STUDY FOR DEVELOPING AND DISSEMINATING EARTHQUAKE-RESISTANT TECHNOLOGIES FOR ENHANCED SEISMIC SAFETY OF BUILDINGS IN NEPAL

(Reinforced Concrete with Brick Infill and Stone Masonry Constructions)

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KEY WORDS

Appropriate technology, institutionalization, implementation, dissemination, standardization

INTRODUCTION

Nepal is a seismically very active country and it has faced number of earthaquake disasters in the past and potential seismic risk of the country is very high as well. Huge number of houses were destroyed and damaged due to past earthquakes and heavy loss of lives was occured due to this damage. In 1934 Great Nepal-Bihar earthquake of 8.4 Richter magnitude around 80,000 houses were destroyed with 8,519 deaths in Nepal and in 1988 earthquake of magnitude 6.6 Richter 70,000 houses were damaged with 721 deaths [1,2].

Damage and collapse of buildings is the primary cause of loss of lives during the earthquake in Nepal as is in other similar countries of the world. However, sufficient attention has not been paid to construct earthquake-resistant buildings and promote earthquake-resistant construction. Despite the rich traditional wisdom of earthquake-resistant construction and the potential threat of earthquake destruction, the prevailing construction in Nepal hardly follows the proper provisions of earthquake-resistant construction. Therefore, the risk is further increasing day-by-day. Similar situation prevails in most of the developing countries of the world and in this sense the Nepalese construction technology and practice can be taken as the representative of the construction practices of the developing world typcically of the growing cities and rapidly urbanizing areas of the region.

Despite this reality, very limited researches have been done to improve the seismic capacity of prevailing construction practices and to enhance the seismic safety of large communities of Nepal and of the region. Therefore, this paper has been prepared to highlight on the need of study on improving current technologies and propose an outline of the study. This paper tries to describe briefly on the proposed building typologies for study, methodology, expected outcomes and proposed time frame for the study.

PRAVALENT CONSTRUCTION TECHNOLOGY AND PROCESS IN NEPAL

Most prevalent construction in Nepal ranges from Adobe (unburnt brick) construction, one of the traditional construction technologies to the reinforced concrete (RC) framed buildings, the modern techology: it consists fired brick in mud mortar, fired brick in cement mortar, stone in mud mortar, stone in cement mortar, timber construction, RC framed with brick and stone infill as the major construction technologes. The building typology and construction practice varies according to the geographical location and level of urbanization in the area where the building is located; in hilly and mountainous rural areas the most familiar construction practice is stone masonry in mud mortar or timber construction whereas in rural areas of southern plains (Terai) brick or block masonry with mud mortar or timber construction is

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popular. In most of the urban areas nowadays, major construction practice RC framed buildings with brick or stone infill walls and stone, brick or block masonry in cement mortar as another important type in these areas.

The study called "Development of Alternative Building Materials and Technologies for Nepal" carried out during the National Building Code Development Project in 1992 to 1994 in Nepal, has done a prototype building inventory survey in different locations of Nepal. This survey has clearly shown that most significant construction typology in major rural areas of Nepal is the stone wall construction and that in the urban areas is RC framed structure with brick, block or stone infill walls [3]. The building inventory survey carried out in Kathmandu Valley during the "Study on Earthquake Disaster Mitigation in the Kathmandu Valley, the Kingdom of Nepal" conducted by JICA and Ministry of Home Affairs (MOHA) of Nepal in 2000 - 2002, has also shown that even in Kathmandu Valley significant proportion of buildings is covered by stone masonry and the RC framed construction [4].

These two typologies of buildings: stone masonry construction and RC framed structures with masonry infill walls can be taken as the representative buildings of Nepal. Figure 2 shows typical construction practice of stone buildings (a) and RC framed building (b).

Figure 2 (a): Typical stone building in rural area

Figure 2 (b): Typical RC framed building

On the other hand, more than 90 % of the buildings in Nepal are constructed by the owners following the advice of local craftsmen. Most residential buildings, even in urban environment, do not receive any rational design for strength and they are also basically constructed with the advice from local craftsmen or the petty contractors. 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.

THE NEED FOR STUDY ON BUILDING TECHNOLOGY

The studies show that similar trend of construction practice will be continued in the future also in the region. Therefore, there is an urgent need to study strengths and weaknesses of these building in terms of earthquake resistant capacity and develop appropriate measures to enhance their capacity. The damages during the recent earthquake around the world have also

reemphasized the fact. Figure 3 shows typical damage of stone masonry (a) and RC framed (b) buildings.

Figure 3: Typical failure of stone house during 1988 Earthquake of East Nepal

Figure 4: Typical collapse of RC Framed Building, 2001Gujarat Earthquake

PROPOSED STUDY

With reference to the above mentioned background, a study project focusing on survey and analysis of prevailing construction practices, and development and dissemination of appropriate for enhancing the seismic safety of the buildings is proposed to be carried out in with the support from Building Research Institute (BRI), Japan; National Institute of Land and Infrastructure Management (NILIM); and United Nations Center for Regional Development (UNCRD). Following section of this paper outlines the objective, approach, and methodology of the proposed study.

