Workshop on developing earthquake engineering industry in India: Opportunities and challenges

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The profession of earthquake engineering in the country has grown only marginally over the past four decades, despite over 60 percent of land area being seismically vulnerable as evidenced in the occurrence of many moderate size earthquakes. Neither the spectrum of activities have grown nor a professional environment is available today for addressing the critical earthquake disaster mitigation needs of the country.

A workshop was held at Indian Institute of Technology (IIT) Kanpur, a few months back to discuss the challenges ahead and opportunities available for developing an earthquake engineering industry wherein earthquake-related services and products can be conveniently available. This report presents a summary of the discussions and recommendations of this workshop. The development of a "White Paper" on the status of earthquake engineering, the importance of sensitising policy makers on earthquake preparedness, and the need to have a nodal agency for co-ordinating a programme for developing the earthquake engineering industry, were amongst the main conclusions of the deliberations at the workshop.

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Despite over 60 percent of the land mass in India being seismically vulnerable, a vibrant "earthquake industry" has not yet emerged wherein earthquake-related services and products can be conveniently available within the country on a commercial basis

The earthquake problem of Indian subcontinent is rather well known. India was amongst the first countries to start earthquake engineering research and teaching in the late 1950's. Since then, major initiatives have been taken pertaining to different aspects of the profession, for example, teaching and research at University of Roorkee, development and publication of Indian seismic codes for earthquake resistant construction, installation and operation of strong motion instruments and seismological observatory, and successful design and construction of many civil engineering projects of national importance in high seismic areas. However, these activities involved only a very small group of persons and/or organisations. The professional interaction across these groups and across the allied interest groups did not grow. The negative fallout of the above "unplanned" growth of earthquake related activities has been a lack of preparedness for earthquake disaster mitigation. Despite the seriousness of the problem and the long existence of the profession, a vibrant "earthquake industry" has not yet emerged wherein earthquake-related services and products can be conveniently available within the country on a commercial basis. For example,

- After the 1997 Jabalpur earthquake a very large housing stock in the government sector was to be repaired and retrofitted. To handle this, consultants and contractors with expertise in post-earthquake handling of buildings were required. It was a major opportunity which would not only have brought significant savings to the organisations which owned the buildings, but also have

given an early relief to the residents.

- Numerous devices and products for controlling seismic behaviour of structures are available internationally but are yet to be introduced in the Indian constructions. Such devices can be very important in reducing earthquake disaster in future earthquakes.

A three-day workshop was held at IIT Kanpur during October 14 to 16, 1998, to discuss the opportunities and challenges of developing an earthquake engineering industry in the country. This workshop was sequel to an earlier workshop that discussed various aspects related to earthquake resistant construction in civil engineering curriculum in India. Participants were invited for the workshop. Select academicians and persons from industry participated in these deliberations. The report presents a summary of discussions and recommendations made during the workshop on the following major themes: *(i)* current status of earthquake engineering in India, *(ii)* perception of industry about earthquakes and earthquake business, *(iii)* opportunities and future prospects, *(iv)* constraints and bottlenecks, and *(v)* specific action plans needed. Due to space limitations, this article does not include the other two themes discussed during the workshop, viz, Indian National Centre for Earthquake Engineering Information, and seismic hazard and earthquake risk assessment.

One mechanism of ensuring the quality of earthquake-resistant design and construction practices is through licensing of professional engineers participating in different aspects of design and construction

Discussions and recommendations

Theme 1 — General

Earthquake engineering industry

- Earthquake engineering industry is generally considered to comprise of the spectrum of civil and structural engineering professionals who conceive, design, produce, maintain, upgrade and provide services for earthquake-resistant facilities and structures. However, the earthquake engineering industry also includes those involved in development of seismic risk analysis techniques, such as seismic survey, geo-technical survey and building typology. Other emerging sectors of earthquake engineering industry include vulnerability analysis of structures and lifelines, microzonation of urban centres, retrofitting of built environment, post-earthquake damage surveys, repair and retrofit of earthquake damaged structures, development, sale and manufacture of devices and instruments (such as isolation systems and ground motion measurement systems), training in earthquake engineering, and development of testing capabilities for industrial use. An extremely important sector of earthquake engineering industry is the community of architects who are responsible for planning and construction of buildings.

