PEOPLES' EARTHQUAKE ENGINEERING IN NEPAL

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Summary:

Evidence shows that many Nepalese traditional houses are constructed with considerations given to earthquake engineering and self-reliance while many new 'western style houses' specially in rural areas lack such considerations. And hence, many modern houses are more prone to damage due to earthquake than some of traditional houses. Western earthquake resistant measures are out of reach of most of the Nepalese people particularly in the rural areas. In this paper, the author explores the politics as well as some of the peoples' experiences in earthquake engineering in Nepal and proposes a method of building earthquake resistant houses with local materials for victims of a recent earthquake in Far Western Nepal.

Nepal and her earthquakes²

The Himalayan range (including Nepal) is in active seismic zone that ranges from Java and Burma in the East to Iran and Turkey in the West. The large earthquakes of 20th century in the Indian subcontinent are shown in figure 1:

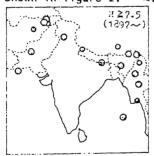


Fig. 1: Major Earthquakes of 20th century.

Table 1: Major 20th century earthquakes and their damage.

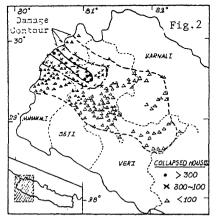
Date	Epi.	Mag.	
	30.0N 31.03	7.5	Far Wester Hepal Not clear about damages
1934	25.5 36.5	8.40	s Death on Myldepail
	27.55 37.09	8.3(=	=M _s) Collap.Hous. 80893(Nepal)
1935 5.27	1 -		Western Nepal(Dhaulagiri) Not clear about damages
	29.6 80.8	6.0(=	=M _b) Far Wester Nepal Death 42, Fallen Hous. 3969
	29.6	6.1(=	77 1/ 1/ 1/ 1/ 1/ 1/ 1/ 1/ 1/ 1/ 1/ 1/ 1/

In Nepal, the historical record of major earthquakes of 20th century is given in table 1 above. 3 It clearly shows that the Far Western Region of Nepal is the most active earthquake zone in Nepal and according to a recent study "it is likely to get another earthquake in a couple of decades." 4

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Nature and extent of damage of 1980 earthquake in Nepal

A strong earthquake of magnitude Mb = 6.1 hit the Far Western Region of Nepal on 29th July 1980. Two and half hours before the main shock, there was a foreshock of Mb = 5.7. It is estimated that 13,258 houses were destroyed with 178 human lives lost and extensive damage to cattle living below the houses. In Fig. 3, the distribution of damages are shown. The severely damaged area lies in a narrow belt between north west Darchula and south east Bajhang.



Intensity of damage of 1980 earthquake of Far West Nepal



Public buildings like schools were hit most

Pic.1



Heavy slate roofed houses received severe damage



Minimum damage to light weight thatch roofed long houses Pic.3

The author made a first hand inspection of the damaged area and had

Pic.2

several discussions with the local victims. It was found 5 that people were more concerned about the damages done to the irrigation canals than any other issues. This is understandable as the canals are the source of water for their agricultural fields that support their life.

Possible reasons for the damage:

- 1. Damages were severe on tall buildings with large openings influenced by western ideas and their perception of this as a status symbol than on the traditional light weight roofed houses of low profile and with smaller openings.
- 2. Slate (stone) roofs are heavy and they symbolize wealth. Hence, they are used by rich people over their houses and by communities over public buildings like schools, local offices etc.. Such heavy roofed houses seemed to have been more severely damaged than the light thatch roofs of the poor.
- 3. It is a practice to use long length (sometimes a full tree as big as 12" diameter and 29'-0" long) of timber for ridge beams which rest freely over the two parallel end walls causing severe casualty with an earthquake.
- 4. The walls were mostly built with stones in mud mortar. Some stones were as small as 1" pieces placed in a haphazard manner without proper bonding making walls unstable with a slight movement. There was no proper fixing of timber joists to the walls.
- 5. Our survey showed that the foundation was often less than a feet in depth and very narrow.
- 6. Many new houses were constructed by local contractors whose only motive appeared to be making a quick profit even at the cost of structural safety. There were no formal approvals required to be fulfilled for erecting a building and hence there was no check and control over the performance of the contractors.

