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CONSTRUCTION OF SMALL BUILDINGS IN HIGH SEISMIC AREAS OF INDIA

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SUMMARY

Unengineered construction has experienced considerable damage in earthquakes in India. These are traditional construction in which the maximum population of the country lives. This paper deals with the construction practice for small buildings in seismic areas of the country and urgency for improving the earthquake reistance of these construction.

1. INTRODUCTION

More than fifty five percent of the area in the country lies within the seismic zone and areas of Assam, some portions of North Bihar, Kashmir and Gujrat area are highly seismic. Some of the most destructive earthquakes have occurred in these areas. Unengineered construction like mud houses, stone rubble masonry and brick homes have experienced maximum damages in these devastating earthquakes. These are traditional construction in which maximum population of the country lives. Earthquake is not only the factor which effects the construction of the dwellings in these areas but other factors like climatic conditions, availability of building materials with natural resources and the economic condition of the people plays an important role. These type of construction suffer damage as they have very little or no tensile strength, poor bonding between walls and bad workmanship. Still these dwellings are being built in the most conventional way due to the knowledge of local construction in the rural areas. In the Urban areas brick homes of one or two storeys, rubble stone construction and a typical Assam type construction in which bamboos are used are built. It is very difficult to rule out the construction of these types of homes in seismic areas of India but some suitable means must be found out to strengthen these homes, so that their strength is adequately increased to withstand the earthquake shock. A study of the construction practices of small dwellings in seismic areas have been presented and their performance in earthquakes and strengthening measures have been discussed.

2. SEISMIC AREAS OF INDIA

The seismic zoning map of the country is shown in Fig. 1. In the preparation of this map greater recognition has been given to features of the various parts of the country. But as considerable data on earthquake occurrances and their associated tectonic features is not available and large maps showing orogenic structural stratigraphic belts have not been prepared for many parts of the country, only tentative modifications have been adopted in the different seismic zones. The whole country has been devided in to five zones like zone I, II, III, IV and V with zone V indicating the area of high seismicity. The modified Mercally Intensity associated with the various zones are V or less, VI, VII, VIII and IX and above for zones I, II, III, IV and V respectively. These limits of intensity have been recommended for the purpose of design but these limits are not necessarily be always the highest intensity that could occur any where within the given zone. As an earthquake is unpredicatable, it is possible in some cases that much higher intensity may be felt at any particular spot. The probabilities are that a structure designed on the assumption that intensity indicated for each zone is about the maximum that is likely to occur, would atleast in sure a reason able amount of safety from collapse. The code provision is for the structures which are designed and for engineered construction but most of the construction discussed here in are low cost and unengineered and no regard has been given to the use of code in most cases.

