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IMPLICATIONS OF 2001 BHUJ EARTHQUAKE FOR SEISMIC RISK REDUCTION IN INDIA

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SUMMARY

The 2001 Bhuj earthquake has been a major turning point in India towards agenda of seismic risk reduction. The earthquake caused attitudinal changes at all levels: public, government, leadership, and professional engineers. A number of new activities and initiatives have been possible due to enhanced level of awareness and interest caused by this earthquake. Several proactive measures are being initiated by the government of India towards risk mitigation and several states are now taking more interest in disaster management. It remains to be seen how much of this will actually translate into safer built environment. In general, where adequate preparation and capacity existed apriori, more effective mitigation activities could emerge in the aftermath of the earthquake.

INTRODUCTION

Indian earthquake problem needs no introduction. Some of the largest earthquakes of the world have occurred in the Indian subcontinent. However, the M7.7 Bhuj (Gujarat) earthquake of January 26, 2001 was the largest earthquake to have hit India in 50 years causing a death toll of 13,805 persons. For the first time, Bhuj earthquake showed in graphic details the vulnerability of typical Indian urban constructions. As a result, impact of this earthquake on the mindset of public as well as policy makers has been enormous.

Scenario in India with regard to seismic safety programmes is considerably different today than was the case prior to the Bhuj earthquake. The paper discusses some of the significant post-Bhuj activities, and also the constraints that limited the impact of this earthquake towards earthquake safety.

PREVAILING SCENARIO

Earthquake engineering developments in the country started rather early and these have been discussed earlier by Jain [1]. As pointed out therein, despite the facts that (a) Indian earthquake problem is rather well known, and (b) development of earthquake engineering started early in India, not much was happening towards addressing the problem of earthquake vulnerability.

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One important reason for this state was the fact that there had not been many earthquakes in urban areas in the last fifty years and this had created a sense of complacence in the system. It also created a situation wherein the public and the officials lost memory of the earthquake problem in India. At a workshop in Ahmedabad in July 2003, senior officials of two cities located in zones IV and V (zone V being the highest) admitted that until participation in this workshop they were not aware of the seismic risk to their respective cities. This instance graphically points out that one can never do enough on awareness generation.

Status of Engineers in Government

Over the years, engineering profession in the country has undergone a significant decay due to various reasons and the overall morale of civil engineers is very low. Increasingly, the engineering organizations of the government are being headed by bureaucrats rather than by engineers. More and more engineers are being engaged in supporting non-engineering activities. The scenario is somewhat better at the central government level than at the state public works and other engineering departments. Civil engineers in a typical municipal body of a major city in India are mostly busy with non-engineering work (including having to "take care of" the politicians and the bureaucrats) and are not competent to review the structural design or drawing of a building. In many instances, the engineering organisations are functioning as liaison entities: asking someone to design, someone else to construct, and yet someone else to handle project management.

Civil Engineering Education

Quality of teachers and students in the civil engineering too has had a decline with time. Many state governments have had a freeze on recruitment of personnel, and by default that was extended to the faculty of engineering colleges too. This has resulted in colleges not recruiting faculty for extended periods even though the senior faculty members have been retiring. Moreover, there is a general shortage of eligible candidates who will want to make a career in teaching. As a result, most engineering colleges are managing with much lower faculty strength than what is desirable. Many colleges that had very good expertise in structural engineering ten years back, are no longer able to provide professional leadership. With deterioration in the civil engineering professional scenario, and the boom in the IT industry, civil engineering has suffered a tremendous loss of prestige. Most students are in civil engineering not out of choice but because they could not get admission in computer science or electrical engineering.

