Need for a national initiative on research and development in earthquake engineering

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The background

Losses in the past earthquakes in India are well documented. However, it may be recalled that:

a. India has not had a great earthquake ($M > 8.0$) since 1950 in the Himalaya. Considering that we had four such earthquakes during 1897 to 1950, such events are quite likely in the near future, and will cause huge disaster not only in the Himalayan region, but also in the major population centres of the Indo-Gangetic Plains. The latter include cities such as Delhi, Kanpur, Patna, etc. Besides Himalaya, there are other potential sources of major earthquakes elsewhere in the country as well.
b. Most earthquakes of recent years (1988 Bihar, 1991 Uttarkashi, 1993 Killari, 1997 Jabalpur and 1999 Chamoli) were moderate ($M \sim 6.5$), and generally occurred away from any major towns. The 2001 Bhuj earthquake ($M \sim 7.7$) clearly gave an indication of what lies ahead in case our buildings continue to be built as at present: 135 modern multistorey buildings collapsed in Ahmedabad located about 240 km from the epicentre. Clearly, Indian construction practices leave much to be desired in general, and with respect to aseismic provisions in particular.
c. Many South American countries (such as Peru) also have substantial earthquake problems due to unsafe constructions. However, even in these countries the engineers and architects are generally competent and constructions by them (for upper strata of the society) tend to be safe. On the other hand, in India a huge percentage of new constructions in the formal construction sector carried out by engineers and architects tends to be unsafe.

Considering the above, the extent of losses in the past Indian earthquakes may not be directly extrapolated for the future. The country has a much larger potential for losses in the event of a strong earthquake occurring in the Himalayas or close to a large city, and our cities are growing at an unprecedented pace. This point is well accepted in the knowledgeable circles.

The road to earthquake safety

In order to address the issue of earthquake safety, the country must initiate actions that lead to improvement of constructions on the ground. Unless this happens, every other exercise (capacity building, research, zonation and microzonation, modifications in bye-laws) will be of no consequence[1]. Improvement in our constructions requires the following:

Community awareness: The public should be aware of the risks, ways to reduce the risk, and demand safe constructions.

Legal framework: Clear framework on legal responsibilities in case of unsafe constructions and non-compliance with codes is needed.

Technical competence: Different players in the building industry should be competent to execute safe constructions; these include architects, structural engineers, construction engineers, contractors, masons and others.

Professional ambience: Only competent personnel should be allowed to execute the construction projects. For instance, we need competence-based licensing of engineers and other building professionals, and certification of masons.

Enforcement: The local civic bodies (municipalities) must enforce code compliance in all construction projects within their jurisdiction.

Research and development (R&D): Substantial gains towards safety agenda can be made with a focussed and appropriate research and development effort. This has been done in India itself after the 1897 Assam and 1935 Quetta earthquakes. R&D needs are elaborated further in the following section.

Research and development needs

Unlike other areas of science and technology, where India can borrow technology from overseas, earthquake engineering requires considerable indigenous R&D effort in view of the uniqueness of our construction typologies. Solutions that work elsewhere may not be suitable for our construction industry due to the usage of different building materials, climatic conditions and living habits.

While the country has been putting in substantial efforts in research towards earth science and seismology (the science of earthquakes), relatively less attention has been paid to engineering research to tackle earthquake risk (engineering to prevent earthquake disasters). As a result, currently the R&D base of earthquake engineering in India is weak, considering the needs of a large country like ours. Some of the problems that need to be urgently undertaken are listed in the following: this is an incomplete list and is meant to only give an idea of the range and type of research problems.

a. Development of new building typologies and technologies that are inherently better in responding to earthquakes. This was done in Assam after the 1897 earthquake, wherein a new Assam-type housing was developed, and in Quetta after the 1935 earthquake, wherein a new type of masonry (Quetta bond) had evolved.
b. Research on design aspects and codal issues, development of codes of practice, the next generation model-codes, supporting explanatory handbooks, etc. For instance, development of seismic design methodologies for constructions specific to our country, e.g. reinforced concrete-frame buildings with brick infill walls.
c. Technology verification tests on full-scale and large-scale models. This will require substantial investments in our laboratories.
d. Development of seismic retrofitting technologies and technology verifications on full-scale models for Indian construction typologies.
e. Geotechnical earthquake engineering problems such as site effects and seismic design of well foundations. Well foundation is a rather unique system used in India for bridge foundations and hence research on this

system cannot be expected from other developed countries.

