Some Innovative Education and Outreach Projects in India for Earthquake Risk Reduction

Sudhir K. Jain and C. V. R. Murty

Indian Institute of Technology Kanpur

INTRODUCTION

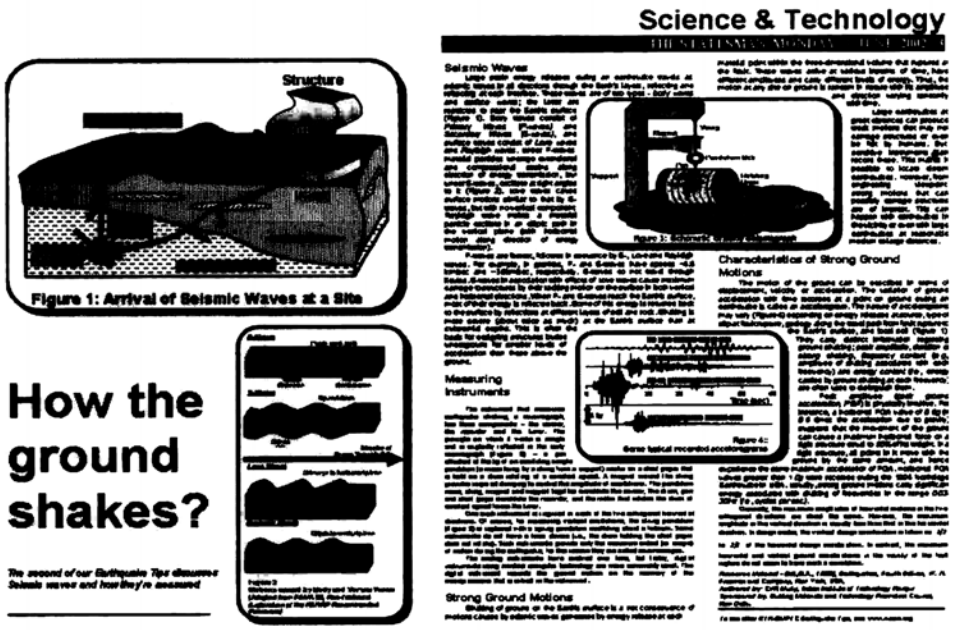
The Indian earthquake problem is well known. About 60% of India's land area is considered prone to shaking of Modified Mercalli intensity VII and above (IS:1893–2002). In fact, the entire Himalayan belt is considered prone to great earthquakes of magnitude exceeding 8.0, and in a span of 53 years, four such earthquakes occurred: 1897 Assam, 1905 Kangra, 1934 Bihar-Nepal, and 1950 Assam-Tibet (Table 1). As seen in Table 1, there have not been any M > 8.0 earthquakes in India since 1950. However, a very large number of deaths occurred in the M 6.4 Latur (1993) and the M 7.7 Bhuj (2001) earthquakes. Of these, the Latur earthquake occurred in an area considered aseismic and placed in the lowest seismic zone (zone I; prone to intensity of shaking V or less on the MM scale) at that time (IS:1893–1984). These examples clearly underline the huge earthquake risk that most parts of the country face.

Earthquake engineering developments started rather early in India. For instance, development of the first seismic zone map and of earthquake-resistant features for masonry buildings took place in the 1930's, and formal teaching and research in earthquake engineering started in the late 1950's (Jain and Nigam, 2000; Jain, 2002). Yet not enough progress could be made toward earthquake risk reduction due to a variety of reasons, including those associated with a typical developing economy (*e.g.*, relatively poor implementation at all levels; priority to provide basic amenities such as food, shelter, and medical care to a huge population). Over the years, no serious efforts were made to involve professional engineers in the agenda of seismic safety. As a result, the professional engineers in the country started looking at earthquake engineering as a superspecialty to be tackled by academics and experts. Moreover, only a handful of academic institutes developed interest in earthquake engineering, and the subject matter of earthquake-resistant construction was not introduced into the curricula of civil engineering education (*e.g.*, Murty *et al.*, 1998; Jain and Sheth, 2002). In addition, there were inadequate continuing education opportunities in the country for practicing engineers to learn seismic engineering.

