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Earthquake Safe Buildings

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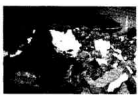

An important step to solving the "earthquake problem" is to recognize that it is really not the "earthquake problem" but the "unsafe building problem"

IN RECENT years, a number of earthquakes have caused thousands of deaths and huge economic losses in India. Earthquakes of comparable size in USA typically cause less than 100 deaths, largely due to systematic effort at constructing safe buildings. Every damaging earthquake in India invites a great deal of media attention. Government agencies announce plans to reduce such disasters in future, experts are interviewed by newspapers and TV channels, conferences and workshops are held all over the country, and the public feels reassured that the problem of earthquake safety is being addressed, till the next large earthquake, when people realize that not much really got done since the last such event. Does it mean that this is a problem that India cannot solve? The answer is: we can solve this problem but need the will to do so.

The 2001 Bhuj earthquake in Gujarat caused more than 13,000 deaths, most of these casualties were in Kutch and Saurashtra regions. However, the earthquake also killed more than 800 deaths in Ahmedabad, located about 220 km from the epicenter. Interestingly, none of the very old buildings in Ahmedabad collapsed during the earthquake. Instead, it was the collapse of 130 multistorey buildings constructed in recent years in the formal sector (involving developers, architects, and engineers) in Ahmedabad that caused these deaths. This is a very clear illustration of the earthquake problem of India: unsafe constructions not only by the public and the illiterate masons but even by many professional architects and engineers. This is at variance with the huge developmental strides India is making otherwise.

After the 1931 March earthquake in Baluchistan, several earthquake resistant railway quarters were constructed in Quetta. These were the only constructions in Quetta to survive the 1935 earthquake in which about 25,000 persons lost their lives. Even though, the country learnt seventy years ago

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that it is possible to make earthquake resistant houses, we continue to add to the unsafe building stock in our communities.

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 Problem Statement

In engineering, often it is more important (and sometimes even more challenging) to define the problem than the solution itself because once a problem is well defined, its solutions start to emerge. 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. In order to solve our earthquake problem, we must start to frankly state the problem.

What is the earthquake problem? Every stakeholder tends to think that his role is the most crucial in addressing an issue. Some one 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. All of these activities are valuable but cannot help reduce the earthquake problem until we start to build safer buildings. If somehow all buildings can be made to withstand the earthquake motions, the problem will simply go away. Clearly, unsafe building stock is THE problem and not the earthquakes as such. It is therefore obvious that 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 average life of buildings is 50 years and that the building stock is growing at the rate of 2% per annum. If no new unsafe building is built now onwards, 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? Before we address this question, we need to ask: why the unsafe buildings are constructed in the first place. The reasons are several:

- *Ignorance:* In many cases, the people involved in planning, design and construction simply do not know the right way to do things. In some cases, they know that they do not know and yet proceed with the task. In other cases, they are blissfully unaware that they lack the competence to do a certain task.
- *Intentions:* Greed to save materials or manpower to cut down costs often leads to unsafe constructions. In many cases, it is the urgency of the tasks that makes people compromise on quality.

However, these reasons are universal around the world and are as much applicable to the developed countries as to the developing countries. How is it then that in general the constructions in the developed countries tend to be safer as compared to that in the developing countries? It turns out that one could indeed put in place a system that significantly improves the likelihood of new constructions being safe. 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 risks and demands safer constructions. The recent earthquakes (2001 Bhuj and 2005 Kashmir earthquakes) have created tremendous awareness but there is still a lack of appreciation on what will make the constructions safer.

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. The questions that need to be addressed are: who is responsible for what, who is to ensure that those responsible are doing what they are supposed to do, and what happens when someone does not do what is his/her responsibility.

Technical Competence: In the last decade, numerous capacity building activities have helped improve the knowledge levels of Indian

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. A lot more remains to be done on this however. We need a lot more training activity, not only for engineers but for all stakeholders including developers, contractors, and masons.

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 which can best be done with the help of a examination-based licensing system for structural engineers in the first instance, and other engineers in due course. Also, a competence-based certification system is needed for the artisans and masons.

Another concern is of low morale of some of the engineering departments in the states and the central government. In many such departments, the 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? Currently, in most cities, the municipal authorities require a certificate of compliance of codes, but do not carry out any verification independently. This is similar to a situation that will arise if the income tax department were to require certificates from accountants and citizens that the individual has paid taxes as per law while the Department is not allowed to look into any income tax returns nor prosecute any defaulters. Clearly, local authorities must start to carry out a cursory review of a small fraction of the structural drawings before such certificates can carry any meaning whatsoever.

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 placing in. A national initiative in research and outreach in "engineering" of earthquakes in lines with the NPEEE is urgently needed.

The above discussion has focused primarily on the 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 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 north-eastern 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 very 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. 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 (e.g., Spence 2004).

Retrofitting is a long-haul process. A time table 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 billions of dollars.

It requires considerable expertise and technology for retrofitting. Considerable technical know how may be needed for retrofitting of complex structures or when 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 with 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. This may in fact be a topic of research by itself.

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

An important step to solving the "earthquake problem" is to recognize that it is really not the "earthquake problem" but the "unsafe building problem". Hence, the focus must shift from earthquakes per se, to the buildings industry. We need to discuss and debate how the building industry can be improved in terms of what it delivers. It is also important to recognize that earthquake safety is a rather challenging engineering problem requiring decades of focused work, and cannot be solved in the short term: it is not easy to change the way people have done a task for decades!

A quote from the 1939 publication of the Geological Survey of India on the 1934 Bihar – Nepal earthquake says 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.

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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