

## Valedictory Session SECOND INDIA DISASTER MANAGEMENT CONGRESS

### Geological Disasters (1) Earthquakes and (2) Landslides and Avalanches

#### Draft Output Report

Under the thematic cluster Geological Disasters, a total of 132 abstract of papers were received (Earthquake, 55 and Landslides, 77), including 12 papers from abroad that bring added experience, lateral thinking and technology to our advantage. Between them, they cover the entire gamut of concerns associated with earthquake and landslide risk reduction, although spotlight was seen on the states of Jammu and Kashmir, Gujarat, Himachal Pradesh, Uttarakhand, Sikkim, West Bengal ( Darjeeling District), Meghalaya, Nagaland and Mizoram and the tsunami affected coastal states. The reported announcement of a national policy on disasters, the already promulgated National Disaster Management Act, the release of NDMA Guidelines on Earthquakes, Landslides and Snow Avalanches, and the much talked about aim of achieving a paradigm shift in focus from the relief centric disaster management to the culture of disaster mitigation and preparedness raise our hopes that everything possible will be done to vigorously implement the related action plans, in a time bound manner.

#### The highlights of the Technical Session on Earthquakes:

1. One of the major concerns expressed at the conference was avoidable deaths due to building collapse. Besides the large highly vulnerable existing housing stock where people live under constant threat of earthquakes, non-compliance of seismic design codes and unchecked non-engineered new constructions add considerably to our woe and worry. The delegates underscored the urgency of speedy implementation of the National Guidelines on Earthquakes released by the NDMA in April 2007 and since two years have already elapsed, it is time for stock taking and midcourse correction.
2. The mission of earthquake safe new construction through zero tolerance for non-compliance of the Earthquake Resistant Design and Construction codes and practices is attainable provided we have a strong political will, tighter techno-legal regime, specialized training of our architects and engineers and artisans. The other major concern relates to earthquake unsafe existing housing stock that requires strengthening. In view of huge investments required, this task will need careful prioritization. Conference papers underscore the need to develop suitable (rapid) screening methods for seismic safety audit of all kinds of existing buildings especially because the methodologies developed in other countries may not suit our situation. The rapid screening methodology proposed for RC framed buildings in India was discussed as also the use of a modified rapid screening methodology to safety audit of buildings in Mussoorie and Joshimath. Several institutions in India are working on this aspect and it is time that a nationally acceptable approach is found. As regards the training of professionals and others as envisioned, we clearly see a shortage of accomplished teachers and right kind of knowledge products and teaching aids. Delegates wondered whether meaningful safety audit will be possible without investing on well designed training programmes on safety audit.
3. The strengthening of seismically unsafe buildings invariably involves condition assessment of buildings and their foundations, decision making on whether retrofitting is the cost-effective

answer, evaluation of anticipated seismic forces, selection of appropriate retrofitting strategy, design and construction. The variability of structure types combine with the even greater variability of geological materials underneath to make building strengthening a highly technical job. The Hand Book on Retrofitting developed by IIT Madras jointly with CPWD was well received at the conference and appears as is a step forward. What we need now is the well considered feedback from the entire sweep of user agencies to make this handbook and such other publications on the subject more user-friendly and responsive to our diverse needs. We need a conscientious effort to make it happen.

