# Earthquake Risk Reduction Development and Disaster Management Programme in India

**Hitesh Sharma[1] Goverdhan[2] S.V.Deo[3]**
[1]Research Scholar [2,3]Assistant Professor
[1,2]Department of Civil Engineering
[1,2,3]N.I.T, Raipur, Chhattisgarh

*Abstract*— A number of groups in the country have carried out post-earthquake reconnaissance studies of the recent damaging earthquakes. However, we are yet to develop a formal learning from earth quakes programme which will ensure that reconnaissance of all damaging earthquakes are Carried out in a systematic manner and the findings disseminated expeditiously.The countryis yet to formally take up activities in seismic micro zonation. There is not much activity inthe area of earthquake prediction. Data sharing remains a major handicap; we have yet todevelop mechanisms for open data sharing. There are not much inter-institutional or inter-disciplinary collaboration activities in thecountry. Except the DEQ, none of the institutions in the country have strong groups ofengineers and earth scientists working together on earthquakes. The result is that bothgroups, engineers and scientists, often tend to have a rather narrow view of the earthquakeproblem. Similarly, architects, town planners, and social scientists have no involvement inearthquake issues. The Himalayan Seismicity programme of the Department of Science andTechnology has enabled nurturing of a reasonable level of activity in the area of seismology. A similar programme on earthquake disaster mitigation needs to be operated by a majornodal agency in the country to nurture the research, development and extensional activities.A vibrant earthquake industrywherein earthquake-related services and products can beconveniently made available within the country on a commercial basis is yet to develop(Murty et al., 1999).India has been traditionally vulnerable to natural disasters on account of its unique geo-climatic conditions. Floods, droughts, cyclones, earthquakes and landslides have been a recurrent phenomenon. About 60% of the landmass is prone to earthquakes of various intensities; over 40 million hectares is prone to floods; about 8% of the total area is prone to cyclones and 68% of the area is susceptible to drought. In the decade 1990-2000, an average of about 4344 people lost their lives and about 30 million people were affected by disasters every year. The loss in terms of private, community and public assets has been astronomical.

***Key words:*** Earthquakes, National Core Group for Earthquake Risk Mitigation, Review of building bye-laws and their adoption

## I. INTRODUCTION

Earthquakes have occurred for millions of years and will continue in the future asthey have in the past. Some will occur in remote, undeveloped areas where damagewill be negligible. Others will occur near densely populated urban areas and subjecttheir inhabitants and the infrastructure they depend on to strong shaking. It isimpossible to prevent earthquakes from occurring, but it is possible to mitigate theeffects of strong earthquake shaking: to reduce loss of life, injuries, and damage.When an earthquake occurs, seismic waves radiate away from the source and travelrapidly through the earth's crust. When these waves reach the ground surface, theyproduce shaking that may last from seconds to minutes. The strength and durationof shaking at a particular site depends on the size and location of the earthquakeand on the characteristics of the site. At sites near the source of a large earthquake,ground shaking can cause tremendous damage.Hazards associated with earthquakes are commonly referred to as seismic hazards.The practice of earthquake engineering involves the identification and mitigation ofseismic hazards.The size of an earthquake is obviously a very important parameter, and it has been described in different ways. Prior to the development of modern instrumentation, methods for characterizing the size of earthquakes were based on crude and qualitative descriptions of the effects of the earthquakes. More recently, modern seismographs have allowed the development of a number of quantitative measures of earthquake size. Since several of these measures are commonly used in both seismology and earthquake engineering, the distinguishing features of each should be understood. Earthquake size is expressed in several ways. Qualitative or non - instrumental and quantitative orinstrumental measurements exist; the latter can be either based on regional calibrations or applicableworldwide. Non - instrumental measurements are of great importance for pre - instrumental events andare hence essential in the compilation of historical earthquake catalogues for purposes of hazard analysis.For earthquakes that have been instrumentally recorded, qualitative scales are complementary tothe instrumental data. The assessment and use of historical records is not straightforward and may leadto incorrect results due to inevitable biases (Ambraseys and Finkel, 1986). Moreover, the observationperiod during which data are employed to determine future projections is an issue of great importance.For example, recent studies (Ambraseys, 2006) indicate that for three active regions around the world, limiting the catalogues used in hazard analysis to a short period of time may grossly overestimate orunderestimate the ensuing hazard. The over - and underestimation is a function of whether the observationperiod was an exceptionally quiescent or energetic epoch. Seismograms recorded at differentepicentres distances are employed to determine origin time, epicentre, focal depth and type of faultingand as well as to estimate the energy released during an earthquake.Descriptive methods can also be used to establish earthquake - induced damage and its spatialdistribution. In so doing, intensity, magnitude and relevant scales are utilized. Intensity is a non - instrumental perceptibility measure of damage to structures, ground surface effects,e.g. fractures, cracks andlandslides illustrated and human reactions to earthquakeshaking. It is a descriptive method which has been traditionally used to establish earthquake size,especially for pre - instrumental events. It is a subjective damage evaluation metric because of its qualitativenature, related to population density, familiarity with earthquake and type of constructions.Discrete scales are used to quantify seismic intensity; the levels are represented by Roman numeralsand each degree of intensity provides a qualitative description of earthquake effects. Several intensityscales have been proposed worldwide. Early attempts at classifying earthquake damage by intensitywere carried out in Italy and Switzerland around the late 1700s and early 1900s (Kanai, 1983). Someof these scales are still used in Europe (alongside modern scales), the USA and Japan. Some of themost common intensity scales are listed below:

### A. Mercalli – Cancani – Seiberg(MCS):

12 - level scale used in southern Europe;

### B. Modified Mercalli (MM):

12 - level scale proposed in 1931 by Wood and Neumann, who adaptedthe MCS scale to the California data set. It is used in North America and several othercountries;

### C. Medvedev – Sponheuer – Karnik(MSK):

12 - level scale developed in Central and Eastern Europeand used in several othercountries;

### D. European Macroseismic Scale(EMS):

12 - level scale adopted since 1998 in Europe. It is adevelopment of the MM scale;

### E. Japanese Meteorological Agency (JMA):

7 - level scale used in Japan. It has been revised overthe years and has recently beencorrelated to maximum horizontal acceleration of the ground.

## II. EARTHQUAKE ENGINEERING EDUCATION IN INDIA (EEE IN INDIA)

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 a 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 Indiaand 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.

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) 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. 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

## III. INSTITUTIONAL DEVELOPMENT

The establishment of a separate Department at Roorkee proved instrumental in rapid early growth of earthquake engineering in India. The DEQ provides under one roof all disciplines associated with earthquake engineering and currently has about 25 faculty members. It was developed unlike other typical academic departments in the sense that providing consultancy and testing services was one of its major aims and this enabled the incorporation of earthquake engineering inputs into major projects. However, the presence of such a department also had a somewhat negative fall-out as it was felt that the DEQ can provide whatever earthquake solutions the country needs, and no efforts were made towards further institutional development. For instance, the five prestigious Indian Institutes of Technology (IIT's) and concerned laboratories of the Council of Scientific and Industrial Research (CSIR) did not take up earthquake engineering in a significant manner until very recently. This meant that the number of highly-trained manpower got highly restricted. More importantly, the DEQ was in a peculiar situation of having to meet two often conflicting objectives: on one hand to promote earthquake engineering education and carry out research and development, and on the other hand, carry out enough industrial consultancies to meet bulk of its expenditures. This also blurred the difference between the Department encouraging and supporting the professional engineers versus it competing with the professional firms. And finally, it did not challenge the Department to have a healthy competition from groups in other institutions. The institutional development with regard to the earth science groups working on earthquake problem has been somewhat better. A number of universities have fairly strong earth science groups, many of them carry out earthquake related research. Two major organizations, Geological Survey of India and Seismology Division of the India Meteorological Department, have had a long history of working on earthquakes. Besides, a number of research institutions in earth sciences were set up after independence which has considerable interest in earthquakes.

