



IMPROVING SEISMIC SAFETY IN DEVELOPING COUNTRIES: THE CASE OF URBAN HOUSING IN INDIA

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Abstract

India is on the brink of a massive housing boom, with an emphasis on building more low cost housing, including a goal of 30 million new housing units by 2022. This paper, part of a special session on nontechnical strategies to improve the seismic safety of housing in developing countries, addresses some of the challenges in improving the seismic safety of such housing in India. Unsafe building stock is a product of a number of complex issues that include the type of governance, the overall construction milieu, awareness of stakeholders in the building delivery process, and the capacity of professionals engaged in the building industry. Simplistic prescriptions for training or assigning the blame on corruption cannot solve the problem of these unsafe buildings. The problem needs to be addressed at several levels in a systematic manner. Mechanisms to provide and/or improve the technical expertise of those involved in housing design and construction need to be in place because this is clearly a weak link in the system. A formal structure for accountability of those in the building process, particularly the architect as the lead professional responsible, needs to be developed. A culture of safety has to be built into the delivery system for housing.

Keywords: safety, seismic, developing countries, housing, awareness



1. Introduction

India will witness a huge boom in the housing sector in the next decade, both in urban and rural areas, in view of colossal housing shortages as identified through the Census 2011. In addition to housing in urban and rural areas, there are housing schemes targeted at economically weaker sections of society and at slum rehabilitation in urban areas. The delivery mechanism for the millions of housing units will need a careful scrutiny. While the financial mechanisms are in place, there are huge gaps in the technical support available for the beneficiaries of various government programs on housing. It will be critical to ensure safety in the way houses are designed and constructed. The main cause of fatalities in earthquakes in India is collapsed buildings, as evident from fatalities statistics from many recent earthquakes. Frequent earthquakes in the Indian subcontinent are reminders for taking purposive action for safety of the built environment.

2. Thrust on housing

India, with a population of 1.21 billion, has about 380 million people (31% of the population) living in urban areas. It is expected that the urban population of India will rise to 600 million by the year 2030. According to the Census of India 2011, 17.4% of urban households in India or a total of 13.75 million households live in slums [1]. The Census of India defines slums as “a compact area of at least 300 populations or about 60-70 households of poorly built congested tenements, in unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities.” The vulnerability of such environments stems from unsafe and poor construction practices and use of unsuitable and vulnerable materials that are likely to not only perform poorly during earthquakes but liable to be vulnerable to earthquake-induced fires. Moreover, the congestion in slums would likely render rescue and relief operations difficult by compromising accessibility within the built environment.

The Government of India in the Union Budget 2014-15, has proposed an allocation of Indian Rupee 40 Billion, to set up a mission on low cost affordable housing, that will be anchored in the National Housing Bank [2]. The Government has also announced the Sardar Patel Urban Housing Mission with a mandate to build 30 million houses by 2022, mostly for the economically weaker sections and low income groups. In-situ improvement of slums, that is, vertical expansion, is being encouraged as the way forward, where the emphasis is on a “safe and healthy environment, affordable transport and energy, safe and clean drinking water, employment and empowerment” [3]. INR 80 Billion has been allocated for the National Housing Bank with a view to expand and continue to support rural housing in the country.

These staggering numbers are coupled with the high exposure to seismic hazard with 60% of the landmass exposed to shaking intensities of VII to IX and above [4].

3. Improving Seismic Safety in Urban Housing

According to the Census 2011, 18.78 million households are facing a housing shortage in urban India due to four main reasons—homelessness, living in congested houses and thus requiring new houses, obsolescence of houses and non-serviceable temporary or *kachcha* structure. In urban areas, 95% of the shortage is for the Economically Weaker Sections (EWS) and the Low Income Group (LIG). Clearly, a housing shortage exists for the most vulnerable sections of society.

