



PROMOTING SAFER BUILDING CONSTRUCTION IN NEPAL

Amod M. DIXIT¹

SUMMARY

Nepal lies in an active seismic belt. The history is full of devastating earthquakes. The earthquake risk in Nepal is believed to be one of the highest in the world.

On the other hand, more than 98 % of the buildings in Nepal are constructed by the owners following the advice of local craftsmen. Consequently, most residential buildings, even in urban environment, do not receive any rational design for strength. Thus, in both urban and rural areas the traditional craftsmen play the pivotal role although they are not given any specific training on seismic safety, and they do not have adequate access to information related to safer building practices. Further, although most municipalities do have a system of building permits, there is no provision in the process to check the submitted plans against the strength criteria. There is poor institutional and technical capacity within the local authorities for implementing strength-related provisions even if they were to be introduced in to the building permit process. Under such apparently difficult situation, promoting safer building construction can not be possible without taking a radical approach such as shifting the emphasis from training the engineers to training the masons, and relying more in convincing the house-owners on earthquake safety rather than only controlling them through the process of building permits.

Adhering to such approaches, the National Society for Earthquake Technology-Nepal (NSET) has been successfully implementing initiatives for improving seismic performances of new constructions in urban and rural areas of Nepal. Efforts for integrating seismic safety in construction practice of owner-built houses is considered a part of a comprehensive strategy that includes public awareness programs, regular consultation for house-owners, informal training to masons and petty contractors, and education and training programs at the community levels. Efforts are being made to build the capacity of local authorities (municipalities) in adopting seismic provision of building codes in their building permit process. Seismic intervention in public school in rural areas with community participation and with local mason involvement serves as tool to promote safe construction. Awareness tools like simplified shake table demonstrations and earthquake safety exhibition with real-scale construction model are found very effective to convince the people on the benefits of seismic provisions. This paper analyzes the existing construction mechanism and trends, and describes the approach, tools and effectiveness of the initiatives taken for increasing safety of the owner-built buildings in Nepal. Lessons learned from the implementation of programs are also discussed in the paper.

¹ General Secretary, National Society for Earthquake Technology, Email: adixit@nset.org.np

INTRODUCTION

Earthquake Risk of Nepal

Nepal sits astride the boundary between the Indian and the Tibetan plates along which a relative shear strain of about 2 cm per year has been estimated. The existence of the Himalayan Range with the world's highest peaks is evidence of the continued tectonic activities beneath the country. As a result, Nepal is very active seismically.

In fact Nepal has a long history of destructive earthquakes. The earliest recorded event in the most comprehensive catalogue to date occurred in 1255. There were significant earthquakes in 1833, 1934, 1960, and 1988. In this century alone over 11,000 people have lost their lives in four major earthquakes. A 1934 earthquake produced an intensity of IX-X on the Modified Mercalli Intensity (MMI) scale in Kathmandu Valley, and destroyed 20% and damaged 40% of the valley's building stock. In Kathmandu itself, one quarter of all homes was destroyed. Many of the temples in Bhaktapur were destroyed as well.

A recent global comparative study done by the Bureau of Crises Prevention and Recovery of the United Nations Development Program ranks Nepal 11th in the world in terms of earthquake risk, which that is measured on the basis of average death per unit population, UNDP [1]. Earlier, another comparative study of 21 cities in the seismic belt identified Kathmandu as the most at-risk city in terms of casualty due to earthquakes. Earthquakes are found to be the most "lethal" in Kathmandu.

A simple loss estimation study for Kathmandu Valley was conducted as part of the Kathmandu Valley Earthquake Risk Management Project (KVERMP), which was implemented by the National Society for Earthquake Technology-Nepal (NSET) and Geo Hazards International, administered by the Asian Disaster Preparedness Center (ADPC), and funded by the United States Agency for International Development (OFDA).

The loss estimation study indicates that massive damage can be expected to Kathmandu Valley's buildings, structures and population if the shaking of 1934 were to repeat. As many as 60 percent of all buildings in Kathmandu Valley are likely to be damaged heavily, many beyond repair, during the scenario earthquake. Bhaktapur, which suffered the worst damage in 1934, has historically suffered more than the rest of the valley in earthquakes, possibly because of its soil conditions. As many as 75 percent of all buildings in Bhaktapur are likely to be heavily damaged.

