Historical Developments in India Towards Seismic Safety and Lessons for Future

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ABSTRACT:
The Indian subcontinent has been the setting for some of the largest earthquakes of the world. The subcontinent has also contributed to many of the early developments in science and engineering of earthquakes. For example, after the earthquakes of 1897 and 1935, some very effective new technologies emerged locally for house construction that have stood the test of time. However, notwithstanding these early developments, the present scenario is quite alarming as numerous buildings continue to collapse in earthquakes in India due to use of vulnerable building typologies and lack of building code enforcement. The paper outlines some historical developments and their impact on the risk reduction agenda. It shows that tremendous progress has been made in recent years towards awareness and capacity building, but this remains woefully inadequate considering the aspirations of a country striving to be a world leader economically and otherwise. The seismic risk reduction work will gain tremendously if we shift some of the attention from "earthquakes" to the "construction". A robust enforcement system is needed for constructions in the formal sector, and new building typologies must be developed that are inherently better against earthquakes. The former is really an issue of governance, while the latter requires massive R&D initiative towards "engineering for earthquakes" and a vibrant communication and disseminations system.

KEYWORDS:
Indian earthquakes, seismic safety, historical developments, earthquake resistant construction, risk reduction

1. INTRODUCTION

Some of the biggest earthquakes of the world have occurred in the Indian subcontinent. For instance, during the period 1897 to 1950, India witnessed four earthquakes of magnitude 8.0 or greater. Several earthquakes in the subcontinent have led to huge losses of life; the 1935 Quetta earthquake in Baluchistan in present-day Pakistan, for example, caused deaths of almost 50% of about 50,000 population in the town of Quetta.

The earthquakes of the late 19th and early 20th century triggered a number of early developments in India towards science and engineering related to earthquakes. In that respect, India used to be somewhat at the forefront in this field until a few decades ago. The institutionalization of earthquake engineering in the country took place as early as the late 1950s and early 1960s. Notwithstanding these early developments, the death toll in Indian earthquakes remains high (Jain, 2005). In fact, in view of increased construction activity and a booming population, the earthquake risk in the country has been growing at a fast pace.

This paper reviews briefly some of the historical developments in India and their impact (or lack of it) on the earthquake-risk reduction agenda in the country. It discusses the current status of seismic vulnerability and explores the possible reasons that may have contributed to the lack of adequate progress towards risk reduction. The paper concludes with an outline of some of the urgent tasks ahead in order to make substantial progress.

2. EARLY SCIENTIFIC DEVELOPMENTS IN INDIA

Studies and documentation of damaging earthquakes in India date back to two centuries. Lt Baird Smith studied several early earthquakes in India and wrote articles about them in the Journal of the Asiatic Society of Bengal. The Kutch earthquake of 1819 (M8.3) created a fault scarp about 100 km long and 3 m high (named Allah Bund:

embankment created by God); it provided the earliest clear and circumstantially described occurrence of faulting during earthquakes (Richter, 1958). During this earthquake, it was learnt that the buildings on rock sites generally perform better than those on the alluvium (an observation of what today is called a "site effect" in scientific terms). For instance, buildings situated on rock were not by any means so much affected ….as those whose foundations did not reach to the bottom of the soil (MacMurdo, 1824).

Thomas Oldham, the first Superintendent of the Geological Survey of India (GSI), carried out investigations of the Cachar earthquake of 1869. He compiled the earliest earthquake catalog for the Indian subcontinent, which was later completed by his son R.D. Oldham who succeeded him as Superintendent of the GSI. R. D. Oldham carried out a very notable study of the 1897 Assam earthquake (M8.7) and his memoir (Oldham, 1899) was considered by Richter (1958) as one of the most valuable source books in seismology.