Urban areas are governed by Building Rules and Regulations that vary from state to state. In the Indian state of West Bengal, for example, a number of Building Rules are in place. The areas which fall within the municipal city limits are governed by the Kolkata Municipal Corporation (KMC) Building Rules. Areas that fall outside KMC but are within the Kolkata Metropolitan Area (KMA) are governed by West Bengal Municipal Rules. The state is witnessing rapid urbanization with 31.89% decadal growth of the urban population according to the Census, 2011. This is resulting in burgeoning building activity in areas which are yet to fall within the purview of the KMA, and where even the West Bengal Municipal Building Rules are not in place. It is not unusual to see suburban areas transforming into urban areas with contrasting images of rural and urban in some very rapidly urbanizing areas and new housing stock is being added without having to follow any rules and procedures. This is a dangerous trend.



Unsafe building stock is an outcome of a number of complex issues that include, but are not limited to, the type of governance in a particular place, the overall construction milieu there, awareness of stakeholders in the building delivery process, capacity of professionals engaged in the building industry, and others. Simplistic prescriptions for training or assigning the blame on systemic and individual corruption cannot solve the problem of unsafe building stock. The problem needs to be addressed at several levels in a systematic manner and needs to include several components that together ensure safe buildings.

In 2001, the responsibility for disaster management was transferred from the Ministry of Agriculture to the Ministry of Home Affairs. The Tenth Five Year Plan, prepared in the backdrop of the Orissa super cyclone, Gujarat earthquake and the end of the International Decade of Natural Disaster Reduction (IDNDR), for the first time, recognized disaster management as a development issue. The Plan document included for the first time, a separate chapter on Disaster Management and outlined a multi-pronged strategy for total risk management for sustainable development. The Disaster Management Act, 2005 [5] was enacted to develop the institutional and coordination mechanisms for effective disaster management. This Act stipulates that a National Plan on Disaster Management shall be prepared in consultation with the State Governments and expert bodies and organizations in the field of disaster management. The Act also stipulates that every Ministry and Department of the Government of India shall make provisions, in its annual plan budgets, for carrying out activities and programmes set out in the disaster management plans. Subsequent to this, the National Disaster Management Authority (NDMA) was set up under the Chairmanship of the Prime Minister.

Soon after its formation, NDMA organized a series of consultations with experts and stakeholders to formulate guidelines for strengthening earthquake risk management in the country, which were issued on the 16th of May 2007. The objectives of the guidelines are to reduce the immediate impact of earthquakes in the short term (through awareness, capacity building, and preparedness planning) and the earthquake risk in the medium and long term (by enforcement of earthquake resistant design, seismic strengthening of lifeline structures, regulation and enforcement).

‘Six pillars of seismic safety’ [6] were conceptualized in the guidelines as the framework for improving the effectiveness of earthquake risk management in the country, namely, (1) earthquake resistant construction of new structures, (2) selective seismic strengthening and retrofitting of priority structures, (3) regulation and enforcement, (4) awareness and preparedness, (5) capacity development, and (6) emergency response. The guidelines gave due importance to the Model Building Byelaws formulated by the Expert Committee constituted by the Ministry of Home Affairs, Government of India (MHA, GoI). However, the deadline given to the State Governments to review and adopt the Model Building Bye Laws have passed and many States have not adopted the same. The guidelines also listed a number of topics on which Standards and Codes are not available in India and proposed that the Ministry of Earth Sciences along with the Bureau of Indian Standards prepare an action plan for developing new codes and revising the existing ones and placing these in the public domain. The guidelines further encourage a licensing process for professionals dealing with safety aspects of buildings such as engineers, architects, masons and artisans.

NDMA’s Earthquake Policy Document contains two other provisions related to banking and insurance that if implemented, could have far-reaching consequences. The guidelines state that “Insurance companies will be encouraged to introduce innovative insurance schemes in moderate and high earthquake risk zones”. The document also envisages setting up another layer of enforcement by insisting that banks and financial institutions will “consider the compliance of seismic safety before offering housing loans including those for construction of multi-storeyed complexes.”

