BRIDGING THE KNOWLEDGE GAPS FOR SAFER CONSTRUCTION

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Abstract

Recent earthquake in developing countries has caused large scale human and property loss. The main cause behind the catastrophe can be attributed to poorly constructed buildings. While technological knowledge existed for progressive improvement of these buildings it could not be implemented because the knowledge has not been able to reach to the users who were involved in the building construction such as owner, technician, builders, and craftsman. Typical gaps that hindered the effective use of knowledge were - very slow rate of knowledge dissemination as training schools do not facilitate the process, their curricula do not address the ground realities, lack of conducive policy and legal environment which could have accelerated the knowledge transfer process. Further, existing misconception and lack of awareness on the roles of different key players in the building construction process that puts too much emphasis on design compared to quality control of process and materials. This paper explores these gaps in the context of experiences gathered in the past decade in improving earthquake safety and implementation of building code in Nepal.

Introduction

Perception of risk and its mitigation are two major facets of seismic protection. Enough knowledge is available in academia, research institutions to meet both the facets and make most of vulnerable building stock safer for at least medium level of seismic event if not the severe ones. However, the available knowledge is not able to translate its capability for greater seismic protection in developing countries. There remains a fatally large gap between availability of knowledge and its implementation. In these countries buildings are mostly non-engineered controlled by local availability of construction materials and skills and the building production mechanism is very informal. Present dissemination mechanism does not seem capable of transferring knowledge for incorporation of seismic resistance in buildings.

Large majority of human and property loss can be attributed to loss of residential building in developing countries (Coburn & Spence, 2002). Until this building stock is improved, safety of human and property loss cannot be realistically reduced in these countries. Seeing the socio-economic constraints, cultural issues, building development mechanism, engineering community hardly plays any effective role in this issue. The statutory and regulatory system in these countries to control the building quality is mostly limited to urban areas and even there it is mostly redundant and inefficient and plagued by bureaucratic and political reasons.

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Despite development in earthquake engineering worldwide it has failed to improve building stock and protect human life and property in developing countries. Affordability, lack of awareness, weak human memory (caused by large time gaps between seismic events) and lack of legal control, lack of engineering knowledge are generally considered major hurdles to the implementation of aseismic construction. However recent earthquake induced losses in Turkey, India and Iran canvases different picture. Despite these preconditions were fulfilled in one way or other, seismic safety could not be implemented there. It raises very concern that these are not only the preconditions for implementation of seismic safety. If the process of implementation is reviewed it becomes clear that the available knowledge could not be translated into the end users' language and the stakeholders of seismic safety were not involved into the process. Further, the gap between "expert" knowledge and its implementers is widening which has made available knowledge of no use for seismic protection. Un-recognition of communities' safety culture, disregard of crucial players, lack of understanding of socio-economic constraints and wrong policies has virtually made seismic safety an unachievable goal. The wrongs still can be corrected by bridging the knowledge gap that exists between "experts" and "lay people", recognizing the players of arena, correcting the focus and addressing the problem at grass root level. This paper will address the knowledge gap and how these can be bridged.

Understanding the Knowledge Gaps

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 characterized by their lack of will to implement proactively seismic safety. Constrained by economic realities, seismic safety receives little priority. This is true at the householder level as well. A traditional fatalistic approach often provides a ready excuse for no action. Implementation of building code is considered a liability which no one wants to take. Till the safety culture becomes part of life, seismic safety is essentially a mirage.

Building Production

Building structures in these countries are mostly procured by the owner itself, mostly employing a local skilled craftsman to direct construction operations. They play a pivotal role in the overall construction activity, and the owner relies on them heavily for all types of advices. They provide overall technical and organizational support - even though they have no formal training. According to very conservative estimates 98% (adopted from HMG/N 1992) of the country's building stock in Nepal and 94 % (adopted from BMTPC, 1998) in India are designed and constructed in this way. More than 90% of the populations in developing countries live in these buildings (Arya, 2000). 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.

Professional advice is rarely sought (even in urban areas) and, if sought for private houses,it 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 (Figure 1). 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.

Traditional materials and skills

The formal education system - the major track for dissemination of knowledge - and its trainees do not recognize informal/ non-engineered construction materials and skills. 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 have very limited access to any training on earthquake resistant construction and are still waiting to be recognized as stakeholders of building industry. 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. The scenario has somehow stopped possible improvement in traditional building construction types.