R. D. Oldham and his colleagues took great care to describe in detail the intensity of shaking over a wide area. They recorded clear evidence that widespread warping and faulting of rocks deep below the surface produced the earthquake. He inferred the ground velocity in the shaking and used instrumental measurements to assess ground uplift. The descriptions of 1897 Assam earthquake by Oldham provided the principal model for the highest grade, XII, of the MMI Scale (Richter, 1958). It was Oldham's study of seismographic recordings of the Assam earthquake that for the first time revealed the existence of three distinctive types of waves, thereby laying a key foundation of modern seismology. The first seismograph in India was installed in 1898 at the Bombay Observatory.

In the GSI report of the 1934 Bihar – Nepal earthquake (GSI, 1939), S. C. Roy, Director of the Meteorological Department in Burma, contributed an important seismological chapter. He gave a detailed interpretation of various seismic waves through the crust of the Earth, and from readings of their arrival times at Indian and other seismographic observatories he located the epicenter of 1934 earthquake. Roy was also one of the first to count the frequency rate of aftershocks using records at a seismograph station. Because the number fell from 200 to 16 in a month he concluded that the crustal strain had been relieved completely.

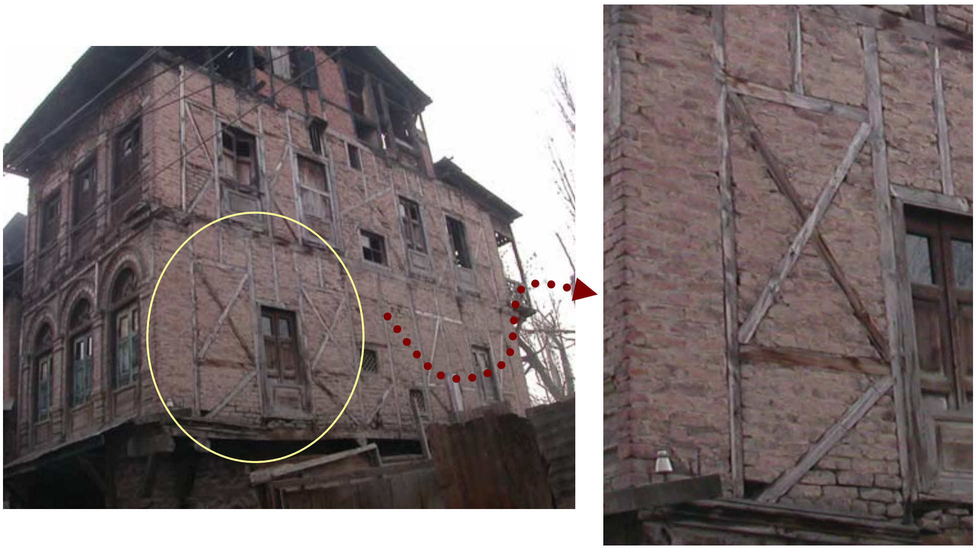

Figure 1: Dhajji Diwari building in Srinagar; overall view and close up showing timber confining members in masonry wall

3. EARLY DEVELOPMENTS ON SAFE CONSTRUCTIONS IN INDIA

India not only witnessed early developments towards the "science of earthquakes" but several early developments also took place in the subcontinent towards "engineering for earthquakes" in the form of safer constructions with earthquake resistant attributes. Figure 1 shows one of the construction typologies that became prevalent in Srinagar area (in Jammu and Kashmir), known as Dhajji Diwari. This construction uses burnt-clay brick masonry that is confined in small panels by the surrounding horizontal, vertical and diagonal timber elements. Dhajji Diwari type buildings have consistently shown superior behaviour in earthquakes. It is surmised that this typology may have emerged in the area after one of the damaging earthquakes of the 18th or the 19th century, considering that one does not see such constructions elsewhere in Kashmir; even Muzaffarabad located only about 130 km from Srinagar does not have any buildings of this type.