Capacity development in earthquake education also finds a prominent place in the guidelines. However, the onus is left to the State Governments to ‘endeavor to strengthen earthquake education by incorporating the best available technical and non-technical inputs on seismic safety in educational curricula’. Much emphasis has been placed on the role of NIDM and State ATIs developing an action plan to offer a comprehensive curriculum related to earthquake management.

Disaster management planning has been mandated for National and State Governments and all governmental institutions including the designated nodal agencies related to earthquake safety as a first step in ensuring a coordinated, prompt and effective response to any disastrous earthquake anywhere in the country. The effectiveness of the guidelines would depend on the extent to which they are implemented at the National and State levels and whether NDMA can enforce this with equal success throughout the country.



4. Model Building Bye Laws

The Government of India (GoI), on the recommendation of the National Core Group on Earthquake Mitigation set up a committee for the development of Model Building Bye Laws and the Review of City, Town and Country Planning Act and Zoning Regulations [7]. The documents studied by the Committee included the Model Town & Country Planning Legislation, the Ahmedabad Urban Development Authority Byelaws that had been revised following the Gujarat earthquake in 2001, Model Town and Country Planning Act, 1960 and the revised Model Regional and Town Planning and Development Law 1985. The latter document was in the nature of a guideline and formed the basis for the enactment of comprehensive urban and regional planning legislation in the states and union territories of India.

4.1 Land Use Zoning

Regulations for Land Use Zoning in Natural Hazard Prone Areas explicitly mention that areas under Seismic Zones III, IV and V are to be considered as prone to earthquake hazards. Zones with soil conditions liable to liquefaction or settling under earthquake vibrations and unstable hill slopes where earthquakes could trigger landslides are specifically mentioned as being risk prone and the Model Bye Laws under Section 3.3.1.d require that special geological/geotechnical studies be carried out in such areas. Structures for human occupancy are required to be set back by a minimum of 15m on either side of an active fault trace identified by Geological Survey of India (3.8.1.e). Building construction is disallowed in sites liable to liquefaction unless appropriate protection measures are taken (4.4.1.i).

4.2 Structural Safety

The Model Bye Laws make detailed recommendations for building regulations/bye laws related to structural safety. Codal provisions from the Bureau of Indian Standards (BIS) applicable to design against natural hazards are included in the Model Bye Laws for the guidance of professionals. The Model Bye Laws also incorporate formats for ensuring compliance with various codal provisions through a four part Structural Design Basis Report (SDBR) containing general information about the building and suitably modified for load bearing masonry, reinforced concrete and steel buildings with provision that for the last two building typologies, the SDBR has to be submitted not later than one month prior to commencement of construction (5.2).

The Model Bye Laws include a section on review of structural design through provision of proof checking by third party verification. Only load bearing buildings up to 3 storeys are exempted from the proof checking requirements for structural design. In addition to certification of structural safety in design as discussed, structural safety in construction is provided for by a clause wherein all construction except load bearing construction up to 3 storeys has to be carried out under the supervision of the Construction Engineer on Record (CER) or Construction Management Agency on Record (CMAR) for various seismic zones. A certificate of structural safety in construction is required to be submitted on project completion as per Model Bye Laws. Quality Control and Inspection are included through a mechanism for certification of safety in quality of construction for all buildings higher than seven storeys. Falling hazard mitigation is explicitly covered in the Model Bye Laws through provisions on outdoor display structures, communication towers etc (5.8).

Through the certification of structural safety in the three stages of design, construction and quality control, the Model Bye Laws attempt to put in place a system where the building activity is strictly controlled and monitored through a system of checks and balances.

