

Lessons from Haiti: the Indian earthquake scenario

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The earthquake that occurred on 12 January 2010 in the vicinity of the boundary of the North American and Caribbean tectonic plates devastated the island of Haiti with tragic consequences. The earthquake however did not occur on the plate boundary *per se*, but on a subsidiary horizontally slipping fault. The shallow focus of the earthquake and the fault's location close to the population centres added to the vulnerability of the local building stock. The entire infrastructure of the island nation, one of the poorest in the world, was razed to the ground within a few seconds and it will be decades before the Haitian society could be put on proper tracks, provided other problems like hurricanes, civil strife and military coups would not exert a drag on the earthquake reconstruction efforts.

One of history's worst natural calamities that killed about two hundred thousand unsuspecting poor people, this killer earthquake in fact was forewarned by the earthquake scientists as observations from various subdisciplines as seismological, geodetical and geological studies were brought to bear on this question, several years back. Manaker *et al.*¹ who published a research paper in the *Geophysics Journal International* on the global positioning system (GPS) estimates of the strain rate along the Enriquillo Plain Garden Fault Zone (EPGFZ), a through-going causative structure along the southern margin of the island had suggested that this fault was likely to produce a magnitude 7.2 earthquake if the elastic strain accumulated on this fault since the last major earthquake (in the 18th century) were now to break in a single event. We think this earthquake is one of the recent examples of the success of scientific research in identifying a potential fault on the basis of slip deficit and the maximum expected magnitude (note that this is not a short-term prediction). There are many other globally identified potential structures, but this particular study bears out the broad efficacy of the methodology, at least for simple homogeneous plate boundary faults. This is a major milestone in the scientific research on the earthquakes.

Here the scientists have used the geological inputs, historical database and GPS-based geodetic estimates to make the closest forecast, and if heeded by the authorities, this information would have made a major qualitative change in the way we manage potential natural calamities of mind boggling tragic proportions.

We had a similar devastating event on 26 December 2004, although it is not the earthquake *per se* that had produced major damage on the Indian shores but it owed to a killer wave generated due to the vertical sea floor displacement near the earthquake source. Least expected in this part of the globe, the tsunami's transoceanic devastation was unprecedented historically. However, the global geoscientific community should have known this better to guide the society to safety, considering the fact that there is always a lead time between the earthquake and the tsunami arrival from minutes to hours depending on where you are located with respect to the earthquake source. Consequent to that event we had engaged ourselves in long lasting discussions on our readiness to tackle such calamities and also, since then we built institutions for tsunami warning and re-focused on earthquake and GPS monitoring in the country.

The Haiti earthquake is essentially a man-made disaster as we can see from the reports that none of the engineered buildings withstood the earthquake, not even the presidential palace. The Haiti experience should now motivate us to make a thorough review of our preparedness to tackle the earthquake-related calamities in the country. Indian terrain is prone to large and great earthquakes as the political boundary of our country somewhat follows the tectonic divides in the west, north and the east. One of our major concerns now should be the 2500-km long Himalayan plate boundary that extends from the northwest to northeast, a zone that hosts potential fault lines that could generate both large and great earthquakes (magnitude 7 and above). Although the causative mechanisms and the temporal and spatial nature of seismicity are still debated, there is a consensus among the

scientists about identifiable gaps along the Himalayan axis where there are deficits in slips which do not commensurate with the accumulation of elastic strain (estimated geodetically, although for a short interval) and also by the fact that these areas are historically quiet in terms of earthquakes². For instance, the central Himalaya is one such region where it is historically deficient in earthquakes compared to other areas. This is one region that can reasonably be expected to generate a large or a great earthquake in the foreseeable future³. The northeast Himalaya also hosts seismic gaps, an area that generated great earthquakes in 1897 and 1950, not to speak of the earthquake in the Tibetan region in the succeeding year, with devastating impact on the landscape by the earthquake-triggered landslips and flooding. How prepared are we to face such eventualities that would take place in the future in these areas? One of the biggest threats would be land slip-impounded dams and consequent sudden flooding of the downstream side.

