The Padang Earthquake 2009 – Lessons and Recovery

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Abstract

The West Sumatra earthquake of 30/09/2009, with a moment magnitude of 7.6, killed about 1150 and severely injured about 1,200. Around 135,000 houses were severely damaged and an estimated 1,250,000 were made homeless or otherwise severely affected. The earthquake epicentre was not on the line of subduction of the Indo-Australian Plate beneath the Eurasian plate, and there was no tsunami. Many buildings in the public sector collapsed through the soft storey syndrome, exacerbated by poor detailing of reinforcement, especially at the joints. There were some cases of liquefaction, which is a potential hazard for significant areas in the city.

The earthquake is not the most severe to be expected in the region. Padang remains at risk because it sits in a gap in recent seismic activity along the Sunda Trench. Large areas of the city would be overwhelmed by a tsunami.

Response to the earthquake consists of (1) “building back better” where buildings and infrastructure have been destroyed, (2) improving preparedness and emergency response, and (3) retrofitting buildings and infrastructure not damaged, but at risk from future earthquakes. There is a variable response to the first two aspects, and a very limited response to the third aspect. Retrofitting masonry non engineered buildings presents a particular challenge.

“Building back better” does not include relocation of the population away from tsunami or liquefaction prone areas. Nonetheless there are a few shining examples which address these problems, such as a combined evacuation centre and school in steel framed construction – at three times the normal cost of a school.

Keywords: Padang Earthquake, disaster risk reduction, failure modes, robustness, education and training

1. Introduction

The West Sumatra earthquake of 30th September 2009, with a moment magnitude of 7.6, killed about 1150 and severely injured about 1,200. Around 135,000 houses were severely damaged and an estimated 1,250,000 were made homeless or otherwise severely affected. The earthquake epicentre was not on the line of subduction of the Indo-Australian Plate beneath the Eurasian plate, and there was no tsunami (Fig. 1).

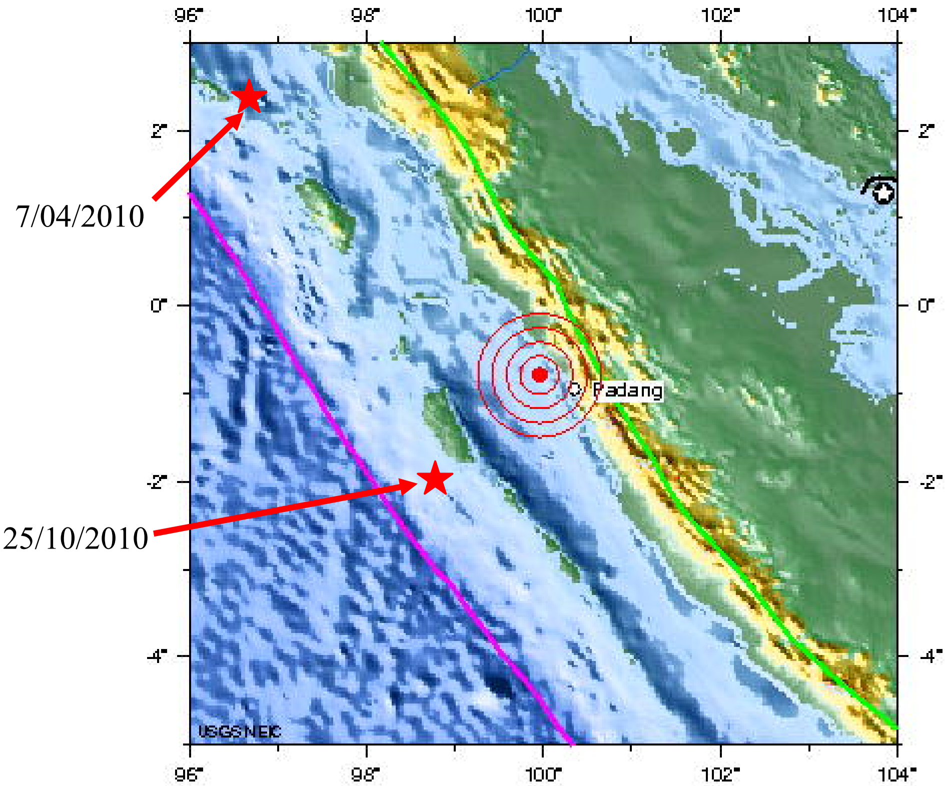

Figure 1 – Location of Padang Earthquake, 30/09/2009, and more recent earthquakes

Padang remains in the gap of recent major earthquakes along the Sunda trench, so that a much larger earthquake is to be expected in the foreseeable future. The recent earthquakes of 7th April 2010 (magnitude 7.8) and 25th October 2010 (magnitude 7.7) located near islands west of Sumatra have not diminished this risk. It is therefore important to see how the Padang Earthquake has affected disaster mitigation efforts in anticipation of "the big one". The Padang Earthquake has revealed weaknesses in seismic resistance which need to be rectified in reconstruction and which present a challenge in retrofitting. Since this earthquake did not result in a tsunami the vulnerability to a tsunami has not been tested.