In the 1897 Assam earthquake, areas within a radius of about 500 km suffered serious damage (the comparable area of radius was 10 km in the 1993 Latur earthquake). In the area around Shillong, all the stone buildings were leveled to ground, about half of the "ekra-type" buildings (wooden frame work with walls of san grass covered in plaster) collapsed due to heavy stone chimneys, while the plank buildings constructed on the "log hut" principle did well. This earthquake led to the development of "Assam Type" housing (Figure 2), which later became prevalent in the entire north-eastern region of India. This building type has shown outstanding performance in earthquakes over the last one hundred years, although it is now being phased out in favour of reinforced concrete and masonry buildings of questionable quality.

Figure 2: "Assam Type" housing in Shillong

Another noteworthy example of safer constructions in the subcontinent is from Baluchistan. The 1931 Mach earthquake in Baluchistan made the railway officials decide to build a few "earthquake resistant houses" for railway officers in Quetta. A young railway engineer, S. L. Kumar, constructed these houses and published his understanding of earthquake engineering and described these earthquake resistant constructions in an article (Kumar, 1933; Jain and Nigam, 2000; Jain, 2002). Kumar also went on to present a first seismic zone map of India in this article and proposed design seismic coefficients for different zones. These houses built by Kumar were the only constructions in Quetta to survive the 1935 earthquake (M7.6) in which about 25,000 persons lost their lives. Thanks partly to the testimony to good engineering provided by these railway quarters, for the first time in the subcontinent seismic design codes were developed and adopted for the reconstruction programme by the army, the railway and the civil authorities (Thomson, 1940; Robertson, 1948). In fact, during the reconstruction programme, a new masonry bond termed as "Quetta Bond" was developed wherein it became possible to provide vertical reinforcement in the masonry.

That the post-1935 developments in Quetta were greatly influenced by the successful demonstration by Kumar's "earthquake resistant constructions" becomes obvious that elsewhere in India, another large earthquake around the same time did not lead to earthquake-resistant reconstructions. For instance, the GSI report on the M8.4 Bihar – Nepal earthquake states the following (GSI, 1939):

> "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."

4. DEVELOPMENTS POST-INDEPENDENCE, UP TO THE EIGHTIES

A. N. Khosla, an eminent engineer in the Punjab Irrigation Department started his career in 1916 with the surveys and investigations for the Bhakra dam project site. During his long career, Khosla was deeply involved in the Bhakra dam project until its completion in 1963. The dam is located in a highly seismic region, not too far from the site of the 1905 Kangra earthquake (M8.0) in the Himalaya and it is reasonable to expect that he was confronted with the challenges posed by earthquakes to engineering structures. While serving as Chairman of the Central Waterways, Irrigation and Navigation Commission (now, Central Water Commission) during 1945 to 1953, and as Chairman of the Central Board of Geophysics, Khosla was instrumental in organizing the seminar on the Great Assam-Tibet earthquake of 1950 (M8.7) (Rao, 1953). In his preface in the proceedings of the conference, Khosla said: “The seismological work in India has not so far received adequate attention and when compared with Japan, USA and some other countries, it is lagging far behind……the science of geophysics, although a new comer in the field, has vital bearing on many aspects of our development plans, engineering, industrial and agricultural.”

Khosla was Vice Chancellor of the University of Roorkee during 1954 to 1959 and had an opportunity to visit the California Institute of Technology (Caltech) in USA in 1957. He saw first-hand the ongoing work there in earthquake engineering, and worked out a collaboration arrangement with Caltech to establish the discipline of earthquake engineering at the University of Roorkee (now the Indian Institute of Technology Roorkee). He subsequently put in action a viable plan to develop laboratories and establish post-graduate teaching at Roorkee in the subject. Under his plan, Professor Jai Krishna, a faculty member at Roorkee in structural engineering, was sent to Caltech for several months to learn earthquake engineering and on his return Professors D. E. Hudson and G. W. Housner of Caltech visited Roorkee for about six and two months, respectively. This collaboration led Roorkee to host the first “Symposium on Earthquake Engineering” in 1959, and start teaching of structural dynamics. In the year 1960, a School for Research and Training in Earthquake Engineering (SRTEE) was established at Roorkee. Under Jai Krishna’s leadership, the first national seismic code (IS1893, 1962) was published by Indian Standards Institute (now, Bureau of Indian Standards) in 1962. He also formed the Indian Society of Earthquake Technology in 1962.