f. Seismic hazard assessment, including development of attenuation relations appropriate for our geological conditions, development of modern zone maps, etc. The current seismic zone map (IS1893-2002) is an ad-hoc revision of the 1970 zone map. A comprehensive exercise needs to be taken up for developing a probabilistic zone map. Currently, substantial effort in the country is being made towards seismic microzonation; however, microzonation cannot be effective till a good zonation has been done.

g. Assessment of vulnerability of Indian buildings and infrastructure. We need to know how vulnerable are the building typologies used in different parts of our country.

h. Development of methodologies for vulnerability assessment (ranging from crude but rapid to detailed) of different types of buildings in our country.

i. Seismic risk studies for our cities. We need to develop answers to questions such as: what is the likely loss scenario in Delhi (or Guwahati, or Meerut or Chandigarh) in terms of loss of life and in economic terms that has a 10% probability of occurrence in the next fifty years.

Besides research problems such as the above, we need a focused effort towards technology transfer to the profession and training of professionals. Hence, outreach efforts should be an integral part of the R&D agenda.

The challenges

The research infrastructure for earthquake engineering in India is rather weak. Just as an example: the country has too few shake tables, geotechnical centrifuges, and pseudo-dynamic test facilities for research in earthquake engineering. Moreover, one hardly sees in scientific journals any experimental research coming out of such experimental facilities. Further, the currently available experimental facilities in our country are too modest when compared to other countries, including those which started earthquake engineering research more recently (e.g. Singapore, Korea).

Trained and highly skilled manpower in earthquake engineering in the country is limited. It is reflected in the fact that only a few specialists of earthquake engineering have to be called upon to participate in most of the meetings! A large country like ours needs much larger numbers of highly trained and motivated experts in earthquake engineering.

Clearly, our educational institutions and R&D laboratories do not have enough capacity to absorb a large amount of funding to tackle the current R&D needs of the country. In other words, research effort and the capacity building have to go hand in hand. As more expertise is developed and more institutions and centres start to show results, more funding can be earmarked and further substantial research problems could be taken up. Thus, we need a twenty-year focused effort for research in earthquake engineering.

The proposal

To address the above situation, a comprehensive National Initiative on Research and Development in Earthquake Engineering should be launched. This should involve creating a dedicated funding that will increase with time (as the capacity to undertake research projects improves). Further, individuals and research groups that do not have much past track record of undertaking relevant research may be assigned small grants liberally, realizing fully well that not all of them will be successful. Those who do well could then be assigned larger grants. A National Committee on Research in Earthquake Engineering may be formed to manage and monitor the Initiative. A similar effort was launched by the Ministry of Human Resource Development (MHRD) in March 2003, focusing on earthquake engineering education and has shown exemplary results[2]. The National Programme on Earthquake Engineering Education (www.nicee.org/npeee) of the MHRD is managed by a Programme Implementation Committee (PIC), chaired by one of the IIT Directors and consisting of representatives from the seven IITs, IISc, engineering colleges, institutions of architecture and polytechnics. One of the IITs acts as the secretariat and provides overall coordination. A somewhat similar management structure may be appropriate for the research initiative as well.

Table 1 indicates a suggested budget for the first five years of the proposed programme, wherein a large number of small grants are awarded and those with good track record are gradually assigned larger projects. For instance, projects of value up to Rs 50,000 could be effective in conducting training programmes and capacity building activities. It is expected that the budget needed after the first five years will be substantially larger, depending on the experiences gained in the interim.

Table 1. Suggested budget in the first five years (significantly larger budget may be provided as the capacity for research and development improves)

Range of research and outreach grants	Number of grants	Total amount (lakh Rs)
Up to Rs 50,000	250	100
Rs 50,000 to 200,000	100	100
Rs 200,000 to 1,000,000	50	250
Rs 1,000,000 to 5,000,000	20	400
Rs 5,000,000 and above	10	2000
	Total	2850

Concluding remarks

It may be recalled that the initiatives to develop new building typologies after the 1897 and the 1935 earthquakes were need-driven and led by the local professional engineers (and not by academics or researchers). This was possible due to the urgency and the facilitating environment that happens in the wake of a major disaster. In the absence of such an environment (human memory of disastrous earthquakes is rather short), it will be a challenge to keep the agenda of R&D on the right track. One will need to focus on quality rather than the quantity: earthquake risk is something that takes decades to effectively address.

1. Jain, S. K., *Curr. Sci.*, 2005, **89**, 1464–1466.
2. Jain, S. K. and Agrawal. P., In Proceedings of the 13th World Conference on Earthquake Engineering, Vancouver, Canada, August 2004.

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