The earthquake of 25/10/2010 generated a tsunami up to 3m in the Mentawai Islands, which was a significant factor in the death toll exceeding 400.

2. Characteristic damage

Structures

Many buildings in the public sector collapsed through the soft storey syndrome, exacerbated by poor detailing of reinforcement, especially at the joints, and poor quality concrete. (Figs 2-4)

Figure 2 – 6-storey Ambacang Hotel

Figure 3 – Food Security Agency Building, Padang

Figure 4 – Provincial Public Works Office, Padang
Evidence of soil liquefaction at this site

In the commercial district failures were most significant in buildings on streets aligned east-west, with relatively few on streets north-south (Figure 5). The strong motions were in the east-west direction. The relatively robust performance of the buildings facing east or west is attributed to the long party walls of load bearing masonry or brick infilled reinforced concrete frames, without openings.

Figure 5 – Directional vulnerability of commercial buildings (Sarwidi, 2010)

One structure which survived with very superficial damage was a mosque under construction (Figure 6). This was being funded from international sources. The basic design was a seismic resistant form, with strong columns compared with beams, large buttresses and piling to prevent failure through soil liquefaction. Concrete strengths used were higher than usual for the district, and the finished concrete quality was very good.

Figure 6 – Mosque under construction which survived intact

Soil liquefaction

Large areas of Padang are flat and barely above sea level. The proximity to volcanoes means that ash and mudslides have filled the valleys in geological time. It is not surprising that the potential for soil liquefaction is high.

Sand ‘boiling’ occurred in some locations and there were many cases of subsidence (Figure 6).

Figure 6 – Ocean boulevard liquefaction.
Note low elevation affording minimal tsunami protection

Landslides

Many landslides occurred in the mountainous hinterland (Figure 7). In many cases poor slope stability was exacerbated by cut and fill for roads. In most instances villagers rebuilt in adjacent areas where a landslide had not occurred.

Figure 7 – Pariaman District Landslide (AP Photo/Dika Alangkara)

3. Response and recovery

Response to the earthquake consists of

i. "building back better" where buildings and infrastructure have been destroyed,
ii. improving preparedness and emergency response, and
iii. retrofitting buildings and infrastructure not damaged, but at risk from future earthquakes.

There is a variable response to the first two aspects, and a very limited response to the third aspect. "Building back better" does not include relocation of the population away from tsunami, landslide or liquefaction prone areas. Retrofitting masonry and non engineered buildings presents a particular challenge.

Structures with post disaster function

There are a few shining examples which address the need for safe refuge and emergency accommodation after a major earthquake and tsunami, such as a combined evacuation centre and school in steel framed construction nearing completion in July 2010 (Figure 8). Features of this building include

- Located approximately 1 km from the coast in an area at risk of a tsunami.
- Consisting of three storeys and a helipad,
- Steel framed, concrete encased columns,
- Founded on RC piles 18-24m to resist liquefaction
- Built by a Jakarta construction company and labour force,
- Funded by Buddhist Compassion Tzu Chi Foundation

Figure 8 – Regional school with post disaster function

Figure 9 – Stair flights in the new building after stripping of the formwork

This building is estimated to cost three times that of a traditional school. However, this is justified because of its crucial post disaster function.

It is unlikely that the standard of disaster resilience built into this building could have been achieved using familiar local construction methodology in reinforced concrete. It takes at least a decade of reform and a change in cultural perception to eliminate detrimental practices. This is illustrated by the quality of the reinforced concrete stairways in this building (Figure 9) which reflect local standards practice in concrete construction – the reinforcement is not properly supported on bar chairs and the concrete is not properly compacted.

Tsunami preparedness

A number of the DART sensors deployed around Indonesia are not functioning, so that the effectiveness of the warning system is compromised. As always, a strong motion signified by a *duration* exceeding 20 seconds is the most reliable and earliest warning of potential tsunami. The people of Padang have rehearsed evacuation following a tsunami warning. This has often consisted of running a kilometre or more to higher ground. Some people did evacuate after the motion was felt in 2009, returning to their homes 1½ hours or more after the event.

There is still a need for clearer thinking about response to potential tsunami. The earthquake response instructions of the beach hotel where the author stayed were to evacuate via the staircases as soon as motion stopped. However, it would be safer to stay put if the hotel had not collapsed lest there be a tsunami.

4. Capacity building

The author's occasion for reviewing recovery in Padang was the UNESCO–IPRED Workshop (International Platform for Reducing Earthquake Disaster, organised by the Research Institute for Human Settlements (Indonesia) and the Provincial Government of West Sumatera. Japan International Cooperation Agency IISEE (International Institute of Seismology and Earthquake Engineering), 5-8/07/2010.