## IV. CODE COMPLIANCE AND LACK OF CODAL IMPLEMENTATION

Indian codes, developed by the Bureau of Indian Standards (BIS), are not mandatory and are only in the nature of guidelines. The construction as such is governed by the municipal bye-laws which are within the jurisdiction of the state governments. Unfortunately, the seismic provisions have not yet been incorporated into the building bye-laws. Since majority of the building construction activity in the country is carried out in an informal manner with no involvement of engineers, most of it is done with no regard to seismic safety. The government departments and public sector organizations manage a large fraction of the formal sector constructions and are formally committed to follow the codes. However, even in such organizations, the seismic aspects do not get due attention. The situation is similar even when professional consultants are involved in a project. One needs tokeep in view that the concept of liability of the professional for poor services has not yet developed in thecountry. Even when an engineer wants to ensure aseismic construction, he is often unable to do so due to lack oftraining, sometimes vaguely worded and obsolete codal provisions, and the absence of codal commentaries. Some government construction agencies and private sector consultants, however, do tend to fulfill the codal requirements rigorously. On the one hand, the country has failed miserably in ensuring earthquake-resistant constructions in high seismic regions. On the other hand, numerous major projects such as large dams and nuclear power plants have been built in high seismic regions with due regard to earthquake safety and for which seismic analysis and design have been handled within the country. Also, considerable experience has been gained in the country in seismic repair and strengthening of masonry buildings following a number of moderate earthquakes in the recent years. Yet, at the higher end of the earthquake technology, the gap in our state-of-the-practice with the developed countries has been widening. Till date, no structure in India has utilized base isolation or other seismic control devices; the only exception is the construction in progress of two base-isolated one-storey demonstration buildings in Killari village in the 1993 Latur earthquake affected region (EERI, 1999).

## V. Approaches ‘of Government of India

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.

### *A. Earthquake Risk Mitigation:*

A comprehensive programme has been taken up for earthquake risk mitigation. Although, the BIS have laid down the standards for construction in the seismic zones, these were not being followed. The building construction in urban and suburban areas is regulated by the Town and Country Planning Acts and Building Regulations. In many cases, the Building regulations do not incorporate the BIS codes. Even where they do, the lack of knowledge regarding seismically safe construction among the architects and engineers as well as lack of awareness regarding their vulnerability among the population led to most of the construction in the urban/sub-urban areas being without reference to BIS standards. In the rural areas, the bulk of the housing is non-engineered construction. The mode of construction in the rural areas has also changed from mud and thatch to brick and concrete construction thereby increasing the vulnerability. The increasing population has led to settlements in vulnerable areas close to the river bed areas which are prone to liquefaction. The Government has moved to address these issues.

### *B. National Core Group for Earthquake Risk mitigation:*

National Core Group for Earthquake Risk Mitigation has been constituted consisting of experts in earthquake engineering and administrators. The Core Group has been assigned with the responsibility of drawing up a strategy and plan of action for mitigating the impact of earthquakes; providing advice and guidance to the States on various aspects of earthquake mitigation; developing/organizing the preparation of handbooks/pamphlets/type designs for earthquake resistant construction; working out systems for assisting the States in the seismically vulnerable zones to adopt/integrate appropriate Bureau of Indian Standards codes in their building byelaws; evolving systems for training of municipal Disaster Management in India. engineers as also practicing architects and engineers in the private sector in the salient features of Bureau of Indian Standards codes and the amended byelaws; evolving a system of certification of architects/engineers for testing their knowledge of earthquake resistant construction; evolving systems for training of masons and carry out intensive awareness generation campaigns.

### *C. Review of Building Bye-Laws and Their Adoption:*

Most casualties during earthquakes are caused by the collapse of structures. Therefore structural mitigation measures are the key to make a significant impact towards earthquake safety in our country. In view of this the States in earthquake prone zones have been requested to review, and if necessary, amend their building bye-laws to incorporate the BIS seismic codes for construction in the concerned zones. Many States have initiated necessary action in this regard. An Expert Committee appointed by the Core Group on Earthquake Risk Mitigation has already submitted its report covering appropriate amendments to the existing Town & Country Planning Acts, Land Use Zoning Regulation, Development Control Regulations& Building Bylaws, which could be used by the State Governments & the local bodies there-under to upgrade the existing legal instruments. The Model Building Bylaws also cover the aspect of ensuring technical implementation of the safety aspects in all new constructions & upgrading the strength of existing structurally vulnerable constructions. To facilitate the review of existing building byelaws and adoption of the proposed amendments by the State Governments & UT administrations, discussion workshops at regional level in the country are being organized. It is expected that all planning authorities and local bodies will soon have development control regulations and building byelaws which would include multi-hazard safety provisions. Disaster Management in India.

### *D. Development and Revision of Codes:*

There are Bureau of Indian Standard (BIS) codes which are relevant for multi-hazard resistant design and construction. Some of the codes need to be updated. There are some areas for which codes do not exist. An action plan has been drawn up for revision of existing codes, development of new codes and documents/commentaries, and making these codes and documents available all over the country including on-line access to these codes. An Apex committee consisting of representatives of Ministry of Consumer Affairs, BIS and MHA has been constituted to review the mechanism and process of development of codes relevant to earthquake risk mitigation and establish a protocol for revision by BIS.

*E. Hazard Safety Cells in States:*

The States have been advised to constitute Hazard Safety Cells (HSC) headed by the Chief Engineer, State PWD with necessary engineering staff so as to establish mechanism for proper implementation of the building codes in all future Govt. constructions, and to ensure the safety of buildings and structures from various hazards. The HSCs will also be responsible for carrying out appropriate design review of all Government buildings to be constructed in the State, act as an advisory cell to the State Government on the different aspects of building safety against hazards and act as a consultant to the State Government for retrofitting of the lifeline buildings. Rajasthan, West Bengal, Delhi and Chhattisgarh have already constituted these cells and other States are in the process.

*F. National Programme for Capacity Building of Engineers and Architects In Earthquake Risk Mitigation:*

Two National Programmes for Capacity Building in Earthquake Risk Mitigation for Engineers and Architects respectively, have been approved to assist the State Govt's in building up capacities for earthquake mitigation. Under these two programmes 10,000 engineers and10,000 architects in the States will be given training in seismically safe building Disaster Management in India - *A Status Report* 19designs and related techno-legal requirements. Assistance is being provided to the State/UTs to build the capacities of more than 125 State Engineering Colleges and110 Architecture Colleges to be able to provide advisory services to the State Govt's to put in place appropriate techno-legal regime, assessment of building and infrastructures and their retrofitting. These institutions will function as State Resource Institutions. Twenty-one Engineering and Architecture Institutions have been designated as National Resource Institutes to train the faculty members of selected State Engineering and Architecture colleges. 450 engineering faculty members and 250 architecture faculty members of these State Resource Institutions will be trained during the current year.