Developing countries tend to have a much wider range of construction types, ranging from dwellings done without

TABLE 1
Significant Past Earthquakes in India

Date	Event	Time (IST)	Magnitude	Max. Intensity	Deaths
16 June 1819	Cutch	11:00	8.3	IX	1,500
12 June 1897	Assam	17:11	8.7	XII	1,500
8 February 1900	Coimbatore	03:11	6.0	VII	Unknown
4 April 1905	Kangra	06:20	8.0	X	19,000
15 January 1934	Bihar-Nepal	14:13	8.3	X	11,000
15 August 1950	Assam	19:31	8.6	XII	1,530
21 July 1956	Anjar	21:02	6.1	IX	115
10 December 1967	Koyna	04:30	6.5	VIII	200
23 March 1970	Bharuch	20:56	5.2	VII	30
21 August 1988	Bihar-Nepal	04:39	6.6	IX	1,004
20 October 1991	Uttarkashi	02:53	6.4	IX	768
30 September 1993	Killari (Latur)	03:53	6.2	VIII	7,928
22 May 1997	Jabalpur	04:22	6.0	VIII	38
29 March 1999	Chamoli	00:35	6.6	VIII	63
26 January 2001	Bhuj	08:46	7.7	X	13,805



▲ **Figure 1.** Example of Earthquake Tip in a Newspaper.

any engineering input using the most traditional materials to the most modern multistory buildings. This adds an additional challenge to the problem of earthquake risk reduction in such countries. A majority of deaths and injuries during earthquakes in such countries are caused by nonengineered dwellings; hence, at times the issue of earthquake engineering at the higher end of spectrum is missed out.

Damaging earthquakes provide an opportunity to make progress toward earthquake risk reduction. The government and the decision makers are generally much more receptive to the issues of earthquake safety *after* the tragic event. Not much progress was possible even at such times, however, due to lack of adequate quantity and quality of manpower needed for carrying the initiatives forward.

Clearly, human resource development (HRD) is the most crucial and important element for earthquake risk reduction in this scenario. HRD should cover a very wide range: from sensitizing the common man to developing a strong research and development base. The elements should include training of professional engineers, developing capacity in the engineering colleges in this subject, training of trainers, information dissemination, and development of the right professional ambience. For a large country such as India with a population of one billion people, such a task is huge by any standards. This paper discusses a few innovative initiatives in India wherein the two authors have been involved.

EARTHQUAKE TIPS

The project IITK-BMTPC Series on Earthquake Tips was started in early 2002. The Indian Institute of Technology Kanpur (IITK), with sponsorship of the Building Materials and Technology Promotion Council (BMTPC), New Delhi (in the Ministry of Urban Development, Government of India), took up this project to disseminate the basic concepts of earthquake-resistant construction widely through simple language. The project consists of developing twenty-four Earthquake Tips on two A4-size pages of written material with graphics (Figure 1). It is targeted at an educated person interested in building construction. The Tips cover topics such as basic introduction to earthquakes, terminology such as magnitude and intensity, concepts of earthquake-resistant design, and aspects of aseismic design and construction of buildings. One Tip is released every month for publication to all interested journals, magazines, and newspapers. The Tips are also placed at the NICEE Web site (http://www.nicee.org).

The project was targeted at the average civil engineer engaged in design or construction. It was proposed that efforts would be made to develop material such that an interested and educated citizen who is not a civil engineer would also be able to gain some useful information from the Tips. It was expected that the Tips generally would be of interest to professional journals and magazines, and only a lukewarm interest from newspapers in carrying these was anticipated. However, several major newspapers became interested in the Tips and thus the readership included nonengineers as well. Hence, the level of the Tips was brought down marginally by avoiding the use of technical terms. The project has enjoyed a great measure of success: A large number of architecture, construction, and structural engineering journals and many prestigious newspapers are publishing them (Table 2).

Many journals and newspapers had reservations about carrying the Tips on two counts: (a) The tips were not exclusive to them, and their editorial policy generally prohibited articles that were also published by others, and (b) mention of BMTPC as a sponsor of the Tip did not fit in with their pub-

TABLE 2 Periodicals Publishing IITK-BMTPC Series on Earthquake Tips	
Newspaper	**Where Published**
The Statesman	Calcutta, New Delhi, Siliguri
The Tribune	Chandigarh, Delhi
The Hindu	Chennai, Coimbatore, Bangalore, Hyderabad, Madurai, Delhi, Vishakapatanam, Thiruvan-thapuram, Kochi, Vijayawada
The New Indian Express	Bangalore, Bhuvaneshwar, Calicut, Chennai, Coimbatore, Hyderabad, Kochi, Madurai, Mangalore, Shimoga, Trivendrum, Vijaivada, Vizag
Journals and Magazines	
Journal of the Indian Institute of Architects	
Spatio-Economic Development Record	
The Indian Concrete Journal	
Journal of Structural Engineering	
Indian Buildings Congress News	
Journal of Indian Concrete Institute	
The Master Builder	
Indian Construction	
Construction Journal of India	
Builders' Friend	
Civil Engineering & Construction Review	
Construction Materials Purchase	
Bridge and Structural Engineer, ING-IABSE	
New Building Material and Construction World	