In addition to building damage, it was estimated that functionality of most of the critical facilities and emergency response system would be significantly reduced. Death and injury expectations are similarly shocking. The estimates are 40,000 deaths, 95,000 injuries, and 600,000 to 900,000 homeless due to Kathmandu Valley's next major earthquake.

Unsafe Buildings are the Roots of Earthquake Risk

While rampant poverty, rapid population growth, and lack of awareness of earthquake risk are believed to be the cause, poor building performance has been singled out as the most important constituent source of the ever-increasing earthquake risk in Nepal, GESI [2]. Therefore, improving seismic performance of new constructions and improving the same for the existing buildings should become one of the main thrusts towards earthquake safety in Nepal. Promoting safer building construction is an objective necessity for Nepal where urban population, for example that of Kathmandu, seem to be doubling every 10-15 years. Such rapid growth of urban population demands a very high rate of building production, which, in the absence of proper building permit process, and a general lack of the knowledge and skills for earthquake-resistant construction, end up in shanty construction that are extremely vulnerable to earthquake.

Most residential buildings, even in urban areas of Nepal, do not receive any rational design for strength. Even though most municipalities (58 altogether) do have a system of building permits, there is no provision in the process to check strength criteria. The building permit process takes into account only the compliance related to planning such as the ground coverage, floor-area ratio (FAR), and the stipulations of the building bylaws (height, provision of toilet, sewer and solid waste disposal etc). There is poor institutional and technical capacity within the local authorities for implementing strength-related provisions if they were to be introduced into the building permit process.

To compound the problem, there is no system of controlling the professional standards of engineers/designers through reference to professional qualifications/ membership, peer review process or by legal means. Further, the owner-builders, who follow the advice of local craftsmen and mason-leader, build a significant proportion of the buildings in Nepal. Neither the owner-builder nor the crafts-persons are aware of the possible disastrous consequences from an imminent earthquake. Neither do they have adequate access to information related to safer building practices and incorporation of simple earthquake-resisting features at nominal extra cost. Even the building construction projects funded by national and multilateral agencies usually do not spell out adequate requirements related to seismic safety in their terms of reference to their consultants.

Approaches for Promoting Safe Building Construction in Nepal

The National Society for Earthquake Technology-Nepal (NSET) found itself confronting this complex situation in which earthquake-resistant construction was not more than a sweet dream than reality. Soon it was realized that any possible intervention should be a holistic combination of 4 main strategies, notably, a) raising awareness, b) improve capacity of engineering community, including the diploma engineers (engineering technicians or junior engineers as they are called in developing countries), c) improve the capacity of the main actors of the building production process – the masons, the chief masons, and the petty contractors, and d) institutionalize quality control of construction materials as well as that of the construction processes, especially in case of reinforced concrete frame constructions.

NSET embarked upon the process of promoting safer, earthquake-resistant building construction in Nepal using the combined strategy as described above. This was also reflected in the Kathmandu Valley Earthquake Risk Management Action Plan prepared by NSET in collaboration with almost all major stakeholders of Kathmandu Valley. NSET [3] includes among the top 10 priority actions the followings initiatives:

1. NSET will request the Ministry of Housing and Physical Planning to constitute the Building Council and direct it to draft the rules and procedures for implementing and enforcing the building code, and formally adopt requirements to implement and enforce the building code.
2. NSET will work with the Ministry of Housing and Physical Planning and others to prepare training materials and provide training for building inspectors, masons and engineers on applied aspects of design and construction of buildings to conform to the Building Code.
3. NSET will manage and co-ordinate the "School Earthquake Safety Project" which will (1) inform selected communities about the vulnerability of their schools and what can be done to reduce the risk; (2) prepare school-specific plans for improvements in seismic safety; and (3) mobilize support to improve the safety of the school buildings.
4. NSET will encourage engineering institutes to develop and offer short courses for practicing engineers on earthquake engineering principles and procedures.

UNDERSTANDING THE BUILDING PRODUCTION MECHANISM

There are three distinct types of building construction mechanism in practice in Nepal. Figure 1 shows the distribution of the construction process for residential buildings of Kathmandu valley. A prevalence of owner-built structures is seen. The owner-built structures are all non-engineered.

