



## **EARTHQUAKE RISK PERCEPTION AMONG STAKE-HOLDERS IN MUMBAI, INDIA**

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### **ABSTRACT**

This paper presents the results of a survey to evaluate earthquake risk perception among various stakeholders in the country. In this study, state government officials of Maharashtra, local government officials of Mumbai metropolitan region and construction professionals were surveyed regarding their understanding of earthquake risk, its contributory factors, measures to reduce earthquake risk and their own roles in risk mitigation. The survey shows that while there is good understanding of earthquake risk among state government officers, it is lesser among the local government officers and even less among construction professionals. The study also shows variable understanding of the main causes of seismic vulnerability of buildings among different stakeholders. The study further reveals that the construction professionals, both engineers and skilled artisans, have inadequate understanding of their own role in contributing to seismic vulnerability of buildings. It is also found that most stakeholders are very enthusiastic about upgrading their skill and knowledge to improve the seismic vulnerability. The results also show that much greater sensitization and capacity building among all stakeholders is critical for success in earthquake risk mitigation efforts. The results of this study can be used to improve the focus of various disaster management and earthquake risk mitigation programs.

### **Introduction**

Earthquakes disasters result in severe devastation and cause the deaths to a large number of people every year. In India, nine major earthquake disasters have occurred during the last two decades resulting in the death of over 30,000 people and injury to countless others. The main cause of human casualty during earthquakes is the damage and collapse of buildings. It has been observed that while the understanding of earthquake hazard in the scientific community in India is comparable to that in developed countries, the casualties during earthquakes of similar magnitude is an order of magnitude higher than those in the developed countries. This difference in the seismic resistance of buildings has been often prescribed to the absence of compliance

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with standards and poor level of technical skills in the profession (Sinha et al. 2001).

A study was recently undertaken by IIT Bombay as a part of an international collaborative study involving 8 countries to evaluate the current situation of earthquake risk perception among policy makers, decision makers and construction professionals, with the aim to explore future directions for better understanding of earthquake risk among these groups. The following groups have been targeted: (a) State government officers of the Government of Maharashtra, (b) Local government officers of Mumbai metropolitan region, and (c) Masons and other skilled professionals engaged with construction work in Mumbai metropolitan region. The study was structured to evaluate their understanding of several issues including the seismic hazard in the country, the uncertainty associated with seismic hazard assessment, structural vulnerability and its reasons, retrofitting options, and responsibilities of various stakeholders.

An important concern in surveys covering low-probability events is the possibility of large bias or error due to infrequent occurrence and corresponding possible lack of understanding among the survey respondents. However, surveys can be properly structured through a combination of leading and blind questions, providing relationship with other relevant experiences of the respondent, etc. Some recently published studies considering risk perception include oil platform risk (Rundmo and Sjoberg 1996) and hazardous material risk (Carle et al. 2004) and similar a strategy was followed during the survey reported in this paper. The responses of various groups were collected using specially designed survey forms, which can be downloaded from IIT Bombay (Sinha 2008).

The survey targeted state government officers who are responsible for disaster risk management or safer building construction at the state level. The survey included the departments and agencies responsible for urban construction and disaster management. The 5 officers who were interviewed belonged to Urban Development Department and Relief & Rehabilitation Department. These five officers represent the collective views of the important officers dealing with this subject in the state government.

The survey also included local government officers who are responsible for disaster risk management and for regulating building constructions at the local level in the Mumbai metropolitan region. A total of 30 officials from the local governments were interviewed during the project. The people interviewed included the Chief Engineers, Assistant Municipal Commissioners and Executive Engineers from various wards of Municipal Corporation of Greater Mumbai (MCGM), and the engineering department of Kalyan-Dombivli Municipal Corporation. In the MCGM, all 24 Assistant Municipal Commissioners were requested to provide their response, while the survey succeeded in getting response from 15 wards.

The skilled construction professionals included in this study include the house builders or head masons are those who are actually constructing the conventional or common houses, particularly in urban areas. The construction professionals have also included engineers who are responsible for quality control at construction site. A total of 43 construction professionals were interviewed in this study. At the time of their interviews, these construction professionals were working with leading developers at some of the major construction project sites in the city.