*G. Training Of Rural Masons:*

A programme to assist the States/UTs in training and certification of 50000 masons has been formulated in consultation with Housing and Urban Development Corporation (HUDCO) and the Ministry of Rural Development. The training module for masons to include multi-hazard resistant construction has also been prepared by an expert committee, and revised curriculum will be introduced in the vocational training programme of Ministry of Human Resource Development.

*H. Earthquake Engineering In Undergraduate Engineering/Architecture Curricula:*

The role of engineers and architects is crucial in reducing earthquake risks by ensuring that the constructions adhere to the norms of seismic safety. In view of this, the elements of earthquake engineering are being integrated into the undergraduate engineering and architecture courses. Model course curricula have been developed for adoption by various technical institutions and universities. And circulated to the Universities and Technical Institutions for integration into the under graduate curriculum. Ministry of Home Affairs is working with All India Council of Technical Education (AICTE) and Council of Architecture (COA) for Disaster Management in India - *A Status Report* 20introduction of revised curricula for engineering and architecture course from 2005-2006.

*I. Retrofitting Of Lifeline Buildings:*

While these mitigation measures will take care of the new constructions, the problem of unsafe existing building stock would still remain. It will not be possible to address the entire existing building stock, therefore the life line buildings like hospitals, schools or buildings where people congregate like cinema halls, multi-storied apartments are being focused on. The States have been advised to have these buildings assessed and where necessary retrofitted. The Ministries of Civil Aviation, Railways, Telecommunication, Power and Health and Family Welfare have been advised to take necessary action for detailed evaluation and retrofitting of lifeline buildings located in seismically vulnerable zones so as to ensure that they comply with BIS norms, Action plan have been drawn up by these Ministries for detailed vulnerability analysis and retrofitting/strengthening of buildings and structures. The Ministry of Finance has been requested to advise the financial institutions to give loans for retrofitting on easy terms. Accordingly the Ministry of Finance had advised Reserve Bank of India to issue suitable instructions to all the Banks and Financial Institutions to see that BIS codes/bye laws are scrupulously followed while financing/refinancing construction activities in seismically vulnerable zones.

*J. National Earthquake Risk Mitigation Project:*

An Earthquake Mitigation Project has been drawn up, with an estimated cost of Rs.1132 coror. The project has been given in-principle clearance by the Planning Commission. The programme includes detailed evaluation and retrofitting of lifeline buildings such as hospitals, schools, water and power supply units, telecommunication buildings, airports/airport control towers, railway stations, bus stands and important administrative buildings in the States/UTs in seismic zones IV and V. Disaster Management in India The programme also includes training of masons in earthquake resistant Constructions, as well as, assistance to the State Governments to put in place an appropriate techno legal regime.

*K. Accelerated Urban Earthquake Vulnerability Reduction Programme:*

An accelerated urban earthquake vulnerability reduction programme has been taken up in 38 cities in seismic zones III, IV & V with population of half a million and above. These cities are Dehradun, Delhi, Jamnagar, Rajkot, Bhavnagar, Surat, Greater Mumbai, Bhiwandi, Nasik, Pune, Bhubaneswar,Cuttack, Chennai, Patna, Asansol, Guwahati, Vadodara, Koimbatore, Ahmedabad,Agara, Varanasi, Bareily, Meerut, Lucknow, Kanpur, Kolkatta, Srinagar, Jammu,Indore, Jabalpur, Amritsar, Jalandhar, Vijayawada, Dhanbad, Mangalore, Kochi, Kozhikod and Trivandrum. 474 Orientation programmes have been organized for senior officers and representatives of the local planning and development bodies to sensitize them on earthquake preparedness and mitigation measures. Training programmes have been organized for engineers and architects to impart knowledge about seismically safe construction and implementation of BIS norms. So far 1088 engineers and 825 architects have been trained. For enhanced school safety, education programmes have been organized in schools, colleges and other educational institutions. About 370 educational institutions have been visited by the earthquake disaster management specialist in these cities. This programme will be further extended to 166 earthquake prone districts in seismic zones IV &V. Awareness generation programmes; community and neighborhood organizations have been started in these cities. These cities are also being assisted to review and amend their building bye-laws to incorporate multi hazard safety provisions. City Disaster Management Plans are being developed under the project. Nine Cities have prepared city Disaster Management Plans so far. Disaster Management in India.

*L. Mainstreaming Mitigation In Rural Development Schemes:*

Rural housing and community assets for vulnerable sections of the population are created on a fairly large scale by the Ministry of Rural Development under the Indira Awas Yojna (IAY) and Sampooran Grameen Rojgar Yojna(SGRY). About250 thousand small but compact housing units are constructed every year, besides community assets such as community centres, recreation centres, anganwadi centres etc. Technology support is provided by about two hundred rural housing centres spread over the entire country. The Ministry of Home Affairs is working with the Ministry of Rural Development for changing the guidelines so that the houses constructed under IAY or school buildings/community buildings constructed under SGRY are earthquake/cyclone/flood resistant; as also that the schemes addressing mitigation are given priority under SGRY. Ministry of Rural Development are carrying out an exercise for this purpose. This initiative is expected to go a long way in popularization of seismically safe construction at village/block level.

*M. National Earthquake Risk Mitigation Project:*

(1) Aims and Objectives of the Project: To strengthen the structural and non-structural earthquake mitigation efforts and reduce the earthquake risk and vulnerability in the high risk districts prone to earthquakes. .
(2) Component-wise activities indicating structural and none structural measures (e.g. Infrastructure, Equipment’s and Stores, Capacity Building, etc): Structural Safety Audit of Lifeline Structures, Seismic Strengthening and Retrofitting of Critical Structures; Training of Trainers; Development of Training Materials; Video Films; Documentation of Case Studies; etc.
(3) Number and Names of States/UTs involved : 13 (Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Chandigarh, Delhi, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Sikkim, Uttar Pradesh and Uttaranchal).
(4) The requirement of funds during the XIth Five Year Plan is estimated to be Rs. 1132 crore. The allocation proposed For the year 2007-08 is Rs. 15 crore.

*N. Micro Zonation of Major Cities:*

(1) Aims and Objectives of the Programme: To carry out the Micro Zonation of High Risk Cities in Seismic Zones IV and V to prepare strategies to reduce the earthquake risk and vulnerability in the high risk districts.
(2) Component-wise activities indicating structural and none structural measures (e.g. Infrastructure, Equipment’s and Stores, Capacity Building, etc): Micro Zonation of Districts; Training of Trainers; Development of Training Materials; Video Films; Documentation of Case Studies; etc.
(3) Number and names of States/UTs involved : 13 (Andaman& Nicobar Islands, Arunachal Pradesh, Assam, Chandigarh,Delhi, Gujarat, Haryana, Himachal Pradesh, Jammu &Kashmir, Punjab, Sikkim, Uttar Pradesh and Uttaranchal).
(4) The requirement of funds during the XIth Five Year Plan isestimated to be Rs. 250 crore. The allocation proposed for The year 2007-08 is Rs. 10 crore.

In order to address the issue of earthquake safety, actions that lead to improvement of construction on the ground need to be initiated. For this, specific actions which should be undertaken by different Ministries/Departments are enumerated below

*1) Community Awareness:*

Due to three major earthquake events in last six years (2001 Gujarat, 2004 Sumatra and 2005 Kashmir), there is now a very considerable mass awareness amongst the public about earthquake risk. The CBSE too has now introduced some coverage about this in schools which is a very welcome step. However, what is lacking is a system by the government and the society to canalize this awareness into concrete actions in terms of safer constructions. Investments in Disaster Education, Public Awareness, Community Leadership Development, Disaster Education of unemployed youth, physically challenged, elderly, women and school children are essential. A large number of professionals require training and retraining for which we will have to generate quality teachers, quality text books, quality training kits etc. This will call for innovation in disaster education, effective use of multi-media and self-education in different vernacular languages. All knowledge based institutions may be encouraged to give priority to such initiatives.