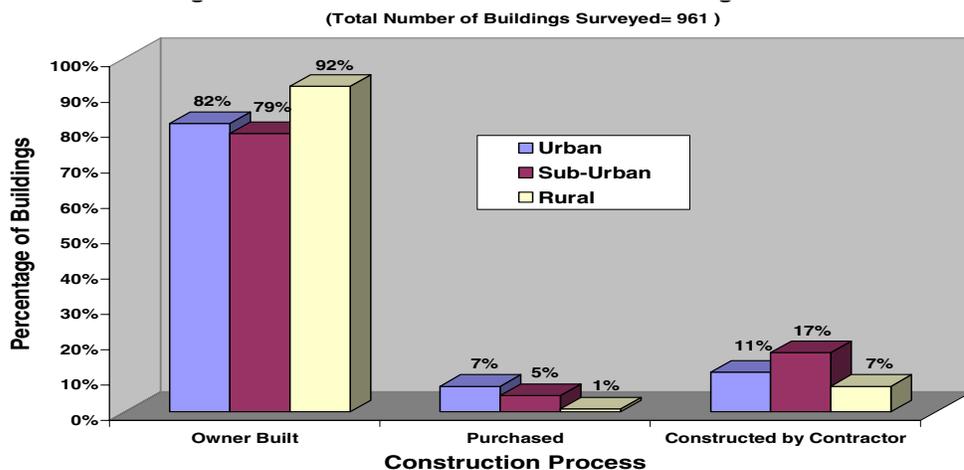


Figure 1: Building Construction Process for Residential Buildings in Kathmandu Valley

These are the structures (e.g. buildings) that is designed and constructed as per standard engineered practices. In case of buildings, engineered construction are those that are supposed to have undergone the formal process of regular building permit by the municipal or other pertinent authority. The formal building permit process is supposed to require involvement of an architect/engineer in the design and construction for ensuring compliance to the existing building code and planning bylaws. In Nepal, formal building permit process is implemented only in urban areas. Building code exists but not implemented strictly! Consideration of seismicity on building design depends upon the individual initiative of the designers and the availability of fund.

Non-engineered Constructions

These are physical structures (e.g., buildings) the construction of which usually has not gone through the formal building permit process. It implies that the construction of non-engineered building has not been designed or supervised by an architect/engineer. Such buildings are obviously prevalent in the rural or non-urban (including urbanizing areas in the periphery of municipal areas). Although building by-laws exist and complied within municipal areas, they do not demand structural design considering earthquake effects during building permit process. Thus, a large percentage of the building stock even in Kathmandu Valley is non-engineered as the structural design is not considered in during design and there is no involvement of engineering professionals during construction phase in most of the cases. In the urban areas of Kathmandu, it is estimated that more than 90 percent of existing building stock are non-engineered (partly because there are many old historic buildings), and every year about 5000 more such non-engineered buildings are added.

Owner-built buildings

These are buildings constructed by the owner at the guidance and with the involvement of a head-mason or a carpenter who lacks any modern knowledge on earthquake resistant construction. Traditional construction materials such as timber, stone rubble or brick (fired or un-burnt) and mud as mortar are

used. There is usually no input from any engineer. These are usually rural constructions. However, such constructions are seen also in the poorer part of a city, or in the city suburban areas.

There is an increase in the prevalence of frame-structures nowadays. Unfortunately, many of them are non-engineering, which is a potentially high vulnerability situation.

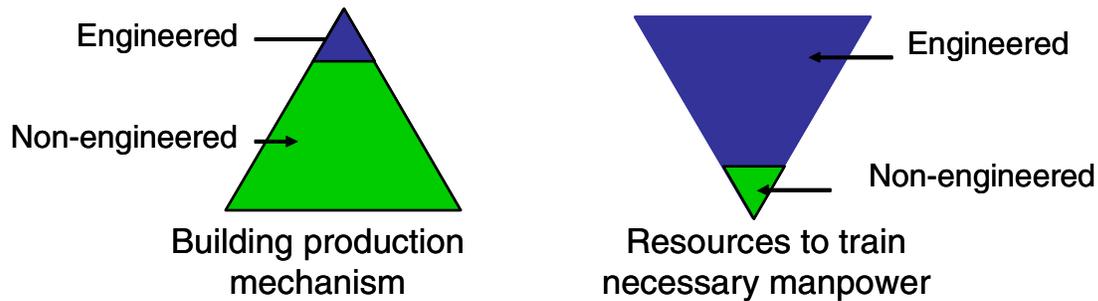


Figure 2: Resources distribution in comparison to construction mechanism

The ratio of the number of buildings with different construction mechanism and efforts to prepare necessary manpower and documents can be compared with these two inverted triangles (Figure 2). The first triangle shows the ratio of buildings by different construction mechanism and second one the existing resources allocation. For real improvement in the existing earthquake scenario, the picture should be changed by adopting radical methods.