This paper provides comparison of the responses with scientific studies regarding the seismic risk of Mumbai and describes some of the most important results from the survey of risk perception among these stakeholders

## **Earthquake Risk of Mumbai**

Mumbai metropolitan region is categorized in Seismic Zone III in IS 1893: 2002, denoting a region of moderate seismic hazard. Mumbai has not experienced a damaging local earthquake during the last few hundred years. However, the city strongly felt the ground shaking due to the Killari earthquake in 1993 and the Bhuj earthquake in 2001. The city has also experienced slight ground shaking numerous times during the recent past due to local low-magnitude earthquakes and earthquakes with epicenter in Koyna region around 200 km to the south of the city.

The peninsular India has experienced a few damaging earthquakes in the recent past in regions falling in seismic zone III (similar to Mumbai). The Killari earthquake (1993) of Mw 6.3 resulted in the death of around 8,000 people while the Jabalpur earthquake (1997) of Mw 6.0 resulted in the death of over 100 people. Both earthquakes resulted in damage to a very large number of modern buildings, such as those constructed from concrete and steel. Recent research also indicate that the seismic hazard around Mumbai may be underestimated by the IS code, and the design level earthquake determined from a probabilistic framework may be stronger (Jaiswal and Sinha 2007).

Several studies have been conducted at IIT Bombay during the last 15 years to assess the likely consequences of code-level earthquakes in Mumbai. These studies indicate that the consequences of moderate earthquake are likely to be devastating. The studies indicate that while the hazard is not very high, a large number of buildings are highly vulnerable and modern buildings do not always conform to the standards. These studies have found that such an earthquake will result in several tens of thousand casualties (Sinha and Adarsh 1999 and Sinha et al. 2009). These studies reinforce the need for taking up comprehensive disaster risk management programs and highlighting the importance of risk reduction through lowering the seismic vulnerability of the built environment (Wenzel et al. 2007).

## **Risk Perception Among Stakeholders**

The risk perception queries can be divided into three parts: (1) Issues common to all three stakeholders, (2) Issues common to only two stakeholders, and (3) Issues of particular interest to only a particular stakeholder. The main issues that have emerged based on the responses of the various stakeholders have been divided in similar groupings and are described below.

### **Issues Common for State Government Officials, Local Government Officials and Skilled Construction Professionals**

All stakeholder groups interviewed were aware of the possibility of damaging earthquake affecting Mumbai. The state government officials felt that the earthquake hazard is high and should be taken very seriously. A large number of local government officials, however, felt that earthquake risk was not sufficiently high. Most skilled professionals, both engineers and non-

engineers, felt that a damaging earthquake was unlikely to occur during the next 50 years (typical life span of buildings currently under construction).

The state government officials felt that the root cause of vulnerability of building stock is the low level of awareness among the construction professionals as well as the public at large. They also cited poor enforcement of regulations as an equally important factor. They felt that increasing their awareness will significantly improve the seismic resistance of the buildings under construction. They also felt that the enforcement system, which is administered by the local governments, needs to be significantly improved.

The local government officials cited a combination of lack of motivation or awareness of the home owners (or Developers), economic condition of the people, lack of technical know-how and lack of access to practical techniques for earthquake-resistant constructions, and lack of effective building enforcement system as the root causes in the order of priority. The response of the local government officials is thus more varied, and identifies several factors. The building enforcement system is the responsibility of the local government and has been cited by them as the least important factor for improper constructions in the city.

The root cause of vulnerability was identified by the skilled construction professionals to be the lack of know-how or techniques (by 40% respondents), followed by bad quality of materials (by 40% respondents). Another 10% respondents felt that the home owners (Developers) were not willing to pay additional cost of earthquake-resistant design.

Most respondents from all stakeholder groups felt that the media has a vital role in convincing and encouraging the people about earthquake risk management and reduction of risk through retrofitting of structures. They also felt that where cost effective, retrofitting techniques should be spread so that its demand can be created. Over 50% of the local government officials felt that mere awareness may not be adequate and financial incentive through property tax reduction and free technical support for retrofitting may be required.