Thus, the institutional developments towards earthquake engineering in India were in place rather early, by the late fifties and early sixties. The Earthquake School at Roorkee provided consultancy services for numerous major projects such as nuclear power plants, dams, and major bridges in seismic regions.

The 1967 Koyna earthquake (M6.5), in an area considered non-seismic at that time, killed about 200 persons and caused substantial structural damage to Koyna dam. The event clearly showed the importance of the earthquake engineering discipline for India, which had not otherwise experienced significantly damaging earthquakes since 1950. And, it regenerated interest in supporting the Earthquake School at Roorkee.

One of the interesting projects Roorkee carried out in collaboration with Professor Hudson was to develop and install several hundred Structural Response Recorders (SRRs) (Cloud and Hudson, 1961; Krishna and Chandrasekaran, 1962) in seismic regions of the country. The SRR consists of six seismoscopes (natural periods: 0.40, 0.75, and 1.25sec; damping: 5% and 10% of critical) to measure the horizontal motion. These oscilloscopes together provide three points on the 5% response spectrum and three points on the 10% response spectrum. The SRRs are not only inexpensive instruments, but also require no maintenance; these do not operate on electricity or battery. In case of damaging earthquakes, SRRs have not only supplemented the information about strong ground motion obtained from modern strong motion accelerographs (SMAs), but in some instances (e.g., Bihar 1988, and meizoseismal area of 2001 Bhuj earthquake) SRRs have provided the only recordings in the absence of modern SMAs (e.g., Jain et al., 2000; Chandra, 2002).

In the 1970s, the Department of Science and Technology of the Government of India established the “Himalayan Seismicity” programme under which a substantial number of research projects on seismology have been supported over the years, giving a positive impetus to the “science” of earthquakes. The Programme also provided funding for strong motion instrumentation in some of the high seismic regions of the country, and a few engineering projects, such as the development of the shake table at Roorkee. Unfortunately, research support towards “engineering for earthquakes” has not been commensurate.

In the above scenario, and in the absence of any damaging earthquakes from 1967 to 1988, the engineering of earthquakes tended to stagnate. Besides Roorkee, other academic institutions remained aloof from earthquake engineering. There were no serious efforts to bring the professional engineers within the ambit of earthquake safety, and the professionals tended to view earthquake safety as something for the specialists to address. The Indian seismic codes remained only “recommendatory in nature” and legally were not mandatory for routine buildings. In fact, the development of the code itself started to stagnate, as can be seen from the fact that the main earthquake code IS1893 first published in 1962 was revised in 1966, 1970, 1975, and 1984. The work on revision of 1984 version has been going on for the last more than twenty years and part I of the code was released only in 2002 while some of the other parts of this code are yet to be published.

With rapid expansion of India’s economy over the years and an erosion in the quality of governance at different levels, the construction environment itself deteriorated. Poor quality of design and construction became the routine rather than the exception. Efforts towards regulating the engineering profession through competence-based licensing of engineers have not made much headway, and an “Engineers Bill” has now been talked about for more than two decades.

5. DEVELOPMENTS IN RECENT YEARS

The 1980’s and 90’s saw two developments in India. One was a matter of chance that nature plays with regard to earthquake occurrence, and the other was coincidental. Starting with the 1988 Bihar-Nepal earthquake, moderate (magnitude 6.0 to 7.0) and large (magnitude exceeding 7.0) earthquakes have been occurring in India every two to three years (e.g., 1991 Uttarkashi, 1993 Latur, 1997 Jabalpur, 1999 Chamoli, 2001 Bhuj, 2004 Sumatra Earthquake and Tsunami, and the 2005 Kashmir). Around the same time, many young Indian academics, trained in the US and elsewhere in structural dynamics and earthquake engineering, returned to India and joined some of the Indian Institutes of Technology as structural engineering faculty. It was a matter of coincidence that even though the leadership at these institutes was not looking explicitly towards developing earthquake engineering as a discipline and these academics were hired to teach traditional structural engineering, this younger group of faculty started to make significant contributions in developing earthquake engineering in the country.