lication policy, since sponsored items are generally carried as advertisements. Efforts were made through personal discussions to explain to them the public interest in the project, and it was emphasized that since public funds from BMTPC were used for this project, it is not possible to give exclusive publication rights to any single publication. After sustained discussions, many of the publications agreed to carry the Tips. On the whole, the Tips project has been received extremely well in the country as seen from the response of publishers and readers.

CONTINUING EDUCATION PROGRAMS FOR PROFESSIONAL ENGINEERS

Training professional engineers in earthquake-resistant construction is a huge and perhaps never-ending project. In general, the training needs in the civil engineering profession do not receive the same kind of priority as in other fast-changing areas of technology, say, in telecommunications. It is generally difficult to convince civil engineers that they may benefit from investing their time and money in training. An enormously successful training program in seismic design of reinforced concrete buildings has been conducted by IIT Kanpur for professionals for the last ten years in a number of locations in India and in Nepal and Bhutan (Table 3).

The first of these training programs was of three days duration, conducted at Guwahati (Assam) in October 1992. Encouraged by the response of these participants, it was decided to expand the program by increasing its duration to five days. Also, some programs of different duration and on different topics have been conducted (Table 3). Most of these courses are the self-supporting type, wherein the entire costs are met by the registration fees charged to the participants. However, some courses are supported by a single organization, and in a few instances a professional association or organization manages the course and collects the fees from the participants.

The courses are aimed at civil engineers engaged in design or construction and at senior engineers responsible for directing these activities. While some researchers and engineering college teachers participate in these courses, the courses remain targeted at the limited clientele of professional engineers. This enables the course faculty to remain focused on the type of material that is suitable to the audience. The age profile of the participants ranges from twenty-five years to seventy-plus years. Occasional requests for participation are received from engineering students (undergraduate or postgraduate levels); such persons are generally dissuaded from participating, since without some work experience the course may not be very useful to them. The program has attracted repeat participation from many engineers.

TABLE 3
Short Courses on Seismic Design Conducted by IIT Kanpur Since 1992

Venue	Date	Duration	No. of Participants	Notes
Seismic Design of Reinforced Concrete Buildings				
IIT Guwahati	October 1992	3 days	32	Sponsored by IIT Guwahati
IIT Kanpur	May 1993	5 days	63	
New Delhi	October 1993	5 days	93	
New Delhi	May 1995	5 days	121	
Imphal	October 1995	5 days	57	
Bombay	December 1995	5 days	108	
Bombay	December 1996	5 days	93	
IIT Kanpur	May 1997	5 days	35	For Department of Telecom
Madras	July 1997	3 days	31	For L&T Madras
Kathmandu (Nepal)	December 1997	6 days	25	
IIT Kanpur	June 1999	5 days	58	
Imphal	October 1999	5 days	55	
Bhutan	December 1999	5 days	16	Sponsored by Royal Bhutan Government
Nagpur	December 1999	2 days	82	Managed by Indian Society of Earthquake Technology, Nagpur Chapter
Hyderabad	July 2000	2 days	65	Managed by Association of Consulting Civil Engineers
IIT Kanpur	May-June 2001	5 days	193	
IIT Kanpur	August 2001	2 days	95	Managed by Institute of Engineers (I) Kanpur
Bombay	August 2001	2 days	63	Managed by M/s Epicons, Bombay
Ahmedabad	December 2001	5 days	193	
Jabalpur	January 2002	5 days	161	Sponsored by the Government of Madhya Pradesh
Gandhinagar	May 2002	4 days	26	Sponsored by Government of Gujarat
Seismic Design of Bridges				
IIT Kanpur	November 1998	4 days	36	
IIT Kanpur	September 2000	5 days	53	
IIT Kanpur	October 2002	5 days	68	
Gandhinagar	December 2002	4 days	70	Sponsored by Government of Gujarat
Architectural Considerations in Seismic Design of Buildings				
Kathmandu (Nepal)	April 1998	5 days	24	
IIT Kanpur	August 1998	5 days	18	
Gandhinagar	September 2002	4 days	44	Sponsored by Government of Gujarat

The course objective is to provide the participants with the basic concepts of seismic engineering with emphasis on seismic design and detailing procedures for multistory reinforced concrete buildings. Many of the participants are engaged in design of various other types of structures and request that those also be covered. In order to do justice to the subject, however, the focus is kept on reinforced concrete buildings. It is expected that once a participant has learned the basic concepts of seismic design for reinforced concrete buildings, it will be relatively easy for him to learn about other structures through the self-education process. Most participants are not comfortable with the use of higher mathematics, since they left college many years ago. Hence, the important concepts are explained in physical terms without resorting to complex mathematics.

