Earthquake Engineering :: Sharing Knowledge and Expertise

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The January 26 earthquake in Kutch region of Gujarat once again brought into focus earthquake science and our preparedness for such natural disasters. India has had three major quakes during the past decade. This time the situation is particularly grim because of the huge loss of life and widespread destruction in a relatively prosperous region of the country. Not only have urban and rural buildings been razed to the ground, the quake has caused great local and national financial loss.

As is said often – quakes don't kill people, it is the unsafe buildings, which do. The Bhuj quake's aftermath is a living example of this. Earthquakes of much greater intensity have been experienced elsewhere in the world, but the death tolls have been much lower than in Bhuj. Buildings can be made quake-resistant, if no1 quake- proof, by following building codes defined by the seismic history of a particular region. The Bureau of Indian Standards (BIS) has evolved a seismic hazard map of the country, and set building codes for each of the five regions – for both engineered and non-engineered structures. But unfortuna1ely, these codes are not mandatory and hence not adhered to. As a result, even engineered structures in urban areas like Ahmedabad crashed literally like a pack of cards.

On the other hand, consider the case of California, which falls in a highly seismic region in the west coast of the U.S. In October 1989, a high magnitude quake rocked the Santa Cruz Mountains in central California. The impact was felt in downtown San Francisco – l00 kilometers away – where occupants of the Transamerica Pyramid were unnerved. The 49-story office building shook for more than a minute. The U.S. Geological Survey (USGS) instruments, installed years earlier, showed that the top floor swayed more than one foot from side to side! However, no one was seriously injured, and the Transamerica Pyramid was not damaged. This famous San Francisco landmark had been designed to withstand even greater earthquake stresses, and that design worked as planned during the quake.

"No building is earthquake-proof. But a properly engineered tall building should be able to withstand the maximum credible earthquake for its area without collapse, and lesser seismic events without major structural damage," says R. Shankar Nair, chairman of Council on Tall Buildings and Urban Habitat, Chicago. "Of course, mistakes do happen, even in the U.S. But if American standards of design and construction had prevailed in the Bhuj area (an economic impossibility, of course), there would have been casualties from the collapse of a few small buildings and from falling objects, but no large, recently-built multistory building should have collapsed."

"California offers many good models which can be adapted to Indian conditions with the objective of better earthquake safety. But what we need most is enforcement of Indian standards on earthquake design. Most often theseare not being followed," observed Sudhir K. Jain, professor and head at the department of civil engineering, Indian Institute of technology in Kanpur (IITK), who was a co-leader of a joint Indo-U.S. team to the Bhuj region soon after the January 26 quake. William Lettis, a geologist, from the Lettis & associates, Walnut Creek, California, was also a co-leader of the team. Funded by the National Science Foundation, the team was a part of "Learning from Earthquakes" program of the Earthquake Engineering Research Institute (EERI), Oakland, California.

Though the top floor of the 49-story Transamreica Pyramid swayed more than one foot from side to side in the 1989 San Francisco earthquake, no one was injured nor the building damaged. Casualties were comparatively few in that quake. Most houses that collapsed were built on unstable ground.

The nine U.S. team members spent ten days in the field with their Indian counterparts in an investigation of the impact of the earthquake on the built environment, lifelines, port facilities, emergency response, shelter and interim housing. The team began its reconnaissance investigation in the city of Ahmedabad, and then moved to the more severely damaged epicentral areas.

Members of the team included several Indian-American engineers. The U.S. experts included Donald Ballantyne (EQE International, Inc., Seattle), Rakesh Goel (Cal Poly State University, San Luis Obispo Civil and Environmental Engineering), James Hengesh (URS Corporation, San Francisco), Praveen Malhotra (Factory Mutual Research Corp, Boston), Chandan K. Saikia (URS Corporation), Mahendra Pal Singh (Virginia Tech) and Krishna Vatsa (George Washington University).

The team not only surveyed the damaged caused to structures, and installations, but also performed initial aerial and field reconnaissance of the Kutch region including the epicentral area of the Bhuj earthquake. “The tectonic setting of the Kutch region is not well understood. The region has characteristics of both intraplate and plate margin environments. The presence of an active fold and thrust belt suggests that this region is part of the diffuse Indian / Asian plate boundary, or at least a transition zone between the stable portion of peninsular India and the plate boundary,” noted Lettis and Hengesh in a field report files from Gujarat. “However, some properties of the region, such as crustal thickness, rigidity and attenuation may be similar to more stable continental environments. Further research is to document the style and rate of deformation in the Kutch region prior to using the Bhuj earthquake as an example of a classic intraplate event.”

