The Indian earthquake problem

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After every damaging earthquake in India, a lot of coverage is given in newspapers and on TV to the issues of earthquake safety. Different government agencies announce plans towards this. Many experts are interviewed on TV channels to share their wisdom on ways to mitigate such disasters. Numerous conferences are held all over the country. And, the public feels reassured that the problem of earthquake safety will now be taken care of, until the next such earthquake when we realize that not much really got done since the last event. In the backdrop of the tragic Kashmir earthquake, it is time for a sober introspection of the 'earthquake problem in India'.

The 1931 earthquake in Mach, Baluchistan led to the construction of several earthquake-resistant railway bungalows in Quetta[1]. These were the only constructions in Quetta to survive the 1935 earthquake that killed ~25,000 persons. Subsequently, seismic codes were developed and adopted for reconstruction in Quetta by the army, the railway and the civil authorities. Clearly, it is possible to construct houses that will not kill people in an earthquake.

Current scenario

After the 2001 earthquake the Indian middle class saw for the first time, multistorey buildings fall like a pack of cards, and realized that these housing types are similar to the ones in which they are living or have plans to retire into. The Central and State governments announced numerous plans and activities. It was hoped that India would now have an effective programme for earthquake safety, and that most (if not all) new constructions would now comply with seismic codes. Have such hopes been realized?

Discussions with professional colleagues around the country and the messages posted on the discussion forum of the Structural Engineers Forum of India (www.sefindia.org) clearly show that a huge number of unsafe buildings continue to be built every day in different cities and towns. After the 2001 earthquake, many municipal authorities have started asking the structural engineer (and others such as architects and builders) to certify that the building complies with seismic codes. Unfortunately, such certificates are easy to procure, sometimes on payment of small money, and need not have any correlation with how a building is built. Until the municipal authorities start enforcing measures to ensure that the building indeed complies with codes, false certificates will continue to be issued for a variety of reasons.

The country is going through a major development phase wherein infrastructure is being added at an unprecedented pace. It is a great opportunity to ensure that all new infrastructures comply with seismic requirements. Unfortunately, this is not happening. For instance:

- About 6000 school buildings were constructed across the state of Gujarat during April 1999 to December 2000 by pre-cast construction technology that was deficient in seismic aspects. About three-quarters of these schools either collapsed or were seriously damaged during the 2001 Bhuj earthquake[2].
- The Austin Creek Bridge connecting the North Andaman with the Middle Andaman was inaugurated in 2002 and did not have aseismic features, even though Andamans are a high seismic zone. The deficiencies were pointed out and yet no corrective actions could be undertaken, and the bridge went out of function after the 2004 Sumatra earthquake[3].

The problem statement

Why do we see the above state of affairs in a country striving to stand in the row of developed countries, awaiting a permanent seat in the Security Council, and known for being the leader in the highly competitive IT world? In engineering, often it is more important and sometimes even more challenging to define the problem than the solution itself. Quite often, our national or professional pride comes in the way of stating the problems as they are, leading to a loss of opportunity for finding a solution.

Every stakeholder tends to think that his role is the most crucial in addressing an issue. Hence, differences of opinion are expected between scientists, engineers, administrators, social scientists and NGOs on how to solve the problem. Someone would say that mass awareness campaigns are needed to create a demand for safe constructions. Another would say that more seismic instruments are critical. Many recommend seismic microzonation before any progress can be made. However, no one will disagree that the problem will simply go away if somehow all buildings can withstand the earthquakes. Clearly, unsafe building stock is the problem and the solution is to (a) ensure that all new constructions are earthquake-resistant, and (b) all existing structures are made earthquake-resistant over a period of time through sensible retrofitting.

Let us assume that the average life of buildings is 50 years and that the building stock is growing at 2% per annum. If no new unsafe building is built in future, in 20 years about 60% of buildings will be earthquake-resistant even without any retrofitting. It is therefore obvious that our priority should be to develop robust systems for ensuring safe construction of new buildings. Simultaneously, we need to develop systems, policies and methodologies for seismic retrofitting of existing structures to prepare for sensible retrofitting programmes.

Ensuring safety in new constructions

How can one ensure that all the new buildings are safe? Last year, in a scientific conference abroad, one prominent scientist from Europe mentioned that the problems of unsafe constructions remain and that in his opinion the cities should hire honest engineers and pay them well, so that they do not indulge in corruption and new buildings are built to be safe! This is just to illustrate that the sophistication in building industry is often overlooked by the public, administrators, politicians,

and sometimes even by civil engineers and architects. Human greed and lack of knowledge are universal and despite these, it is possible to develop adequate checks and balances.

Important components for ensuring safe constructions are listed below (not in the order of importance).

Public awareness: It is easy to implement safety programmes if the public is well aware of the seismic risks. The 2001 Bhuj and 2005 Kashmir earthquakes have created tremendous awareness. What remains to be done is to give the public, a perspective on the need for changes in our construction environment.

Legal framework: After the 2001 earthquake, many State governments and municipal authorities have made the code compliance mandatory. There is now a need to develop a clearer understanding on accountability of architects, structural engineers, contractors, construction engineers, developers, and municipal authorities towards safety.

Technical competence: In the last decade, numerous capacity-building activities have helped improve the knowledge levels of structural engineers about seismic codes. The National Programme on Earthquake Engineering Education (www.nicee.org/npeee) has trained numerous faculty members of engineering and architecture colleges, and many such colleges now include the subject in their curricula. However, a lot more remains to be done on this.

Professional ambience: The professions of architecture, medicine, accountancy and law are regulated in our country. The respective councils of these professions ensure (i) competence of those licensed to practice, and (ii) ethical practices by their members. A system for regulating engineering profession is long overdue in India.