The Model Bye Laws recommend a system for registration of professionals involved in planning and design, including town planners, architects, structural engineers, structural design agencies, geo-technical engineers, construction engineers, construction management agencies, quality auditors, quality audit agencies and developers to address every aspect of the building industry from planning and design to construction, supervision and quality control. Scope of work for every professional and eligibility criteria based on qualifications and experience are stated in the Model Bye Laws for buildings of various categories classified according to plinth area and number of storeys. The registration of all professionals mentioned above is on a renewable basis. However, the certification mechanism is based on qualifications and experience and lacks any



competency-based certification. Licenses are renewable on a three year basis but the renewal process is also not linked into a competency-based system requiring proof of professional updating, etc.

The Model Bye Laws represent an important step towards mitigation of natural disasters. However, the Model Bye Laws are optional and have been not been adopted as a mandatory part of the regulatory framework in most states. Some states have issued a series of Government Orders covering many aspects of the Model Bye Laws but legal opinion on this is divided, with one section stating that these orders have no legal standing.

For example, the West Bengal Municipal Building Rules, 2007, published in the Kolkata Gazette Extraordinary in February 2007, regulating building activities in the municipal areas, notified areas and Industrial Townships in West Bengal but had no references to the Model Building Bye Laws. There are 28 references to the latest version of the National Building Code of India in the Municipal Building Rules, 2007 addressing different aspects of the design and construction of buildings. Some of the aspects to which the National Building Code is referenced are fire safety, structural design, material specifications, workmanship, building services, height regulations and parking considerations. Hyderabad city, in Andhra Pradesh has done the same. In the absence of their holistic adoption by all the states, the strategies and approaches encapsulated in the bye laws will remain of academic interest only.

5. Benchmarking against international practices

International experiences in earthquake vulnerability reduction have now coalesced into a fairly standardized approach to the problem. A policy document titled “Guiding Principles and Elements for Effective Seismic Safety Programs” [8], (referred from here onwards as Guidelines) endorsed by the International Association of Earthquake Engineering (IAEE) and World Seismic Safety Initiative (WSSI) provides the following elements for effective seismic safety: policy, accountability, building codes and enforcement, preparedness and planning, and risk reduction of existing and new building stock.

At the policy level, a shift in focus is taking place in India, from the response and recovery approach to the pre-disaster mitigation approach where interventions and an action agenda are being developed for the pre-disaster stage as part of effective disaster management policy and practice. To this end, the National Disaster Management Authority (NDMA) published the National Disaster Management Guidelines for the Management of Earthquakes in April 2007 to “assist the ministries and departments of the Government of India, state governments and other agencies to prepare Disaster Management Plans” (NDMA, 2007, p. 1). The Disaster Management Act, 2005 (DM Act, 2005) lays down the institutional and coordination mechanisms for effective disaster management at the national, state and district levels through the creation of a multi-tiered institutional system consisting of the NDMA, SDMA (State Disaster Management Authorities) and the DDMA (District Disaster Management Authorities).

Some exemplary approaches towards ensuring safe buildings have been practiced with considerable success internationally. Some elements in these programmes include the engagement of only competent individuals in building design and construction, regular revision and updating of codes and standards, effective dissemination of the same, and strict enforcement regimes that ensure compliance and hence safety. The practices in place in many cities in India are benchmarked in this following section against international best practices, and some recommendations made for creating a climate of seismic safety in the built environment.

5.1 Lack of transparency in hierarchy of accountability

Earthquake safety is often addressed as an implicit component within structural safety in the Municipal Corporation Bye Laws where a self certification by the structural engineer is the only requirement. Hence, the responsibility for structural safety rests solely on the structural engineer, with the Municipal Authorities disengaging themselves from it. While Building Rules can state that the structural engineer “shall be held responsible for the structural design and execution of the same on site and for contravention of the provision of the Act, these rules and other relevant rules and regulation related to structural safety” these are not explicit on punitive action in case of violation of structural safety. The structural engineering community is as aware of these laxities as is the general public. The architects too are outside the ambit of accountability towards structural safety, though it is often the architectural design decisions that lead to poor seismic performance, as demonstrated time and again in earthquake- related building failures worldwide.