- The stakeholders in a well developed earthquake engineering industry are: owners of structures, tenants and renters, financiers and lenders, insurers, design professionals, construction professionals, earth scientists and seismologists, government regulators, academicians, information and technology providers, and equipment manufacturers.

Growth of earthquake engineering activities in the country

- Only a limited number of organisations and professionals are currently participating in earthquake engineering related activities. There is a need to increase the number and type of active participants to develop a vibrant earthquake engineering industry.

- India is at the threshold of a major boom in the construction activity. In the next 25 years, major construction opportunities in the world is projected to occur in India and China. This provides a tremendous opportunity for growth in the earthquake engineering industry.

- Most graduates with training in earthquake engineering do not practice what they learn owing to *(i)* lack of suitable challenging opportunities in sizable number, and *(ii)* more lucrative career opportunities in other sectors particularly in the software industry.

Sensitisation of different interest groups

- The ultimate beneficiary of a vibrant earthquake engineering industry is the public at large, including the decision makers, administrators and the financial institutions who need to be educated about the earthquake hazard and its implications. This education is to be imparted to all stakeholders - common man, bureaucrats, consulting engineers, contractors, politicians, policy makers, etc.

- Implications of earthquakes must also be considered for the city or the society as a unit through development of suitable seismic risk assessment for different areas of our country. Many difficult decisions can be facilitated through the availability of these risk assessments.

- The practising engineering community needs to be sensitised regarding the limitations of the codes of practice to ensure rational design of structures.

- Even though the earthquake technology is quite well developed in India, the earthquake industry is rather primitive. Hence, poor implementation of earthquake technology in the country is a major bottleneck in the growth of earthquake engineering industry.

- The incremental cost of incorporating earthquake-resistant features in structures is often marginal. This needs to be suitably highlighted at all levels.

- Mass media need to be sensitised regarding their responsibility for communicating the salient features related to earthquakes to the common man.

- India has recently begun enjoying the benefits of well-developed environmental laws. Similar legislation is required from earthquake hazard considerations.

Incentives for earthquake-resistant constructions

- Incorporation of earthquake-resistant construction practices should be encouraged through financial incentives. Industrial projects are usually cost driven and if financing agencies require earthquake auditing, owners will insist on the usage of earthquake-resistant measures.
- Strict regulatory measures may also be necessary to ensure compliance of earthquake resistant construction practices, particularly in high seismic areas.
- One mechanism of ensuring the quality of earthquake-resistant design and construction practices is through licensing of professional engineers participating in different aspects of design and construction.
- There is a need to balance the cost of the original structure with its repair and strengthening costs after earthquake damage. Justification of investment in seismic safety measures should not be based merely on short-term cost-benefit analyses.
- Seismic safety clearance should be made mandatory for important and critical structures before giving them financial clearance. As a result, there is a need to sensitise financial institutions and insurance industry such as IDBI, ICICI, HDFC and HUDCO.

Education

- Most knowledge that is currently imparted in academic institutions is theoretical. There is a need to impart practical knowledge related to earthquake hazards and earthquake resistant design practices.
- There is an urgent need to train a large body of practising engineers on earthquake-resistant construction practices at regular intervals and on a continuous basis.
- Currently, most of the training programmes in the country are meant for design engineers. As a result, the construction engineers are left out. One or two day training programmes targeted at construction engineers need to be taken up across the country, especially in high seismic regions.
- A handbook of practical technologies is required to be developed to guide the end users on sound earthquake-resistant construction practices, particularly in high seismic areas. This handbook should also be brought out in local languages.
- There is a need to disseminate earthquake engineering information in local languages in a manner that sustains the interests of the common man. This will facilitate better appreciation of earthquake safety.
- Construction of earthquake-resistant structures also requires suitably trained artisans and other skilled workers. There is also an urgent need to develop suitable training mechanisms to satisfy this requirement.