There has been a considerable decay in the capabilities of artisans and technicians associated with building industry in India. A mason today has far lower competence than one two decades ago. Hence, a certificate system is needed for the artisans and masons. The state of Gujarat has moved ahead in this direction.

Another concern is the low morale among some engineering departments in State and Central governments. In many such departments, professionals have lost considerable amount of self-esteem and have become subservient to the bureaucrats in the ministries for even relatively minor decisions. We cannot expect to receive good services from a demoralized group of professionals.

Enforcement: It does not cost anything to wear a seat belt in an automobile. And yet, the police must enforce it before the public learns to comply. Should we then expect every property developer to voluntarily incur extra expenditures for code compliance, particularly when he himself will not stay in the building? Therefore, municipal authorities must not only collect certificates of compliance of seismic codes, but also verify such certificates independently by a cursory review of structural drawings. Since the 2001 earthquake, the author has discussed with numerous concerned officials on this and found that the municipal authorities are reluctant to undertake the task of effective enforcement.

It is ironic that we require a license to drive a car and we penalize a licensed driver for unsafe driving, but we refuse to regulate unsafe constructions! However, the author was pleasantly surprised during a visit to Kachchh district in 2003, to see that the relatively junior administrators in the towns of Bhuj, Anjar, Rapar, Gandhidham and Bhachao had implemented a semi-informal system of review of structural drawings before issuing building permissions!

Research and development: Our construction practices differ from those in the developed countries, and several technical problems require indigenous research and development. There is a clear need to focus research on 'engineering' of earthquakes as against the focus on 'science' of earthquakes that the country has been doing. A national initiative in research and outreach in 'engineering' of earthquakes in lines with the NPEEE, is urgently needed.

While we have made some progress in terms of public awareness, legal framework and capacity building of engineers, we have done pathetically little towards improving professional ambience in building industry and towards enforcement.

The above discussion has focused primarily on urban constructions. What about the rural and informal constructions that are not regulated by the municipal authorities? Several approaches are needed in this regard:

- We need technological solutions wherein the common man can construct an ordinary earthquake-resistant house with locally available resources. Examples of traditional constructions having excellent earthquake resistance include the Assam-type housing in the northeastern states and Dhajji–Dwari constructions in Kashmir. Research is needed to develop contemporary versions of these and other types of constructions.
- We must discourage construction of reinforced concrete frame buildings without competent engineering supervision. Instead, buildings with confined masonry or those with reinforced concrete shear walls are more appropriate when adequate engineering inputs are not available.
- As practices in the urban areas will improve, so will the same in the rural sector; the informal sector imitates the formal sector.

Seismic retrofitting of existing constructions

Unfortunately, the sophistication required for undertaking retrofitting has not been adequately articulated in the country. Either there is a casual attitude towards it or too much aura associated with retrofitting. After the 2001 earthquake, several government departments in Gujarat assigned the design of seismic retrofitting for a large number of public buildings to some structural engineering firms. Unfortunately, no effort was made to ensure that the firms are capable of delivering such services, or that the expectations from them are realistic. It is becoming clear now that many of those firms had no expertise for such a task. Some facts about retrofitting need to be recalled:

Retrofitting can be expensive: The cost of retrofitting may range from 10 to 50% of the cost of a similar new facility[4].

Retrofitting is a long-haul process: A timetable running into decades is needed depending on inventory of unsafe constructions and the resources available. As an example, California Department of Transportation (CALTRANS) took about 35 years to retrofit its bridges at a cost of about Rs 42,000 crores.

It requires considerable expertise and technology for retrofitting: Considerable technical knowhow may be needed for retrofitting of complex structures or

when the objective is to achieve better than life-safety performance. For instance, CALTRANS had to spend about Rs 220 crores per year for research on retrofitting technologies. In India, we are yet to develop consensus documents on seismic assessment of existing buildings, and criteria for seismic retrofitting.

Government must undertake retrofitting of important facilities: We cannot, on one hand insist that every child must go to school and then have them go to schools located in unsafe buildings. The tragic scenes from Muzaffarabad, where about 400 children died in collapsed school buildings, could recur in many cities in India. A serious retrofitting policy of the public buildings is needed before we expect private buildings to be retrofitted.

A prioritization system is needed: Since not all facilities can be retrofitted at the same time, to maximize the safety with the amount spent, we must have a rational prioritization system considering seismic hazard at the site, vulnerability of the facility, consequences of damages, etc.

In brief, a lot of preparation and background work is needed before a serious effort at retrofitting can be launched.

Concluding remarks

The best approach to earthquake problem is to work on all the fronts simultaneously: engineering, science and instrumentation, public awareness, public policy, etc. The author does not underestimate the contributions science can make to reducing earthquake disasters. However, it is important to put in perspective that earthquake safety is a rather challenging engineering problem requiring decades of focused work, and that in our enthusiasm for science we cannot afford to trivialize or ignore this aspect.

Closure to this article is best provided by a quote from the 1939 publication of the Geological Survey of India on the 1934 Bihar–Nepal earthquake[5].

> Leprosy is not a common disease, but the medical profession has done its utmost to eradicate it for the sake of humanity. Great earthquakes are not a daily disease of any part of the earth's crust, but it should be our duty to do all that we can to reduce its effects. Unless this matter is looked upon in a broad way, posterity may yet look back upon our short-sightedness with regret.
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> In the Quetta area an excellent building code has recently been drawn up, and reconstruction has been rigidly enforced in terms of that code. Such enforcement is, perhaps, easier in such a military area, but at least Quetta provides an example of the practicability of a building code and of its usefulness. It is, perhaps, not too much to hope that the rest of Northern India will some day follow Quetta's lead.

This quote is as much valid today as it was sixty-five years ago!

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