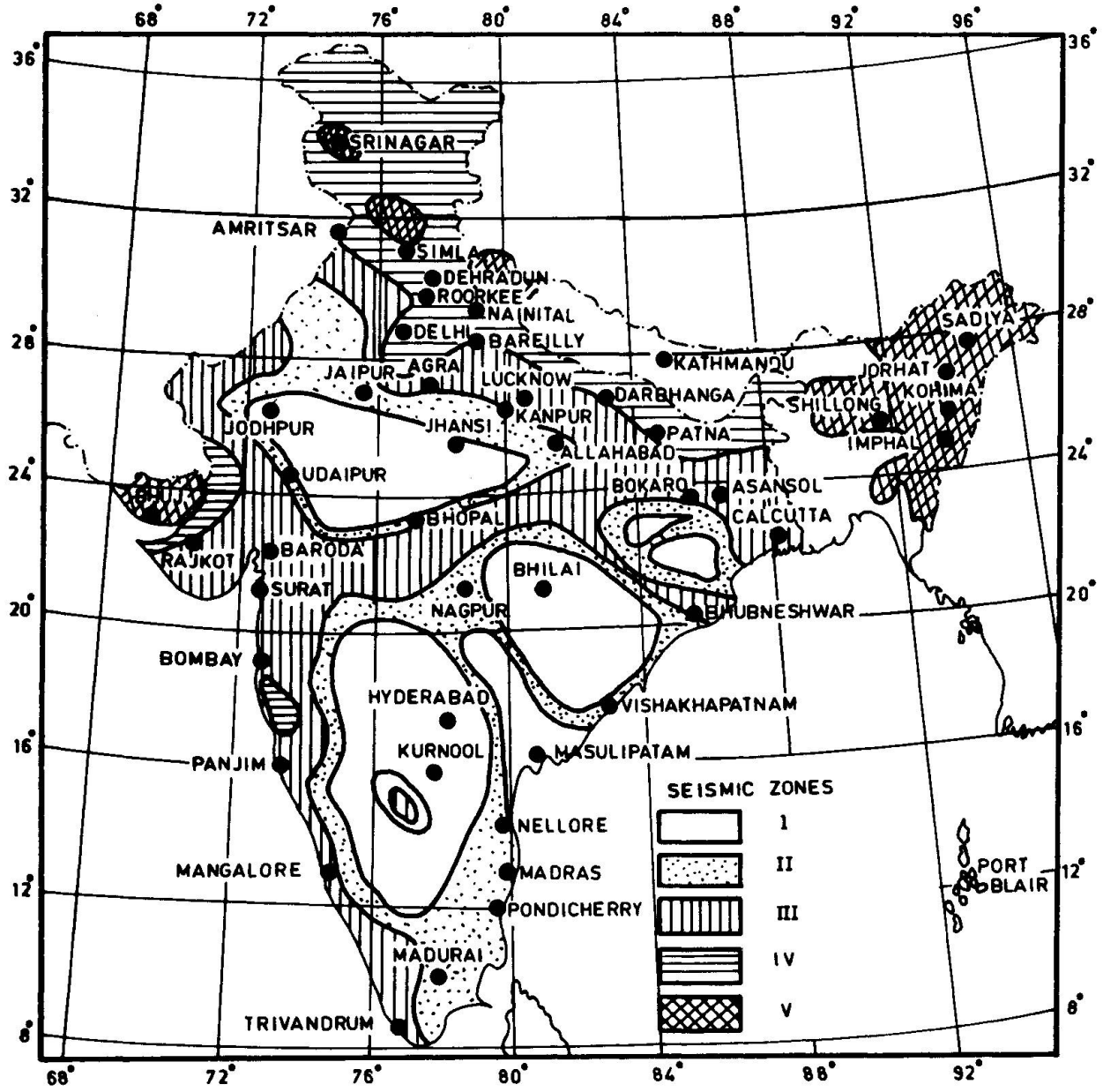

FIG.1_SEISMIC ZONING MAP OF INDIA

3. CONSTRUCTION PRACTICES OF SMALL DWELLINGS

3.1 The Village Hut or Mud House

Traditional construction for dewllings takes the form of a village hut, as Indian villagers have been living in this from centuries and this form of construction is still prevalent today. These huts are usually made of mud walls with suitable coverings as roof. These are unengineered construction in which no proper foundation is made and the plinth itself is raised from ground level to about 30-35 cm in mud in the form of a raft or block. All walls are made of mud with suitable openings left for doors and windows. These mud walls are thick at the base level and as the height of the wall progresses its thickness is reduced and in most cases the wall is of same thickness all long. The clay mud for making these homes is generally mixed with local species of straw usually either the paddy or wheat husk and pounded well with clay to make a paste. The paste is allowed to be soaked in water for few days before the actual construction starts. After the plinth is raised rough blocks of clay are made by hand, and when still moistare laid one over the other arbitrarily with no set pattern. The whole height of the wall is acheived in a few days with intermediate drying of the wall in Sun. The walls made of clay have rough surfaces on both faces and in order to make them smooth, they are smeared with same mud plaster and sometime cowdung is alsoused for this purpose. Mudhomes always have pitched roof with timber and bamboos serving as ridge and purlins and thatched covering is provided for the roofing. Some areas will have claytiles put on as roofing. The walls of these homes are badly eroded by weathering action and rain and its life is short. In some areas of the country the walls as well as roofing both are made of thatch and they are highly prone to fire too. In order to reduce the fire hazard of thatched homes, the walls are smeared with mud plaster on both sides. These village huts have practically no lateral resistance and get badly damaged during moderate or low intensity earthquakes.

3.2 Semi-Permanent Houses

Another type of construction which is quite prevalent in villages are semi-permanent type. In this different categories of houses could be found depending upon the economic well being of villagers and these homes are definitely better than mud homes. These are constructed of unburnt bricks or adobe in mud mortar on poor foundation. Another type is of poor quality burnt bricks which has extremely low compressive and tensile strength set in mud mortar and some what good quality bricks set in mudmortar or in very rare cases cement mortar. The walls of these homes are generally 1½ to 2 bricks thick, and have very low heat transfer capacity. In most cases these homes too have either thatched roof or clay tiled coverings. For building these homes in villages where the majority of the country resides, have no guide lines and all these are built in an unengineered manner without due regard to lateral stiffness and strength as these are constructed along the accepted traditional practice. In the north-eastern part of the country majority of private dwellings are of this type.

3.3 Assam Type Huts

Assam in the eastern part of the country is known as the home of earthquakes lies in a highly seismic zone and is the most unstable region in the country. It has suffered several catastrophic earthquakes during last century such as earthquakes of 1897, 1930, 1943, 1947 and 1950. Experiences of earthquakes have taught the people to build a lighter home. The construction of homes in this area is generally light weight with use of local building materials. Tatch (obtained from ul00-grass), bamboo, ekra (a reed), timber grows profusely throughout Assam and has been used widely at a good advantage by the people. The most common type of homes for low income group in Assam is popularly known as "Assam type" building. It generally consists of sloping roofs with a ridge longitudinally at the centre and covered with thatch, tile or C.G.I. Sheets. The walls are made of bamboo or timber framing with ekra matting and mud plastering. The broad classification is as follows:

3.4 Kutcha Temporary Homes

This construction is prevalent in villages. The building materials used are thatched roofing, bamboos for posts walls and roofing frame, ekra matting for walls, cane tying and mud for plastering the walls. The bamboo posts are driven about 60 cm in the ground, plinth is raised to 30 to 60 cm of mud raft. The height of the house above the plinth level is generally 2.25 m to 2.75 m. The walls are provided with either ekra or bamboo mats and plastered with mud on both sides generally 1 cm thick. The doors are single leaf made of bamboo-chatai with bamboo frame. It will have a sloping roof provided with bamboo frame covered with 15 cm thick thatch.. Where the timber is easily available the bamboo is replaced by timber and roofing will have trusses and height of the dwelling will increase by 30 to 45 cm than bamboo homes.