*2) Legal Framework:*

The Ministry of Law & Justice may take up the issues on legal responsibilities in case of unsafe constructions and non-compliance with codes. As a first step, a white paper could be developed clarifying provisions of laws that may be applicable in connection with constructions (safety of structures in general terms and not just against earthquake; earthquake is just one of the issues). The white paper should also study the legal provisions of other countries and identify areas that require new laws or modifications in existing laws. In parallel, one of the Ministries (perhaps Finance Ministry) should engage the insurance companies to develop better insurance system for new constructions. As of now, the insurance 33 premium in our country does not depend on whether the construction complies with the safety codes and hence insurance is not being an effective tool to encourage safe contractions.

*3) Technical Competence:*

The Ministry of Human Resource Development (MHRD) is already operating a hugely successful National Programme in Earthquake Engineering Education (NPEEE).This programme has enabled substantial capacity building of our engineering and architectural colleges, but much remains to be done. Hence, this programme must operate for longer period to have its full impact. Moreover, the programme should include some means to keep the teachers trained in earthquake engineering to remain engaged with the subject through a variety of outreach activities. Another area needing intervention is training of professional engineers and architects. Ministry of Home Affairs has already undertaken some efforts in this direction: these may be reviewed and strengthened/ modified, if needed. Perhaps the Ministry of Urban Development also needs to be engaged towards capacity building of professional engineers and architects. Emphasis in the XIth Plan will need to be given to capacity building in all areas of disaster management. Priority will have to be given to highly vulnerable areas for generating database for mapping as well as hazard vulnerability and risk assessment related to disasters like cyclone, flood, and earthquake, chemical, industrial, etc. While building databases, availability of qualified and trained manpowerwill be equally important as this will ensure quality of dataand facilitate proper implementation of rules/regulationsand codes which are either already in existence or arelikely to be evolved. Similar action will be required toimpart training to health experts particularly in bioterrorism (security) as this has still remained totallyuncovered area.

*4) Professional Ambience:*

BasedCompetencelicensing ofengineersand certification of masonsare two of the mostimportant and critical areas that our country has deferredfor too long. Even though the State of Gujarat is movingahead on both these issues, most State Governments arenot in a position to take up and sustain such efforts(Gujarat being an exception). Hence, it is very importantthat these be taken up by the Central Government. While it is relatively easy to take these up, it is more difficult to ensure effectiveness through quality control in the process of licensing and certification. These steps will be useless if adequate safeguards are not provided to ensure that only competent persons receive license/ certification. In the past, there have been some discussions about the appropriate ministry taking up licensing of engineers (MHRD versus Ministry of Urban Development; Engineering Council of India versus Institution of Engineers versus AICTE). In the long term it really does not matter which Ministry does it as long as it is done effectively. In the longterm, licensing of other professionals associated with building industry (contractors, developers, etc.) also must be taken up, and, hence, licensing of engineers by the Ministry of Urban Development may have some advantages.

*5) Enforcement:*

This is another area that has been ignored for too long. After the 2001 earthquake, many (perhaps most; it will be interesting to verify this) States have made earthquake code compliance mandatory but none has seriously enforced these. Some towns/states now ask for a certificate from the engineer/architect/developer. But, this will not be effective as municipalities merely ask for code compliance certificates and do not even carry out random checks whether the certificates are genuine. In the next three years a robust system of enforcement of codes in new constructions should be implemented. This basically means that the municipalities will be doing for structural safety what they currently do for fire safety: review building drawings before giving building permission and ensure that the work at site does not violate these plans. It will be facilitating the enforcement agencies to enforce the codes if the building codes to be followed are made user35friendly. Suitable steps will need to be taken in this direction.

*6) Research and Development:*

The current state of research in engineering aspects of earthquake safety in the country is totally inadequate for a variety of reasons, even though a lot of money is being spent by DST on seismic instrumentation and seismic microzonation. Very important research problems critical for earthquake safety agenda of the country must be taken up in a focused manner, for instance: (a) developing new building typologies and technologies that are inherently better in responding to earthquakes (this was done in 1897 in Assam, and in 1935in Quetta), (b) research on design aspects and codal issues, (c) development of codes of practice, the next generation model-codes, supporting explanatory handbooks, etc, (d) technology verification tests on full scale and large-scale models, (e) development of seismic retrofitting technologies and technology verifications on full-scale models, (f) geotechnical earthquake engineering aspects such as site effects, seismic design of well foundations, etc. (g) seismic hazard assessment including Development of attenuation relations appropriate for our geological conditions, development of modern zone maps, etc. The Department of Science and Technology must initiate a National Initiative on Research in Earthquake Engineering.

(a) Efficient Disaster Management demands data in useable form and this demand varies from situation to situation. In view of huge uncertainties, often subjective judgment becomes inevitable .Equally important is, therefore, the strategy for management of data quality and information demand. Data sharing amongst the various data generators is an even more important aspect and needs to be addressed. Ideally all such schemes engaged in data generating, getting plan funds should be treated as national asset and be made available without any pre-condition for use for disaster management authorities and others. This will not only ensure that critical data will be available at the time of any disaster but also ensure that there is no avoidable duplication of the effort. There is need to prepare a white paper on this entire36issue, in particular about the sharing of data already available/to be made available. Such a paper needs to bring out an action plan and mechanism as to how the data sharing is to be done, who will be ensuring that there is awareness about the availability of data and what will be mechanism to disseminate this knowledge to all concerned.

(b) The Jawaharlal Nehru National Urban Renewal Mission, envisaging an investment of Rs.55,000 crores, covering 63 cities, inter-alia, provides a great opportunity for improving safety of our cities with respect to natural hazards which often tend to become disasters as experienced in recent part. It needs to be considered that each project, when sanctioned particularly in disaster prone region should include a component for the assessment of impact of natural hazards that may occur in the area, and the likely damage it may cause to life and assets to be built in to the scope of the project to address mitigation schemes.

(c) Scientific assessment of development efforts and its impact in any given hazard zone, be that from natural or manmade disasters, would require that the projects must relate to large scale single or multi-hazard maps and micro-zonation studies. It will be essential that all maps are integrated maps. For instance, production of landslide hazard map will not be possible unless maps of topography, geology and geo-morphology, land use and land management, old and dormant landslides and earthquake induced landslide potential are available to the same scale. What is more, for maps to be useful, they must necessarily be user-friendly, especially to architects, engineers, planners, builders, etc. Production of the various maps at large scale and their objective interpretations are beyond the capacity of any single agency. Multi agency projects with proven multi-disciplinary expertise should, therefore, be encouraged, with an appropriate coordination mechanism.

(d) The Survey of India will need to be entrusted with the responsibility of generating large scale maps which will form the basis for disaster management studies. They will also need to generate a Digital Elevation Map (DEM) of high resolution (1/2minterval along vertical) for the purpose of 3D terrain modeling. There will be a need to carry out prioritization of the areas on which Survey of India will carry out the 1:10,000 mapping for the whole country and map all towns and cities on 1:2000 scales.37Coastal Zone and flood prone areas of the country will need to get priority in the preparation of DEM.