Professionalization of Engineers

In India, the profession of engineering has not been regulated. For instance, professions of medicine, law, chartered accountancy, and architecture are governed by legislation that provides legal status and regulates these professions. There is no such legislation for civil engineers, and the entire profession is quite disorganized. There is no competence-based licensing system in the country for structural engineers and any person with a degree in Civil Engineering can generally practice as one. In a few cities, the structural engineers' licenses are issued by local authorities based on qualifications and number of years of experience but that does not prevent a less than competent person obtaining a license. Thus, on one hand there are no mechanisms to ensure that an engineer is competent, and on the other hand there is no fear of loss of license for an engineer in case he provides sub-standard services. This has resulted in low fees / salaries, low morale and low quality of professional work.

ATTITUDE CHANGES

The Latur earthquake of 1993 was the most deadly earthquake in India since independence; but it had a limited impact on the mindset of the country towards earthquake safety since only rural areas were affected. The large casualties were caused by collapses of rubble stone masonry houses with very heavy

roofs, and the earthquake did not carry the message of vulnerability of modern building stock in the urban areas. After the Gujarat earthquake of 2001, TV screens showed in graphic details the vulnerability of typical Indian urban constructions. As a result, impact of this earthquake on the mindset of public as well as policy makers has been enormous. It is far easier today to argue with someone in favour of seismic safety than was the case before the earthquake.

Public

Earthquake Tips was a project that envisaged publication of two pages every month about earthquake resistant construction in different journals and newspapers (Jain [2]). It was possible to persuade many prestigious newspapers, journals and magazines to make an exception to their editorial policy of exclusivity in view of the urgent need to sensitize the public on this important agenda and they agreed to publish the Tips. This would not have been possible before the earthquake.

Another example of mass awareness is the fact that the Central Board for Secondary Education (CBSE) has recently agreed to introduce the subject of disasters in class VIII, and a small textbook has been published by CBSE for the same.

Leadership

The top leaders of the country too have shown concern about earthquake safety since the earthquake. In June 2003 during a visit of a group of civil engineering students to the Rashtrapati Bhawan (President's House), the President of India Dr. Kalam listed earthquake problem as one of the four major problems that civil engineers of the country need to tackle in order to make India a developed nation. Later, in his address at a convocation at IIT Roorkee, the President of India again mentioned the earthquake problem. An international conference in February 2004 at Delhi on Disaster Mitigation was inaugurated by the Prime Minister of India wherein he stated, "My Government looks at disaster management as an important component of national development". The same conference was addressed by the Deputy Prime Minister in the valedictory session.

Professional Engineers

Before the 2001 tragedy, earthquake engineering was an exotic subject and a common engineer did not think it his business to be concerned about. Some of the otherwise very competent structural engineers simply did not have adequate knowledge and expertise in earthquake resistant design and construction. The author had situations wherein senior engineers would argue that nothing happened to RC Buildings in earthquakes.

This earthquake has had a deep impact on the attitude of engineers at all levels. Many engineers who for long years ignored the seismic aspects are now interested in learning and practicing aseismic design. There is a far greater demand for continuing education programmes on seismic design by the professional engineers after the earthquake.

In Ahmedabad after the earthquake, a number of builders and engineers associated with the buildings that collapsed and killed people were arrested and remained in jail without bail for several months (e.g., Jain [3]). This even though somewhat harsh has had some impact on the engineers in Gujarat; there is a better seismic code compliance in urban areas of Gujarat now than was the case before the earthquake.

Immediately after the earthquake, a very large number of conferences and workshops were organized around the country by different societies and academic institutions. Even three years down the line, there is a far more discussion on earthquake safety in any professional conference of civil or structural engineering than was the case before the earthquake. An interesting measure of the general increase in awareness and interest of the structural engineers in the subject of earthquake engineering can be seen

through the discussion group of the Structural Engineers Forum of India (www.sefindia.org). Of about 1400 messages posted between January 2003 to February 2004, about 25% include the words *earthquake* or *seismic*.