IISEE has been active for 50 years in providing courses in earthquake engineering and disaster management. It has cooperation with research institutes in Chile, Egypt, Indonesia, Kazakhstan, Mexico, Peru, Romania and Turkey – the original and principal member countries. The Institute has distinguished alumni working in these and other countries. However the experience in Padang reveals the depth of education and training needed to build disaster resilience. The need for improved standards range from education in schools and communities through development of construction skills to enforcement of standards and contract administration. Thus it can be said that institutions such as IISEE are necessary but not sufficient for disaster risk reduction.

5. Retrofitting

As mentioned above, in the three part response of building back better, improving preparedness and emergency response and retrofitting existing buildings and infrastructure for improved resilience, it is in the third aspect that achievement is most wanting.

Adjacent to the Provincial Governor's residence in Padang is an exhibition hall where many NGOs display their activities and proposals. These are mostly in the area of restoring community services and building back better. None address retrofitting. Grundy (2007a & b) reported the light concrete frame infilled with conventional domestic masonry, developed in response to the Yogyakarta Earthquake in 2006 (Figure 10).

This concept is now found in a number of NGO proposals for building back better. It has proved effective where it has been tested by earthquakes. The challenge is to adapt this concept to existing masonry housing. It is not possible to insert RC beams and columns into existing masonry.

Grundy (2010) has proposed a methodology of "strapping on" columns to walls in need of constraint. This can be achieved with timber (Figure 11) or reinforced concrete (Figure 12). If timber is used the interface between the timber and brick must be grouted or bonded. These added columns must be complemented by plinth beams on either side of the wall at the base, and cap beams on top of the wall or on either side, which have proper connection to the columns, not shown here.

It should be immediately apparent that the house framing system illustrated in Figure 10 will require training or retraining of bricklayers and other trades if it is to be executed properly. A similar training program is required if the strap on solutions proposed by Grundy are to be effective.

Even more challenging is the educational component – establishing in the community the need and desirability of retrofitting. This requires the engagement of NGOs, provincial government and village leaders in the program.

Figure 10 – House built with RC frame infilled with masonry (Suryabrata et al, 2007)

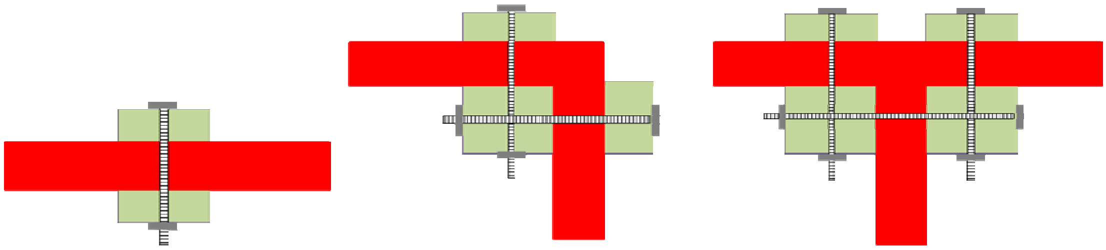

Figure 11 – Timber framing added to existing brickwork, threaded rods @ 30 cm

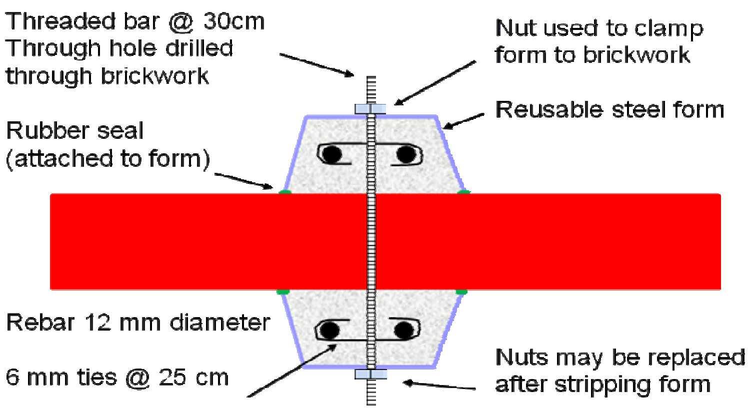

Figure 12 – RC column cast in situ fastened to brickwork

6. Conclusions

The Padang Earthquake of 30/09/2009 revealed that the city is ill prepared for a potentially much larger earthquake and tsunami accompanied by landslides and soil liquefacion, predicted in the not-too-distant future.

Damaged building are being patched up, but not rigorously retrofitted a a future large earthquake.

There are some examples of construction designed to survive and function after a major earthquake.

Improved perception of adequate design for disaster risk reduction needs to be underpinned by improving skills in construction trades and management.

Some possible methods of retrofitting non engineered buildings are proposed.

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