Belief is Power: The Vernacular Earthquake Resistant Community



Moribagad, a village in Bajhang district in Far Western Nepal was one of the villages located in the severely damaged areas. Yet, it was found that there was minimal damage done to this village when all other sorrounding villages suffered heavily (Patal). Although the total reasons for Moribagad's earthquake resistant character may be unknown without a detailed scientific investigation, an on the site brief enquiry showed some interesting facts about people's earthquake engineering. Villagers said that they were saved by their local goddess becuase they followed her rules. They believed that whoever disobeyed the divine sanctions, the local goddess of the

divine sanctions, the local goddess of the village would get very angry and bring misfortune to that family's house.

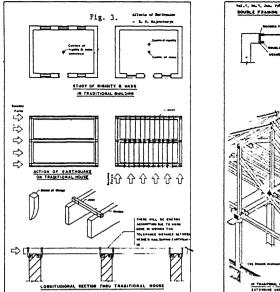
Divine Sanction 1: Villagers believed that no one should build a house with a middle floor. This meant that no houses could exceed more than 2 floors because as soon as one built more than 2 storeys, there would be one or several middle floors. Therefore, all the houses were long and horizontal with a maximum of two storeys the total height upto the springing line of the roof did not exceed 10'-0". Animals were kept at the ground floor with a clear height of less than 5'-0"

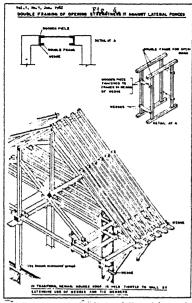
Divine Sancion 2: No house should have slate roofs. (i.e. traditional stone roofs which were very heavy). Hence, all the houses had thatch roofs that were very light.

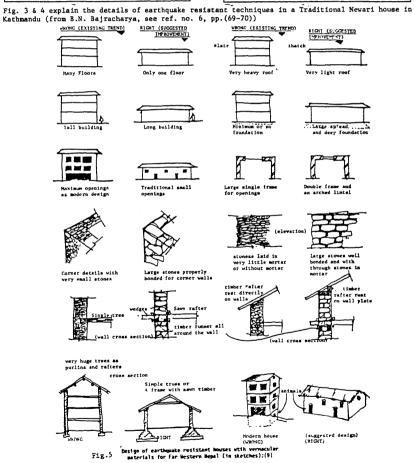
The two sanctions are nothing but two fundamental principles of an earthquake resistant house. This shows that ordinary people, perhaps, knew the method of building earthquake resistant houses and that they used 'divine sanctions' to enforce these rules. These sanctions became the basis of the author's proposal on building earthquake resistant houses. Limited funds, poor accessibility and urgent needs of the that were considered on the proposal emphasized self-reliance. The second inspiration to the design of earthquake resistant shelters with local materials came from a study of the traditional construction techniques of Kathmandu valley Newar architecture.

Earthquake Resistant Techniques of Traditional Kathmandu Architecture:

The Newar Architecture of the Kathmandu valley is an interesting case of attempts by people to construct earthquake resistant houses. The typical house is 3 to 4 storey high in load bearing adobe construction with a facade of burnt bricks to protect it against rain. It has a simple squarish or reactangular plan. The house depth is about 6 metre with average floor to ceiling height of 2 metre and the length verying from 3 metre to 10 metre. The houses are built around courtyards. Today, courtyard once owned by one family is shared by many as the extended family broke down. The ground floor is used for animals and storage; the first floor is storage for valuables like utensils and cupboards; the second floor is for sleeping and living while the top floor is for cooking, dining and prayer. The thick walls (more than 2'-0" in ground floor) are constructed in mud bricks while the floor and the roof are supported by closely spaced timber joists over which wooden boards recieve a thick layer of mud topping. The roof is almost largely double pitched and has brick tile covering. Some of its interesting features regarding earthquake engineering aspects are discussed below:







- a) **Symmetry:** In many traditional houses, perfect symmetry has been achieved in terms of mass and rigidity by distributing the masses and stiffened walls evenly over the ground area so that the centre of mass and centre of rigidity of the building is nearly
- b) **Openings:** All openings are minimal and at least 3'-0" from wall corner so as not to weaken the structure. Doors and windows have two complete frames tied to each other, one outside and another inside unlike a mere lintel of modern buildings.
- c) Earthquake Resistant Wall⁷: The central wall has been built normally thicker than the two external walls. This is to ensure that the c.g. of the building is always towards the centre and thus increasing the stability of the structure.
- d) Ring Beams: The whole building has been designed as monolithic by timber beams running across the walls at each floor. This helps equally to transmit load uniformally on the walls thereby increasing the stability of the structure. This is further strengthened for community buildings like temples where the horizontal timbers are fastened to the vertical timber posts to act as a frame structure. The sloping roof that tends to slide off during an earthquake is held tightly to the wall by extensive use of wedges, tie and struts.
- e) **Wedges:** The traditional Newar houses are secured by timber joists to the wall by wedges inserted on both ends of the wall making a pin joint with a gap between the wedge and the wall so that load transfer from the wall to another wall will not be completed until the floor joist moves through this tolerance factor (gap) during the earthquake. "This mechanism of wedges serve a dual purpose of providing structural integrity between floor joists and wall and at the same time absorbing some portion of earthquake energy thus reducing the earthquake effect on the building."