(e) The national emergency communication network, involving the contemporary space and terrestrial-based technologies in a highly synergistic configuration and with considerable redundancy, will need to be developed and deployed countrywide. With almost a hundred per cent reliability, this network will ensure real-time dissemination of warnings and information direct to the affected community and local authorities. It will also be ensured that the information disseminated is user-friendly. The variety of ICT enabled community-level resource /information centers /kiosks being set up in India by various governmental agencies as well as NGOs will need to be strengthened and utilized for developing preparedness and resilience of disasters at the grassroots level.

(f) The Government seeks to sustain and augment the mangrove forests in the country by both regulatory and promotional measures. The Coastal Regulation Zone Notification (1991) under the Environmental Protection Act (1986) recognizes the mangrove areas as ecologically sensitive and categorizes the mass CR-I (i) which implies that these areas are afforded protection of the highest order. Under the promotional measures, as said before, the Government has identified mangrove areas on a country-wide basis for intensive conservation and management. Only promotional measures will not do. States have to review &strengthen their extant legislative measures and ensure that pristine mangrove areas are not dismantled /diverted to other developmental activities.

(g) Allocation of plan funds to State Governments for schemes for hazard identification and risk assessment will need to be given priority once they have prepared the project paper, completed preliminary work and details of the scheme etc. Hazard identification and risk assessment across the country must be bound by uniformly followed procedures, fine-tuned to local conditions. In the absence of such procedures, any sporadic activity based on some adhoc procedure carry the potential of doing more harm than good. It will be essential that while clearing plans for State Governments, there is an integrated approach particularly for creation of adequate capacity for relief and rescue operations, e.g., for funding projects for construction of school buildings, some of the school buildings need to be identified which will be used as relief centers and building designed so that they withstand the impact of disaster and also have adequate capacity to provide space as relief centers. Such schools should be equipped with essential services which become important at the time of disaster. (h)State Governments have to be asked to make comprehensive Management Action Plans for achieving long-term results in a phased manner. To make these plans more meaningful, workshops, training programmes are to be organized at local/regional/national levels under which capacity building and awareness generation/community participation, which includes livelihood activities for the villagers are the areas which are given emphasis.

Discussion will be required with various Ministries/Departments regarding the status of implementation of the relevant projects/schemes being undertaken by them and the manner in which the schemes may be restructured for better convergence and implementation and for further mainstreaming disaster risk reduction in the process of their implementation during the XIth Plan. Across the board, disaster risk reduction measures can straightway be incorporated into all infrastructure projects and other development programmes involving construction of buildings etc., such as Sarva

Shiksha Abhiyan, Indira Awas Yojana, and Jawaharlal Nehru National Urban Renewal Mission etc. This exercise may have to be completed very quickly, say in the next two months.

## VI. Required Interdisciplinary Research (as a Necessity)

Interdisciplinary research can be one of the most productive and inspiring of human pursuits—one that provides a format for conversations and connections that lead to new knowledge. As a mode of discovery and education, it has delivered much already and promises more—a sustainable environment, healthier and more prosperous lives, new discoveries and technologies to inspire young minds, and a deeper understanding of our place in space and time(National Academy of Sciences 2005*).* Various terms have been used to describe research that crosses traditional disciplinary boundaries (see Chapter 5, National Research Council 2006 for a complete discussion). Such blurring of disciplinary boundaries is often conceptualized as a continuum, with disciplinary at one end—e.g., research that is being pursued by investigators from only one established discipline, such as civil engineering, or sociology, or geology, with the theoretical basis for the research grounded in that discipline; to multidisciplinary—e.g., research that is pursued by investigators from at least two established disciplines, but the work does not necessarily require interaction, integration, or collaboration, so researchers could work on parallel but separate tracks; to cross-disciplinary— research that is being pursued by investigators from at least two established disciplines, e.g., civil engineering and sociology, but at least some of the research does involve interaction, integration, and collaboration across the disciplines; to interdisciplinary—research that is being pursued by investigators from at least two established disciplines, but where most of the work involves interaction, integration, and collaboration across the disciplines. Furthermore, the theoretical foundation for the interdisciplinary research is a merging and integration of theoretical concepts and frameworks from the two disciplines (Wenger 2007). As a further illustration of Wenger's continuum described above, one of the center researchers describes what he observed as three very different levels of engineering/- social science collaboration:

(a) On a very fundamental level, experts from one discipline benefit from hearing or understanding the outcomes of experts from another discipline. For example, engineers benefit from the outcomes of social science research. This sort of collaboration is "parallel," where each group works on part of a global topic, and one group essentially benefits from understanding the perspective of the other groups. As such, their single disciplinary research is enriched in a general sense by the findings and recommendations of various other disciplines. What is Interdisciplinary Research?

(b) A second level of collaboration is when social scientists and engineers work together on a project, but where this togetherness is in the form of a sequential collaboration where one group needs the findings of the other group to be able to advance its own research. Engineers may need to know the results of a specific social science research task to be able to move forward, or it may be the reverse.

(c) A third level, and by far the most integrative level of engineering/social science collaboration, is when both social scientists and engineers work together at the same time on a given project in which both groups need real-time information on the progress of the research, and both contribute a vital part to the creation of integrated knowledge (whereby one cannot advance without the other one advancing at the same time). This third level requires collaboration through continuous exchanges and coordination meetings through the lifetime of the project, and the findings are usually published simultaneously at the end, typically with multiple authors from both fields of expertise listed on individual papers. It is important to point out that the term interdisciplinary can apply to different engineering disciplines working together, or different earth science or social science disciplines working together, as well as to problems that require engineering, physical scientists, and social scientists to collaborate. Directly relevant to the consequence based problems of earthquake risk reduction, Karl Popper pointed out, "We are not students of some subject matter, but students of problems. And problems may cut right across the borders of any subject matter or discipline" (Popper 1963, quoted inNAS 2005: p16).Challenges to interdisciplinary collaboration are numerous. Some of these pertain to issues of attitude and communication, such as researcher hostility or indifference, disciplinary jargon, and lack of common vocabularies. Others relate to organizational issues such as lack of funding and incompatibility with academic incentive and reward structures. The National Research Council report on hazards and disasters research (2006) found that the EERCs, to the extent that they were successful in catalyzing interdisciplinary research, succeeded because of persistent NSF pressure to meet the interdisciplinary mandate, as well as factors such as center leadership and duration of contact among researchers, which was necessary for developing trust and respect across the disciplines.

## VII. Major Challenges in Earthquake Risk Reduction

Understanding the complex challenges in earthquake risk reduction requires understanding the context of the problem. Environmental constraints, development pressures, demographic changes, technical challenges, and a fragmented institutional framework all shape the nature of these challenges. As noted in the NEHRP strategic plan, vulnerability to earthquakes in the United States is growing at an alarming rate, fueled in part by population growth in moderate to high seismic zones, increasing urbanization, and an aging infrastructure (FEMA 2003). A single large earthquake could cause losses in excess of $100 billion to the built and human environment, more than twice the losses in the 1994 Northridge earthquake, the most costly U.S.

earthquake to date (EERI 2003:p1).Hurricane Katrina demonstrated interconnections between society, the environment and the regulatory and policy framework, all of which contributed to the extraordinary vulnerability of New Orleans. In 2003, an interdisciplinary panel of scientists and engineers produced a research plan to address the following factors contributing to increasing seismic vulnerability (EERI 2003: p 4):

### *A. Codes:*

The primary objective of building codes and regulations is to protect the lives of occupants, rather than avoid future economic loss. Despite recent advances, current building codes are based on incomplete knowledge of structural and foundation Performance, resulting in the construction of facilities that, while code compliant, may have significant vulnerability and therefore lead to economic losses.