Conflicts and Dilemma

Olive-smith (1986) discusses that the drastically lower rates of mortality in developed world induced by disasters because of improved technology. However, this technology is neither affordable nor accessible to the larger part of the developing nations so it cannot be expected to safeguard human life and its property if the same approach afforded for seismic safety. Furthermore, the conventional method accepts that seismic safety can be implemented through engineered solutions enforced by legal tools. However, engineered solutions are neither affordable nor accessible to larger chunk of population in most of the developing countries. In addition, consideration of legislation and statutory guidance is imperative, its role could be effective where it can be efficiently implemented (Homar & Eastwood, 2001). It is where failure in most of case happens.

Construction Materials

It is commonly accepted that traditional construction materials such as mud, stone, unreinforced masonry are weak construction materials and are source of building seismic vulnerability. These constructions by nature are non-engineered and are produced by employing local materials and skills. Rather than understanding the socio-economics behind use of these materials and developing earthquake resistant measures to make them earthquake resistant it is usually advocated to restrict their use.

Knowledge Dissemination at Grass root level

The technology dissemination is considered complete once it reaches engineering community and mid-level technicians where as they produce less than 10% building stock in developing countries (adopted from Arya2000). The local craftsmen who produce more than 90% of the buildings are almost always abandoned from the process of knowledge dissemination. The state investment is very biased towards the engineers and it hardly makes any investment towards promotion of craftsman (Figure 2). Even if they are involved in the process, the training imparted to them is mostly formal class room training. These people come from different leaning process (listening, learning by doing) which is hardly acknowledged. The training fails even before it starts.

Knowledge Dissemination to professionals

Even at academic institution training in earthquake-resistant design and construction is still not viewed as an integral part of long-term earthquake mitigation strategies in many of the countries. There seems an impression that making the Building Code mandatory will solve all the problems without developing enough capability. Because of lack training on earthquake resistant design even engineers lack knowledge on earthquake resistant design construction and make fundamental conceptual mistakes in formulation of a building. Most consider it merely an extrapolation of vertical load design and different between design philosophy between vertical load design and lateral load design are hardly appreciated. Consequently, even if lateral loads are considered, the basics of clearly-defined load paths, ductile detailing, etc. are often ignored.

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.

Bridging the Gap

Awareness and Education Programs

Raising earthquake awareness is a major component for bridging the knowledge gap. By awareness raising myths and fallacies can be eradicated, fatalism can be reduced and community can be convinced of impending seismic risk and way out to mitigate it. NSET has developed few innovative ideas to aware people from all walks of life – policy and decision makers, politicians, media, international agencies to grass root level people. Of course, the objectives of awareness raising are different for the different target groups: for politicians and high officials, it to convince them of the necessity to look at disaster risk reduction as a development issue, for the general public it is enabling them to understand the risk and to identify possible measures that could reduce the vulnerability on an incremental basis. Some of these activities are discussed below:

Earthquake Scenario: An earthquake scenario due to any real earthquake in human memory which can be somehow related with them can be an effective tool for awareness raising. However it must be in common man's language and so he should be able to link himself with the story. Factual figures and qualitative presentation is more important in such scenario. Seeing effectiveness of an earthquake scenario, and to help people understand impending earthquake risk in Kathmandu Valley, NSET developed an earthquake scenario under Kathmandu Valley Earthquake Risk Management Project (KVERMP) during 1997 – 2000 AD, in association with Geo Hazards International (GHI) and the Asian Disaster Preparedness Center (ADPC). The scenario was successful in explaining the personal and communal losses and suffering in form of a storey if 1934 Great Nepal-Bihar Earthquake repeats. The scenario was published and widely distributed. The document includes a description of possible damages to various vital systems in Kathmandu, and an explanation of the repercussions of this damage on life in Kathmandu Valley.

