



Seismic protection in developing countries: Where are the gaps in our approach?

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ABSTRACT: Recent earthquakes in Turkey and India have caused human loss and destruction of buildings on a large scale. The economic and human losses have opened a Pandora's box of problems in the implementation of seismic protection in these countries and placed blame on many of the stakeholders in the construction industry. Affordability, lack of awareness, weak human memory (caused by large time gaps between seismic events) and lack of legal control are generally considered major hurdles to the implementation of seismic protection. However, the losses to middle-class housing in Ahmedabad in the 2001 Bhuj (India) earthquake highlighted how increased affluence does not necessarily result in safer buildings. Similarly, the extraordinary losses in the 1999 Marmara Sea (Turkey) earthquake happened despite the awareness of the hazard. There, despite the inevitability of this earthquake, shoddy structures continued to be built. Both these countries have some sort of legal system to control bad construction, but it could not be turned into safer buildings. These examples raise concern that affordability, lack of awareness, and the legal system are not the only issues. The difficulty in providing seismic protection is more of a socio-economic, legal and human issue than merely a technical one. Unfortunately, there remain fatal gaps between the socio-economy, the legal system, implementation processes, building codes and local needs and practices. Until these issues are addressed, seismic protection in these countries will remain essentially a mirage. This paper describes these gaps, taking examples from Nepal, India and Turkey, and examines how these gaps could be mended.

1 INTRODUCTION

Large parts of Nepal, India and Turkey are seismically highly active and have experienced frequent earthquakes that have caused large-scale loss of people and property. To reduce these losses, earthquake design codes were introduced in Turkey in 1944 and in India in 1962. Nepal's was prepared in 1993 in response to the 1988 East-Nepal earthquake, but is still waiting its official implementation.

There are a set of laws in Turkey, India and Nepal to control shoddy construction. In general, local government is responsible for the implementation of safer construction. A building permit from the local authority is a prerequisite for beginning any building construction in the municipal areas in these countries. The municipality is entitled to enforce the code and check that the building construction conforms to the approved drawings. It has the power to demolish buildings not conforming to approved drawings or built without permits. However, the outlook for the enforcement of these powers in these countries does not seem that bright.

Nepal is still in an embryonic stage of earthquake engineering knowledge, whereas both India and Turkey are much more advanced. However, from past earthquake damage, it is clear that the knowledge available has not been translated into real practice in India and Turkey or Nepal. It raises the question: why the codes and other policies are not implemented even though there exist a set of legal tools to implement them? Why is the message to the pertinent people not being delivered? What are the obstacles to reaching the vulnerable people? Is it a total failure of public policy for seismic safety? It is said that people have short memories, but how short are they? In the case of Turkey, there are large earthquakes (M_A7) every five years (on average) in close proximity along the North Anatolian Fault, but people do not seem receptive. Perhaps there other factors those turn out to be more important than safety? These issues are briefly discussed.

2 KNOWLEDGE DISSEMINATION

2.1 Academic institutes

Training in earthquake-resistant design and construction is still not viewed as an integral part of long-term earthquake mitigation strategies in these countries and there seems to be an impression that making the code mandatory will solve all the problems. More than 54 % of India (BMTPC, 1998) and 100 % of Nepal fall into a severe seismic zone. However, few of the educational institutes in India or Nepal offer specific courses on aseismic design and construction on a regular basis. In India, earthquake engineering is taught only at a post-graduate level. Sometimes they are offered as an elective at undergraduate level, but Nepalese institutions are still struggling for manpower to run such courses. It has led to a severe gap between the thrust of the earthquake codes and their users - engineers. University graduates have no conceptual knowledge of aseismic design. Most consider it merely an extrapolation of vertical load design. Consequently, even if lateral loads are considered, the basics of clearly-defined load paths, ductile detailing, etc., are not known. It has clearly stopped the improvement of knowledge base for safer construction and largely prevented implementation of seismic safety.

Further, very little research is available in these countries on issues of seismic safety. Despite the contrasting socio-cultural scenarios, economy, building types, construction materials, there is a heavy reliance on the experience of developed countries on this issue. This has created a big gap between demand and supply of knowledge base leading to sluggish implementation of seismic safety.