The codes of seismic practice are not revised at regular intervals. As a result, the earthquake engineering industry is unable to take timely advantage of the vast body of knowledge that is continuously generated. These codes must be revised much more frequently; this may be facilitated by specifying expiry dates on the codes of practice

Codes of practice

- There is a large number of codes addressing the design of structures, even of a single type. These need to be amalgamated into a single comprehensive volume.
- The seismic design provisions should be integrated into the main body of the reinforced concrete and structural steel design codes. Meanwhile, adequate references should be included in the main text of the codes providing additional requirements to account for seismic risk.
- The professional bodies consisting of practising engineers need to take up the development of model seismic codes along with commentaries and explanatory handbooks. Such model codes will be very useful source materials for development of Indian standards.
- It will be quite effective if model draft specifications covering earthquake-resistant construction aspects are developed and publicised which can be included in tender documents to ensure their implementation.
- Recently, efforts for development of explanatory handbook for reinforced concrete design have been initiated by the Indian Concrete Institute in collaboration with Larsen & Toubro Limited. Similar efforts also need to be taken up in other topics such as seismic design of concrete and steel structures, bridges and tower-like structures.
- The codes of seismic practice are not revised at regular intervals. As a result, the earthquake engineering industry is unable to take timely advantage of the vast body of knowledge that is continuously generated. These codes must be revised much more frequently; this may be facilitated by specifying expiry dates on the codes of practice.

Theme 2 — Current status of earthquake engineering industry in India

General

- Earthquake engineering industry in India is primarily confined to a small group from the academia, and an even smaller number of design engineers. The potential requirement of the country indicates that a much larger number of organisations/individuals need to contribute to the development and practice of earthquake engineering. Until and unless a critical mass of human resources is built-up, the benefits of the earthquake engineering knowledge to the society cannot be fully realised.
- Further, the quality of the available human resources in earthquake engineering is not uniformly acceptable. The lack of quality usually stems from the inability of these people to keep themselves abreast with the latest developments in the field.
- There is a dearth of good quality continuing education programmes in the country that can upgrade the skills and understanding of the large number of potential earthquake engineering professionals.

Lessons from past earthquakes

- Detailed and critical analyses of the performance of different types of structures during past earthquakes need to be catalogued. This information should be used to evaluate the relative safety of different traditional and modern construction technologies.
- The above experience needs to be translated into appropriate codal provisions. The regular updating of the codes of practice is essential to reflect the lessons learnt from recent earthquakes. Further, earthquake events provide a special opportunity in the form of heightened awareness of general public about earthquakes which can be utilised to further the cause of earthquake engineering industry.

Nodal agencies

- A national nodal information agency is required to disseminate all information pertaining to earthquake engineering. Regional nodal agencies may be subsequently needed to complement this effort.
- A national regulatory agency may help in verifying the design of special structures. The Executive Council of the Indian Society of Earthquake Technology may be entrusted to develop mechanisms for this.
- Professional bodies such as Indian Society of Earthquake Technology need to be reactivated by revitalising their local chapters. This way, the expertise can be distributed across the country.

Theme 3 — Perceptions of industry about earthquakes and earthquake business

Business opportunities in earthquake engineering

- Earthquake industry goes well beyond analysis and design of structures. The opportunity and market for the other stakeholders is currently latent and proactive effort is required to develop them to their full potential.
- Upgradation of skills is currently limited to the design engineers. Tremendous potential is available to train construction engineers and skilled workers in earthquake engineering.
- A major challenge to further growth of this field is the indifference of the policy makers, practising engineers and planners. This is mainly due to the lack of understanding of seismic issues, low probability of occurrence of earthquakes, long interval between consecutive earthquakes, and short public memory of past earthquake events. There is need to interact and to regularly sensitise them on these issues.
- Earthquake-resistant construction practices are sometimes considered to be a burden on the owners due to increase in cost. This is due to lack of information on cost implications, and lack of incentive for good design and detailing. Exhaustive analyses need to be performed on case studies to understand cost implications including earthquake resistant features.

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- It is expected that the expertise generated by earthquake engineering industry in India will also enable it to participate in similar activities in other countries in the neighbourhood and central Asia. Hence, it presents excellent business opportunities in these countries.

Interaction between industry and academia

- Some countries which have achieved high level of seismic safety have well developed and active industry-academia relations. These relations should be critically evaluated and adapted for the Indian conditions.
- There is a need to improve the partnership between the industry and academia. The experience of the industry has not always been very positive due to time over-runs by the experts in the academia. It may be recognised here that the primary mandate of academic institutes is teaching and research. Hence, the time of faculty members may be better utilised if the industry approaches them only for critical intellectual inputs rather than mundane work.
- The academia is often not able to provide multi-faceted or multi-disciplinary advice due to their inability of fostering teamwork encompassing several specialisations. This limitation of the academic institutions needs to be recognised by the industry on the one hand, and needs to be suitably addressed by the academia on the other hand.