As a policy, the same two instructors teach the course to ensure good coordination in the technical contents. In some instances, one or two guest lectures are delivered by other resource persons. A bound volume of course notes of about 550 pages is provided to the participants. In addition, before every lecture, they are provided a copy of all transparencies that are used during the lecture. This enables the participants to concentrate on the lectures without trying to note down the information on the projection screen. The participants are encouraged to interrupt the instructor anytime during the lecture with questions or comments. This results in a lot of questions being asked during the lectures and gives constant feedback to the instructors on how the lecture is being received. At the end of the course, every participant is requested to anonymously fill out a questionnaire on the conduct of the course, suitability of the course material, and quality of teaching. These questionnaires are subsequently reviewed carefully by the instructors and useful suggestions incorporated in the next course.

Since 1992, about 2,000 engineers have been trained through these continuing education courses. In numerous instances, some of the participants have subsequently explained how the course has helped them improve their design and construction practices. It was heartening for the authors to see in the small town of Imphal (near the border with Myanmar; in highest seismic zone V) several buildings under construction with correct seismic detailing of reinforcements as a result of the efforts of course participants.

National Programme on Earthquake Engineering Education (NPEEE)

After the Bhuj earthquake (2001) in India, the need to include appropriate components of earthquake engineering in the civil engineering and architecture curricula became obvious to decision makers. Changes in the curricula alone, however, cannot be effective until there are course materials and a sufficient number of qualified teachers in the subject. Hence, a comprehensive National Programme on Earthquake Engineering Education (NPEEE) has been launched in India by the Ministry of Human Resource Development of the Government of India.

The project envisions eight premier institutes of technology in India (the seven Indian Institutes of Technology and the Indian Institute of Science Bangalore) to act as resource institutes to provide training of teachers from colleges of engineering, architecture, and polytechnics. The project includes the following activities:

- Conducting short (one- to four-week) and medium-length (one-semester) training programs for teachers at engineering colleges, polytechnics, and architecture colleges. These courses will also allow participation of a limited number of working professionals.
- Sponsoring a limited number of young teachers for international exposure to work for up to a year in an international environment. This training could be in the form of established courses or as research assignments.
- Providing partial financial support to a large number of teachers to attend international conferences and hence to gain exposure to the international state of the art in this subject.
- Inviting a few international experts to the premier institutions for teaching, research, and long-term collaborations.
- Developing teaching aids, course materials, textbooks, manuals, and commentaries.
- Developing modest teaching laboratories in about ten engineering colleges and strengthening more advanced teaching/research laboratories in the eight premier institutions.
- Providing library resources in earthquake engineering to about one hundred engineering colleges.
- Organizing workshops and conferences to share ideas and sensitize different stakeholders.

The program is open to all recognized engineering colleges/polytechnics and schools of architecture having related academic degrees or diploma programs, irrespective of whether these are government- or privately funded. The program has now been formally sanctioned by the Government of India initially for three years with a budget of about Indian Rupees 137.6 million (about U.S. $3 million). This amount does not include institutional overheads, salaries, buildings, or other infrastructure, since the eight premier institutes are publicly funded. A National Committee on Earthquake Engineering Education (NCEEE) and a Programme Implementation Committee (PIC) have been formed. First meetings of these committees took place in December 2002, and a complete Programme Implementation Programme was chalked out. The funds for the project were released in March 2003, a national workshop was conducted at New Delhi on 5 April 2003 to launch the program, and the first set of training courses under NPEEE commenced in July 2003. The Web site of the program (http://www.nicee.org/npeee) keeps interested persons up to date on NPEEE activities.