2.2 Mid-career training

There are very few opportunities for mid-career professionals to update their knowledge base with recent developments in general and earthquake-resistant design and construction in particular because of lack of value placed on such training. Hence, the gap between knowledge of an average practicing engineer with developing earthquake engineering is rapidly increasing. So often, these professionals are unable to understand the new requirements of progressive codes. Further, there does not exist on-the-job-training for fresh graduates. It has led to a gap between thrust of code and professionals.

2.3 Vocational schools

Construction artisans in these countries are not formally trained. Their skills are passed down from generation to generation, or learnt from other masters. Many of them are illiterate. Without formal training, newer techniques for use with modern materials are not being introduced to craftsman and technicians. It has led to a fatal gap between professionals and craftsman which has hampered translation of spirit of code for the safety.

2.4 Traditional materials and skills

The formal education system - the major track for dissemination of knowledge - and its trainees do not recognise informal/ non-engineered construction materials and skills which produce more than 98 % (adopted from HMG/N 1992) of the country's building stock in Nepal and 94 % (adopted from BMTPC, 1998) in India. This has created a big gap between two of the stakeholders in the

construction industry (i.e., between craftsman and professionals). The process of dissemination of knowledge is considered complete once it reaches the engineer/technician level. The craftsmen are still waiting to be recognised as stakeholders. It has led to omission of a major stakeholder in the implementation of overall seismic safety.

Similarly, training undertaken in engineering schools is biased towards modern materials and technology. It discriminates against masonry or other traditional construction, depicting them as an obsolete and unsafe option, although these will still govern the future and there exist quite a number of traditional construction typologies that have stood their ground against severe earthquakes (Fig 1). The scenario has somehow stopped possible improvement in traditional building construction types.



Figure 1: A traditional building with minor damage. Note ground failure in foreground of house (source: National geographic, July 2000).

3 BUILDING PROCESS AND URBAN PLANNING

3.1 Building Production

Building structures in these countries are mostly procured by the owner itself, mostly employing a local skilled artisan to direct operations. Even community buildings are procured by the community (NSET, 2000) themselves. The efforts are characterised by a high degree of informality and individual decisions – owners make decisions even on strength factors. The traditional artisan plays a pivotal role in the overall construction activity, and the owner relies on them heavily for all types of advice. They provide overall technical and organizational support - even though none of them has formal training. According to very conservative estimates, four out of five Indian homes (IT, 2001a) and more than 98 % of Nepalese houses are designed and constructed in this way. Further, construction of these buildings is largely dictated by local availability of construction materials and skills in contrast to Building Standards which are mostly focused towards modern materials and technology and appreciate formal construction. Even if Standards dealing with traditional material and technology exist, these can not reach pertinent users.

3.2 Professional advice

Professional advice is rarely sought (even in urban areas) and, if sought for private houses, is mostly limited to the building permit process, or for an occupancy permit. However, this does not lead to the incorporation of earthquake-resistant features. Governmental buildings or large construction projects are developed more formally, but these projects are a very small percentage of total construction. Even in this sector, whether or not earthquake resistance is incorporated depends on the implementing agency. It has led to lack of knowledge in practice for the sake of seismic safety even if available.

3.3 Architectural arena

In formal construction in these countries, architects usually control the project, and structural engineers work as sub-contractor and have very little say. Given that most structural engineers lack knowledge of aseismic construction, architects cannot be expected to be concerned about seismic safety. The aesthetic and architectural requirements almost always control the whole scenario. The ad hoc omission of frame elements and structural walls to meet a particular space requirement is common. Building forms are often irregular in plan and elevation, and have inefficient or non-existent load paths.

In Turkish, Indian and Nepalese cultures, framed structures (i.e., of reinforced concrete) with minimum column thicknesses are preferred so that the columns can be concealed within the masonry walls (Gülkan 2000; NBSM 1994). This has led to a consistent column size of 230 mm to 250 mm wide columns (one-brick thick). In India, even high-rise buildings can be seen with 250 x 500-700 mm columns. The columns are frequently oriented randomly to match wall direction. This is one of the main reasons of failure of framed structures in the 1999 Izmit and 2001 Bhuj earthquakes. Even where architects permit use of big square columns (quite rare), their placement is random - leading to torsionally eccentric buildings. Concealing drainpipes in these narrow columns (WSSI/ EMI, 2001) for aesthetic reasons is common in India. This scenario has led to potentially vulnerable buildings even if professional advice from a structural engineer is sought.

