UNDERSTANDING TRADITIONAL WISDOM OF EARTHQUAKE-RESISTANT CONSTRUCTION IN THE HIMALAYAS

A. M. Dixit[1], R. Guragain[2], S. N. Shrestha[3], M. Gupta[4] and A. Sharma[5]

[1]Executive Director and General Secretary, National Society for Earthquake Technology-Nepal (NSET), Nepal
[2]Director, National Society for Earthquake Technology-Nepal (NSET), Nepal1
[3]Deputy Executive Director, National Society for Earthquake Technology-Nepal (NSET), Nepal
[4]Executive Director, Sustainable Environment and Ecological Society (SEEDS), India
[5]Director, Sustainable Environment and Ecological Society (SEEDS), India
Email: adixit@nset.org.np; rguragain@nset.org.np; sshrestha@nset.org.np; manu@seedsindia.org; asharma @seedsindia.org.in

ABSTRACT:

Existence of traditional knowledge on earthquakes and earthquake-resistant methods of construction in the cultures along the Himalayan range is known for quite some time. A few scientists have tried to explore aspects of such constructions. However, no inventory of such historical buildings/monuments exists, let alone a systematic study of the earthquake-resistant features of this time-tested construction monuments that have survived one or more episodes of large to very large earthquake shaking during the past centuries: These buildings are like open laboratories in which signatures of indigenous wisdom in earthquake-resistant construction, technologies that have protected these structures against vagaries of nature including earthquakes, and the socio-cultural factors that have been at play for their preservation could be observed and studied. Such knowledge is considered useful also for the implementation of earthquake risk reduction initiatives: it is becoming increasing evident that the success of the program for improving seismic performance of construction depends much on the level of acceptance of the proposed technologies by the communities. The target monuments of the proposed study are the true example of the building culture that not only was acceptable in the concerned community, but were well integrated into the respective social and cultural lives. Hence, knowledge of prevalent indigenous technologies and their seismic behavior, and the history of application and conservation, could be very helpful in identifying proper improvements in construction practices using traditional construction materials, and for sustainable earthquake protection and conservation.

These issues are expected to be addressed by the pan-Himalayan study of historical buildings, conceptualized by National Society for Earthquake Technology-Nepal (NSET), and being implemented jointly by SEEDS, other researchers and research institutions of the Himalayan region. The goal of the multi-year project is to understand the nature of the employed construction materials and technologies, the construction processes employed and the wisdom behind it, the designs adopted, and then a proposal to develop a database with a focus on understanding the seismic behavior of these buildings. The study also helps to understand how biodiversity shaped the building typologies in the region and the changes in the employed structural systems over the time in any locality.

The paper will present a summary of the works done and analyze the problem in more details, and then describe the proposed methodology and scope of study, and will further elaborate the project concept and scope.

KEYWORDS:

Earthquake, historic buildings, Himalayas, indigenous technology, earthquake resistant features, traditional wisdom

1. INTRODUCTION

Many historical building structures are surviving for last couple of centuries in Pan-Himalayan region despite these has been struck time and again by destructive earthquakes. These buildings are open laboratories in themselves where traditional wisdom is strongly built in. Despite this fact, the built-in wisdom, technologies that have protected these structures have yet not been studied comprehensively.

This study envisions studying the historical buildings in the region, understanding employed material and technology, construction process and wisdom behind it and then developing a database. The study will be focused towards understanding the seismic behavior of these buildings. The study will also help to understand how biodiversity shapes the building typology in the region and change in structural system over the time.

2. OBJECTIVE AND OUTCOMES

Following are the objectives of the study:

- Understand building technology, material, evolution process diversification in the region
- Explore earthquake resistant features in historical buildings
- Develop methodology to preserve/ revive, modify, adapt the earthquake resistant technology in present context
- Develop a conservation strategy for the indigenous earthquake resistant technology

Following are the expected outcome of the study:

- A data base for structural features of typical historical buildings,
- Understanding of traditional technology and materials with special focus with earthquake resistant technology,
- A strategy for conservation and revival of the technology in present context.

3. STUDY AREA

It is foreseen that the study area will span between Manipur, Nagaland (India) in the east to Kashmir in the West encompassing Northern part of Bangladesh and hill and mountainous region of Nepal. In the North-South direction it will cover the Himalaya in the North to the Siwalik in the South. Figure 1 presents the study area.