The accountability of structural engineers holds little meaning in a system where the main professional in charge of the project, namely the architect, is not formally accountable for safety. For example, the Kolkata Municipal Corporation Building Rules, 2009 have a provision for the Municipal Commissioner to “make a reference to the Council of Architecture for taking necessary action under the Architects Act, 1972”, in case of violations (Rule 51-(11)ii). The KMC Rules however, are not explicit on seismic safety, and hence assigning responsibility for “violation” would be difficult in the actual event of an earthquake- induced building collapse.

5.2 Capacity gaps

In India, housing projects in the metropolitan cities, developed by well-known developers are awarded to architects, who, in turn, engage the services of structural engineers and other professionals. For architects, possession of a Bachelor of Architecture degree from an institute recognized by the Council of Architecture of India constituted by the Architects Act, 1972 is the only requirement for professional practice. This does not ensure understanding and knowledge of earthquake resistant architectural design as this is not a part of the course curriculum in any of the 420+ colleges that offer undergraduate programs in Architecture. There was a thrust on capacity building of teachers of architecture in India during 2003-2007 as part of the National Programme of Earthquake Engineering Education, but the programme tenure was not extended and the momentum could not be continued and sustained. As a result, today, there is a huge dearth of architecture faculty with any exposure to earthquake-resistant design practices who are responsible for training the thousands of graduating architects joining the workforce each year. It is widely understood that it is the architectural design decisions at the earliest stages of design conceptualization that have far-reaching impacts on the earthquake performance of a structure, as a good architectural configuration lends itself much better to even nominal engineering inputs compared to a poor configuration.

A major initiative towards sensitizing the architectural students on seismic safety issues was started under the aegis of the National Information Centre of Earthquake Engineering (NICEE) in 2008 and has gained tremendous popularity. An annual 6-day workshop on earthquake resistant practices for students of architecture was started in July 2008 and is in the 8th year of operation. The objective of this Workshop is to sensitize students of architecture in earthquake resistant design practices through technical lectures followed by design studios where they are given hands-on guidance in earthquake resistant design by working on an architectural design project. This initiative is an attempt to reach future professionals and sensitize them to earthquake resistant design concepts and fill a knowledge gap that may exist in the course curricula that they are taught in their colleges. It needs to be understood that the field of architectural education is also not level, notwithstanding controls by the Council of Architecture that regulates architectural education in the country.

In India, certification of structural engineers is not competence based. For structural engineers, licensing is based on educational qualifications and number of years of experience and not on any proven expertise in structural design in general and seismic safety in particular. Mere possession of a degree in Civil Engineering does not mean that the engineer has any competence in designing earthquake resistant structures. There is need for continuing education for engineers for those already in the profession and also for recent graduates who may need to augment their understanding of earthquake engineering concepts and design. The state of Gujarat has initiated registration for civil engineers through the Gujarat Professional Civil Engineers Act, 2006. The Act provides for the formation of the Gujarat Council of Professional Engineers (GCPE) which will be the governing body for registration. The registration of structural engineers will require the engineers to take a written competency test besides having the necessary qualifications and experience [9] (Clause 14.1, GPCEA, 2006). This can serve as a model for other states as well.

5.3 Monitoring and evaluation

The independent assessment or peer review of building projects, as proposed in the Guidelines is not the norm. In the city of Kolkata, for example, the Kolkata Municipal Corporation has constituted a Building Committee to approve the schemes for certain classes of buildings so that responsibility rests not on an individual but on a committee. However, unless the Committee members have expertise in structural safety, the purpose is defeated. A formal mechanism for periodic inspection and approval of construction does not exist in Kolkata though a



system exists for self declaration at various stages of construction. In Kolkata, the only building inspection during construction is conducted after completion of the building up to plinth level [10]. A second inspection is required for inspection of drains and appliances connected with drainage [11]. There are no systems in place for inspection of structural components during building construction. Interim construction inspections for new buildings above a certain cubical content as introduced in the regulatory mechanism in Japan after the 1995 Kobe Earthquake could be considered.