### *B. Knowledge:*

The knowledge of earthquake hazards and their impact is still evolving, and we continue to design and construct new facilities without fully understanding the potential hazards.

### *C. Costs:*

The cost of using current technology to rehabilitate older construction is often high, as is the cost of improving new construction to minimize risk. Decision makers either do not completely understand the risk, or do not perceive adequate economic incentives to warrant sufficient investment. They lack the decision-making tools necessary to identify these incentives.

### *D. Systems:*

The growing interconnectedness of society, enabled by extensive transportation systems and modern communications, greatly expands the impacted area of a damaging earthquake far beyond the epi central region. Global trade, commerce, and defense may all be affected if a critical link in a communications or distribution network is taken out of service by an earthquake. A local disaster can quickly become major challenges.

## VIII. Major Challenges in Earthquake Risk Reduction

National one, which in turn can lead to an escalation in financial loss not seen after earthquakes a decade ago. Building on this report, authors of the National Research Council report, Facing Hazards and Disasters, in writing on interdisciplinary research needs, identified several research needs (see Chapter 5,National Research Council 2006: p 197)that cut across disciplinary boundaries, including:

### *A. System-level simulation and loss assessment tools*

### *B. Assessment of cost effectiveness of loss mitigation*

### *C. Financial instruments to transfer risk*

### *D. Advanced and emerging technologies for emergency response and effective recovery*

Methodologies and measurement of progress in reducing vulnerability and enhancing community resilience to earthquakes several major challenges confronting the earthquake risk reduction community were identified by the project committee and workshop participants:

#### *1) Understanding Nonstructural Damage:*

Much of the progress over the past20 years has come in improved models of structural damage, but nonstructural damage has been largely unaddressed even though it accounts for about 75%of economic losses and is a key factor in determining post-earthquake functionality(downtime of businesses and critical facilities).

#### *2) Understanding And Forecasting Social And Economic Consequences:*

The social sciences have done an excellent job of characterizing the kinds of social consequences that flow from earthquakes and other natural hazards. We have some initial models of economic loss, casualties, and shelter demand, but we still have a long way to go to produce the kinds of consequence estimates that will get the attention of decision makers and support better emergency response planning.

#### *3) Understanding the Decision-Making Process:*

Although significant progress has been made on describing the decision-making process, we still do not know the key leverage points that can affect decisions by public officials and building owners as well as the larger public. As part of this challenge, we need to improve our ability to characterize and communicate risk and uncertainty. New technology provides many new ways to communicate earthquake risk information, but much of our work still relies on paper maps and conditional probability statements.

#### *4) Incorporation of Advanced Sensors:*

Low-cost sensors can now provide almost real-time information on the state and performance of buildings and infrastructure systems. As the built environment becomes "smart," we need to understand how to use this information to provide real-time adjustments and emergency response. This can involve a range of responses from valve shut-offs to automated warning systems.

#### *5) Motivation for Action:*

The infrequent nature of catastrophic earthquakes presents challenges for preparedness at the individual and organizational levels. Understanding how to motivate desired behavior is a major hurdle in the earthquake risk reduction community.

In 2005, the Subcommittee on Disaster Reduction (SDR) of the President’s National Science and Technology Council took a broad look at issues in disaster risk reduction. The SDR facilitates national

## IX. Earthquake Risk Reduction: Addressing the Unmet Challenges

Strategies for reducing disaster risks and losses that are based on effective use of science and technology. Their report notes that while the number of lives lost each year to natural disasters is falling, their costs are continuing to increase. The report argues that communities need to enhance their disaster resilience, and they identified six Grand Challenges that need to be addressed to facilitate this resilience (SDR 2005):

(1) Provide hazard and disaster information where and when it is needed. Mechanisms for real-time data collection and interpretation must be readily available to and usable by scientists, emergency

 

managers, first responders, citizens, and policy makers.

(2) Understand the natural processes that produce hazards. Scientists and engineers must continue to pursue basic research on the natural processes that produce hazards and understand how and when processes become hazardous.
(3) Develop hazard mitigation strategies and technologies. Scientists must invent, and communities must implement, affordable and effective hazard mitigation strategies.
(4) Recognize and reduce vulnerability of interdependent critical infrastructure. Protecting critical infrastructure systems is essential to developing and maintaining disaster-resilient communities.
(5) Assess disaster resilience using standard methods. Consistent actors and regularly updated metrics will support comparability communities and provide a context for action to further reduce vulnerability.
(6) Promote risk-wise behavior. Develop and apply principles of economics and human behavior to enhance communications, Trust, and understanding within the community to promote "risk-wise" behavior. These grand challenges reflect complex systems-level problems that demand interdisciplinary teams of experts to take them on.

## X. The Interdisciplinary Nature of these Problems

The director of the National Science Foundation in recent Congressional testimony noted, "The current scientific era is characterized by interdisciplinary research with much of the promise of future work occurring at the interstices between traditional scientific disciplines...We must continue to push the frontiers through interdisciplinary, transformative research" (Bement 2007).Edward Stone of the Jet Propulsion Laboratory observed that "Interdisciplinary research is becoming more important as we try to understand how systems work. While many fundamental, single-discipline questions remain to be addressed, science and engineering are ready to address much bigger questions, such as ecologic and planetary systems. No single discipline has the capability to even start addressing whole systems" (NAS 2005).The National Academies Committee pointed to four fundamental forces that have led to an increased need for interdisciplinary research:

(1) The inherent complexity of nature and society
(2) The desire to explore problems and questions that are not confined to a single discipline
(3) the need to solve societal problems
(4) the power of new technologies(NAS 2005)Other fields, outside of earthquake risk reduction, appear strongly committed to the concept of interdisciplinary research and are moving ahead with new institutes and programs, particularly in the environmental sciences. In a National Academies report commissioned by NSF on Grand Challenges in Environmental Sciences, it was pointed out that most of the major challenges in the environmental sciences require multidisciplinary solutions, as "environment "can be conceptualized in biological, chemical, physical, or social scientific terms. Natural systems—ecosystems, oceans, drainage basins, etc. — are not divided along disciplinary lines (National Research Council 2001). The interim director of the recently created Graham Environmental Sustainability Institute at the University of Michigan has stated: The issues are complex. They cut across political and geographical boundaries. They involve understanding the intricate linkages among living and inanimate life-support systems... The practical solutions are not at all clear...Many of the most pressing problems cut across disciplines and methodologies and fall between institutional boundaries...Not only are the issues cross-disciplinary, but often require significant commitments of human and capital resources There are even some scientific fields where interdisciplinary research has led to the creation of new disciplines, such as geo biology and geo microbiology For example, The Interdisciplinary Nature of these Problems12in 2000, the American Academy of Microbiology held a colloquium on Geo biology Exploring the Interface Between the Biosphere and the Geo sphere," where participants called for the interdisciplinary training of researchers and funding of research projects in this new field. Subsequently, the American Geophysical Union formed a section on Bio geo sciences, and the Geological Society of America created a Division on Geo biology and Geo microbiology (NAS2005: p 142).In recognition of the need for an interdisciplinary approach in complex engineering problems, the National Science Foundation provides funding for a variety of engineering centers throughout the U.S. with a goal to "enable transforming systems technologies and educate a globally competitive and diverse engineering workforce in an integrated, interdisciplinary research environment, where academe and industry join in partnership to advance fundamental engineering knowledge, enabling technology, and engineered systems" (NSF 2007).NSF views these engineering centers as change agents for academic engineering programs and the engineering community at large. The three earthquake engineering centers that received funding from NSF under this ERC program are examples of such an environment, where problems that cut across disciplines and institutional boundaries can be addressed. The NSF-funded earthquake science center at SCEC is another example, where the "major research issues of earthquake science are true system-level problems—they require an interdisciplinary, multi-institutional approach that considers the nonlinear interactions among many fault-system elements" (Benthien 2007). The following section highlights some of the successes of these centers, along with other examples in the earthquake field of important interdisciplinary projects.

