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Understanding Traditional Wisdom of Earthquake-Resistant Construction in the Himalayas

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ABSTRACT: Existence of traditional knowledge on earthquakes and earthquake-resistant methods of construction 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 such time-tested monuments that have survived one or more episodes of large to very large earthquake shaking. 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 the history of application and conservation, and the seismic behavior of the constructions 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 the National Society for Earthquake Technology-Nepal (NSET), and proposed to be implemented jointly by NSET, SEEDS, and other research institutions of the Himalayan region. The goal of the multi-year project is to explore the traditional wisdom in earthquake-resistant construction, and to develop of an inventory of such buildings and their earthquake resistance. The study will also help 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, describe the proposed methodology and scope of study, and will further elaborate the project concept and scope.

1 INTRODUCTION

Many historical buildings, mainly religious or community structures, are standing for the last couple of centuries in cultures along the 2,500 km long Himalayan range surviving several episodes of destructive earthquakes. These buildings can be considered as open laboratories or museums, displaying the strength of the traditional system and wisdom of earthquake-resistant construction. Unfortunately, the traditional knowledge and wisdom, rich as they could be, have not been studied comprehensively neither in terms of the technologies employed nor in terms of the causative factors for their longevity in a seismically active belt.

This study envisions studying the historical buildings along the southern slopes of the Himalayan range covering Pakistan, India, Nepal, Bhutan and Bangladesh. It will inventory the surviving historical buildings; record in details the employed material and technology, explore the construction process and wisdom behind it, and analyze their earthquake-resistance using modern software for structural analysis. Social and environmental factors that could have contributed to the continued survival of such monuments will also be analyzed together with developing understanding the contribution of biodiversity in the building typology and configuration and the changes in structural system of the buildings over the time.

2 OBJECTIVE OF THE STUDY

Following are the objectives of the study:

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

3 EXPECTED OUTCOME

The following are the expected outcome of the study:

- An inventory of typical historical buildings and their structural features.
- A Report with analysis of the traditional technology and materials with special focus on earthquake-resistant elements employed,
- A strategy for conservation, revival and replication of the time-tested technologies in present context.

4 SCOPE OF STUDY

The study area will encompass the southern slopes of the Himalayan Range covering settlements of Pakistan-India, Nepal, Bhutan, and Bangladesh. In the North-South direction it will cover the Himalaya in the North to the Siwalik in the South. Fig. 1 presents the study area.

A minimum of five buildings will be studied in each country by the respective partnering institutions in each country. At this moment, NSET is made responsible for the study in Pakistan and Nepal, and SEEDS will be responsible for the study in India and Bhutan. The Bangladesh Earthquake Society (BES) is being approached for the study in Bangladesh. Subsequently, institutions from Pakistan and Bhutan will be identified as equal partners in the project.

5 METODOLOGY

At present, even preliminary data is not available on building typology, building materials and process, technology of construction, and the building evolution process that could allow credible assessment regular buildings. 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 following provide the details.

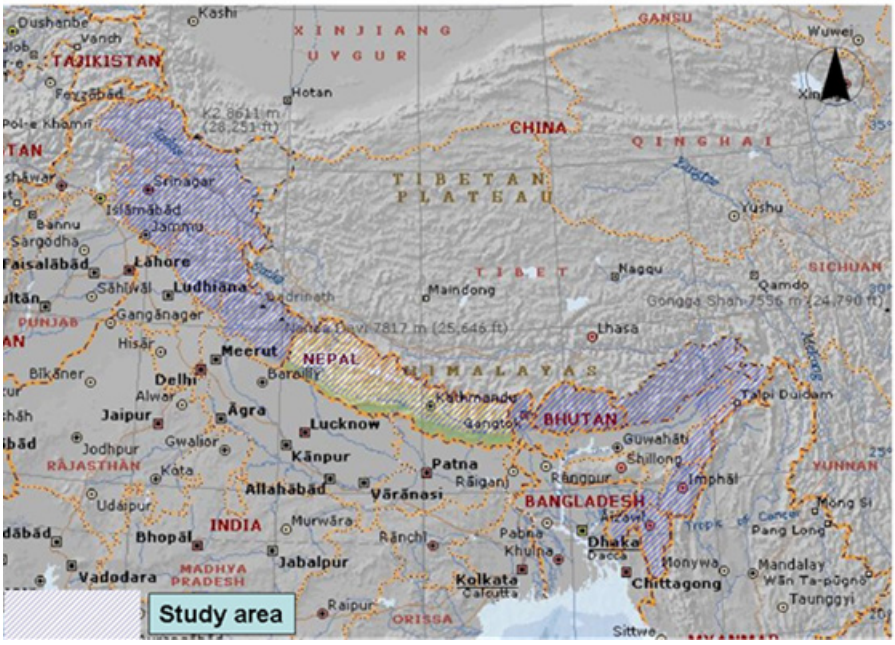

Figure 1: The study area.