For instance, substantial work was undertaken at IIT Kanpur towards code development starting in the mid eighties, leading to a new code on ductile detailing of reinforced concrete buildings (IS13920, 1993). In the year, 1992 a massive continuing education programme was undertaken by IIT Kanpur faculty on “seismic design of reinforced concrete buildings” to disseminate the correct concepts of earthquake resistant design to the professional engineers (e.g., Jain and Murty, 2003). Systematic reconnaissance studies have been conducted, often with support from the “Learning from Earthquakes” project of the Earthquake Engineering Research Institute (EERI), and findings widely disseminated by publishing papers and reports on all damaging earthquakes starting in 1988 by the group at IIT Kanpur. Later, this brought more and more institutions into the post-earthquake reconnaissance studies.

Colleagues from most of the IITs and other institutions and industries, gathered at Kanpur in 1996 for a 3-day discussion workshop and identified the issues that need to be tackled for teaching of earthquake engineering to undergraduate and postgraduate engineering students (Murty et al., 1998). The workshop articulated the need for a national information centre which will help bring latest literature in earthquake engineering to the academics and professionals in the country. It also articulated the challenges faced by the academic institutions in pursuing more vigorous teaching and research in earthquake engineering. The workshop at Kanpur laid the foundation of two extremely successful capacity development programmes in the country: the National Information Centre of

Earthquake Engineering (NICEE) (www.nicee.org), and the National Programme on Earthquake Engineering Education (NPEEE) (www.nicee.org/npeee).

As a follow up to the recommendation of the 1996 workshop, a concept proposal was developed in 1997 for NICEE and fund-raising efforts started. By the time of 2001 earthquake, an endowment corpus of Rs 5 million (~ US 120,000) had been raised. The ~ 14,000 deaths in 2001 Bhuj earthquake created unprecedented awareness amongst professionals, academics and the general public, and NICEE was poised to kick start its activities in a very receptive environment. Currently, NICEE has been leading a number of capacity building activities by publishing and disseminating information, and by sensitizing students, academics and professionals.

The deliberations of the 1996 Kanpur workshop also enabled this group of academics to work with the Government of India to develop the National Programme of Earthquake Engineering Education. Under the NPEEE, more than 1,400 teachers of engineering colleges were trained by the seven IITs and the IISc Bangalore faculty, and tremendous capacity building took place in the country through a variety of activities (Jain and Agrawal, 2004). As a result of the above activities, a large number of engineering colleges in India now teach earthquake engineering in their curriculum. Many architectural colleges too are now providing some coverage to the subject.

The following activities towards sensitizing the architectural community are listed just to indicate the type of interventions by NICEE and NPEEE (some are funded by NPEEE and executed by NICEE):

a) About 40 one-day seminars all over the country for professional architects on seismic safety by the Indian Institute of Architects (IIA), at the behest of NICEE and with funding from Government of India and the industry.
b) Development of a model curriculum for the undergraduate architectural students through a national brain-storming workshop.
c) Development of ~600 Power Point slides with notes (Murty and Charleson, 2006) for covering the 27 lectures of the model curriculum developed in b) above. These are available at nominal charge in soft and hard copy format so that the faculty of architecture could teach these topics.
d) Development of an Indian version of RESIST software by Professor Andrew Charleson of New Zealand for use by students in India. The programme enables a student to get a rough idea of the sizes of frame elements or shear walls needed for a building design project, given the wind and seismic zones in which the building is located. It is an excellent tool to sensitize the students to start thinking of adequate structural sizes while planning the building, and has been distributed to most of the architectural colleges in India.
e) A number of training programmes in earthquake engineering of one-week duration for the teachers of architecture.
f) Free mailings of “IITK – BMTPC Earthquake Tips” (Murty, 2007) to about 10,000 professional architects in India. Subsequently, inclusion of the Tips in the professional directory of the IIA, so that every architect member of IIA will have the Tips readily available on his or her book shelf.
g) Participation by NICEE in an annual national convention of architectural students (~5,000 students gathering) where NICEE set up a stall, distributed ~1000 copies of Earthquake Tips free of charge, and conducted an Earthquake Quiz with cash prizes. Similar participation in the SAARCH convention in Delhi in March 2008.
h) A one-week workshop at IIT Kanpur for the architectural students from across India, which aims to sensitize them in earthquake resistant design practices through technical lectures followed by design studios (http://www.nicee.org/Architecture_Report/Arch_Workshop_Report.htm). The students were given guidance in earthquake resistant design by working on an architectural design project.