Champions of Earthquake Safety

When a country has low levels of awareness on earthquake safety, experts in earthquake engineering tend to be the only community to champion the cause of earthquake safety. The subject experts have an inherent handicap in championing a cause: they stand to gain professional advantages from seismic safety programmes, and hence, their pleadings for safer constructions are not always effective. It is best if the agenda of seismic safety is owned by the administrators and the experts are simply to provide intellectual inputs. For instance, the problems of environment or AIDS are not necessarily championed by the subject experts. Many administrators and professional engineers are now championing the cause of earthquake safety and that will have a very positive impact in the long term.

SOME DEVELOPMENTS

Government of India and State Governments

Prior to the Bhuj earthquake, the Ministry of Agriculture of the Government of India was the nodal ministry for natural disasters. Understandably, the emphasis was on relief distribution rather than disaster mitigation. From July 2002, the Ministry of Home Affairs (MHA) was made the nodal ministry for disaster management and this has a long-term positive implication on seismic risk reduction in India. The Ministry is initiating several pro-active steps towards risk mitigation and preparedness, which will be visible in the times to come. A National Emergency Management Authority is being set up. A National Core Group for Earthquake Disaster Mitigation has been formed by the MHA to advise on various tasks associated with earthquake risk reduction. The MHA together with United Nations Development Programme (UNDP) have initiated a Disaster Risk Management Programme to address the vulnerabilities of 169 districts in 17 states. Also, an Urban Earthquake Vulnerability Reduction Programme (UEVRP) has been launched by MHA and UNDP in 38 cities of the country: these cities have been chosen on the basis of seismic zone (zone III and above) and population (more than 500,000). These two programmes are being used by the MHA and UNDP to engage the state governments and the city officials in the agenda of disaster mitigation.

After the 1999 Chamoli earthquake in India, the Government of India had set up a “High Powered Committee on Disaster Management”. Its initial mandate was natural disasters, but the same was later expanded to also include the man-made disasters. The Committee submitted its report in October 2001. The work of High Powered Committee helped create sensitivity and understanding within the central government on disaster issues that could be leveraged after the Bhuj earthquake.

For the first time, the Tenth Five Year Plan (2002 – 07) of India has a separate chapter on disasters entitled “Disaster Management: The Development Perspective”, showing that the issue of disaster management is being institutionalized in the country.

Several state governments are now taking considerable interest in seismic risk reduction. Uttaranchal state has set up a separate Ministry for Disaster Management. After the 1999 Super Cyclone, the state of Orissa had set up the Orissa State Disaster Management Authority (OSDMA), and this formed the model for formation of Gujarat State Disaster Management Authority (GSDMA) immediately after the 2001 earthquake. Organizations such as GSDMA and OSDMA provide the institutional mechanisms wherein after the emergency and reconstruction phases are over after a major disaster, there is an entity that still owns the agenda of disaster mitigation. The states of Uttaranchal and Gujarat have passed disaster management acts in their respective states.

Seismic Codes

Before the Bhuj earthquake, in most parts of the country, seismic codes were not mandatory, and it was at the discretion of the engineer to follow the seismic codes. The government constructions on the other hand generally followed the seismic codes. After the earthquake, a large number of cities or states have made the compliance with seismic codes mandatory. What however remains to be done is to put in place a system for enforcing the codes. As of now, almost none of the local authorities are directly enforcing the codes. In some cases the city authorities are requiring a certificate from the structural engineer that the building complies with the code; unfortunately, many engineers have no difficulty in giving such certificate regardless of whether the building conforms to the codes. In many cases, the city authorities are now asking that the application for seeking building permit should include structural drawings but they do not verify if the drawings comply with the seismic detailing.

