Seismic Protection of Non-Engineered Building in North East India

Th. Kiranbala Devi, S. Elizabeth

Abstract*— Northeast India is regarded as one of the most seismically six active regions worldwide. Moreover, rapid urbanization in the region have provided a higher level of man-made constructions deviating from the typical traditional houses to multistoried structures but most of these structures are non engineered construction. Even though engineered, more emphasis is given to architectural concept than the structural design, which is indeed very important. So the implementation of earthquake resistant building design and construction code at the local level has been more of an exception than the rule, thereby implicating increased vulnerability to earthquake disasters. That's why there is a need for the construction of a simple construction practices for use by the community. This paper deals with the different types of non engineering building construction that are practiced in Northeast India and the ways for strengthening these building to make them a low cost earthquake resistant building.

***Keywords*: Community, Construction code, Disaster resistant, Non- engineered building, Strengthening technique.**

I. INTRODUCTION

Northeastern Region of India is prone to natural disasters like Earthquake. The region has experienced 18 large earthquakes (M>7) during the last hundred years including the great earthquakes of Shillong (1897, M=8.7) and Assam-Tibet border (1950, M=8.7) (Tiwari 2002). At the latest, Sikkim earthquake of 18th September, 2011 (M=6.9) caused severe destruction of properties and loss of lives. Besides, several hundred small and micro earthquakes have also been recorded. The past earthquake has revealed that buildings constructed by materials like stone, bricks etc which were not particularly engineered to be earthquake resistant has cause many loss of life. It could have been minimized if the buildings were designed by the qualified architects and engineers. But most of the people in this region do not want to do so because they have a thinking that consulting and designing their buildings with the engineers is a waste of time and money. So they prefer to build their buildings with their own ideas or by just hiring the contractor. But any type of buildings in a seismically active region needs special attention because different buildings suffer different degrees of damage during earthquakes. Fig.1 shows the damage scenario of different non engineered houses due to Earthquake. So the safety of the non-engineered buildings is the highest concern in an earthquake because it is not the earthquake themselves that kill people but the collapse of man-made structures.

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(a) The European Quarters in 1897 Shillong earthquake

(b) Severely damaged stone masonry low-cost school buildings in 2006 Sikkim Earthquake

Fig.1 Damages of Non-Engineered Houses

II. NON-ENGINEERED CONSTRUCTION IN NORTHEAST INDIA

In Northeast India, people living in the lower economic group are unable to build engineered houses. The traditional houses like those of wood, bamboo and earth with straw reinforced are the most common type of houses practicing in rural areas. For the roofing, corrugated iron sheets and thatch are the most common. Also the houses are built by people themselves through self-help. In urban areas, with the rapid growth of urban population, masonry and reinforced concrete has become a material of choice for residential construction. Unfortunately, there is no level of knowledge in design in many cases.

A. Types Of Non-Engineered Houses

1. Earthen houses

The earliest type of houses that were used to build was the earthen houses. One of the earthen houses that are practiced in Manipur is "Meitei Yumjao". It is built with bamboo of different size using locally developed technique as bamboos were easily and abundantly available. Now all the bamboo

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pillars have been replaced by wooden ones (Bahadur, 1994). And in Assam, the Ikra type of house is practiced where the walls are of timber frame work, inside those panels Ikra used to fill, and then it is plastered in both sides with mud mortar. Currently, these types of constructions are being built mostly in rural areas; in urban areas they are not used anymore.

2. Bamboo in Construction

Bamboo used in the construction of houses is either in the form of full culms or splits. In a bamboo housing system, the bamboo posts acts as compression members which are simply inserted into the ground and are tied with horizontal bamboo girders with the help of cane to give a proper shape. The Chin-Kuki groups commonly build houses in the pile-dwelling style. The Naga groups build houses having roofs made of bamboo splits and arranged in alternative turns (Bahadur, 1994). Bamboo mat are also made and nailed to either sides of timber frame to make a wall. Sometimes these walls are plastered with cowdung and mud. Nowadays, these types of houses with matt walls are more common in lower income family especially for temporary purpose.

3. Timber

A relatively smaller group of populations in urban areas uses the house forms having walls constructed with timberwith maximum up to two storey height. But the people inhabiting the hilly regions cut wood from the hills to make their houses.