IMPLEMENTATION STRATEGY FOR ACHIEVING SEISMIC SAFETY IN BUILDINGS

Towards promoting safer building construction NSET has been playing a key role in advocating the issues related to general and specific seismic safety requirements including in the owner-built buildings. Through partnership approach with various organizations and stakeholders, NSET supports and launches public awareness programs, conducts training programs at community levels, for integrating seismic resistance into the process of new construction, in increasing the safety of school children and school buildings, in improving the seismic performance of existing buildings and in increasing the experts knowledge of the earthquake phenomenon, vulnerability, consequences and mitigation techniques

Considering rapid erection of new buildings in Kathmandu Valley what has led to building up of a large number of unsafe buildings, a two-pronged strategy is implemented to achieve earthquake resilience of buildings in Nepal.

- A. New construction: Stop increasing risk, all new construction should be earthquake-resistant so that there is not increase in risk.
- B. Existing buildings: Decrease unacceptable risk, existing structures should be either retrofitted or reconstructed to withstand reasonable shaking.

Three approaches of implementation

Considering the diversity of the building construction process and also the prevalence of non-engineered buildings, the process for promoting safer buildings should be guided by 3 approaches viz. a) Top-down, b) Botton-up, and c) Horizontal networking.

Top-down approach

The top-down approach consists in advocating for the mandatory implementation of the building code in the building permit process. The approach saw the first success last year when the government made compliance to the national building code mandatory for all public buildings. It has also urged the municipalities to incorporate stipulation of the building code into the municipal building permit process.

Bottom-up approach

This approach believes in creating the demand as well as conducive environment for incremental compliance to building safety against earthquakes. Obviously, raising awareness and capacity building of the main actors of the building production process are the key elements of this approach. Some of the activities under this approach are described below.

1. Publication of a calendar showing good practices of construction: A step of building code implementation is the publication of calendar with simple earthquake resistant construction technique. This is the most effective and successful event. Many municipalities, inside and outside the valley, are now using the NSET calendar during their building permit process. The number of involvement of different municipalities per year is increasing.
2. Mason Training under SESP: In all the process of seismic retrofitting and reconstruction under the School Earthquake Safety Program (SESP), NSET engineers work with masons providing them hands on training on earthquake-resistant construction. The practical method avoids grafting the knowledge rather the masons are encouraged to think and find the logic behind the approaches. This allows proper consideration of the indigenous knowledge and effective techniques gained from their long experiences. It makes them accept the improved technique as a normal practice. It is all in form of on-the-job training. Besides, separate formal training courses about construction are conducted in form of classes. The training programs conducted at respective construction sites. The target groups are craftsmen of village, but the class is opened to all those are interested. The technical knowledge of earthquake-resistant construction is given to them systematically.

The training courses follow hierarchical procedure starting from problem identification to problem solving and testing of methods of learning. The training programs are basically in form of interaction including lectures, photographs display, presentation of slides and drawings using overhead projectors, visit to place where methods are being employed in school and condition of simple tests. Attention is paid to the level of trainees' knowledge and perception capability while presenting during training.

Once weak points of prevailing construction are described and consequences are presented through photographs of past earthquakes, the trainees' start to mull over it trying to find solutions. Several tests are conducted to support the knowledge in relation to effect of placement of reinforcing bars in beams and slabs, quality of work governed by material and workmanship such as excess water effect, curing effect etc.

3. Free earthquake clinic: NSET runs a weekly program to give advice and orientation on earthquake-resistant construction for house owners who are going to construct new house. The message transmitted is that "small improvements in design and construction of buildings can make large change to its overall earthquake resilience". NSET engineers describe with the help of photographs, slides show and small physical models, the prevailing and recommended construction techniques. House-owners are encouraged to come alongwith their leader-mason or

even engineer/technician to discuss their planned design. The free earthquake clinics are very successful.

4. Mobile earthquake clinic: NSET organized periodic mobile earthquake clinic, which consists of an engineer and a trained mason. The team moves to the construction sites of owner-built building construction and offers advice. This program is very successful not only in terms of the number of buildings advised on earthquake safety, but in terms of the changing the mindset of the entire neighborhood visited.
5. Nepali Version of Mandatory Rules of Thumb and Design Guidelines: NSET has now translated five documents (Three mandatory rules of thumb and two design guidelines) into Nepali and they are under publication.