Theme 4 — Opportunities and future prospects

General

- The Himalayan region of India has experienced large earthquakes at frequent intervals; in fact, this region has seen some of the largest earthquakes ever recorded in the world. The recent earthquakes in the peninsular and southern India have also shown that damaging earthquakes can occur in most parts of the country. This has thrown up new challenges and unique opportunities to the earthquake engineering community.
- Due to demographic pressure greater number of people are forced to reside in areas such as, unstable slopes, coastal flood planes and recent land-fills that have higher seismic risk. Moreover, due to poverty and lack of appreciation for seismic risk, large-scale use of inappropriate construction technologies is taking place. These facts together with high population growth and rapid urbanisation mean that seismic risk in our country is rapidly increasing, which can only be addressed by a vibrant earthquake engineering industry.
- The widespread use of earthquake-resistant design in developed countries has already shown that the loss of lives can be drastically reduced and economic losses can be minimised. On the contrary, in developing countries the primary focus of policy makers remains on basic hu-

man needs (food, shelter, health, education), and natural disaster mitigation has not been given the due priority.

- The different components of earthquake engineering industry need to take up the challenge of contributing to the development of this field. This will also provide new business opportunities and markets to the earthquake engineering industry.
- The experience following an earthquake disaster is a very valuable learning tool for the earthquake engineering industry. Evaluation of post-earthquake developments will help identify opportunities to reduce the consequences of earthquakes in other areas of our country. For instance, the experience gathered by the Maharashtra government after the 1993 Killari earthquake was not effectively utilised in the aftermath of the 1997 Jabalpur earthquake. This could have been avoided if the Madhya Pradesh government had a suitable mechanism to make use of the experiences of Maharashtra government following the 1993 event.
- The effectiveness of governments to positively respond to future disasters can be enhanced by increasing their sensitivity to the requirements of disaster-hit communities.
- Today, more number of agencies are involved in earthquake engineering activities than a decade ago. This can be attributed to the widening scope and the growing realisation of importance of earthquake engineering industry. Nevertheless, the numbers are still insufficient to adequately face the challenges posed by the frequent earthquakes in the country, and there is tremendous scope for further growth in this field.

Opportunities in disaster preparedness

- There is growing realisation of the importance of earthquake preparedness for successful mitigation of the risks. There is need for a multidisciplinary effort to evaluate the earthquake risk in different parts of the country. These efforts should be carried out at both the macro-level (state or district wide) as well as micro-level (city or sub-city wide). The outcome of these investigations will be invaluable in planning disaster preparedness strategies and orienting the government machinery.
- Following the devastating 1993 Killari earthquake, the government of Maharashtra has developed disaster management plans for the entire state to improve the response following any future disasters. Such proactive initiatives provide fresh opportunities to the earthquake engineering industry and this needs to be emulated in other parts of the country. It is heartening to note that a similar emergency response network has also been proposed in Andhra Pradesh to address the cyclone hazard along the coastal regions.

The main impediments to the growth of earthquake engineering industry is the lack of adequate highly-trained manpower, lack of necessary facilities for dissemination of knowledge and inadequate legal framework. Furthermore, there is prevailing attitude that earthquake engineering needs to be confined to a few experts who can be called upon to address related problems and issues

- The private sector has a very important role to play in disaster preparedness. Close interaction between the government, the voluntary agencies and the private sector is essential for successful mitigation of earthquake risks. For example, the private sector may assist in creation of emergency communication network like in Japan, and thereby enhance the capacity of society to withstand disasters.
- The industry needs to be involved right from the policy planning stage in the efforts towards earthquake disaster preparedness.
- Earthquake disaster mitigation strategies can only be successful through full and whole-hearted support of the public. For this the public needs to be educated on the earthquake vulnerability of different regions of the country. For example, even though over 60 percent of our land mass is vulnerable to damaging earthquakes, the popular thinking of the public is that only the Himalayan region is vulnerable. Interestingly, despite Jabalpur being placed in seismic zone III of the IS code, most affected people during the 1997 earthquake were unaware of the seismic hazard of the region.
- Professional bodies such as the Indian Society of Earthquake Technology should take the lead in publicising the different issues of disaster mitigation and preparedness. They should also encourage their members to write popular articles in mainstream media. This will help in publicising the likely consequences of earthquake disasters in a region, and help the society to prepare for them.