In fact, EERI has been studying Indian quakes as part of its "Learning from Earthquakes" program with the objective of learning lessons from quakes so as to reduce quake risk in future. In the past, after the Uttarkashi (1991), Killari/Latur (1993), Jabalpur (1997), and Chamoli (1999) quakes, EERI supported the IITK team for post-earthquake reconnaissance. After the Jabalpur quake, the IITK team made important observations on buildings with open first story or "soft story". Open first story is a typical feature in modern multistory constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas. This has been verified in numerous experiences of strong shaking during past earthquakes.

Many earthquakes in the past, like San Fernando (1971) and Northridge (1994) have demonstrated the potential hazard associated with such buildings. Major damage to critical hospital facilities in the San Fernando earthquake was attributed to the soft first story. Alarming amount of damage to the buildings with open basements for parking has been reported during the Northridge earthquake. The Jabalpur earthquake also illustrated the handicap of Indian buildings with soft first story," the IITK team observed. The Jabalpur earthquake, the first one in an urban neighborhood in India, provided an opportunity to assess the performance of engineered buildings in the country. In the Bhuj quake also, a lot of buildings with soft stories have collapsed.

The EERI-IITK collaboration has been further strengthened with the setting up of the National Information Center for Earthquake Engineering (NICEE)— the first of its kind in India. "Objectives of NICEE are rather simple. Collect and disseminate earthquake engineering information, literature, etc., to any interested person in the country. We felt that it will go a long way in capacity building within the country to be able to reduce earthquake disasters in the future," Says Jain, who is NICEE coordinator. The United States too has similar set-ups for earthquake engineering (at the University of California, Berkeley, the California Institute of Technology, Pasadena, and the State University of New York, Buffalo) since individual institutions cannot afford to purchase all the information. For NICEE, IITK has adopted the SUNY Buffalo model in which the publications acquired by the center are housed in the main library itself.

EERI has been providing its report and publications to NICEE free. Others who are contributing include the Multidisciplinary Center for Earthquake Engineering Research at Buffalo (MCEER) and the Pacific Earthquake Engineering Research Center, California. George Housner of Caltech – considered father of Earthquake Engineering by many- also has been providing encouragement and contributing a lot of books.

The engineering of earthquake-resistant constructions is rather a new discipline, and rapid developments are taking place in this area. But the gap between state-of-the-art and that in India has been widening in time. One of the contributing factors to this widening gap is the non-availability of latest books, journals, reports, and other materials emanating from other countries to the Indian researchers and professionals. NICEE is trying to compensate. "it appears to me that the most pressing need today is toward institution building and manpower development. To implement any ideas or concepts you will first need people," says Jain.

Indian scientists have been collaborating with American scientists in another vital area- study of crustal deformations in India using satellite technology. They have been using high precision Global Positioning System surveys to study the crustal deformations, using a constellation of GPS satellites owned and operated by the U.S. government.

As the Indian plate moves in a northeastward direction with a certain velocity, it collides with the Eurasian plate. For the past 25 million years, India has been colliding with Asia. The collision has consumed an entire ocean, several island arcs and an unknown fragment of the continent of India, resulting in the elevation of the Tibetan plateau to an average height of five kilometers. The instantaneous rate of collision holds the clue both to the stability of the Tibetan plateau and to the recurrence intervals of great earthquakes in the Himalayas. Hitherto, the collision rate has been poorly known. Quantifying the resulting strain is extremely useful for earthquake hazard studies.

In order to determine the collision rate, a group led by Roger Bilham at the University of Colorado began GPS measurements in Nepal and Tibet in 1991. The group conducted measurements in 1992 and 1994, and re-measured all points in November 1995 collaborating with French scientists and the Nepalese Survey Department. It collected GPS data throughout India, collaborating with scientists at the Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Bangalore, led by Vinod K. gaur. An eminent geophysicist, Gaur has been selected for the 2001 Edward A. Flinn III award of the American Geophysical Union, in recognition of his "unselfish cooperation in research through facilitating, coordinating, and implementing activities that have greatly strengthened the infrastructure for geophysical research."

The Indian Meteorological Department (IMD) also plans to strengthen its GIIS network by setting up more stations across the country. The Department of Science and Technology is funding a string of permanent, semi-permanent and field GPS stations at various scientific institutions. One field station was moved to the Bhuj area soon after the January 26 quake for local area studies. The instrumentation like (GPS receivers and monitoring equipment for some of the stations is being supplied by a U.S.-based firm Trimble. DST officials say GPS data collection in India has received a boost with the U.S. Department of Defense lifting certain restrictions on collection of high resolution data in May fast year.

The USGS and IMD have been in talks for sometime with regard to IMD joining USGS' Global Seismographic Network (GSN). But there has been no agreement on sharing of data. GSN has replaced an earlier 40-year-old network called World Wide Standard Seismographic Network (WWSSN). "We have closed virtually all stations of this network, including those in India, and overlaid the world with the GSN. While some of these GSN stations were sited in old WWSSN sites, the proposed GSN stations in India would have been at old WWSSN sites. But there has been no agreement on exchange of data with IMD," says john S. Derr, GSN chief.

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