Horizontal networking

This third approach tries to develop partnership of approach and fosters synergetic cooperation among various initiatives for achieving earthquake safety. The following provide the details.

1. Creation of a National Forum for Earthquake safety: National Forum for Earthquake Safety (NFES) consists of several professional organizations, municipalities and government agencies. NSET is a member of NFES. NFES was involved in helping the Lalitpur Sub-metropolitan City (LSMC) to implement the building code as a pilot project. LSMC was the first municipality of Nepal to have made building code compulsory for all new construction. So far NFES has worked successfully.
2. Institutionalization of academic programs: NSET welcomes M. Sc. students of civil engineering classes as interns as project researchers which allow to students to understand the earthquake risk of Nepal and necessity of earthquake risk mitigation and preparedness in general and earthquake engineering principles and procedures in particular. As the graduates of academic institutions, vocational training centers, trade schools etc. are the ones who will be shouldering responsibilities at different levels in the professional field, NSET has recommended incorporating seismic resistant design and detailing as well as guidelines/manuals in the regular academic curricula of bachelor's level of engineering. The process is ongoing.
3. Working with other agencies: NSET sits in several committees with the government and UN agencies that focus on reducing earthquake risk in Nepal. An example of such committee is the Disaster Health Working Group through which NSET has developed and established a plan for health sector emergency response and preparedness guidelines have been prepared for the assessment of structural and non-structural vulnerability of Hospital systems of Nepal.

LESSON LEARNED

Institutionalization is long-term process

To achieve better seismic performance of buildings the approach and processes should address the needs at more than one level and take into account the grass-root realities. It must create an awareness that leads to increased demand for safer buildings and skills. It must strengthen capabilities at all levels. It should allow some flexibility in how the various levels of safety norms/standards are adopted.

Two pronged strategy should be taken

Seismic retrofitting of existing buildings is worthy and not every body can afford it. However, emphasis on retrofitting should be continued because of two reasons – a) it creates awareness, and b) it is actually feasible in public institutions such as public schools.

In case of residential buildings, it is much easier to intervene for new seismic-resistant construction.

In urban areas retrofit masonry buildings and construct earthquake resistant RC buildings

Trend shows that adobe and mud-based construction in urban area is significantly reduced and there is a remarkable growth in brick-in-cement and Reinforced Concrete (RC) frame constructions. So, to stop increasing risk in RC construction, it is necessary to create a condition of enforcing the building code requirements. For decreasing existing risk, existing masonry (brick in mud, and brick in cement) structures should be encouraged for retrofitting.

But in Rural areas, intention should be paid to incorporate earthquake resistant elements in brick in mud or stone in mud buildings.

Only one approach may not work

Seismic safety of buildings has to be improved by better use of material and improved technology and skill in one hand and by legal enforcement and awareness rising in the other. The approach of creating building act and laws can provide legal environment where as awareness at community level or training to masons transfer the ownership of knowledge and the process leading to a desired level of sustainability.

Incremental safety approach works

Although, inherently weak materials and its improper use and poor construction technology/skill make the owner built buildings unsafe and earthquakes in Nepal are recurrent leading to high casualty, destruction and economic loss result from unsafe buildings; it is almost impossible to change the construction scenario at once. It is a foregone fact that buildings will continue to be constructed by using locally available construction materials and that non-engineered buildings will continue to prevail at least in the foreseeable future.

In technological aspects, the local craftsmen play pivotal role. Technicians and engineers have little control over the construction of owner built buildings. Proper training of craftsman can built his confidence, in using the technology and skill to construct safer buildings.

Thus, the appropriate technology should be developed or transferred. For example, instead of changing very high strength construction material or applying higher technology in construction, stitching the walls, providing bands, tying roofs and floors and vertical rods at corners etc. in case of masonry buildings, and improving ductile detailing, and workmanship in case of RC buildings are important than adopting new construction material.

Programs like School Earthquake Safety Program (SESP) should be continued

In all the villages where SESP has conducted, the house owners of respective locality have been replicating the construction methods employed in school building to construct their private houses without intervention from NSET-Nepal. Except some minor features, newly constructed houses adopt all basic earthquake resistant construction technology like bands, wall stitching, vertical tensile rebar etc. It shows higher level of perception on what masons are trained. Obviously, it can be said that the process of replication would multiply in future to set a new technological culture in construction. In this aspect, the retrofitting project of school has much higher social value compared to other risk reduction programs that hardly are able to translate technology in real ground in root level.

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