Theme 5 — Constraints and bottlenecks, and how to overcome them

General

- The main impediments to the growth of earthquake engineering industry is the lack of adequate highly-trained manpower, lack of necessary facilities for dissemination of knowledge and inadequate legal framework. Furthermore, there is prevailing attitude that earthquake engineering needs to be confined to a few experts who can be called upon to address related problems and issues.
- The weaker sections of the society are also found to suffer more severely during earthquake disasters. The earthquake engineering problem is thus essentially a human problem, and must be handled with adequate sensitivity and concern for the potential victims.
- One of the major constraints in earthquake engineering industry is the poor concern for implementation of various seismic standards and codes of practice. Unfortunately, the Indian codes and standards do not always reflect the profession's latest understanding of this field.
- The building bye-laws and development control rules in India do not

have any structural requirements, and therefore the seismic requirements also do not find a place in them. Moreover, the seismic specifications cannot be left to the discretion of the owner, who is often not conversant with these requirements. It is heartening to note that the proposed development control rules for the hill districts of West Bengal have explicit provisions for seismic requirements. This example needs to be emulated in other seismically vulnerable regions of the country.

- There is a general perception that some of the provisions in the seismic codes are often difficult to follow and implement in practice. Often, these difficulties can be overcome by the availability of well-documented and lucid commentaries of the codal provisions and explanatory handbooks illustrating their implementation. The development of these commentaries and handbooks may be taken up by the Bureau of Indian Standards and by the professional societies.

- There is a general resistance from the profession to modifications in seismic codes. Part of this resistance is due to the perceived cost of upgrading the skills of the professional engineers for implementation of the revised provisions. Professional societies may play a proactive role in assisting the industry in upgrading their skills. This will also ensure better compliance with the codal provisions.

- Experimental verification of practical detailing provisions has not been carried out in the country on a large scale. The industry needs to be impressed upon to support these activities.

- Frequent and intensive interaction between the engineers and scientists engaged in earthquake engineering needs to be aggressively pursued. Furthermore, speciality sessions on earthquake engineering related issues should be planned in the annual convention of professional bodies such as Indian Roads Congress, Indian Buildings Congress, Indian National Engineering Academy, Indian Science Congress, and Architects' associations.

Risk cover

- Financial incentives such as realistic earthquake insurance premium reflecting the seismic vulnerability of different structures can act as a motivating factor to encourage rational design and good construction practices. It is essential that the nodal agencies such as the Tariff Advisory Committee of the insurance sector recognise the difference in earthquake risks depending on the location and choice of construction technology. The professional societies must also assist the insurance sector in developing rational insurance policies.

- The special seismic requirements should be realistically incorporated in the tender documents. This will draw the explicit attention of the contractors to the additional technical requirements and their financial implications.

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- The private industry needs to play a proactive role in earthquake engineering industry. The assistance of industry associations such as CII and FICCI will help sensitise the private industry to the economic consequences of earthquakes.

Human resource challenges

- In the country, the number of agencies, organisations and competent individuals involved in earthquake engineering is exceedingly small and is totally inadequate to fulfill the needs of a large country like India. Greater diversity of opinion and freshness in approach can evolve only if this family is significantly enlarged. This requires development of suitable long-term plans based on a rational assessment of the future requirements of the country.

- The severe shortage of earthquake engineering professionals in certain specialisations, for example, engineering seismology, and geotechnical earthquake engineering, can be overcome through suitable government intervention by facilitating opportunities for training of working professionals in appropriate international environment.

- It is also necessary to introduce earthquake-resistant design concepts in the diploma-level curriculum. Similarly, other related fields such as architecture also need to include sufficient exposure to the different aspects of earthquake-resistant design in their curriculum.

- There is growing realisation that many post-graduate students are not interested in pursuing career in earthquake engineering industry. There is dearth in both quality and number of post-graduates seeking a career in earthquake engineering industry. This situation can improve if better and more lucrative career opportunities are created in large numbers.

