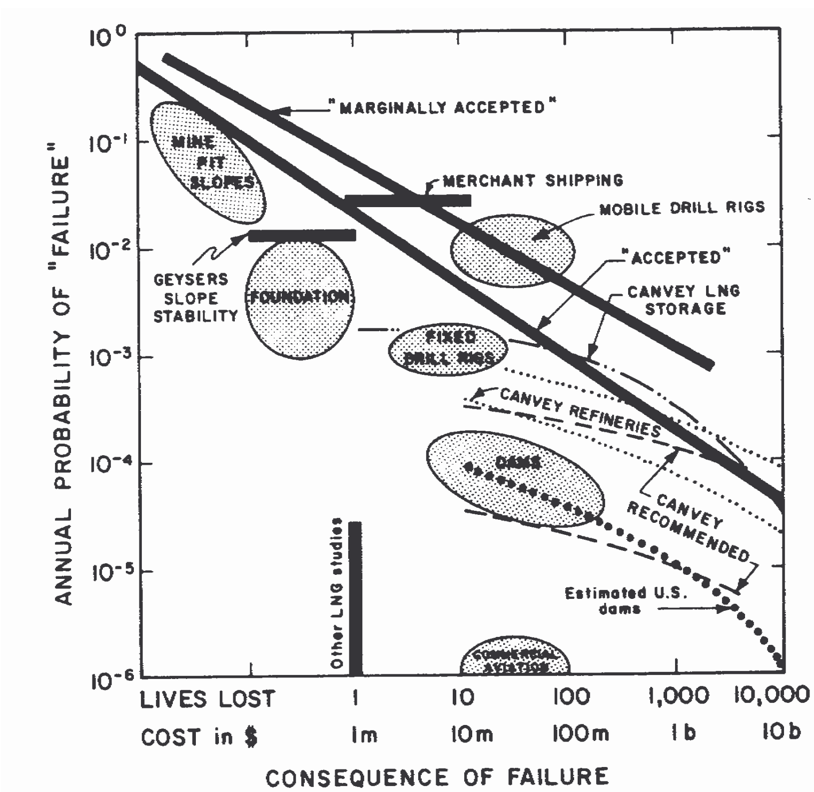

Figure 1: Risk of failure versus loss (Whitman, 1984) compared with ANCOLD design criteria

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