5.1 Preliminary Study

This study will help to develop a consensus among the partners and develop a mindset for the detailed study and will also help to understand the extent of the work. The preliminary stage will yield basic data on the buildings and help identify directions for the detailed study. Further, it will help develop a consensus methodology, and define the budget requirements for the detailed study. It is expected that, this preliminary phase would take 6 months to 1 year, covering the following activities:

Literature survey: Available published or unpublished materials and other secondary information will be collected and analyzed. It will help to further refine the study concept, and enhance our understanding of the building typologies, materials, construction and evolution processes etc. However, survey of materials conducted so far has identified very limited volume of literature specific to this study.

Rapid Inventory: A rapid inventory has been envisioned that will cover a reconnaissance survey of historical buildings to help develop a concept on buildings, and understand the 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 repaired, signatures of time on the buildings, and any other special features, if any, that contributed to the longevity of the structures. The surveyors will be encouraged to fill up the checklist and understand the building process and record it, prepare a freehand-drawn preliminary plan of the buildings and make 6-10 photographs of the target buildings for further analysis. A couple of buildings in the region have already been visited and photographs of a few of them are presented in Fig. 2.

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: A Technical Team, consisting of representatives from each participating institution, will visit the different sites in the different countries to pre-test the developed methodology, calibrate the acquired information from the preliminary survey vis-à-vis the field observations by the Technical Team on the target buildings, and develop consensus on the methodology, and build mutual confidence.

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

A stone house with timber bands (in Central Nepal).

A historical Palace with timber bands in Kathmandu Valley (survived at least 2 to 3 events of intense earthquakes including intensity IX MMI, Nepal Bihar Earthquake, 1934).

A rammed earth building with trapezoidal wall section (also note wider base, small windows).

A timber house with Dhajji Dewari in Azad Jammu and Kashmir that survived the 8th Oct 2005 South Asian Earthquake (note: external stone walls collapsed).

Figure 2 : Few examples of earthquake resistant construction with indigenous materials and technology in the Himalayan region.

5.2 Detailed Study

At this stage, it is premature to provide a detailed account of the detailed study simply because we want to allow evolution of understanding and the methodology itself: crystallization of the concept will be made after the completion of the *Preliminary stud*y when the team would better know the optimal extent of work and expected outcomes. The detailed study will select typical representative building structures and analyze them. This phase is expected to take 4 to 5 years. This phase is expected to have the following five basic activity directions:

Detailed Inventory: This will cover detailed survey of the buildings, preparation of as-built drawings, filling up of 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 will be analyzed, and buildings grouped together to facilitate their study according to the employed construction materials and technologies, 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 making a judgment on survivability of the building. Based on the findings, and also those from secondary sources, vulnerability of the structure will be determined. However, as far as it is known, no established methodology is available so far for vulnerability assessment of this class of buildings.

Quantitative Analysis: In this phase a set of representative buildings will be analyzed analytically to understand their behavior, and to find out the causative factors behind their survivability. The major hurdle in this phase would be unavailability of analytical study tools for these traditional buildings. The best among the available combined with those that can be adapted for meeting the needs will be used.

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

6 ORGANIZATION OF THE STUDY

Considering the scale of the work, wide scatter of potential stakeholders, and the possibility of academic interest, the project wishes to constitute a steering committee and a technical committee for providing transparency of technical and management approaches, and also to bring in wider involvement of the society.

At this stage, an organizational plan has been prepared only for the Preliminary S Phase. The detailed Study Phase organization will be developed once the preliminary phase is completed.

6.1 Steering Committee

A steering committee has been proposed to guide the Technical Committee, and for providing overall oversight to the project. It will also review the process and outcomes on a periodic basis. It will also assist in fund raising for the study.

6.2 Technical Committee

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

6.3 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, relevant checklists, and 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 make them aware them of the objective of the work and uniformity in work.

6.4 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 by nodal points, these need to be transferred to NSET for processing. During data processing, NSET will send processed data, its comments to its partners for critique.

7 MAJOR HURDLES OF THE STUDY

- Absence of even preliminary data on building typology, building materials and process is not available at a level that could allow any preliminary assessment also.
- 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 are expected, thus the co-ordination among different stakeholder would be a big job.
- For uniformity in collection of data, a cumbersome training would be required for all the field study team.
- Established qualitative or quantitative vulnerability assessment methodology for foreseen type of the building structures in study area is not available, hence needs to be developed.

8 CONCLUSIONS

A hierarchical, multi-year plan for the study of historical buildings in the Himalayan region has been conceptualized to understand the built-in earthquake-resistant elements and measures that reflect the traditional wisdom and ages-old technologies of building construction. The project will lead to a comprehensive database on these building typology and help develop a conservation strategy for the indigenous earthquake resistant technology in the region. It is hoped that our observations on some buildings that have been visited and studies to a certain extent, will generate enough interest and support from the conference partners.

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