The only historical example of a large earthquake in the central Himalaya occurred in 1803 (although two smaller events occurred in the 1990s), which was estimated to be within the range of magnitude 7.5–7.9 (ref. 2). This triggered landslides that smothered villages located up in the hills and also generated distant soil liquefaction and amplified acceleration in the Ganga alluvial plains including the Delhi region. Although total casualties may be counted in 1000s, it would be prudent to calculate the earthquake risk in the region if such an earthquake occurs today in the Himalaya. The fact of the matter is that we have the knowhow to construct houses and other buildings that will not kill people in an earthquake. This is the key to earthquake safety. But according to some earthquake engineers of our country this is still a dream that is yet to be realized. In an article published in *Current Science*⁴, one of our prominent earthquake engineers reiterates the fact that many of the new constructions in the earthquake-prone areas do not comply with seismic codes, because certificates of safety are

easy to procure for reasons known to all of us. This is particularly crucial, he says, as the country is going through major constructional activities and it is the right time to ensure that all the infra-structural projects comply with seismic safety regulations. In the same article, the author invokes several examples of noncompliance of seismic codes. Even though the north Andaman lies in a high seismic zone, a major bridge connecting the middle Andaman and north Andaman that was inaugurated in 2002 did not comply with seismic codes and was expectedly damaged in the 2004 earthquake. He also quotes the example of pre-earthquake construction style existed in Gujarat prior to the 2001 Bhuj earthquake. Of the 6000 schools constructed during the period April 1999 to December 2000 by 'pre-cast construction technology' without following seismic safety measures, about three-quarters of these buildings were completely damaged in the 2001 earthquake.

He suggests two practical solutions: one, ensure that all new constructions (at least in the high earthquake zones) are made to resist earthquake shaking and, two, all existing buildings are made earthquake-resistant by retrofitting. So our overriding concern would be to see how we can make these activities cost-effective, and such an endeavour requires long-term systematic efforts. At the same time we have to take into account the fact that a country like India follows a variety of building practices. In a large part of the country, mostly owing to income disparities, there are not only differences in building styles but also in the quality of construction materials used. In areas where traditional styles are followed, we need to find out and strengthen the traditionally available methods for earthquake resistance. It is worth remembering that Larry Baker, the

late legendary architect had made some meaningful suggestions to strengthen the traditional houses in the Himalaya. Let us start this exercise by retrofitting the rural schools in the high hazard areas so that a repeat of the Haitian experience could be avoided. Concomitantly, we should overhaul our town and municipal planning by-laws to include the natural hazard safety measures using already existing appropriate building codes, developed through the Bureau of Indian Standards. Of equal importance is to develop an environmental land zonation for both the urban and rural areas of the country and strictly adhere to its recommendations in planning building activities.

To start with, we need to make a comprehensive study of vulnerability of buildings and structures in cities and villages for various earthquake intensities, says another leading expert in earthquake engineering⁵. Arya presented a earthquake risk scenario assuming an earthquake similar to magnitude 8.0, 1905 Kangra earthquake were to occur today in the Himalaya, using the 1991 census⁵. If all the 1,815,858 houses in the region are without earthquake resistant provisions, the direct losses would be Rs 51.04 billion and about 65,000 lives would be lost and about 399,695 houses would be destroyed completely. If all the houses were made earthquake-resistant, the direct losses would be reduced to Rs 19.6 billion. The extra cost of retrofitting would be Rs 6.35 billion and the loss of life would be reduced to one-fifth and number of ruined houses would be only one-fourth. This study brings out the economic and social benefits of preventive measures. We need to develop such scenarios for many parts of the country.

As for India, we need to focus both on the earthquake engineering and also on the scientific research of the earthquake

processes. We need to intensify our geological, seismological and geodetic research on the earthquakes, focusing more on the potential regions, which would lead to a map of potentially active faults in the country. Some progress has been made on preparing the *Seismotectonic Atlas of India* (by the Geological Survey of India), but there is still scope for improving and preparing a map of hazardous faults with more geological and seismological inputs. Most importantly, scientists should learn to work together by forging meaningful collaborations within and between the institutions and address the issues through a cross-disciplinary approach, a major lacuna that prevents us from making a global impact. We also have to go a long way to integrate development with disaster mitigation strategies, which would certainly include grassroots level community-based initiatives. Seismic safety should be made mandatory for critical facilities, including the upcoming nuclear stations and metro rail projects. We should not be caught unawares when the next major earthquake occurs in the country.

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