The 2001 earthquake and a receptive state government in Gujarat enabled small-scale pilot activities in Gujarat before these were scaled up for rest of India (Sheth and Jain, 2002; Jain and Sheth, 2002; Sheth et al., 2004; Jain, 2004; Jain et al., 2004). The Bhuj earthquake caused enough concern that many state governments and cities made the compliance of seismic codes mandatory for the first time. Gujarat also showed the way forward by supporting a number of important projects, e.g., the first state-of-the-art microzonation of an Indian town (Gandhidham) which could in due course become a model for the indigenous efforts, and the IITK-GSDMA Project on Codes (http://www.nicee.org/IITK-GSDMA_Codes.php) wherein a lot of work was done on codes, commentaries and explanatory handbooks for earthquake, wind and fire. Under this project, not only several existing seismic codes could be revamped, but a number of new codes/ guidelines were also developed for the first time:

a) Structural use of reinforced masonry
b) Seismic evaluation and strengthening of existing buildings
c) Seismic design of buried pipelines
d) Seismic design of earth dams and embankments
e) Guidelines on measures to mitigate effects of terrorist attacks on buildings

The regular occurrence every two-three years of damaging earthquakes since 1988 has also had its impact on how the Government of India deals with the disasters. After the 1999 Chamoli earthquake, Government of India formed a “High Power Committee” to look into the issues of disasters and make recommendations. After the 2001 Bhuj earthquake, the subject of natural disasters was moved from the Ministry of Agriculture to the Ministry of Home Affairs, and after the 2004 Sumatra earthquake and tsunami, the National Disaster Management Authority (NDMA) was formed. Ministry of Home Affairs has supported a number of training programmes under the National Programme for Capacity Building of Engineers and Architects in Earthquake Risk Management (NPCBEERM). Since its formation about three years ago, NDMA has issued guidelines on several disasters, including earthquake. It is however too soon to say how effective the NDMA will be in terms of implementation of safety programmes.

6. AREAS OF CONCERN

All developments in earthquake engineering need to be viewed as to the impact that they make on promoting safety of the built environment. Hence, a valid question remains: Is the seismic risk in India now declining with time or does it continue to grow? Even if the percentage of vulnerable buildings remains constant with time, the overall earthquake risk would anyway continue to grow due to population increase (more population is at risk) and/or due to growth in the built-up area (more number of buildings at risk). Hence, one could take the most liberal view in the first instance and rephrase this question as: Is the seismic risk-per-capita, or seismic risk-per-sq.m of built up area now declining? Unfortunately, notwithstanding the tremendous amount of work in recent years, the answer to this question is not very encouraging. Indeed, the seismic risk in the country continues to grow regardless of how one poses this question. Our current design and construction practices continue to encourage more and more vulnerable buildings in our small and large towns. In fact, unlike some other developing countries, in Indian scenario even with the “engineered constructions” wherein architects and engineers are formally involved one cannot be sure of the safety standards.

There is inadequate perception of risk in the engineering community and there is too little in the form of leadership in the practicing engineering community to take the agenda of earthquake engineering forward. The compliance with seismic codes, even though better now than was the case ten years ago, still remains fairly poor in the absence of any enforcement system. What is of more serious concern is that there seem to be no active agenda at this point of time for effective enforcement to ensure safe constructions.