National Information Centre of Earthquake Engineering (NICEE)

The engineering of earthquake-resistant construction is rather new, and rapid developments are taking place in this area. Unfortunately, the gap between the international state of the art and that in India has been widening with time. There are several reasons for this. One of the contributing factors is the nonavailability of the latest books, journals, reports, and other materials emanating from other countries to Indian researchers and professionals. This nonavailability is on account of several reasons, for instance:

- Due to a severe resource crunch and the rising cost of international currency vis-à-vis Indian currency, most organizations in the country are not able to maintain the desired level of subscriptions.

- Many earthquake engineering publications come out of numerous societies and associations in different countries, rather than through established book publishers. The libraries are ill-equipped to track down and order such publications.
- The interlibrary loan systems do not work well in Indian libraries. Hence, there is no institutional mechanism through which a professional can access publications available at an academic institution elsewhere in a timely manner.
- Membership in international professional societies is quite expensive for most Indian professionals; these societies provide information on current developments in the field and on availability of new publications, etc.

The National Information Centre of Earthquake Engineering (NICEE) was set up at IIT Kanpur to meet the needs of the country in terms of "information" on earthquake engineering. Need for such a center emerged from a workshop conducted at IITK in October 1996 (Murty *et al.*, 1998). The objectives of NICEE are:

- To keep track of the availability of new publications and other materials in the area of earthquake engineering.
- To create and maintain a decent storehouse of publications and other materials on earthquake engineering.
- To disseminate information about availability of the above material at IITK to interested professionals, researchers, and academicians.
- To make the material available to interested persons in a timely manner.

NICEE was conceived such that only minimal costs are associated with infrastructure development. It provides for nominal but adequate manpower support to enable NICEE to be effective. A large chunk of the budget goes to obtaining the literature and other materials. It was decided to locate publications acquired by NICEE in the main library of IIT Kanpur rather than create a separate library. This offers several advantages: (a) minimal costs of infrastructure since the IITK main library infrastructure is being used, (b) low manpower requirements, and (c) easy maintenance of the acquisitions in the long term.

NICEE is managed by a National Advisory Committee consisting of representatives from different institutions in the country, industries, and individuals. The committee monitors activities of NICEE and advises it on policies and guidelines.

In the proposal for NICEE an annual budget of Rs 1.5 million (about U.S. $30,000 per year) was envisioned, with about 80% of the amount going toward acquisitions. It was suggested that an endowment corpus of Rs 15 million (about U.S. $300,000) be created and the interest income on the same be used for the running expenditures of NICEE. Numerous organizations were approached for funds toward the corpus, and a total sum of Rs 5 million (about U.S. $100,000) was contributed by four organizations (Housing and Urban Development Corporation, Telecom Commission, Railway Board, and Ministry of Agriculture). These funds are kept as a specific-purpose endowment within the overall endowment of IIT Kanpur. Meanwhile, the Board of Research in Nuclear Sciences provided a recurring grant for three years toward NICEE.

While the fundraising activity for NICEE was in progress, its activities were started in a modest way without making a formal announcement of its formation. This gave considerable experience in the system before the formal launce. The occurrence of the M 7.7 earthquake in Gujarat on 26 January 2001 expedited the formal launch of the Centre. Within a few days of the earthquake, the Web site of NICEE was launched (http://www.nicee.org), and NICEE started receiving an enormous response.

In the meanwhile, NICEE formed strong relationships with numerous organizations and individuals around the world, and many have contributed significantly to the Centre by providing their publications or other materials as gifts, *e.g.*, Multidisciplinary Center for Earthquake Engineering Research (MCEER) and Earthquake Engineering Research Institute (EERI) in the USA, New Zealand National Society for Earthquake Engineering (NZSEE), Professor George Housner of California Institute of Technology in Pasadena, and the late Professor N. C. Nigam in India.

With time, the scope of NICEE activities was enlarged. For instance, through an electronic mailing list, interested persons are now being sent information on various related developments. Two major e-conferences have been conducted by NICEE as discussed below.

e-Conferences

To commemorate the first anniversary of the tragic Bhuj earthquake of 26 January 2001, a two-week e-conference on "Indian Seismic Codes" was organized beginning 26 January 2002. The e-conference was free of cost; no registration fee was charged to the participants. About 1,200 persons participated; about 100 persons from about ten countries made about 300 postings during the two weeks. The popularity of the e-conference can be gauged from the fact that during the two weeks of the e-conference, about 220 persons added subscriptions. The conference proceedings have been provided on the NICEE Web site and a summary published in a leading Indian journal (Rai and Sheth, 2002). The conference helped clarify many issues of concern to the participants and also identified many important changes needed in the current Indian seismic codes. For instance, it clearly emerged that the Indian code is too strict in requiring that not more than 50% of the main column reinforcement bars can be spliced at the same location. It was found that this requirement is impractical in many cases and is not insisted on by codes of other seismic countries.