3.5 Wooden frame and ekra Construction

This type of construction costs more than bamboo homes. Walls of these homes have the frame work of timber battens with panels generally 1 to 1.5 square meter in area. The battens are of Sal, Hollock or Koroi with sizes 7.5 x 7.5 cm or 7.5 x 10 cm. An ekra or split bamboo matting is provided centrally in the timber frame work. The wall is then plastered on both sides by either mud, lime or cement. The thick-ness of walls being barely 5 cm. For supporting the superstructure wooden piles of 25 to 75 cm diameter driven a few meters into the ground are used. These houses are also supported on short piers of stone, or brick masonry, such that the superstructure is free to move as a whole and it is this characteristics which helps it in good behaviour during earthquakes.

Where stone Masonry is available, it is frequently used with conventional foundation and galvanised iron sheet sloping roof covering. This construction if done well has shown good behaviour and little damage and poor workmanship in these homes have resulted in total collapses.

Another construction which have not behaved well in the Brahmaputra valley is a combination of brick masonry and ekra in which the

lower 1 to 1.25 m of the walls are of brick masonry and upper portion of plastered ekra or bamboo mat within timber panels. Roofing is invariably G.I. Sheeting. The foundations are of conventional type footing or superstructure resting on short piers.

4. DAMAGES SUFFERED BY SMALL HOUSES IN PAST EARTHQUAKES AND IMPROVEMENTS

Due to very poor lateral resistance all most all mud homes have been destroyed in past earthquakes. It has been found that traditional form of construction of walls is the main cause of damage. It has been suggested that walls of mud homes should be thicker at the base and thin at the top, with inner and outer surfaces having parabolic cross-section. In order to increase the strength of mud walls against weathering effect and also against earthquakes introduction of bamboo jaffri in the centre of the wall is desirable. Semi permanent homes have also suffered widespread damage with severe cracks all along the walls. Inspite of the fact that these homes were damaged, such houses are still being constructed in traditional way in the seismic areas. As the damages of huts due to heavy roofs have been wide spread it is desired that roofs should be light since during large vibrations the inertia of heavy roofs break the walls on which they rest. The necessity of tying ends should be avoided and hip roof construction should be preferred.

5. INDIAN STANDARD CODE PROVISION FOR EARTHQUAKE RESISTANT DESIGN AND CONSTRUCTION

The Indian Standard Code for earthquake resistant design caters the need of engineered construction and is completely silent about the dwellings constructed in small towns and village where the construction follows the traditional way, quite unaware of the modern engineering developments and earthquake risks. Even small brick buildings are not designed to be earthquake resistant. The Indian Standard Code of practice for earthquake resistant construction recommends some measures to improve the earthquake behaviour of structures. Here again it is presumed that these provisions are used in engineered buildings and of masonry, timber or concrete construction. Some of the salient features of the code is that a structure should be as light as possible consistent with structural safety and functional requirements. The roof should be adequately tied with the walls so that in the event of an earthquake they may not become loose and fall off. For pitched roofs C.G.I sheets or asbestos sheets should be used in place of tiles. For masonry homes use of mortar, plinth, lintel and roof band is recommended. Reinforcement should also be provided in the form of vertical bars at doors and windows openings. Timber construction should be generally restricted to two storeys.

6. TASKS AHEAD

Seeing the provisions in the earthquake code it is felt that they will cater the needs of engineered construction only. In a developing country where 40% of the population is below poverty line and more than 70% of the people live in villages in temporary homes or poorly built homes unaware of the modern developments it is necessary that simple and relatively in expensive methods for

strengthening traditional construction be developed which could be easily adopted by village artisans without any extra effort. The local and municipal bodies in the high seismic area of the country must formulate rules and regulations for aseismic construction of small homes so that total collapses of the dwellings could be avoided, and life and properly could be saved.

7. CONCLUSION

During severe earthquakes the traditional construction has sufferred maximum damage in India. Still today construction is done according to traditional practices quite unaware of the needs for earthquake. Most of the codes fulfill the requirements for engineered and good quality construction but there is an urgent need for making unengineered construction such as mud houses, unburnt brick homes, thatched construction, stone rubble etc. safe. Hence code specifications are needed for these type of construction. There is also a need to develop simple and in expensive methods of strengthening traditional building to make it earthquake resistant and the methods developed must be simpler enough to be adopted by village artisans without any extra effort. In practice the code specifications are generally empirical and there is a need for making it scientific.

8. REFERENCES

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