Revision of the main seismic code IS:1893 [4] was undertaken by the concerned committee in the early nineties. The 1993 Latur earthquake gave a sense of urgency to this revision. Moreover, since the Latur earthquake occurred in the lowest seismic zone, it was decided to revise the seismic zone map in this code. Unfortunately, the code revision continued to remain incomplete. The 2001 earthquake again put pressure on this front, and Part I of the code (covering general aspects and the provisions on buildings) was released in 2002 (the other parts are still pending!). An important feature of the 2001 earthquake was large number of collapses of open ground storey buildings. This prompted inclusion of an empirical provision in the revised code that requires that the columns in the open ground storey be designed for two-and-a-half times the design seismic forces obtained otherwise. This clause could be modified in the future but for now it serves an important purpose by drawing direct attention to the vulnerability of buildings on stilts.

National Programme on Earthquake Engineering Education (NPEEE)

As a response to the Bhuj earthquake, a comprehensive National Programme on Earthquake Engineering Education (NPEEE) has been launched by the Ministry of Human Resource Development of the Government of India. The project envisages eight premier institutes of technology (the seven Indian Institutes of Technology and the Indian Institute of Science Bangalore) to act as resource institutes. The project includes components such as short-term (one- to four-week) and medium-term (one semester) training programmes for faculty members within the country, international exposure to faculty members, development of resource materials and teaching aids, development of library and laboratory resources, and organisation of conferences and workshops. The programme has a budget of about Rs 135 million (about US$ 3 million), and the first installments were released in March 2003. The programme has already made considerable progress: thirteen courses of one or two week duration have been conducted, a group of seventeen faculty members completed a one-semester programme at IIT Kanpur while another group is undergoing a similar programme at IIT Roorkee, numerous workshops have been conducted to discuss curriculum changes, and curricula at Diploma level in the polytechnics of Uttar Pradesh and Uttaranchal have been modified to incorporate earthquake engineering components. Professor Bruce Bolt of the University of California at Berkeley visited India for one month under the Programme. Complete details of the programme are available at the NPEEE web site (www.nicee.org/npeee) and the programme has been discussed by Jain [5].

National Information Centre of Earthquake Engineering (NICEE)

A workshop in 1996 (Murty [6]) recommended formation of a national resource facility for earthquake engineering literature. A proposal for the National Information Centre of Earthquake Engineering (NICEE) was developed and efforts to raise funds were initiated in 1997. First contribution to its endowment corpus was received in 1999 enabling NICEE to start very modest activities without making a formal announcement of its formation. The Bhuj earthquake in January 2001 created an urgent need for

NICEE: its web site was launched within a few days of the earthquake, and NICEE started its activities on a more formal basis.

Originally, the Centre was conceived as primarily a "library oriented" project. However, the Bhuj earthquake created so much interest in earthquake issues, that NICEE expanded its objective by undertaking a number of other activities, for instance

a) NICEE developed the concept of e-conferences in India and conducted two major e-conferences discussed elsewhere (Rai [7], and Jain [8]). These e-conferences clearly showed the need for an electronic discussion forum and in January 2003 NICEE helped launch Structural Engineers Forum of India (www.sefindia.org), which now has more than 650 members and has been functioning very effectively as a platform for information sharing among the structural engineers.

b) The Centre has distributed free of cost about one thousand sets of two CDs each on the Bhuj earthquake, originally prepared by the EERI.

c) It has published Hindi translation of the manual on non-engineered construction (IAEE [9]), which is being distributed free of charge.

d) The Centre has been organizing an annual one-week workshop to help Masters' students in civil engineering from across the country with literature survey for their thesis work. This is aimed at helping the colleges develop a strong research base through students.

Gujarat Reconstruction Project

As compared to the Latur earthquake, the devastation in the Gujarat earthquake was spread over a far larger geographic area. Also, while in the Latur earthquake only the rural area was affected, in the 2001 earthquake the devastation was caused in the rural as well as the urban areas. In that sense, the reconstruction issues are far more complex in Gujarat. A massive reconstruction project has been in progress with support from the World Bank, the Asian Development Bank and other multilateral funding agencies. A number of workshops have been organized in Gujarat to share the experiences of the reconstruction project with other states and this is very commendable. However, it is of utmost importance that extensive scientific documentation be undertaken on the experiences of Gujarat reconstruction project so that the learning of this earthquake is available for future.