4. Indian examples of cost-effective retrofitting of buildings can best inspire Indians. The experience gained in retrofitting of dwellings particularly after the earthquakes of Uttarkashi(1991), Latur (1993),Gujarat (2001) and Kashmir(2005) and the major retrofitting project in Delhi implemented jointly by the Delhi Government and the GeoHazards International should be appropriately packaged and disseminated to create the much needed demonstration effect. When such dissemination programmes are designed, advantage should be taken of all the other similar projects, either completed or being pursued concurrently. It is hoped that a scientific documentation of the case histories will be peer reviewed and thereafter widely disseminated highlighting the challenges faced, assumptions made, engineering judgment exercised and the expected performance of retrofitted buildings in the event of an earthquake. Retrofitting projects must pay as much attention to the foundation of buildings as they pay to the super structure.
5. Delegates are emphatic that the time tested traditional building construction technologies, like the Dhaji Dewari, the Taaq System and the Gujjar Dhokas in Jammu and Kashmir and the Assam type housing in the North East should not get overshadowed by the glamour of new technology. Rather, both should both be integrated and go through rigorous scientific scrutiny for continuous innovation. The designers and artisans should know about what normally goes wrong in actual implementation of construction plans. It was observed that even the simple things like the ductile detailing practices (for example detailing of beam-column joint) are not being followed. One of the conference papers reminds that the tall structures in Delhi face the threat to their safety because of Rayleigh waves generated due to a distant earthquake. One other paper reminds us that a good design and a good construction do not always lead to a safe house unless it is assured that building materials used are wisely selected with appropriate choice of technology.
6. Seismic microzonation has captured the imagination of the Government of India particularly after the Kachch earthquake of 2001 and reportedly today, the seismic microzonation programmes are at their various stages of progress in 63 cities of India, including important mega cities. Concerns about use of different methodologies, different mapping scales, hugely differing levels of respect for quality geotechnical investigations despite its great importance and pitfalls of deterministic seismic analyses that ignore uncertainties, need to be addressed before we go too far with the ongoing programmes. The most important recommendation that emerge out of this huge national effort is to quickly discharge the obligation of putting independently validated and certified, user friendly Seismic Zonation Maps in the hands of planners, architects, engineers , builders and disaster managers for whom they are intended. Studies of the kind reported for Guwahati city and for Chandigarh are useful but the reliability check of the information used and assumptions made is essential.
7. Seismic risks in hilly areas add a new dimension to the seismic microzonation exercise. This is because buildings may be structurally safe and yet they may come down during an earthquake

if it becomes part of an earthquake- induced slope failure, or a landslide. One of the conference papers cite irregular forms of construction, uneven level of foundations, wrong choice of building materials, and poor quality of construction due to non availability of skilled labour as additional matters of concern in the hilly areas. There is an urgent need to ensure that landslide mapping be made a subset of all seismic microzonation programmes in the hilly areas and we should develop Guidelines to address seismological, meteorological , geological , geotechnical civil engineering , anthropogenic and development concerns in an integrated manner.

8. Records of historic earthquakes are of immense value and deserve to be catalogued from the primary sources of information to provide insights into the earthquake history of a region. Advantage should be taken of the techniques used to identify signatures of past earthquake through, for example, study of geomorphic expressions and dating techniques.
9. For assessment of seismic risk, we critically depend on a reliable attenuation relationship of the region of interest. Blind use of the attenuation relationships developed abroad for their own respective regions is clearly undesirable because these attenuation relationships are based on very different seismic intensity scales under use in different parts of the world. There is a need to develop attenuation relationships for different regions of India based on our own data and these should be tested at every field opportunity. The attenuation relationship used for the state of Tamil Nadu in one of the conference papers must be seen in the above light.
10. A powerful network of seismic instrumentation and monitoring is India's strength. It is refreshing to note from the conference papers that our past earthquake areas are continuously being monitored to record and study the associated seismic activity. For example, the Kuchcha area is being monitored for which a Multi-parametric Geophysical Observatory has been established and a very sensitive dual sphere superconducting gravimeter has been installed. A dense network of more than 20 broadband seismographs has made it possible to observe foreshock clustering and precursory changes in source parameters and results so far raise the hope of earthquake prediction. Similarly, the areas affected by Uttarkashi earthquake of 20 October 1991 and Chamoli earthquake of 29 March 1999 are being monitored by VSAT linked broad band seismic network. Reporting of data by individual institutions, although useful they are, need to carefully digested and correlated not only with the past seismic histories of the areas they represent but also with relevant geo-tectonic details and other allied measurements. The co-seismic vertical ground movements in the Andaman area observed during the great Indonesian earthquake of 26 December 2004, and reported in the conference, also need in-depth studies and explaining. We need to continuously strengthen seismic instrumentation for earthquake monitoring and geotechnical instrumentation for landslide monitoring.
11. Forecasting and prediction of earthquakes are the topics yet to be vigorously pursued in India although in every conference we get some papers following one or more of the known approaches such as continuous tracking of crustal movements, seismic, geo-electric, geomagnetic, geochemical, geothermal observations and geodetic and ground water measurements and reference to unusual animal behaviour . We have seen some attention being paid to geophysical and geochemical methods, statistical analysis, chaos physics, ground and satellite technologies and atmospheric precursors and real-time monitoring. References to prediction of earthquakes through monitoring of foreshock clustering and precursory changes , establishing correlation between magnitude and epicentral distance of earthquakes for the Shillong plateau and a Seismic Alert System in Shillong and Guwahati and hazard assessment using Fractal dimension of the past earthquake sequence are worthy of note.