Earthquake Safety Day: Earthquake safety day is celebrated every year in Nepal in January 15th (or 16th) to refresh memory of people about earthquake induced deaths and destruction in Nepal in 1934 January the 15th. The event draws people from all sections of community: common people, school children, business people, decision and policy makers, representatives from emergency response organizations and critical facilities management etc. The event is organized with many activities for many days such as: Earthquake Safety Exhibition and symposium, public broadcast of earthquake safety message by the Prime Minister; awareness rally through the streets; national meeting with the government ministers; shake-table demonstration; children essay/painting competition; street drama on earthquake safety, etc. Publications on earthquake safety such as: information leaflets, calendars, earthquake-resistant construction posters were distributed to the public. Emergency response organizations, earthquake safety implementation agencies, business houses are invited to exhibit their activities, product and services.

Shaking Table Demonstration: Shaking table demonstration is strong tool for awareness raising, translating technical knowledge in a language that is understandable to common mass, education of craftsman, convincing people, and trust building for the earthquake resistant construction. The tool is able to convince community and craftsman both for need of earthquake resistant construction and its effectiveness. The philosophy behind the demonstration is “seeing is believing”.

NSET has successfully conducted shaking table demonstrations in Nepal, India, Afghanistan, Tajikistan, Iran, and Japan and in Ache, Indonesia. It has been become a show piece in Nepal for any earthquake awareness raising activity. Seeing its effectiveness it has been repeated couple of times in different parts of Tajikistan; and UNDP, Iran is planning to do the same in different parts of Iran.

What it incorporates is two small-scale, similar houses (Figure 3), one built ordinarily and the other one incorporating earthquake resistance features, are shaken simultaneously on a simple table with springs and wheels. The houses are always constructed with typical local architecture so that people could compare their abode with the models and feel the similarity. The demonstration is followed by a commentary in simple, non-technical language so people can understand what is happening. As the demonstration starts from very small shaking with increasing intensity, people can see initiation of damage to collapse of conventional construction and survival of earthquake resistant one. It gives them a feeling that where is the problem and how with low to even no cost technology can provide a significant amount of safety to their abode.

*Radio/TV Programs***:** To get to the doorsteps of the people, several local radio and TV stations are airing earthquake safety and preparedness messages on a regular basis in Nepal. NSET has established collaboration with local FM Radios for mass education on earthquake safety. The program targets the homeowners and convinces them on the possibility and affordability of making their homes earthquake-resistant, and making their family safe by learning about earthquake preparedness. NSET provides expert knowledge to the programs by deliberating on aspects of earthquake risk and its mitigation.

Earthquake Clinics: NSET conducts earthquake clinics (mobile and in-house both) on regular basis. For in-house clinics NSET encourages potential house owners and existing house owners to come to NSET office with drawings to discuss earthquake strengthening of their abode. They are encouraged to come with their petty contractor. In mobile clinic, NSET professionals visit the construction site and discuss with the house owner and the craftsman about deficiencies in their construction, and advice them how these can be mitigated. The NSET provides these advices free of cost. These clinics have become very popular.

Community intervention through schools

Schools are the focal point of any community and this is a matter of concern for all. Any activity in schools has far reaching effect. By raising awareness in schools, the entire community is reached because lessons trickle down to parents, relatives, and friends. Seeing the high potential for schools to introduce seismic protection at the community level and train craftsman, NSET-Nepal is conducting a program to strengthen existing school buildings and promote more earthquake resilient school buildings since1999 AD in different parts of Nepal under its School Earthquake Safety Program (SESP). A holistic vision has taken towards seismic protection of schools and all the stack holders such as school staff, students, local community, local and central government, local clubs has been involved in the process so that they can be made aware of risk and can be taken into trust. The school building strengthening program is taken an opportunity to train masons, technology development and transfer recognizing their accessibility to potential house owner and their role in safer construction.

The program was successful in creating a demand for earthquake resistant construction through demonstration of earthquake resistant construction, awareness raising in community; and developing a supply mode on earthquake resistant construction through on-the-job training to craftsman at the school construction site. The program was successful in creating a discussion between craftsman and engineers and it was able to link local indigenous knowledge with the modern one. Significant improvement in quality was observed in the subsequent buildings where these craftsmen worked later. These masons were able to convince the potential house owners for incorporation of earthquake resistance in their house and replication of the work has been seen around the school buildings.