One of the major challenges ahead is to recognize that the problem is really not the occurrence of earthquakes, as it is of unsafe construction. Too many decision makers, including many scientists and engineers, continue to put too much focus on the “earthquake” (the “science”) and too little on the “construction” (the “engineering”). Unless the construction as an activity and as an industry improves substantially, there is not much that will be gained from all the scientific efforts. For instance, for about the last ten years, there has been too much emphasis on “seismic microzonation” of Indian cities, notwithstanding the facts that (a) even the Indian seismic zone map is very obsolete and a rational probabilistic zone map is urgently needed, and (b) it is not clear how the microzonation will ensure that people will build their houses differently after such maps become available.

Enforcement of the codes indeed remains a major challenge since it is the most important step in the direction towards safety. However, enforcement alone is not enough, considering that in a country like India only a small proportion of the population lives in the urban areas regulated by the municipal system. In order to provide safe construction for the masses, more robust building types are needed that are inherently stronger against earthquakes. The Assam-type houses (that evolved after the 1897 Assam earthquake) and the timber houses in the Andaman and Nicobar Islands (that evolved after the 1941 earthquake) are now being phased out by highly vulnerable masonry and reinforced concrete buildings. While it is understandable that the local population aspire to live in more modern houses made of concrete and bricks, it should be possible for the professionals and researchers to develop safe building construction typologies with these materials, e.g., the Confined Masonry (Brzev, 2008).

Developing new building typologies must remain a very high priority for a country such as India but continues to remain ignored. A correction to this situation will require a major shift in the concepts and attitudes of the leaders in science and engineering in India, so that just as substantial R&D funding has been available for the “science” of earthquakes, a similar focus is also placed on research towards “engineering” of earthquakes (e.g., Jain, 2007).

Earthquakes being low probability – high consequence events, there is always the challenge of who owns the problem: is it the safety activists, the academics, or the government bodies? In recent years, the ownership seems to be moving somewhat towards the government, with the NDMA having been formed with the specific agenda of disasters. This is also visible in the form of newspaper and television advertisements targeted at safety that have been sponsored by NDMA. However, it is still not clear if some of the concerned Ministries do feel the ownership of the tasks that come within their domain; because after all, NDMA will ultimately have to act as a coordinating agency between different ministries and organizations.

7. CONCLUDING REMARKS

India has made a lot of progress towards awareness and capacity-building, and this is particularly visible when one compares the situation with respect to other developing countries in general and with the neighbouring countries of the subcontinent in particular. However, if India were to be measured against its aspirations of counting amongst the world’s leading countries and economies, our progress has been grossly inadequate. Our seismic risk continues to grow, that is, we are continuing to add more unsafe buildings to our already existing unsafe building stock every day.

Besides the “violence” of earthquakes that gave impetus to earthquake engineering, several “peace time” events too have been critical for its growth, e.g., A. N. Khosla being at the right time at the right places, the young academics that joined the IITs to teach structural engineering but happened to have their specialization in earthquake engineering, and the 1996 workshop at Kanpur which inadvertently laid the foundation for NICEE and NPEEE.

The rather frequent occurrence of damaging earthquakes on the one hand, and the coming together of some of “happy” coincidences mentioned earlier, have together contributed to real progress. The window of opportunity for actions and implementation provided by damaging earthquakes is rather short, and if some activities are planned ahead and the road map for them is clearly chalked out, it becomes much easier to seek funding and implement such activities in the immediate aftermath of a damaging earthquake when the ground conditions are most favourable.

Two most urgent and important agenda items ahead for the country are: a) enforcement of codes which is closely connected with the quality of governance, and b) developing and inducting new building typologies which requires vigorous research, communication and dissemination effort. The National Programme on Earthquake Engineering Education (NPEEE), wherein the eight premier engineering institutions have worked together as a cohesive team, clearly shows that support and empowerment in the right manner can bring about real progress.

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