Politics of 'Earthquake Aid':

- 1. After the earthquake in Far Western Nepal, one of the first relief teams was the Red Cross who along with others distributed food, tents, plastic sheets, blankets, cloth, etc.. New ERA, a private non-profit organization (to which author belonged) was commissioned to make a survey and to propose methods of rehabilitation of the victims. From the survey, it was found that the relief measures were not distributed to the needy. Local powerful groups including the politicians and their relatives and friends seemed to have benefitted largely out of such measures. Few people even made fortune by selling the blankets brought in as relief measures for the victims to some Indian shops bordering Nepal. According to the villagers, they never even had chance to smell the blankets. Such incidents seem to be usual in areas where they lack democratic institutions.
- 2. Villagers stated that the author's team was the 9th team that had so far visited the site for various reasons of help but had delivered nothing substantial so far. Most of the team left the site with

promises of help and therefore villagers were not scared to improve their own houses for fear that they might be disadvantaged if help arrived. It was also discovered that people were getting restless with only surveys. Even the King of Nepal had visited the site on the helicopter for several hours, perhaps, to make a reconnaissance survey of the damage. In all, it took about 18 months before a project got started in the field.

3. Project delays as Government hesitates:

After consultations with the target group, the local politicians and decision-makers, it was recommended that several small self-help projects be started to meet the urgent needs of the people. This included, among others, a project for a quick dissemination of information on earthquake resistant building techniques with local materials through "Poster Programme" and "Training and demonstration programme for local building technicians". Some were developmental projects like construction of canals, schools, trails etc. leading to quick comunual benefits, while one was a project on self-help housing with food for work programme. The Netherlands Gevernment through its office in Kathmandu agreed immediately to launch some of these programmes under direct emergency help. The funds were made available immediately but it still took about one year for the Nepalese Government to launch the programme.

Delay 1: The Nepalese Government hesitated to allow the local Nepalese non-governmental organization (such as the author's) to implement the programme. Official bureaucracy postponed the final decision as to who should implement the project.

Delay 2: It was finally decided that the Department of Housing of the Government of Nepal would implement the project. The Department sent their own manpower for another survey that took some time before a new proposal was made. This new proposal concentrated on building one small community in one of the highly damaged districts. This proposal was, however, rejected by the co-ordinating team as it was politically not feasible. There were dangers that other districts would be disadvantaged from this proposal. The Department of Housing refused to negotiate and the project was then handed over to the Panchayat Training Centre. They implemented the projects largely on the basis of the author's proposal after a gap of more than one year. A recent communique from the site was that the work was extremely slow as if the whole intention of the project was just to kill time and to spend the money.

Delay 3: The time for the fresh election was drawing near and the project was assuming a critical role in getting votes. Hence, there were attempts to put personal interests before the project objectives. It was said that one local headmaster recently elected to the National Parliament won the seat on the basis of his promises for the earthquake victims that were not fulfilled. In the midst of the personal gain, the

interest of the people suffered.

Delay 4: Several top level officials were not happy at the author's emphasis on small projects in the proposal and hence, perhaps, looked down upon in terms of their priority. They believed that big and expensive proposals were the answer to the problem.

Conclusions:

On the basis of this study, it can be concluded that traditional construction and technology have lots to offer to help to solve the problems of low cost housing in earthquake prone region. informations (which tend to be ignored) can be a base for expanding our knowledge on this subject. The author is of the opinion that it would be unwise for rural communities (like the one in Nepal) to completely abandon their tradtitional ways of doing things just because there is a modern western technology that is both energy intensive and costly and that tend to make the communities dependent. For poorer communities who will continue to use local materials for a long time in future, there should be attempts to solve their problems with their own available local materials and local expertise as far as possible so that they become more self-reliant. Many politicians rejoice when there is an earthquake as they get greater opportunities for votes through their political propoganda. It may, therefore, be suggested that the projects for earthquake victims be implemented by voluntary organisations without political control.

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