Encouraged by the success of the above, in August 2002 NICEE organized another e-conference, this one of one week's duration on the topic "Professional Issues in Structural Engineering in India." This conference also received an enormous response. Of about 1,600 members in the conference, about 130 members from a dozen countries wrote messages: a good ratio indeed. A great wealth of information on professional issues in structural engineering in India was generated. The e-conference is now leading to several initiatives to help improve professional ambience in the country. For instance, in response to the need articulated in the e-conferences for a forum to discuss and share ideas electronically, a group of engineers has now established a new Web site, Structural Engineers Forum of India, through voluntary contributions (http://www.sefindia.org). The Web site is receiving enormous response.

Earthquake Engineering Review Workshop for Master's Students

After the earthquake of 26 January 2001, many postgraduate students in different universities across the country are pursuing Master's theses in earthquake engineering topics. It was found that many of these students faced two difficulties: (a) Earthquake engineering was a relatively new subject for their university and thesis supervisor, and (b) they may not have good access to the published literature on their thesis topics. Considering the importance of capitalizing on this interest in earthquake engineering in the colleges, it was decided to initiate an annual review workshop at NICEE at IIT Kanpur. The workshop aims to enable such Master's students to conduct literature surveys for their theses. Apart from the literature surveys, the students are shown state-of-the-art equipment and testing facilities related to earthquake engineering available at IIT Kanpur. Also, during the week-long workshop, a series of video shows on lessons from past earthquakes is organized. To help encourage participation, the students are provided return train fare and free room and board at IIT Kanpur. The workshop has already been conducted twice and has received enormous response. Fifty-four students participated in the first workshop (8–14 April 2002), while 60 students participated in the second workshop the next year (25–31 May 2003).

CONCLUSIONS

Developing the long-term capacity to create earthquake-resistant constructions in India has provided numerous challenges. The complexities associated with a developing nation coupled with inadequate earthquake engineering infrastructure have necessitated mitigation strategies in India to be multipronged. The strategies need to (a) cover a large spectrum of participants in earthquake disaster mitigation, namely citizens, teachers, decision makers, technology persons, social groups, and industry; (b) be at a large scale in terms of volume of operations, number of agencies involved in implementation, and types of strategies to be adopted to reach all levels of the huge Indian populace; and (c) grow steadily to make them sustainable, so that they gain acceptance and appreciation from participants in earthquake disaster mitigation.

The initiatives discussed in this paper provide a flavor of the range and variety of methods adopted so far to build capacity and sensitize the stakeholders in earthquake disaster mitigation in India. Some of these strategies may be of some relevance in other developing countries too. It is hoped that these efforts will lead to development of a stronger manpower base in India, leading to an increase in similar initiatives on a scale commensurate with the needs of a large country like India. ■

REFERENCES

Bureau of Indian Standards (2002). *Indian Standard Criteria for Earthquake Resistant Design of Structures, Part 1: General Provisions and Buildings*, Fifth Revision (IS:1893), New Delhi.

Jain, S. K. (2002). Codes, licensing, and education, in S. K. Jain, W. R. Lettis, C. V. R. Murty, and J. P. Bardet (editors), *2002 Bhuj, India Earthquake Reconnaissance Report, Earthquake Spectra*, Supplement A to Volume 18, 398 pp.

Jain, S. K. and N. C. Nigam (2000). Historical developments and current status of earthquake engineering in India, *Proceedings of the Twelfth World Conference on Earthquake Engineering*, Auckland, New Zealand, Paper No. 1792.

Jain, S. K. and A. R. Sheth (2002). Earthquake engineering in the civil engineering curricula, *The Indian Concrete Journal* 76, 558–562.

Murty, C. V. R., R. Sinha, and S. K. Jain (1998). A Report on earthquake resistant construction in civil engineering curriculum, *Newsletter of the Indian Society of Earthquake Technology*, January 1998, 1–10. (Also available at http://www.nicee.org/EQ_Engg/iset_ws.htm.)

Rai, D. C. and A. R. Sheth (2002). e-Conference on Indian seismic codes, *The Indian Concrete Journal* 76, 376–378.

Department of Civil Engineering
Indian Institute of Technology Kanpur
Kanpur 208016
India
skjain@iitk.ac.in *(S.K.J.)*
cvrm@iitk.ac.in *(C.V.R.M.)*