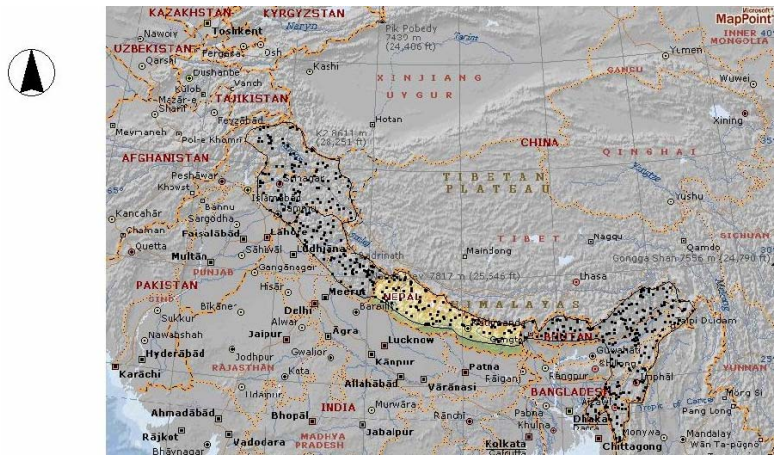

Figure 1: The Study Area

4. METHODOLOGY

At present stage even preliminary data on building typology, building materials and process, technology of construction, building evolution process is not available at a level when any assessment could be made for buildings in Pan-Himalayan region. It is even worse in the case of historical buildings. It has obvious implication on defining extent and scope of the work. Because of this limitation, it has been envisioned to have this study in two phases:

1. Preliminary study and
2. Detail study

The details as follows:

Preliminary Study: This study will also help to develop a consensus among the stakeholders and develop a mindset for the detailed study and will also help to understand extent of the work and will provide basic data, direction for the detailed study. Further, it will help develop methodology, budget for the detailed study. It is expected that, this phase would take 6 months to 1 year. The study covers following activity:

Literature survey: In this part materials will be collected from secondary sources for concept development, understanding of the building typology, materials, construction and evolution process. However, whatever material survey has been conducted shows that very limited literature specific to this study is available.

Rapid Inventory: The rapid inventory will be a very brief survey of historical buildings to help develop a concept on buildings, understand extent of the work. This survey will cover building materials, technology, skills, construction process, age of the building, impact of the earthquakes in past and how it was intervened, signatures of time on building, and special features if any rather than detailed survey of the building. The surveyors will be encouraged to fill up the checklist and understand the building process and record it, prepare a freehand and preliminary plan of the building and take 6-10 photographs for further study. A questionnaire for rapid inventory is attached in Annex 1.

Preliminary classification and concept development: This phase is basically office work where collected building information will be processed and analyzed, building classified according to their material, construction technology by technical team. This phase could start once data from rapid inventory start arriving.

Site visit: The technical team will visit different sites in India and Nepal to test developed methodology, calibrate the acquired information from field with prototype in site for confidence.

Workshop/ Meetings/ e-meetings: During different stages of this phase meetings/ workshops will be organized to disseminate the information, develop consensus, and finalize methodology, critique etc. Workshop is planned for finalizing methodology for Rapid Inventory, after completion of the work.

Detailed Study: At this stage, it is difficult to say much about the detailed study. However, for discussion it has been briefed below. After completion of the *Preliminary study*, we would know the extent of work and what to expect. This study would be detailed study of selected building structures. This phase is expected to take 4 to 5 years. This component will have four basic activity:

Detailed Inventory: This stage would cover detailed survey of the buildings, filling checklists, collecting information on material quality, taking photographs and collecting as many as possible historical records of the building structure. This will give in-depth knowledge about the building.

Building Classification and Concept Development: Once data are gathered, the data can be analyzed, buildings can be grouped together to facilitate their study according to employed construction materials and technology, construction process, occupancy or other identified variables.

Qualitative Analysis: In this phase the collected data will be further analyzed, strong and weak features of the building structure will be identified for identification of survivability of the building. Based on these materials and other materials from secondary sources will be used to identify their vulnerability. However, as far as it is learnt, no established methodology is available for vulnerability assessment of this class of buildings.

Quantities Analysis: In this phase a set of representative buildings will be analyzed analytically to understand their behavior, reasons behind their survivability. The major hurdle in this phase would be: analytical study tools are not available on low strength traditional buildings.

Conservation Strategy: Once the technology and rational behind it is understood, a conservation strategy could be developed to conserve the technology, heritage.

5. ORGANIZATION OF THE STUDY

Seeing the scale of the work, different stakeholders, and possible academic, logistic issues a steering committee, one technical committee has been envisioned. Further, at this stage, organizational plan for only preliminary study has been developed. These are detailed below:

Steering Committee: A steering committee has been proposed to guide technical committee, give directions, and review the process and outcomes, fund raising for the study.

Technical Committee: A technical committee will be composed of engineers, architects, building technologists, academicians from concerned field from different parts of the study area. A core technical group is envisioned out of them for doing office work.

Organization of the Work: As discussed earlier, the preliminary study work is divided into two parts to facilitate the work. These are discussed below:

Technical Support: This part is basically technical support for the study, development of methodology, analytical work. It is envisioned that NSET will provide overall technical support and co-ordination for the inventory work. It will develop the methodology, develop checklists, guidelines required for the work, and provide training to field investigators.

Field Work: It is envisioned that NSET will conduct inventory work in Nepalese side and SEEDS with its partners will do it in Indian part. They will identify the local investigator (Nodal points) in their territory who will be responsible for co-coordinating the inventory team and inventory work in their area. Seeing the large extent of the area in Indian part, there could be many Nodal points. For inventory work engineers, architects, junior engineers or engineering or architectural students could be employed. They will be provided an orientation before starting the work to aware them of the objective of the work and uniformity in work.