### *A. Disaster Management Policy:*

Disaster management is a multidisciplinary activity involving a number of a number of Departments/agencies spanning across all sectors of development. Where a number of Departments/agencies are involved, it is essential to have a policy in place, as it Disaster Management in India serves as a framework for action by all the relevant departments/agencies. A National policy on disaster management has been drafted, and is in the process of consultations. In the line with the changed focus, the policy proposes to integrate disaster mitigation into development planning. The policy shall inform all spheres of Central Government activity and shall enjoin upon all existing sectorial policies. The broad objective of the policy are to minimize the loss of lives and social, private and community assets because of natural or man-made disasters and contribute to sustainable development and better standards of living for all, more specifically for the poor and vulnerable section by ensuring that the developments gains are not lost through natural calamities/ disaster. The policy notes that State Governments are primarily responsible for disaster management including prevention and mitigation, while the Government of India provides assistance where necessary as per the norms laid down from time to time and proposes that this overall framework may continue. However, since response to a disaster requires coordination of resources available across all the Departments of the Government, the policy mandates that the Central Government will, in conjunction with the State Governments, seek to ensure that such a coordination mechanism is laid down through an appropriate chain of command so that mobilization of resources is facilitated. Broad features of the draft national policy on disaster management are enunciated below: -i) a holistic and pro-active approach towards prevention, mitigation and preparedness will be adopted for disaster management. ii) Each Ministry/Department of the Central/State Government will set apart an appropriate quantum of funds under the Plan for specific schemes/projects addressing vulnerability reduction and preparedness. Disaster Management in India iii) Where there is a shelf of projects, projects addressing mitigation will be given priority. Mitigation measures shall be built into the on-going schemes /programmes IV) each project in a hazard prone area will have mitigation as an essential term of reference. The project report will include a statement as to how the project addresses vulnerability reduction. v) Community involvement and awareness generation, particularly that of the vulnerable segments of population and women has been emphasized as necessary for sustainable disaster risk reduction. This is a critical component of the policy since communities are the first responders to disasters and, therefore, unless they are empowered and made capable of managing disasters, any amount of external support cannot lead to optimal results.vi) There will be close interaction with the corporate sector, nongovernmental organizations and the media in the national efforts for disaster prevention/vulnerability reduction.vii) Institutional structures/appropriate chain of command will be built up and appropriate training imparted to disaster managers at various levels to ensure coordinated and quick response at all levels; and development of inter-State arrangements for sharing of resources during emergencies. viii) A culture of planning and preparedness is to be inculcated at all levels for capacity building measures. ix) Standard operating procedures and disaster management plans at state and district levels as well as by relevant central government departments for handling specific disasters will be lay down. x) Construction designs must correspond to the requirements as laid down in relevant Indian Standards. xi) All lifeline buildings in seismic zones III, IV & V – hospitals, railway stations, airports/airport control towers, fire station buildings, bus stands Disaster Management in India major administrative centers will need to be evaluated and, if necessary, retro-fitted. xii) The existing relief codes in the States will be revised to develop them into disaster management codes/manuals for institutionalizing the planning process with particular attention to mitigation and preparedness. xiii) To promote international cooperation in the area of disaster response, preparedness, and mitigation in tune with national strategic goals and objectives .The States have also been advised to formulate State DM Policies with the broad objective to minimize the loss of lives and social, private and community assets and contribute to sustainable development. The States of Gujarat and Madhya Pradesh have States Policies for Disaster Management in place while other States are in process.

### *B. Legal And Techno-Legal Framework:*

#### *1) Disaster Management Act:*

The States have been advised to enact Disaster Management Acts. These Acts provide for adequate powers for authorities coordinating mitigation, preparedness and response as well as for mitigation/prevention measures required to be undertaken. Two States Gujarat &Bihar have already enacted such a law. Other States are in the process.

#### *2) Disaster Management Code:*

In line with the changed approach, the State Governments have also been advised to convert their Relief Codes into Disaster Management Codes by building into it the process necessary for drawing up disaster management and mitigation plans as well as elements of preparedness apart from response and relief. A Committee constituted under the Executive Director, National institute of Disaster Management has drafted a Model Disaster. Management Code which is being circulated to the States so as to assist them in this process. Some States have constituted committees to revise the codes as per GOI guidelines. The revised codes will ensure that the process of drawing up disaster management plans and mitigation and preparedness measures get institutionalized.

### *C. Disaster Risk Management Programme:*

A Disaster Risk Management Programme has been taken up in 169 districts in 17 multi-hazard prone States with the assistance from UNDP, USAID and European Union. These States are Assam, Arunachal Pradesh, Bihar, Delhi, Gujarat, Maharashtra, Meghalaya, Mizoram, Manipur, Nagaland, Orissa, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, Uttaranchal and West Bengal, Under this project, the States are being assisted to draw up State, district and Block level disaster management plans; village disaster management plans are being developed in conjunction with the Panchayati Raj Institutions and disaster management teams consisting of village volunteers are being trained in preparedness and response functions such as search and rescue, first aid, relief coordination, shelter management etc. States and District level multi-hazard resistant Emergency Operation Centers (EOCs) are also being set up under the programme. Equipment needs for district and State Emergency Operation Centers have been identified by the State nodal agencies and equipment is being provided to equip these EOCs. Orientation training of masons, engineers and architects in disaster resistant technologies has been initiated in these districts and construction of model demonstration buildings will be started soon. Under this programme Disaster Management Plans have been prepared for8643 villages, 1046 Gram Panchayat, 188 blocks and 82 districts. More than29000 elected representatives of Panchayati Raj Institutions have already be entrained, besides imparting training to members of voluntary organizations. About18000 Government functionaries have been trained in disaster mitigation and preparedness at different levels. 865 engineers and 425 architects have been trained under this programme in vulnerability assessment and retrofitting of lifeline buildings. 600 master trainers and 1200 teachers have already been trained Disaster Management in India in different districts in disaster preparedness and mitigation. Disaster Management Committees consisting of elected representatives, civil society members, Civil Defense volunteers and Government functionaries have been constituted at all levels including village/urban local body/ward levels. Disaster Management Teams have been constituted in villages and are being imparted training in basic functions of first aid, rescue, evacuation and related issues. The thrust of the programme is to build up capabilities of the community since the community is invariably the first responder. Capacity building of the community has been very helpful even in normal situations when isolated instances of drowning, burns etc. take place. With the creation of awareness generation on disaster mitigation, the community will be able to function as a well-knit unit in case of any emergency. Mock drills are carried out from time to time under the close supervision of Disaster Management Committees. The Disaster Management Committees and Disaster Management Teams have been established by notifications issued by the state Governments which will ensure that the entire system is institutionalized and does not disintegrate after the conclusion of the programme. The key points being stressed under this programme are the need to ensure sustainability of the programme, development of training modules; manuals and codes, focused attention to awareness generation campaigns; institutionalization of disaster management committees and disaster management teams, disaster management plans and mock-drills and establishment of techno-legal regimes.