The construction professionals expressed their lack of technical knowledge about retrofitting, with over 50% having no idea about retrofitting. Most professionals with retrofitting knowledge felt that it is cumbersome and may not be effective. These professionals felt that old and unsafe structures may be demolished and reconstructed as per the latest standards instead of attempting to retrofit them.

The survey of common issues among the various stakeholders has clearly brought out the difference in their perception. The state government officials have the most technically comprehensive information. Their knowledge regarding seismic risk also closely matches with information in published literature. However, their perception on the implementation of technical practices is quite different from those of the other two groups. It is also seen that each group has under-emphasized the importance of their own responsibility in ensuring seismic safety of buildings – very few local government officials attributing it to poor enforcement and very few professionals attributing it to improper construction practice.

The survey also highlights the importance of capacity building to implement programs. While

the state government feels that retrofitting can be an important component of earthquake risk mitigation programs, most construction professionals who would be required to implement these programs are either not even aware of retrofitting techniques or do not have confidence in retrofitting and its ability to increase seismic safety of the buildings. The views of construction professionals regarding effectiveness of retrofitting also closely matches with the experience of other cities that have taken up large-scale seismic risk reduction programs (Wenzel et al. 2007).

### **Issues Common to State Government Officials and Local Government Officials**

Both the state and local government officials were queried regarding the importance of natural disaster management and the impact of disasters in the state. Most state government officials felt that natural disasters severely affect the state's development and has the same importance as basic agenda such as infrastructure, health and education, unemployment and environmental degradation. Local government officials felt that lack of adequate infrastructure and lack of basic services are the biggest problems and more important than the threat of natural disasters.

The officials were also queried regarding the most contributing underlying factors resulting in earthquake disasters. Most state government officials felt that the absence of adequate earthquake resistant features in buildings was the most important factor. They felt that many high-rise buildings in Mumbai lacked the adequate earthquake resistant features. The local government officials did not share the same opinion regarding the most contributing factor underlying factors. Most local officials felt that unplanned city growth was the most important contributor since it results in long-term problems for the city, followed by lack of awareness about earthquake safety among the public.

Both state and local officials felt that media can play a very important part in dissemination of practical earthquake-resistance knowledge to the people in local languages. The state officials felt that the Disaster Risk Management (DRM) program being implemented in the state during the last several years has strived to create mass awareness about earthquake risk and has made a difference in several parts of the state and a similar program can be implemented focusing on Mumbai. In addition to awareness programs, the local officials felt that conducting community based disaster management programs in the neighborhood was a very effective way to spread awareness regarding practical techniques. The local officials also felt that such programs will benefit from participation of multiple stakeholder agencies, integration of disaster issues into livelihood issues, utilization local techniques and knowledge, and promotion of self help groups.

It can be seen that the state government officials have a better understanding of the link between development and disaster management and do perceive disaster management as a distinct activity. The state government officials thus expressed better understanding of the need to mainstream disaster risk management in the various programs undertaken by the government.

On the other hand, the local officials have a more comprehensive view of the problems facing the city. They understand that unplanned development is a major cause of all kinds of problems for the city. The local officials also have good understanding of the importance of

involving multiple stakeholders, mainstreaming disaster risk management in other important programs, utilization of local knowledge, etc. However, the low emphasis on the importance of enforcement also indicates their inability to visualize the common underlying cause for unplanned growth and poor enforcement of construction standards – both are symptoms of inadequacies in urban administration.

### **Issues Common to Local Government Officials and Skilled Construction Professionals**

There was agreement between local government officials and construction professionals that the most important cause of casualties after an earthquake will be the damage to buildings. The local officials also felt that epidemics may be a major cause of post-disaster casualties due to contamination in water supply and damage to sewage system.

### **Issues Specific to State Government Officials**

All state government officials interviewed were aware about earthquake hazard in the state. They were also aware of the consequences of past earthquakes affecting the state that occurred in Koyna in 1967 and Killari in 1993. The officials anticipated about more than 10000 deaths if a major earthquake similar to the Killari earthquake were to strike the state in near future. However, most officials felt that more frequently occurring disasters such as flooding needs to be given greater prominence.

The state government officials felt that earthquake-resistant buildings will cost around 7% more than the non-resistant buildings and is thus economically viable. All state officials also felt that prevention is better than cure particularly when it comes to saving lives and improving the construction practice is thus very important.