Data processing and office work: All the information/ data processing will be done by NSET in co-operation with other partners of the study. So once the information is collected, these need to be transferred to NSET for processing by nodal points. During data processing, NSET will send processed data, its comments to its partners for critique.

6. MAJOR HURDLES OF THE STUDY

- At present stage even preliminary data on building typology, building materials and process is not available at a level when any assessment could be made. It has obvious implication on defining scope of

the work.

- The study area is quite large (around 2500 km in length and 100 km in width). Because of its immense size, very different building typology from east to west and north to south, co-ordination among different stakeholder would be big job.
- For uniformity in collection of data, a cumbersome training would be required for all the field study team.
- These does not exist any established qualitative or quantitative vulnerability assessment methodology for foreseen type of the building structures in study area.

REFERENCES

1. Parajuli, Y. K., 1986, Experiences in Preservation and Restoration in a Medieval Town, Bhaktapur Development Project, Ministry of Panchayat and Local development, Kathmandu.
2. London, P.; Nepal, Vol. 1 and 2, London 1928, repr. in: Bibliotheca Himalayica, Kathmandu 1976.
3. BDPC, The Development of Alternative Building Materials and Technologies for Nepal, UNDP/UNCHS (Habitat) Subproject NEP/88/054/21.03, Appendix A- Prototype Building Inventory, A report prepared by consultants for the Building Code Development Project (BCDP), His Majesty's Government of Nepal, Ministry of Housing and Physical Planning, 1994.
4. JICA, The Study on Earthquake Disaster Mitigation in the Kathmandu Valley Kingdom of Nepal.", a report prepared by Nippon Koei Co., LTD. and Oyo Corporation, 2002 for His Majesty's Government of Nepal, Ministry of Home Affairs, under the cooperation agreement with the Japanese Overseas Cooperation Agency (JICA), 2001

Annex 1: Questionnaire

Pan-Himalayan Study on Indigenous Technology of Earthquake-Resistant Construction of Historic Buildings (PAHSIB)

Questionnaire for Rapid Inventory

(Fill up one firm for each building)

This study is being conducted to develop a database on historical building typology. It will help to study the historical buildings in the region, understand employed material and technology, construction process with special focus towards earthquake resistant technology used in these buildings. Many historical building structures are surviving for last couple of centuries in Pan-Himalayan region. This study will help to understand what helped them to survive. This Questionnaire has also been prepared to facilitate the surveyors.

Part A: General Information

100. Location Information of Building

101. Name of owner (if any): ……
102. Code for building
102.1 Building

B/ I/ N						
Country	State	District	Village/ municipality	Ward	Building	

102.2 Photographs numbers: …….
103. Country: …….
104. State: ……..
105. District: ……..
106. Village committee/ Municipality: ……..
107. Ward number: …….
108. Village/ Tole/ Community: ……..
109. Latitude/ Longitude: _____N, _____S

Part B: Details of Building

200. Details

201. Year of Construction (in AD): …….
202. Major repair and maintenance, extension details:

Year (in AD)	Repair/ maintenance	Extension	Remarks

203. Use of Building: ……

Residential	1	Temple	2	Hostel/ Dormitory	3	Dharmashala/ inn/ Pati	4
Hotel/ Restaurant	5	Office	6	Shop	7	Educational	8
Factory	9	Storage	10	Clinic	11	Others, if any	12

300. <u>Architectural/ Structural Details</u>

301. Plan shape of building: ……

302. Number of stories: …….

302.1 If multi storey building, what is typical height: ……m

302.2: Total height of the building: ……m

303. Structural system: Load bearing masonry/ framed construction/ Mixed construction/ Nogged brick/ stone

304. Basic construction material:

303.1 walling material:

303.1.1 Walling units: ……

303.1.2 Mortar: ……...

303.2 Floor structure: ……

303.3 Flooring material: ……...

303.4 Roof structure: ……

303.5 Roofing material: Slate/ clay tile/ CGI/ Jack arch/ thatch/ timber/ rammed earth

305. If framed construction, please specify the frame type:

306. Earthquake Resistant features:

Structural Elements	Earthquake Resistant features	Remarks
Wall	Stitches	
	Bands	
	Vertical columns	
	Through stone if stone masonry	
Floor	Floor members are well connected with the bearing walls	
	Floor members are well connected with each other	
Roof	Floor members are well connected with each other	
	Floor members are well connected with the bearing walls	

307. Special notes from surveyor:

Part C: Past Earthquakes

400. Details of Earthquake Signature

401. Please record when this structure was struck by earthquakes in the past and what intervention was made (please provide as more detail as possible):

Year of earthquake	What happened to the building	Intervention	Signature of earthquake

500. *Plan of the building* (draw a freehand sketch of the plan and section of the building).

600. *Modality for maintaining the structure (Social structure)*

601. Social structure to keep up the building: _____

602. Who looks after the buildings: _____

603. Source of income to main the building (if public building): _____
_____