Besides a comprehensive rehabilitation project, the Gujarat project has several capacity building components. For instance, the curricula of engineering at diploma, degree, and post-graduate programmes in Civil Engineering in the colleges of Gujarat have been modified to include appropriate component of earthquake engineering (Jain [10]), and a large number of faculty members have received training in the subject (Sheth [11]). This experience has been very useful to the National Programme on Earthquake Engineering Education (NPEEE) discussed earlier in this paper. The state is also working towards voluntary certification of masons, and a compulsory competence-based licensing of structural engineers. A number of studies have been commissioned by the Gujarat government (Sheth [12]), which will be of value to the entire country for seismic risk reduction.

AREAS OF CONCERN

Absence of a system to enforce seismic codes at the local levels, and lack of recognition for need to uplift the civil engineering profession are two issues of major concern for the seismic safety programme in India. Some of the issues that could have been addressed after the 2001 earthquake but have not been addressed yet are:

Insurance and Legal Framework

There is no clarity on legal responsibility of different players in the construction process: the owners, the architects, the structural and construction engineers, and the contractors. In the absence of any clear court verdicts on this issue, a research is needed by the legal experts on legal responsibility of different stakeholders.

Lack of clarity on legal issues and the fact that there is not much accountability in the construction industry mean that the concept of professional liability insurance does not work in India and most engineers do not carry any such insurance. Moreover, the insurance companies do not recognize code compliance in deciding the insurance premium for a facility. Intervention of insurance industry and the financing agencies for new constructions could be of great value in risk reduction.

Revision of Local Bye Laws

The local building byelaws in different cities inadvertently encourage building forms that are vulnerable to seismic shaking. For instance, provision of parking floors (open ground storey), and large balconies are encouraged. In many instances, it is allowed to cover the balconies thereby encouraging the designer to not have beams connected with the exterior columns. A careful revision of building byelaws is needed to remove provisions having adverse seismic implications.

Policy Issues

Since this is the first time country is looking at seismic risk reduction in a serious way, the system lacks depth with respect to policy issues on seismic safety. Many rather simplistic solutions are often suggested for this complex problem. It also leads to unrealistic expectations and goals, for example, “I will like to see all the hospitals retrofitted in the next five years”. The public policy experts need to learn from the experiences of other countries towards seismic risk reduction and then adapt those to Indian conditions. For example, despite massive funding, the state of California has taken more than thirty years for seismic retrofitting of its bridges.

When discussing seismic safety, there is too much emphasis on “retrofitting” as compared to ensuring code compliance of new constructions. A huge stock of unsafe buildings is being added every day, which will be candidates for retrofitting tomorrow. Clearly, the first focus should be on putting in place a system for code compliance of new constructions. Thereafter, a systematic and well-debated approach to retrofitting should be adopted.

Research in Earthquake Engineering

While significant expenditure is being incurred in seismic instrumentation and seismic microzonation, not enough attention is being paid to research in earthquake engineering. For instance, the country needs to develop expertise on seismic retrofitting considering local construction types and local materials. Very little work has been done on seismic hazard analysis, and even major projects such as nuclear power plants or metro rail systems are being designed for rather simplistic design criteria. A probabilistic seismic zone map is yet to be developed.

With significant activity towards faculty development in earthquake engineering having been initiated under the NPEEE, it is important to engage the trained faculty through research or outreach projects connected with earthquake safety. Else, after extensive training the faculty will return back to their old routine in their respective colleges and the opportunity created by their training will not be fully utilized by the country. A programme on research and outreach in earthquake engineering is therefore urgently needed.