### **Issues Specific to Local Government Officials**

Most local government officials were not aware of any earthquake risk studies taken up in the city. Most officials were also not aware of the city's disaster management plan. Even among those who knew of the existence of the plan, very few were aware on who had prepared the plan.

Most local government officials felt that a large earthquake will result in damage to infrastructure and lifeline service. About one-third of the respondents expected heavy damage to buildings; however only a few officials feared large casualty due to the earthquake. Most respondent identified that old settlement, high-rise buildings and city centre were the most vulnerable due to earthquakes.

According to the local officials, the individual house owners would be most responsible for earthquake damage to building and loss of life by ignoring safety of their houses. More than one thirds of the respondents felt that engineers and architect are responsible for professionally incompetent work. A few officials blamed the state government for lack of proper housing safety policy and program. Very few respondents felt that, their own organization is responsible for improper enforcement of the building bylaws and codes.

## **Issues Specific to Skilled Construction Professionals**

Most construction professionals agreed that the buildings should be structurally sound to withstand normal natural forces (including earthquakes, cyclones, etc.). About 44% of the respondents felt that the houses constructed by them may experience light damage like cracks in walls, falling of parapet, etc. in case a large earthquake. Another 37% respondents felt that only the furniture or utensils might fall due to vibrations. About 18% respondents claimed that the houses they had constructed would not experience any damage due to a large earthquake.

Around half the respondents did not know about building code or housing guidelines developed by government. Among those working on major construction projects, only about 50% of them knew about codes and applied them at their construction site. About 70% of the respondents had not taken any formal training on earthquake resistant construction. They claimed to know most of the things through practical experience. Most respondents working on relatively small sites were thus not aware of the building codes and bylaws. The lack of formal training to skilled construction professionals and its impact on the construction practice is apparent from the responses. The responses also highlight the need for systematic efforts on very large scale need to be undertaken for sensitization and training of skilled professionals.

A majority of the respondents were of the opinion that no body is to be blamed for damage to building and loss of lives in case of a big earthquake. About one-third respondents thought that the engineers who designed the building should be held responsible for the losses. Quite a few respondents blamed the government for not taking care to ensure safety of building while passing the design as well as during the progress of the construction. Very few respondents expressed that they would regret the failure of their buildings and take some responsibility on their part.

As regards the help from government to make the building earthquake resistant most construction professionals felt that the government should start training programs for masons and builders. Also they expected the government to take precautionary steps rather than penalizing in case of failure after to earthquake. Some respondents expected government to arrange for awareness programs for homeowners (and Developers) to motivate them to go for earthquake resistant buildings.

## **Discussions and Conclusions**

During this study, an evaluation of earthquake risk perception of state government officials, local government officials and skilled construction professionals was carried out. The survey covered senior officers from the state and local governments. It is seen that the state government officers have high awareness of seismic risk and consequences of a large earthquake in the state. The views of the state government officials on priorities for earthquake risk management programs were found to be at variance with those of the other two groups of respondents.

The local government officers did not exhibit the same level of awareness about

earthquake risk of the city as the state officers. The city officers also gave greater importance to more frequent problems of the city even though these may not be anywhere as devastating as an earthquake.

It is seen that both the state and city officers accorded high importance to raising awareness among all stakeholders. They also feel that earthquake safety can be improved only if sufficient demand is made by the house owners.

The study also found that a large number of skilled construction professionals (both engineers and masons) are not aware of building codes and bylaws. This finding highlights the importance of capacity-building among this group as an integral prerequisite of any effective mitigation program.

Retrofitting has been highlighted as an important strategy for risk reduction by the state government officers. However, it is seen that the construction professionals are not familiar with retrofitting techniques. Those familiar with retrofitting techniques do not feel that large-scale retrofitting will substantially improve earthquake safety due to prevalent construction practice.

From this study, it is also seen that earthquake safety programs will need to consider the prevalent view of all stakeholders that they are not personally responsible for the devastating consequences of an earthquake. The programs will need to enforce accountability of different stakeholders in the construction process as an important prerequisite of fully engaging them in the implementation.

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