Study Area

The proposed study will cover the entire area of Nepal. However, whole area will be divided into different geographical and typological regions based on the availability of buildings, materials and practices for convenience in inventory and survey of buildings. The survey will focus basically on identifying the key features of stone masonry and RC framed with masonry infill construction.

Methodology

Following methodology is proposed for the study:

A. Identification of positive and weak aspects of existing construction in Nepal
   1. Survey of prevalent building typologies (compilation of building practice),
   2. Survey of the existing construction technologies, materials and methods as well as the differences in existing technologies used for earthquake resistance,
   3. Study of seismic performance of existing buildings (survey of all available technology for earthquake resistant),
      a. Detail numerical analysis (for detailing the existing practices)
      b. Material testing (in-situ and lab testing and classifications)
      c. Shake table test for verification of performance of existing construction technology
   4. Study of construction process and building production mechanism
      a. Building production systems and their influence on seismic safety
      b. Quality control issues
      c. Existing laws and policies for enforcement of earthquake-resistant provisions
      d. Technology transfer and dissemination system

B. Technological development for enhancing seismic safety of existing buildings
   1. Development of options for possible improvements in the existing building construction technology,
   2. Development of seismic strengthening / retrofitting options and systems for enhancing seismic safety of existing buildings,
   3. Study of similar technologies in other parts of the world and if suitable import/adapt them for Nepalese buildings,
   4. Study effectiveness of the possible improvement options in new construction by detail numerical analysis, shake table testing, material testing and real scale model building construction (2 model building construction sites for 2 different typologies of buildings),
   5. Study effectiveness of the possible strengthening /retrofitting options by detail numerical analysis, shake table testing, material testing and implementation of strengthening programs in select existing buildings.

C. Implementation, dissemination strategy and policy Improvement
   1. Survey existing policy and systems for technology transfer, dissemination and enforcement of safety provisions (building code implementation etc.),
   2. Develop dissemination plan and sound building code implementation plan,
   3. Formulation of implementation strategy inclusive of education plan, training plan, awareness raising plan, policy back up, developing regulations, strengthening of monitoring mechanisms,
   4. Establishment of technology dissemination portal at the international level (BRI)

Expected Outcomes

Following are the expected outcomes from the study:

1. Improved methodologies for earthquake-resistant construction of stone masonry (SM) and RC framed with brick masonry infill buildings
   - Identification of positive elements of construction that need to be supported,
   - Identification of weak points
   - Comprehensive technology (including design, construction and supervision)
2. Implementation strategy for improving seismic performance of buildings in developing countries
3. Enhanced regional cooperation / networking and sharing of experiences leading to replication strategy
4. Preparing grounds for replication and implementation

Implementation Modality

1. Approach

- Work in close cooperation with appropriate government agency - Department of Urban Development and Building Construction (DUDBC), responsible government agency for study, transfer and facilitation for implementation of construction technology in the country and the National Society for Earthquake Technology – Nepal (NSET) have established tradition of close collaboration in building code preparation and implementation, capacity development, dissemination and earthquake awareness and education. Optimum utilization and strengthening of this close collaboration with government agencies will be done during the study.
- There have been a very good tradition of collaboration among NGOs and local governments, this will also be strengthened and utilized during the study.

- Involve all stakeholders right from very beginning; local advisory committee will be constituted for assuring the involvement of all.

2. Project Execution in Nepal

- NSET will be leading member and DUDBC main partner (gradually DUDBC will take the ownership of the project output)
- A project working team will be constituted consisting of engineers, professionals from NSET, DUDBC and leading municipalities (Kathmandu and Lalitpur in Kathmandu Valley)
- Local surveyors will be deployed for inventory and survey of technology; the surveyors will be from local engineering personnel and students from local academic institutions

Work Plan

Following tentative work plan is proposed for the study:

S. No.	Activity	Schedule																			
		Year 1				Year 2				Year 3				Year 4				Year 5			
1	Mobilization																				
2	Project Kick-off workshop in Kathmandu																				
3	Inventory and Survey																				
4	Preliminary Analysis																				
5	Detail Analysis																				
(a)	Numerical Analysis																				
(b)	Physical Testing and verification																				
6	Final Analysis																				
7	Identification of Intervention Options																				
8	Analysis and Testing of Intervention Options																				
(a)	Numerical Analysis																				
(b)	Physical Testing and verification																				
9	Final Recommendation of Improvements																				
10	Development of Dissemination Strategy																				
11	Construction of Model Buildings																				
12	Dissemination																				
13	Project Briefing Workshops in Kathmandu																				
14	Final Workshop, Reporting and Review																				

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