3.4 Planning issues

At one end these countries are undergoing rapid urbanisation and excessive pressure on urban infrastructure leading to its collapse in many cases, and at other end the relationship between possible earthquake disaster and urban planning has not yet been realised. Urbanisation in these countries is an organic process that takes place without planning. A new transport corridor or a large industry can create enough economic activity so that urban sprawl results. Commonly, the government system lacks the will and capability to understand the rapidly changing requirements of these areas or it is too slow to respond and by the time it realises the need for intervention, it is too late.

In the mid 1980s, Turkey experienced an unprecedented economic boom, and the zoning ordinances and master plans prepared by town planning authorities were swamped by the dynamics of urban growth. Building regulations were quietly brushed away (Hodgson, 2000). This led to ad hoc planning (Gülkan, 2000b). Similar scenarios are obvious in India and Nepal. Large-scale slums and unauthorised settlements result.

Sometimes national or local laws themselves indirectly encourage vulnerable construction or planning. It is because building by-laws are developed by architects and planners who have no understanding of seismic hazard. For example: the demand for more space in upper storeys has led to clearly unstable buildings along main streets in Nepal's Kathmandu Valley. Their floors expand alarmingly with height. Similarly, in Nepalese law, for land to be subject to planning, it must be registered to the person or agency undertaking the planning, and only then sold for development. It results in land registration tax being paid twice – a disincentive. Once divided, land cannot be reintegrated into a single plot. In addition, sub-division of land parcel has led to very slender buildings in these regions.

3.5 Housing need

A rapidly growing population in these countries has resulted in the expansion of human settlements in highly hazard-prone areas such as riverbanks and steep slopes (Coburn, 1992). Economical marginalisation of the population leads to settlements wherever land is available. Industrialisation in Turkey and India has led to urban real estate booms. As the demand is higher than supply, there remains little choice even for the middle class. The building collapses in Ahmedabad in the 2001 Bhuj earthquake are directly attributable to such a boom (TI, 2001a). Where there is a deficit in the supply of housing, authorities hesitate to adopt any strict controls (IT, 2001a) which has led to unmonitored vulnerable construction.

3.6 Rural character

Rather than having a traditional urban character, most urban areas have a rural character and lack civic infrastructure and capability. For example, there are 58 municipalities in Nepal, but hardly any of them have an urban or semi-urban character. The territorial authorities have neither the resources nor the capability to act as a municipality in this transitional period.

4 TECHNO-LEGAL REGIME AND CONFLICTS

The governments of these countries are characterised by their lack of will to implement proactively seismic safety. Consequently there exist little legal framework for implementation of seismic safety.

4.1 Code Compliance

In India or Nepal there is no specific act that regulates or controls building construction. Construction is basically controlled by municipal building bylaws that are more concerned about planning than structural requirements.

In Nepal, National Building Code development Project (NBCDP) in 1994 recommended a Building Act to regularise and control building construction in Nepal. The bill was passed by Parliament in 1998 and received royal assent the same year. However, the Act lost its intended thrust during the parliamentary process. Despite this progress, it is still waiting to be enforced four years later, and the concerned authority is now thinking of further diluting its requirements.

Similarly, design codes in India are only technical guidelines, and compliance with them is not mandatory across the nation (WSSI/ EMI, 2001) as the enactment of building codes is a State matter. In most States, compliance with Indian Standards (IS) is required for government structures. Very few urban areas have adopted compliance with IS for private construction. Even where compliance with IS is mandatory, their enforcement is often found lacking and the codes are violated with impunity. The process is further complicated by the relevant building by-laws not requiring structural engineers to be legally responsible for their designs (IITB) or ambiguity in them. The lack of legal framework has led to avoidance of building standards even if available.

