Bhutan: Improving Resilience to Seismic Risk Project
Terms of Reference
Study of Typology of Rammed Earth Buildings

1. Background

The Royal Government of Bhutan has received a Grant of US$1,285,500 in support of the “Bhutan: Improving Resilience to Seismic Risk” Project from the World Bank, acting as administrator of grant funds provided by the Government of Japan under the Japan Policy and Human Resources Development (PHRD) Technical Assistance Program to Support Disaster Reduction and Recovery. The objective of the Seismic Resilience Project is to improve the understanding of earthquake risk in Bhutan as well as opportunities and challenges associated to its mitigation.

The project consists of the following parts:
- Part A: Investigations and Mapping for Improved Understanding of Seismic Risk
- Part B: National Vulnerability Assessment and Retrofitting
- Part C: Improving Seismic Resilience of Traditional Bhutanese Buildings
- Part D: Development of Emergency Structural Capacity
- Part E: Project Management, Monitoring and Evaluation.

Part C is being implemented by the Division for Conservation of Heritage Sites (DCHS) under the Department of Culture (DoC), Ministry of Home and Cultural Affairs (MoHCA).

DCHS is the key agency responsible for the conservation, promotion and development of heritage sites in Bhutan. The understanding of the traditional construction techniques and the properties of the materials used, plays a vital role for the preservation and promotion of the vernacular structures which are unique and are of cultural heritage value to Bhutan.

The last two earthquakes (September 21, 2009 and September 18, 2011) in Bhutan, have damaged over 13,000 rammed earth houses. This raised concerns among communities, local artisans, engineers and architects and policy makers on the reliability and suitability of vernacular construction techniques in highly seismic prone areas. With the change in outlook towards the traditional construction method, the traditional rammed earth houses are now being replaced with modern construction such as reinforced concrete structures. In this scenario, the study of typology and construction techniques of rammed earth houses under the PHRD program would lead to representative sampling of the rammed earth structures nationwide, and consequently contribute to development of vulnerability assessment formats and guidelines for improved earthquake resilient construction techniques for rammed earth structures in Bhutan.

2. Objective of the assignment

To undertake a nationwide representational sampling survey of rammed earth structures in Bhutan. The survey will identify the various architectural design, construction techniques and damage patterns found in the rammed earth structures, thereby enabling the typology study of rammed earth buildings in Bhutan.
The local consultant will provide technical support to the Division for Conservation of Heritage Sites by carrying out the specified documentation of the traditional rammed earth houses in the selected regions of Bhutan. This study will contribute towards the following:

- Study of typology and design of rammed earth structures
- Study of various construction techniques of rammed earth structures
- Study of damage patterns of rammed earth structures
- Identify reasons for damage (these could be structural, physical or socio-cultural, for example a change in maintenance practices)
- Identify earthquake resilient features in traditional rammed earth structures

3. Scope of work

The assignment will be executed under four different packages in four different regions of the nation where vernacular traditional rammed earth structures are common. The houses to be documented are already identified by the Department as per the suitability of the study. The numbers of houses to be studied differs in different regions and the numbers are calculated purely based on the calculated total plinth area of the houses.

The four identified regions are as follows:

Insert schematic map indicating the 4 regions
1. Paro (Menchulo, Shaba and Esuna)
2. Punakha (Phathari, Kabesa)
3. Punakha (Tana, Zome)
4. Wangdue Phodrang (Damchoe and Eutsa, Phobjikha)

fig. 1: Schematic map of Bhutan showing the regional coverage of four regions.
The consultant is expected to perform the following tasks:

- Document the traditional rammed earth buildings - plan, section, elevation, and other important architectural and structural features.
- Identify and document the various materials used in the rammed earth construction and in particular, rammed earth walls which may have effect in the homogeneity and its characteristics.
- Identify and document the indigenous construction methods applied in traditional Bhutanese buildings, techniques worth to be protected and inherited.
- The systems and techniques applied for connecting rammed earth walls with timber elements - roof truss, floor joists, beams, window frames etc. aiming towards structural reinforcement, should be identified and collected, seeking a clue about their regional and chronological characteristics.
- Identify all the reinforcement and other seismic resilient features of rammed earth structures to define Bhutanese indigenous construction techniques.
- Identify and document the patterns and causes of damages of rammed earth structures for understanding the characteristics of the structure in line with the architectural design.
- Identify and document the social aspects and practices associated with construction of rammed earth buildings.

Documentation Standards to be followed:

**Drawings** (to be prepared finally in Autocad)
- Plan, section and elevation: 1:100
- Window and door details, important architectural features: 1:20
- Damage assessment drawing: 1:50

**Digital Photo documentation**
- A systematic high-res photo documentation of the natural setting, the settlement, individual building, external and internal facades and features, details, structural details, details of damages, other.