5.4 Creating a culture of compliance

Building codes and code enforcement elements need to be viewed in the national context wherein the two important issues are (1) making earthquake codes mandatory and ensuring dissemination of the codes across a wide base and (2) making earthquake codes user-friendly to promote an understanding of the code that will ensure compliance. Exercises in developing commentaries on codes of practice and ensuring their wide dissemination amongst the structural engineering community may be a possible action point. In Kolkata, for example, in the CMC (Amendment) Act, 1993, dealing with contravention of the Act or rules made under the Act (e.g., KMC Building Rules, 1990), some penal provisions have been inserted for offences such as construction of floors without sanction or addition or alterations of floor or floors in contravention of the Rules. The punishment has been fixed at a term extendable up to 5 years and a fine extending up to Rs. 50,000. The offence has been made cognizable and non-bailable. These are steps in the right direction but would need to be expanded in scope to include structural and seismic safety issues in explicit terms. Enforcement is a potential weak link in the construction industry in Kolkata and needs to be aggressively pursued to discourage code and bye law violations.

5.5 Promoting safer technologies

The preferred building typology is RC frame with unreinforced masonry infills. This typology requires engineering inputs and proper detailing and supervision during the construction stage that is often overlooked. In the absence of good engineering, RC frame buildings have performed abysmally in numerous earthquakes worldwide. Thus, there is a need to promote building technologies, such as confined masonry, or reinforced concrete shear walls, that are inherently resistant to earthquakes and formalize their use through inclusion in codes of practice.

5.6 Risk assessment

Risk reduction of existing building stock is extremely relevant in all Indian cities as the old, load bearing unreinforced masonry buildings are very vulnerable and would surely perform poorly if exposed to an earthquake. Prioritization of buildings can be initiated through the Census exercise. A database of existing building stock can be created through the Census exercise.

5.7 Leveraging the insurance sector

Social and commercial pressure from financiers and insurers can help in better compliance of seismic standards [11]. The possibility of making earthquake insurance mandatory for all new buildings can be examined wherein building use permits would be issued only on receipt of the insurance certificate. Engagement of banks and registered lending agencies into the seismic safety agenda can be done through developing a mechanism wherein home loans are sanctioned only after the banks have ensured that the building meets safety criteria. There is a need to increase the penetration of risk insurance in India where financial systems need to be proactive in insuring the risk prone regions. A financially sustainable risk insurance approach has to emerge.

6. Concluding remarks

While urban areas come under some regulatory regimes that require the engagement of qualified professionals such as architects and engineers, there is plenty of room for making the certification and enforcement regime



more robust. Competence based certification of municipal engineers responsible for checking structural design drawings and calculations is an area that needs urgent attention to give the urban local bodies the wherewithal to conduct effective checks. The huge construction boom in the housing sector that is envisaged in the coming decades needs to be safeguarded with a proper technical expertise delivery mechanism in place because this is clearly a weak link in the system. A culture of safety has to be built into the delivery system for housing. The rural housing segment remains the more vulnerable as rural areas do not fall within the ambit of regulations and bye laws. The Uttarakhand disaster in 2014 is a case in point in which thousands of houses that were destroyed in a largely rural area, witnessed very quick reconstruction where victims did not wait for technical expertise to build back better. As a result, a retrofitting programme had to be implemented for the houses that had already been reconstructed. Clearly it was a case of safety coming in late into the reconstruction programme. The slum improvement programmes in the urban areas are emphasizing vertical expansion, which will result in medium to high rise slums. Structural safety needs to be looked at very carefully in all such vertical expansion from the perspective of structural safety in general and seismic safety in particular, especially in the high earthquake hazard prone areas. Finally, it needs to be stressed that housing constitutes a family's haven, which they typically acquire with their life savings. There can be no room for error in such interventions and it is the right of every citizen to have access to safe housing that will not collapse and kill in an earthquake.

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