4. Masonry construction

Masonry buildings of brick and stone are superior with respect to durability, fire resistance, heat resistance and formative effects. Many temples and royal palaces were constructed with bricks. Apart from palaces and temples, there were also constructions of masonry building among common people. It became a common practice in those days. Those types of masonry building that were constructed by common people were only one to two storeys with box type. Some uses thick masonry wall. They stood well even today. Nowadays, lower income group who cannot afford to use rebars in their houses, build masonry building with one to two storey height.

5. Non-Engineered R.C.C. building

RC frame building with infill bricks are common nowadays in urban areas. This type of construction started in Manipur around 1960 not so long ago. Multistorey of this type of construction started in 1970. Now almost all the buildings in Imphal are constructed with RC frame. The structural design of the buildings are not as per the IS codes. Normally 250 x 300 mm columns are used for constructing these multi-storeyed buildings, where as per the IS code the side of a column should be 300mm minimum. Building of extremely poor construction with all defect such as floating wall on gradually extended floor, poor mortar and brick work, feeble load bearing column, irregular geometry in both plan and elevation are plenty in the whole of town areas.

(a) Earthen house

(b) Bamboo house

(c) Timber house

(d) Masonry construction

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(e) RC frame building

Fig. 2 Non Engineered construction

III. LIMITATIONS AND RECOMMENDATIONS ON DISASTER RESISTANCE

Thousands of human lives had been loss in different parts of region in high intensity earthquake. Such losses could have been minimized if the houses were better engineered. Yet it is hard to carry out. Despite in the earthquake prone zone, there is little awareness about the safety measures particularly in the construction of modern houses and buildings including schools. The government agencies neither have time to issue proper guidelines nor inspection of already constructed buildings. The best schools or most beautiful buildings are not safe as per earthquake guidelines. A newly built Government school building in Imphal city was found cracked in its wall and beam in the recent Nepal earthquake of 24th April 2015 ((7.8 M_w), which was felt in the city. Lack of financial resources is one of the common problem faces by the common people for additional inputs to build an earthquake resistance building.

In the absence of a precise prediction on the occurrence of an earthquake, peoples are reluctant to expend extra expenses to built earthquake resistance structure following building code. Such considerations force people in this region to practice non engineered construction which are not safe for unpredictable future earthquake. Thus it becomes necessary to identify the structural deficiencies of the existing non-engineered houses with respect to earthquake resisting housing technique and to formulate strengthening techniques of existing rural houses to make them earthquake resistant.

IV. STRENGTHENING AND NEW TECHNIQUES

Better technologies are needed to reduce the vulnerability to earthquakes of the housing of low-income groups, but forcing the people to use such technologies would be a big burden. So it is necessary to create new techniques to improve the performance of the non engineered houses in earthquake.

A. Earthen House

The ways the earthen houses are built are to some extent earthquake resistance because it uses bamboo, one of the earthquake resistant building materials. The roofing systems are also light in weight. Since it is lightweight, there is no danger of affecting the existing structure or disturbing the surroundings in any way. However, such houses require frequent repairs as earthen wall are damage due to heavy rain and thatched are required to be replaced due to decay and is vulnerable to fire. For the improvement of earthen house one can use cement plastered on bamboo mat walls. Proper foundation should be provided and the foundation is preferably being constructed using brick with cement mortar.

(a)Cement plastering

(b) A model of the modified earthen building in Mizoram

Fig. 3 Modification of earthen building

B. Bamboo House

In bamboo houses, the bamboo itself is an earthquake resistant building material. However, there is no protection of bamboo/wooden posts against any natural cause like settlement or decaying or termites. And one of the most critical is the area of connection design. So before building such types of houses, one should consider all these into account. New techniques adopted by Mitch i.e. the grouted bar connection is a simple technique for column base foundation. This connection consists of a reinforcing bar embedded in a concrete foundation and then grouted into the bamboo column.

(a) grouted bar column base foundation

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(b) a school in Darjeeling using grouted bar column base foundation

Fig. 4 A bamboo house

C. MASONRY HOUSE

The masonry, being weak in tension as well shear, when shaken horizontally during an earthquake, cracks very easily in various ways such as vertical bending cracks near vertical edges, horizontal bending cracks below roof and floor and above plinth.For this reason, it is reinforced, and one of the more popular reinforcing bars (rebar) is steel. But unfortunately not all part of the world is affordable. Scientists and engineers are constantly seeking for new materials for structural systems; the idea of using bamboo as possible reinforcement has gained popularity. Various experiments shows that, the modulus of rupture of bamboo is approximately one third of high strength steel and the bond strength of bamboo in mortar is well enough to use it as a reinforcing material in masonry, especially in Northeast India. Because the masonry houses built are generally one storied and the bamboo can easily be used as a reinforcing member for them. Use of bamboo will make the construction cost within the limit of rural people. The strengthening technique of existing masonry house is shown in Figure 4.3.