Scientists feel that thrust on earthquake prediction must continue. The engineers feel that, given the resource crunch, strengthening of buildings must get precedence. Let us find resource to give a big boost to earthquake safe construction but let it not be at the expense of research on earthquake prediction.

12. Success stories in post disaster reconstruction, especially after the Muzaffarabad earthquake of 2005, the Indian Ocean tsunami of 2004, the Gujarat earthquake of 2001, the Latur earthquake of 1993 and the Uttarkashi earthquake of 1991 throw many lessons of which the most important is adoption of a community-centric, multi-sector approach with efficient coordination mechanisms and empowerment. Case history of Reconstruction Programme undertaken in Baramulla district of J & K highlights promotion of traditional technologies, improved awakening of the communities to disaster preparedness for the future, strengthening of the civil society , improved understanding of seismic design codes, besides delivery of earthquake resistant housing. There is a need to critically evaluate such reconstruction projects. The challenges faced , the mistakes made and the lessons learned should be widely disseminated . These case histories should become part of the training in the management of earthquake and landslide disasters.

The highlights of the Technical Session on Landslides and Avalanches :

1. Landslides and Avalanches listed under Geological hazards are no longer only geological in nature but involve a very strong component of anthropogenic factor complicated by continued neglect of slopes, unabated non-engineered constructions and climate change. The challenge in front of us can be met to a significant extent by a multidisciplinary assault on the problem NDMA has come out with National Guidelines on Management of Landslides released by NDMA in June 2009. It is expected that GSI, the nodal agency, will evolve programmes and projects with a strong multi-institutional networking for pooling of expertise, leveraging of capacities and aiming at creating centres of excellence. The challenge before us is not to take management of Landslides and Avalanches as an all out war to stop them from occurring. It should mean inculcating the same culture of non-violence against Mountains as we find in the thoughts and teachings of Mahavir and Gandhiji.
2. Case records presented at this conference leave one in no doubt that a number of human settlements, roads and highways, communication lines, bridges, water reservoirs and dams are becoming increasingly vulnerable to landslides and other mass movements. This is amply brought out by examples of the human settlements in the over stressed Kashmir Valley , unauthorized and non-engineered constructions in the Sikkim Himalaya, vulnerability of hydroelectric projects in Garhwal Himalaya , perennial threat to pilgrim routes to the shrines of Badrinath and Vaishnav Devi and problems encountered on the Nainital-Kathgodam portion of NH 87 , widened cuts of NH 22 and constant avalanche threat to NH 1A connecting Jammu with Srinagar- a lifeline for civil and defence population. All the above concerns are distributed over a number of states, government departments, public and private sector undertakings, institutions and others. It follows therefore that new knowledge generated, experiences gained, challenges faced, and lessons learnt will continue to remain scattered unless a conscientious effort is made to breed bilateral and multi-lateral interactions among different agencies between the conferences such as this one.
1. Most major slope failures of today are landslide disasters in making and call for timely preventive action. The best way to promote healthy landslide management practices suited to different geo-climatic and geotechnical situations is to create examples others can follow.

Conference throws two examples of major landslides controlled through intensive effort; the Sonapur landslide in Meghalaya and the Varnavrat Landslide in Uttrakhand. The adequacy or otherwise of the steps taken, only time will show but what is to be deeply appreciated is the determined effort for a lasting solution, doing away with palliative remedial action. A few handpicked cases of landslides should be taken on hand to showcase scientific geological and geotechnical engineering best practices including merit of new technology and efficacy of early warning systems. Investment in disaster resilient communities will pay rich dividends. Border Roads Organization is repository of national experience on landslide control and Snow and Avalanche Study Establishment does the same as regards to snow avalanches. Both these organizations, among others, need strengthening. Whereas proliferation of new institutions is to be resisted, we do need more such organizations or centres in areas that deserve specific focus.