Licensing

The Bhuj earthquake very graphically showed that all is not well with the state of structural engineering practice in India, and a system of competence-based licensing is the first pre-requisite to set this situation right. Unfortunately, not much progress is being made in this direction. In recent years, it has been realized that in the WTO regime, country stands to loose significant opportunities without a proper licensing system. Engineering Council of India (ECI) has been formed after the Gujarat earthquake as an umbrella organization of a number of professional bodies. ECI is aiming to develop a comprehensive licensing system for different disciplines of engineering. It is not clear whether the licensing by ECI will be based on competency tests. More recently, the All India Council for Technical Education (AICTE) has made its intentions known to initiate licensing of engineers. AICTE is primarily charged with regulating the technical education sector and it is not clear if they are the right body for licensing of engineers. Nevertheless, one can imagine that this development means that the entire process of licensing of engineers will receive a setback.

CONSTRAINTS

The Bhuj earthquake, even though tragic, provided an unprecedented opportunity to the country for initiating actions towards seismic safety. While many important activities could be undertaken successfully, many other critical activities did not receive the desired impetus. In general, where there was some preparation before the earthquake, it became possible to launch the activities as a result of the increased concern caused by the earthquake. Examples of this include the sensitization of Central Government through the High Powered Committee, the National Programme on Earthquake Engineering Education, and the National Information Centre of Earthquake Engineering. On the other hand, where the preparation was lacking or the issues had not been conceptualized before the earthquake, suitable actions could not emerge. Some examples of the latter include:

a) India does not have adequate documentation on seismic evaluation and seismic strengthening of buildings. In recent years, many such documents have emerged from other countries but most professionals do not have access to those. Moreover those documents cannot be implemented as such without first adapting them to Indian conditions. As a result, most of the work on seismic strengthening of buildings in Gujarat after the earthquake left much to be desired (e.g., Jain [3]). Many building owners elsewhere in the country were concerned about safety of their building immediately after the earthquake. However, the professionals could not provide proper services on this due to lack of such expertise. An opportunity for some good retrofitting work was missed.

b) The earthquake safety in India remained primarily an engineering subject. There is hardly any research or teaching towards public policy, social and economic aspects of earthquake safety. Therefore, the country lacks the depth to deal with the overall problem of seismic risk mitigation. Often, knee jerk simplistic solutions are suggested to the policy makers, which are either ineffective or impractical. For instance, after the earthquake one state made it mandatory that only those having a Masters degree in structural engineering can design a building. This was later withdrawn since not many practicing engineers have Masters degree, and an opportunity to create licensing of structural engineers was lost.

c) Since the country has too few experts in earthquake engineering, they could not cope with the demands on earthquake services created by the earthquake. Had there been a much larger body of experts, the earthquake would have enabled more actions towards risk reduction and quality products for education and awareness generation.

CONCLUDING REMARKS

The 2001 Bhuj earthquake, even though tragic, will be a watershed event for seismic risk reduction in India. Numerous new initiatives and activities have emerged in the last three years that would not have been possible before the earthquake. It is however important to ask the question: as a consequence of these activities, will we see much lower disaster if a similar earthquake were to strike the country say ten years down the line? The answer to this question depends on whether the intentions and the plans can be successfully converted into actions at the ground level, that is, in terms of safer built environment.

It is important that the risk mitigation programmes be put on a stable growth track such that even when there are no strong champions to push the agenda of safety, these programmes move forward due to their own momentum. This can be best done through an overall improvement in the profession of civil engineering. Earthquake is primarily an engineering problem and it requires an engineering solution through safer constructions.

It is seen that in areas where capacity development had taken place before the earthquake, it was possible to leverage the situation arising out of the earthquake and establish strong activities. On the other hand, opportunity was lost on several fronts where prior spadework was not done. Clearly, the country needs to pursue the agenda of capacity building in an aggressive manner: not only for initiating and executing the mitigation programmes now, but also to ensure that any opportunity for betterment created by the next disaster can be fully exploited.

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