### *D. India Disaster Resource Network:*

A web-enabled centralized data base for the India Disaster Resource Network has been operationalized. The IDRN is a nation-wide electronic inventory of essential and specialist resources for disaster response both specialist equipment and specialist manpower resources. The IDRN list out the equipments and the resources by type and by the functions it performs and it gives the contact address and telephone numbers of the controlling officers in-charge of the said resources. The IDRN is a live system providing for updating of inventory once in every quarter. Entries into the inventory are made at district and State level. The network ensures quick access to resources to minimize response time in emergencies. The list of resources to be updated in the system has been finalized. It has 226 items. About 69,329 records in 545 districts throughout the country have already been uploaded since September 1, 2003when the India Disaster Resource Network was formally inaugurated. The system will give, at the touch of the button, location of specific equipment’s/specialist resources as well as the Controlling authority for that resource so that it can bemobilized for response in the shortest possible time. The data base will be available simultaneously at the district, state and national levels.

### *E. Development Of A GIS-Based National Database For Disaster Management:*

The Geographical Information System (GIS) data base is an effective tool for emergency responders to access information in terms of crucial parameters for the disaster affected areas. The crucial parameters include location of the public facilities, communication links and transportation network at national, state and district levels. The GIS data base already available with different agencies of the Government is being upgraded and the gaps are proposed to be bridged. A project for this purpose is being drawn up with a view to institutionalize the arrangements. The data base will provide multi layered maps on district wise basis. These maps taken in conjunction with the satellite images available for a particular area will enable the district administration as well as State Governments to carry out hazard zonation and vulnerability assessment, as well as coordinate response after a disaster. Recognizing the crucial importance of Geographical Information System (GIS) as a decision support tool for disaster management, the Ministry of Home Affairs proposes to establish a GIS database, ‘National Database for Disaster Management (NDDM)’, which will assist in hazard zonation, risk assessment, preparedness and emergency response management.

### *F. Disaster Risk Reduction – Role Of Information And Knowledge:*

Many of us assume that knowledge management is about capturing best practices and experiences people have and store it in a database with a hope that it will be useful later. In fact this is not true and many of us spend more than ten percent of our time in searching for a piece of information we know resides somewhere. Knowledge management is all about getting the right knowledge, in the right place, at the right time. In a broader context, information about disaster preparedness, dos’ and don’ts in emergency, disaster management plans, policies and guidelines are available at various domains from decades. However, millions of people are getting severely affected by disasters every year due to lack of adequate coping with Knowledge Management in Disaster Risk Reduction mechanisms. This may be attributed to the fact that the information lying at one place is not getting transformed into the lifesaving knowledge for the communities at risk. It is a proven fact that India is among the world’s most disaster prone countries due to its geo climatic conditions, large population and socio-economic conditions. With the lead of Ministry of Home Affairs, Government of India, many Government & Non-

 

Government Organizations, research and educational institutions are working towards vulnerability reduction in the country. Due to its large geography, the experiences, approaches and adopted modalities for disaster management is not codified and remains with individuals as a tacit knowledge. The linkages among all agencies working on disaster management need to be strengthened in order to derive the regional best practices and coping mechanisms. In order to enhance the information sharing and management of the knowledge generated in these institutions, it is highly essential to closely knit the organizations/ institutions and moreover people. The network of these institutions will create a common platform and enable its stake holders and people to capture, organize, share and reuse the knowledge generated in the area of disaster management. The network will use various tools to connect the Government, Institutions and people.

### *G. Indian Approach To Knowledge Management In – Disaster Risk Reduction Practice Area:*

Under the Ministry of Home Affairs, GOI-UNDP (United Nations Development Programme) National Disaster Risk Management programme, Knowledge Networking is foreseen as an initiative to establish networks and partnership among prime government agencies, policy makers, disaster managers and specialists from allied fields of engineering, architecture, planning, seismology, hydrology, agriculture and social science to exchange information and working together to reduce the risk of disaster. The initiative is aiming to connect all government departments, statutory agencies, research organizations/Institutions to share collectively and individually their expert know-how's. The exchange is facilitated through physical interaction, workshops, documentation of experiences, sharing on World Wide Web Portal etc.

## XI. RECOMMENDATIONS

(1) Policy and legislative bodies at all levels of government and the nonprofit and business sectors should provide leadership that acknowledges the critical value of the interdisciplinary research approach.
(2) Funding agencies should provide innovative, risk-taking leadership.
(3) Funding agencies, including NSF's NEES program, should support additional grand challenge research projects.
(4) Funding agencies should advocate for problem focused research in earthquake risk reduction, by setting aside a certain percentage of the budget for this purpose.
(5) Funding agencies should support the use of earthquakes as systems-level, natural laboratories.
(6) Funding agencies and partners expand mentoring programs.
(7) Funding agencies and academic departments should establish programs to promote the involvement of junior faculty in inter disciplinary hazards research.
(8) Funding agencies should develop proposal evaluation strategies that recognize the rich and complex nature of problem-focused research by involving reviewers from abroad range of relevant disciplines.
(9) Funding agencies should support research centers
(10) Academic institutions should build communities of scholars and students open to cross disciplinary collaboration.
(11) Funding agencies and academic institutions should create mechanisms to reward researchers whose research interests and capabilities cut across disciplinary and departmental boundaries.
(12) Academic institutions should pool resources across academic departments—and across hazards.
(13) Professional societies should develop specific strategies to reinforce the importance of inter disciplinary research and practice.

## XII. CONCLUSION

By working together to build strategies that promote problem-focused research, the earthquake research community, funding agencies, practitioners, and policy makers can move forward to reduce earthquake risk. Encouraging collaboration among the many disciplines and defining research activities around critical problems are important steps in this direction. The earthquake community must continue to work together to address the complex challenges that remain to be solved. Two important elements emerge which need urgent attention to improve the earthquake safety scenario in the country: the institutional development whereby the discipline of earthquake engineering is nurtured and developed at a much larger number of locations, and involvement of professional engineers and architects into the seismic agenda. Quality manpower in earthquake engineering is clearly in short supply and a major effort needs to be made to strengthen the same

In a developing country such as India, basic poverty issues like food, shelter, health, and education remain the highest priority and natural disaster mitigation does not get the priority that it should. Amongst the major challenges ahead is to sensitize the policy makers, the politicians and the administrators to the issues of. Information and Communication Technologies in form of Internet, GIS, Remote Sensing, and Satellite Communication etc. are indispensable in planning and successful implementation of most Disaster Risk Reduction initiatives. planning process essentially means looking critically at each activity that is being planned, not only from the perspective of reducing the disaster vulnerability of that activity, but also from the perspective of minimizing that activity's potential contribution to the hazard. Every development plan of each Ministry and Department should incorporate elements of impact assessment, risk reduction, and the `does no harm' approach.

There is need to identify and establish appropriate institutional arrangements for mainstreaming disaster risk management. A major challenge is to develop the skills, capacities and tools necessary to change the current focus on disaster response which relies mainly on competencies related to logistics, commodity management, communications, etc.) To one of disaster education (which requires competencies relative to risk assessment, cost-benefit analysis, project planning, advocacy, networking, etc.).

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