Theme 6 — Specific action plans

- A White Paper which highlights the earthquake hazard, articulates the current status of the earthquake engineering in India, and clearly identifies the challenges that must be overcome, should be brought out. This White Paper must also identify the strengths and weaknesses in our present capabilities in this field, and clearly prioritise the areas in which the future efforts must be directed in a concerted manner.

- A nodal agency may be identified to initiate and co-ordinate a national effort to advance earthquake engineering industry in the country. The nodal agency may also be responsible for informing and sensitising the different stake holders. Organisations such as ISET may take up such a role.

- Greater advocacy for fulfilling the needs and requirements of earthquake engineering stake-holders should be carried out among the policy-makers and other decision makers.

- In order to realise the goals of ISET, it needs to play a more proactive role. To do so, it may help if ISET were to set up a professional secretariat. ISET itself should be made more broad-based by inducting more members from the other interest groups, example architects, consulting engineers, construction engineers, equipment manufacturers, non-governmental organisations (NGOs), and insurance companies.
- Insurance industry should be actively involved as an concerned stakeholder in the pursuit of the earthquake risk reduction. The reinsurance companies could also act as an effective vehicle to sensitise the Indian insurance companies in this regard.
- Department of Science and Technology, Government of India, may constitute a separate task force in earthquake engineering as a part of its Science and Engineering Research Council to actively encourage, nurture and support the activities in this field.
- Policy makers as well as lay public should be sensitised on different earthquake engineering issues. Audio-visual modules need to be developed to popularise information on earthquakes and the concepts of earthquake engineering. These modules should be targeted at different levels of the society.
- Design codes need to be frequently revised incorporating the latest advancements in earthquake engineering. A handbook on earthquake-resistant design, describing design, concepts and code provisions through lucid commentaries and detailed worked out examples, should be developed.
- The building bye-laws and development control rules should be revised to include specific earthquake-resistant features.
- The earthquake risk maps should be developed for the densely populated areas of the country. The risk maps should also include, where possible, information on other risks associated with earthquakes such as landslides, fires, and chemical and biological accidents.
- Seismic hazard data from different sources such as IMD, GSI, and ONGC should be integrated and compiled at a centralised location. The other sources of data, such as those available in the private sector, should also be identified. It is necessary to make them available to the interested parties in a suitable manner.
- A directory of interest groups (individuals and organisations) should be compiled. It should also include all those interested in the progress of earthquake engineering industry.
- Training modules should be developed and widely disseminated in different local languages to train artisans on earthquake-resistant features.
- Special training modules should be developed for engineering professionals.
- The earthquake-resistant design features of non-engineered constructions should be widely publicised through ISET and other agencies. The Indian Association of Earthquake Engineering (IAEE) manual on non-engineered constructions should be translated into local languages and be made widely available.

Conclusions

The workshop held intensive discussion on several topics on earthquake engineering industry in India. In addition to the themes discussed here, two additional themes were discussed: on setting up of National Information Centre for Earthquake Engineering at IIT Kanpur, and on seismic hazard and earthquake risk assessment. Due to limitation of space, discussions on these two themes have been omitted from this report. The workshop endorsed the proposed Centre at IIT Kanpur and made useful suggestions for the same. The workshop expressed serious concern that capability of seismic hazard assessment in the country today is marred by very limited manpower and inadequate data and software and offered suggestions on what needs to be done to improve our capabilities in the area of seismic hazard and earthquake risk assessment.

This report discusses the major conclusions that were arrived at during the discussions. The essential steps that must be taken immediately to build a vibrant earthquake engineering industry for a better earthquake disaster preparedness are given in the box.

Steps for vibrant earthquake engineering industry

- A White Paper should be prepared highlighting earthquake hazards, status of earthquake engineering in the country and challenges ahead.
- Policy makers and lay public need to be sensitised about issues related to earthquake engineering.
- A nodal agency should initiate and co-ordinate a national effort to advance earthquake engineering industry in the country.
- A directory of the various individuals and organisations which can contribute to the earthquake engineering industry needs to be compiled.

Subsequent the workshop, efforts have been initiated to prepare a White Paper on status of earthquake engineering. A task group has been identified for the same. It is expected that this work will take off in the near future. Also, significant progress has now been made towards the setting of National Information Centre for Earthquake Engineering at IIT Kanpur.

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