4.2 Professional Act

In India or Nepal, there is not an act that requires professionals to be responsible for their advice and act ethically. In Nepal, the NBCDP recommended an Engineers' Act and prepared a draft of it. The Engineers Act was passed by parliament in 1998 and received royal assent the same year. In the process, however, the draft was heavily edited and amended, diluting its aim to make professional designers responsible for their designs. The act could now be described as being a "Paper Tiger".

In India, the Engineers Bill that spells out professional liability has been waiting for ten years to be put forward in parliament. An Engineers Council Institute has been formed to implement it, but it itself has no legal status (Raj, 2002).

In Turkey, there is a Law of Engineering and Architectural Services. However, legal precedents do not exist for the courts to have recourse to the design engineer, project engineer ("engineer of record"), or approving agency in the case of losses because of design errors (Gülkan, 2000a). Furthermore, the judiciary system in these countries is inefficient as a normal case may take 20 years (IT, 2001) for judgment. By that time, the money recovered from the faulty party has very little monetary value compared to the costs involved in the whole process (due to high inflation rate) (Gülkan, 2001a).

Due to lack of professional legal framework, professional liability or licensing system even a novice engineer can legally certify safety of any construction if required (IT, 2001a) if required. It has resulted in negligence, unprofessional behaviour and professional prostitution.

4.3 Ambiguities in laws

In Turkey quite a good set of laws exist (Development Law, Disaster Law, Contracts Law, Municipal Law, Law on Engineering and Architecture Services, Public Health Law, etc.). Similar power is provided to municipalities through some laws in Nepal and India (The Indian Express, 2001a). However, as many of their clauses conflict with each other and these laws integrate in a complex way, the implementation of seismic safety is hampered. Often, the laws are too vague to be interpreted leading to lack of prosecution.

4.4 Rural urban issue

The legal framework, codes are oriented towards urban provisions, whereas most of the population in these countries lives in rural areas. In Nepal, India and Turkey more than 88 %, 72 % and 26 %, respectively, of the population live in rural areas (WB, 15 Aug 2002). There does not seem to be any plan or policy to address this basic reality in general and even if it exists it is not reaching them. It has led to the omission of a big chunk of population from getting benefits of seismic safety.

4.5 Power to municipalities

The laws provide limitless power to the municipality for building construction in municipality territories. It is responsible for regulating, monitoring, and controlling building construction in its territory. Laws provide powers to the municipality to demolish non-conforming buildings, and to disconnect them from utilities. These are hardly ever implemented because of ambiguities and conflicting clauses, lack of desire by the officials, lack of capability of municipality or for other societal reasons. It has turned the municipality into a mere “paper tiger”.

4.6 Regularisation of illegal buildings

In India, the illegalities in construction have become so pervasive that no one questions them (The Indian Express, 2001b). People do not hesitate to buy illegal construction (IT, 2001b). After the Bhuj earthquake struck Ahmedabad in India, it was discovered that the local government had voted to regularise the status of illegal buildings rather than punish the offenders and/or require them to be improved or demolished. This easy option was reportedly taken because of pressure from the real estate sector (Indian Express, 2001a, 2001b). When authorities have a lack of will or the capability to tear down an existing illegal building, the violators can get some sort of amnesty (Gülkan, 2000a). Even if the authority acts to clamp down on illegal construction, it is very short-lived, and most of the time it comes by individual efforts rather than institutional. It has encouraged builders, contractors and real estate agents for construction of shoddy buildings.

4.7 Quality assurance

At a planning and design level, professional peer review of designs and drawings does not occur. At the same time, quality assurance systems at construction sites do not normally exist. In India, for example, contractors inspect their work themselves and owners and municipality officials make only superficial checks, if any. Similarly, in Turkey, the “engineer on record” is responsible for quality assurance at a site. However, as he gets his fees from the contractor, he is paid by the contractor (Gülkan, 2000), the conflict of interest results in little enforcement of quality assurance. In owner-built construction, hardly any technicians are involved.