Incremental Approach

Appreciation of incremental safety in buildings is more important than code defined safety level which in many case requires radical change in construction materials and technology which is neither affordable nor accessible in large majority of developing countries. The building stock there is so vulnerable that even a small intervention would significantly improve chances of the survivability of building in “low” to “medium” earthquake event if not the “major” one. Such interventions are possible by intuitively trying to avoid the damage mechanisms observed in past earthquakes in similar buildings. This fact needs cherished as “something” is more important than “nothing”. This fact needs to be appreciated rather than discouraged as usually done by formal sector as seismic safety is more a socio-economic, cultural issue rather than mere a technical one.

Reorganization of Local Culture

Local seismic cultures are based on intelligent use of local recourses so these are affordable, sustainable and users’ friendly. The importance of the local seismic culture therefore rest upon the fact that it makes intelligent use of local skills, materials and resources and becomes an effective and culturally sensitive way to produce earthquake resilience buildings (Homar & Eastwood, 2001). Many of the seismic safety cultures and their physical manifestation, for example, adaptations made to building, may not be apparent to “out-siders” this does not mean they did not exist (Oliver-Smith, 1994). The need is to recognize this fact and incorporate in earthquake mitigation planning.

Grass-roots level training programs

Local craftsmen are the best messenger to carry earthquake resistant technology to community because of their accessibility and communities' trust on them. For it they need to be convinced of affordability of mitigation intervention. The masons help to get the buy-in from the community – they convince the communities to accept the technology, concepts, construction process and additional costs for this.

To often earthquake safety public education program fails even before it starts. The problem is: too much attention is paid on content of the education massage and not enough on the nature of the audience (Stalling 1986). Same problem has been often observed in craftsman training. It is because these craftsmen come from different leaning process: learning by listening and doing. However, often training imparted to them is very formal class room training. The training covers more theoretical aspects of construction rather than practical aspects which fail to draw their attention. In this regime NSET has taken very different approach for craftsmen training. NSET has developed interactive class room trainings, which is supplemented by on-the-site trainings, sub-assemblage tests etc to help them understand where they are making mistakes and how these can be mitigated, how they can improve their quality (Figure 4).

To cover other stake holders of construction industry, apart from the craftsmen, NSET is conducting technical trainings for contractors, technicians, engineers and even for school teachers in collaboration with government and non-government organizations. Course for such training programs have already been developed and a few are published. Further, there are several training programs conducted by NSET and others on aspects of individual and collective safety from earthquakes before, during, and after an earthquake.

Conclusion

NSET's approach and success shows that bridging the knowledge gap is most at all levels for introduction of seismic safety though the approaches could be different for different audience. Any approach adopted for bridging the gap should address the socio-economics of local community. Further, construction technology dissemination to stakeholders of construction industry is key for introduction of seismic safety in building structures, however dissemination process should be able to understand the gaps and limitation of its stakeholders. In addition to it, top-down and bottom-up process work together to achieve the goal.

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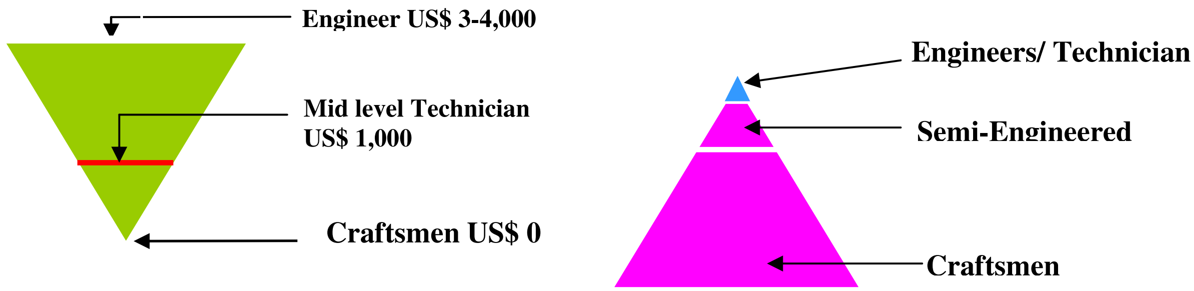
Figure 1: Conceptual mistakes in an engineered building



a) Investment (fees only in Nepal) *b) Involvement in building production*

Figure 2: Comparison of investment versus involvement in building production

a) Shaking Table Demonstration in Nepal ***b) Shaking Table Demonstration in Tajikistan***

Figure 3: Shaking Table test of 1:10 scale Typical Nepalese Residential Houses

a) Testing of building components	***b) Class room training to masons***

Figure 4: Mason Training