4. Key staff and qualifications

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the Key Staff</th>
<th>Position</th>
<th>Professional Experience</th>
<th>Specific Expertise</th>
<th>Estimated input (in man days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Architect</td>
<td>Head of Project Team</td>
<td>10 years of which 5 years as Team Leader</td>
<td>Documentation and Architectural Survey Experience in Conservation of rammed earth buildings</td>
<td>90</td>
</tr>
<tr>
<td>2.</td>
<td>Engineer</td>
<td>Structural Engineer</td>
<td>5 years</td>
<td>Experience in working on traditional buildings especially rammed earth</td>
<td>90</td>
</tr>
<tr>
<td>3.</td>
<td>Architect</td>
<td>Team member</td>
<td>5 years</td>
<td>Documentation and Architectural Survey</td>
<td>90</td>
</tr>
</tbody>
</table>
- Prior experience in Earthen Architecture Conservation projects
- Back ground in Earthen architectural and structural services
- Proven experience data collection and analysis
- Skilled facilitator and experience in carrying out focus groups, interviews and community consultations
- Ability to work under pressure and handle multiple activities concurrently
- Excellent fluency in spoken and written English is essential
- Immediate availability

The identified key personnel should be responsible and fully participate in the overall planning and implementation of the work. Timely inspection of the work on site will be strictly monitored and if the consultant fails to deploy the identified key personnel, it will result in cancellation of the contract.

5. Inputs from the client
The client will be responsible for providing the following inputs to the consultants:

- **Documentation:**
  Copy of the work carried out by the Division for Conservation of Heritage Sites, Department of Culture for the Damage Assessment of 2009 and 2011 earthquake.

- **Questionnaire sheets (QS):**
  Tool which is to be used for interviewing the craftsmen. The information gathered using this tool will revive the vernacular practices of the rammed earth construction. It will help to better understand the materials, construction practices, strengthening measures, system of construction, social aspect and practices prevailing in the region, etc.

- **Investigation sheet (IS):**
  Tool which guides the researcher on what information is required for the documentation of the structures. It will form the basis for the documentation works which will ultimately lead to furnishing the objectives of this assignment. This tool is prepared in such a manner that technical judgment is necessary and will be a scientific document prepared by technical expertise.

6. Timeline, deliverables and payment
The recruitment of consultants is based on Fixed Budget Selection (FBS). The individual eligible architectural firms will be selected for four different locations. The contract is for a period of 90 days from the date of signing the contract.

<table>
<thead>
<tr>
<th>Sl#</th>
<th>Location</th>
<th>Budget (Nu.)</th>
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<tbody>
<tr>
<td>1</td>
<td>Paro (Menchulo, Shaba and Esuna)</td>
<td>486,000.00</td>
</tr>
<tr>
<td>2</td>
<td>Punakha (Phathari, Kabesa)</td>
<td>488,000.00</td>
</tr>
<tr>
<td>3</td>
<td>Punakha (Tana, Zome)</td>
<td>487,000.00</td>
</tr>
<tr>
<td>4</td>
<td>Wangdue Phodrang (Damchoe and Eutsa, Phobjikha)</td>
<td>493,000.00</td>
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</table>
(Payment): Payment will be made only upon the approval of the submitted report by the client. However, if the output is not as per the requirement of the client, the payment will not be released.

**Timeline:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Submission (starting from the signing of the contract)</th>
<th>Timeline for review / approval by the client</th>
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<tbody>
<tr>
<td>Presentation of Methodology by the Department of Culture</td>
<td>1 week: The appointed consultants will have 1 week for understanding the methodology and clarifying any doubts</td>
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<tr>
<td>Full documentation of two houses as per the requirement of the document</td>
<td>1 week</td>
<td>1 week</td>
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<tr>
<td>Full documentation of four houses, if necessary, with modifications as per the instruction of the Department</td>
<td>Three weeks</td>
<td>1 week</td>
</tr>
<tr>
<td>Full documentation of another four different houses.</td>
<td>Three weeks</td>
<td>1 week</td>
</tr>
<tr>
<td>Submission of the Final Report</td>
<td>Three weeks</td>
<td>1 week</td>
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The Department will review the submitted document after every submission and inform the outcomes of each deliverables. If the submitted documents are not in line with the requirement of the Department, the consultants will have to resubmit the documents after incorporation of the necessary changes.

The documents can be submitted in hard/ soft copies for the interim reports for evaluation as per the convenience of the consultant. However, the final report should be submitted in hard print (1 copy) as well as soft copy as desired by the client.

All information gathered belongs to Division for Conservation of Heritage Sites, Department of Culture.

**7. Reporting**

The consultant will report to the Head of the Division for Conservation of Heritage Sites, Department of Culture, Ministry of Home and Cultural Affairs, Royal Government of Bhutan, and/or designated focal person from the office.

**Annexure:**
1. Investigation sheet
2. Questionnaire
3. Plan, elevation and section documentation sample