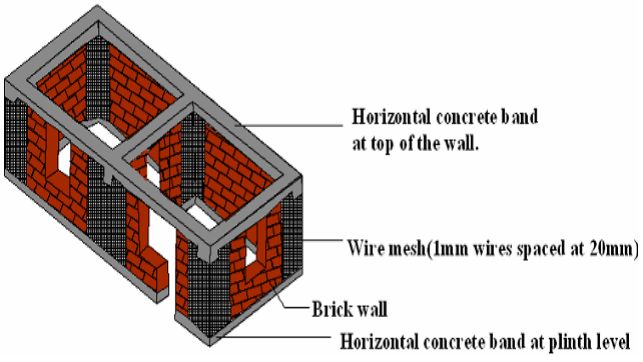

Fig. 5 Strengthening Techniques of Masonry House

D. NON-ENGINEERED R.C.C. BUILDING

Earthquake resistance in RC frame structures can be enhanced by either of the following approaches:

• Strengthening the components, such as columns and beams, by jacketing with concrete, steel, or fiber wrap overlays

• Increasing the overall capacity of the structural system by installing new concrete infill walls or steel bracings.

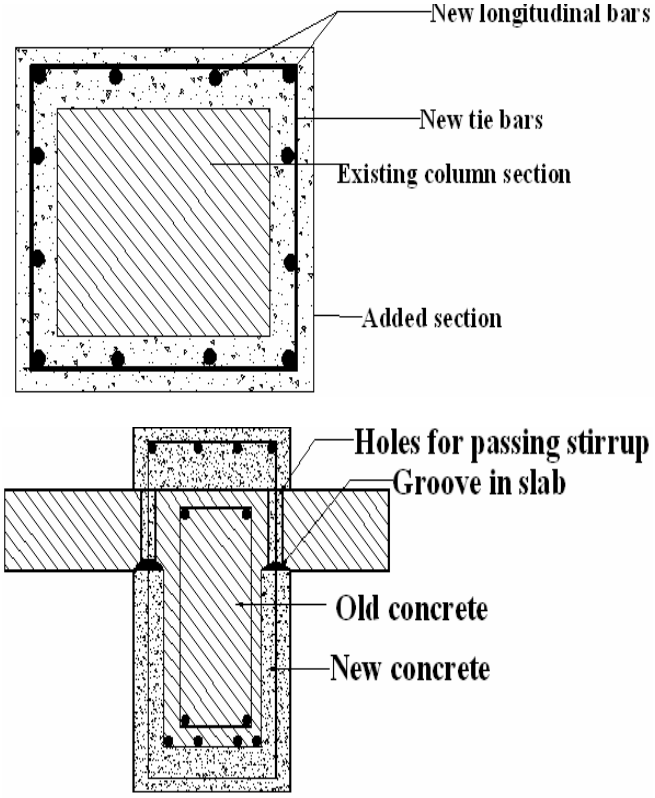

Fig. 6 Strengthening Techniques for Existing Non-Engineered RCC Buildings

An alternative procedure which has been recently developed for RC frames with unreinforced masonry infill walls proposes the use of carbon-fiber, reinforced polymers (CFRP) applied on existing unreinforced masonry infill walls to increase the overall lateral load capacity[10]. Although its cost is higher, this method is easy to apply and much faster when compared to the installation of new concrete infill walls

V. CONCLUSIONS

Northeast India is at particular risk with regard to seismicity. It is exposed to high seismic hazard and relatively poor people. Therefore, we have to learn to live with the earthquake hazard and try to minimize its impact on human civilization (Tiwari, 2000). The safety of the non-engineered buildings is the highest concern in an earthquake because it is not the earthquake themselves that kill people but the collapse of man-made structures. Thus it is necessary to implement earthquake resistance features in this type of building. Better technologies are needed to reduce the vulnerability to earthquakes of the housing of low-income groups, but forcing the people to use such technologies would be a big burden for the region like Northeast. So apart from adopting a set of standards, Engineers should find out the affordable and suitable solution and have to allow a higher level of risk and have to set priorities.

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