2. Most of the projects involving landslide control have no built in mechanism to know about the efficacy of control measures and cost-effectiveness of the designs. Adequate investments are essential for monitoring of major landslides over a length of time for early warning and cost effective remediation. NDMA, State Governments and our national project funding agencies must insist on making slope management an integral part of development projects and their control effort should involve a comprehensive slope treatment after a thorough investigation in place of the usual piece-meal (palliative) approach without adequate investigation.
3. Capacity Building is primarily building of our institutions. Thanks to creation of Snow and Avalanche management that we not only have one dozen papers in this conference on the multi-faceted aspects of Snow and Avalanche management. Western Himalaya, Himachal Pradesh and Uttrakhand together regularly displays a spectrum of deadly avalanches and this matchless opportunity have been availed of by SASE to tests avalanche evaluation models, forecasting techniques, early warning systems, preventive works, avalanche control measures, search and rescue, and field training in avalanche management.. Our network of Automatic Weather Stations (AWS), Upper Air Stations (UAS) and Doppler radar for collection of snow meteorological and avalanche related data on daily basis has facilitated coordinated avalanche disaster management, avalanche forecasting, awareness generation and delivery of avalanche zonation and a digital Avalanche Atlas.

A further impetus to Airborne hyperspectral imaging, Spectroradiometer, LiDAR, digital photogrammetry and GPR and continued innovation in tapping the full potential of Unmanned Aerial Vehicles and related robotics and sensor technology in the ongoing studies on snow and glacier will go a long way in national capacity building in the area of Snow and Avalanche management

4. Landslide management in the country can only be as efficient as the quality of investigations we make and appropriateness of technology we use. Geohazards across the globe, be they earthquakes, landslides, avalanches or volcanoes, are closely being studied and much better understood thanks to a spate of fast emerging new technologies. The Interferometric Synthetic Aperture Radar (InSAR) Monitoring study reported at the conference, is now routinely being used, for example, in monitoring landslide activities along strategic and transportation corridors in Canada, China and Latin America. The fact that Geohazard sites could be frequently revisited makes it possible to keep a constant vigil on the problematic sites for timely remediation and early warning. Germans have come out with a technology that equips cars with special radio receivers that would trigger horns even in parked cars, in the event of an early warning. India enjoys a pre-eminent position in space technology and it is time that

we multiply Satellite based warning systems (SatWaS) and Geohazard monitoring. There is an enormous potential for use of Ground Based Synthetic Aperture Radar Interferometry (GBSAR) networked with Global Positioning System (GPS). National investments should come to this area.

5. Planning and Engineering of slopes and landslides critically depend on the reliability and user friendliness of Landslide Zonation maps. Geological Survey of India, the nodal agency for Landslide management, and many other organizations are engaged for decades in developing Landslide Zonation Maps at varying scales of mapping. These institutions must address four major concerns expeditiously. First of all they must converge on the criteria leading to choice of mapping scale and methodology used. Secondly, they must ensure that the maps are not open-ended but validated based on quality field evidence. Thirdly, all maps should be made user-friendly to architects, planners, engineers, builders and disaster managers for whom they are intended. And finally, all completed and certified maps should be placed in public domain with conscientious effort to promote their use. Studies on zonation of Satluj and zonation of rain-induced landslides at this conference and such other studies can help the process of validation.
6. The melting of glaciers due to Climate Change has attracted our attention to Glacial Lake Outburst Floods. Investments are necessary to pro-actively identify potentially dangerous glacial lakes and early warning systems should be developed to forewarn the population under threat.
7. The science of landslide investigation needs enormous improvement. Geological, geotechnical, seismological, meteorological and anthropogenic studies are all vital but the weakest link in the chain is the usual absence or poor quality of geotechnical investigation. The DST's initiative of opening a National Geotechnical Institute as discussed at the conference is laudable. Finding land, constructing a building and procuring the state of the art equipment will pose no problem, if funds are available. What needs ensuring is that geotechnical professionals of vision, experienced in institution building, are associated with this task right at the onset and a young scientists and engineers are pro-actively trained at the best centres of the world to be ready in time to man the institute.
8. The launching of South Asia Disaster Knowledge Network is a laudable initiative. Launching of India Disaster Knowledge Network is also realization of the vision reflected in the recommendation of the High Powered Committee Report to the Government of India, 9 years ago. This one single initiative can make all the difference, if dedicated groups are charged with the specific responsibilities. Besides recourse to the best in information communication technology, the challenge will lie in managing flood of unfiltered information from diverse sources and platforms, and timely presenting the continuous flow of information to fulfill the needs of stakeholders.
9. Educating the children on the diverse aspects by embedding the subject in school curricula is a visionary move which will ensure future success at the hands of posterity. It is time that we develop appropriate knowledge products and train a breed of teachers who will be able to do justice with the subjects they teach.