5 BUILDING CODE ISSUES

5.1 Level of Sophistication

These countries have a very complex socio-cultural setting and its built environment covers the widest possible range: from non-engineered dwelling built without any technical input to most modern structures. This has led to a dilemma for code writers. The question always raised is-what is the appropriate level of sophistication in Standards (Gülkan, 2002; Jain, 2002). Should the code be

progressive and include the latest knowledge base, or should it strongly orientated to traditional building materials and skills? The Turkish earthquake code (1998) is a progressive code, but at the same time it is doubtful whether the code can be adopted outside the bigger cities (Gülkan, 2000a). Similarly, doubts for implementation of even intermediate level of sophistication in codes are being expressed in India (Jain, 2002).

The 1975 version of the Turkish earthquake code, under which most buildings in Izmit were designed (Gülkan, 2000a), did not require a capacity-design approach. Similarly, even the latest version of the Indian earthquake code (IS1893-2002) does not require this approach. However, it requires design for shear by a capacity-design approach. Although its stated design philosophy calls for a strong column / weak beam approach, the code does not address this further. Many well-known requirements for good earthquake-resistant design and construction are omitted. The lack of consistency between different material codes (Jain, 1996) and the earthquake code further complicates the situation. Further, there does not exist any code for ductile detailing of steel structures in India (Jain, 2002).

5.2 Code updating

The updating of codes is a slow process in these countries. As an example, the 1978 Indian earthquake code was applicable until this year - even though the process started in 1993 (after the Killari earthquake) to revise it. Similarly, in Turkey the code prepared in 1975 was unrevised until 1998. It has led to a gap in state-of-practice in these countries and others and no translation of latest knowledge could be available in practice.

6 IMPLEMENTATION ISSUES

6.1 Safety culture and Awareness

It seems that neither decision makers nor general public are aware of inherent seismic risk in these countries. The governments of these countries are characterised by their lack of will to implement proactively seismic safety. Constrained by economic realities, seismic safety receives little priority. This is also true at the householder level. A traditional fatalistic approach often provides a ready excuse for no action. The enforcement of a building code is difficult for a politician or official. If enforced too strictly, local people and builders become unhappy, and this is a risk for a politician wanting re-election. Till the safety culture becomes part of life, seismic safety is essentially a mirage.

It is interesting to note that increased affordability in Ahmedabad resulted in a more luxurious life style rather than safer living. An extreme case was the construction of a swimming pool on top of an unsafe building that led to its collapse during the Bhuj Earthquake (TI, 2001b). Similarly, it is observed that even when the risk is well known, it can be taken for granted. Of course, the general population accuse the authorities after the disaster - as was seen after the Izmit earthquake along the North Anatolian Fault (NAF), and after the Bhuj Earthquake. Even though recent history shows the NAF to be predictably active, people were unaware of the risk.

6.2 Capability of municipality

Local governments lack technically-qualified staff and funds, and cannot fulfil even the simple task of keeping registers. They also lack simplified procedures and check-lists, which would enable them to check simple and common designs.

The bylaws of these countries do not clearly state who should check the design, and what should be the checker's qualification. In Turkey, the design check is the sole responsibility of local government as the law explicitly holds local government responsible for life and property safety of people it serves (Development Law). Similarly, it is the responsibility of the municipality in Nepal and India. This has led to confusion and technicians rather than engineers checking and approving designs. While the building permit process should control and regulate building construction, it is more often principally a revenue generation source for the municipality.

7 CONCLUSION

A real institutional structure does not exist in these countries for creating an effective quality assurance system for buildings. Can urban planning, progressive codes, effective acts and bylaws with their proper implementation mitigate human and economic losses? The answer is “no” for India and Nepal until some pragmatic solutions and policies are developed. A majority of their people live in rural areas, often inaccessible by modern transport. Until then, seismic safety will remain essentially a mirage - as conventional solutions proposed by modern codes are not viable, economically unaffordable, technically unfeasible, and logistically impossible in most of the rural areas of these countries.

Because of the widely varying socio-cultural and economic conditions within the country, there is not a single ideal solution for the implementation of seismic safety. It is more than just a technical issue. The selection of approaches must be based on the local social fabric, economy, and realities. Any regulatory approach must be appropriate, affordable, and implementable in the first place. Furthermore, it must be continually reviewed. Interlocking checks and balances are essential. Such a solution should not seek a radical change, but it should be strongly pro-active. At the same time, bottom-up and top-down processes should work together.

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