"BEHAVIOUR OF MAN-MADE AND NATURAL SYSTEMS DURING 30 th SEPT 1993 EARTH-QUAKE AT KILLARI, MAHARASHTRA, INDIA".

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ABSTRACT

The survey of earthquake damage was carried out from 3rd November to 9th November 1993 by the authors at and around Killari,Maharashtra, India. Damages to various man-made structures and natural systems are discussed.For a moderate shock of 6.4 magnitude the loss of life and property was very heavy . The reason for this is also analysed. Importance of ductile detailing is explained. The critical nature of role of expert is discussed. In most of the Technical Institutions of India earthquake resistant design is not included in the syllabi of civil engineering courses. The need for introducing it and also educating the masses is stressed.

KEY WORDS

Killari damage survey education of masses ductile lintel band non-engineered construction

INTRODUCTION

The earthquake affected area comes in zone I as per seismic zoning map of India (IS 1893-1984),indicating least possibility of earthquake. The details of earthquake are as follows:
Epicentre 76°35'E 18°03'N
Origin Time 3.56 am IST(30 SEPT 1993) ie 10.26 pm GMT(29 SEPT 1993)
Magnitude 6.4 (Richter scale)
Modified Mercalli Intensity(Maximum) VIII+
The damage survey of the earthquake affected area was carried out. Based on observations and analysis, recommendations are given for construction of new houses.

RESPONSE OF BUILDINGS

Earlier Killari region was not considered as earthquake prone. So in majority of constructions no consideration was given to earthquake resistant design principles. During earthquake vibrations, inertia forces are induced in the structure. For minimising the earthquake damage : i) Mass of structure must be as minimum as possible. ii) All components of building must be tied together by various means, so that whole structure acts as a single unit.

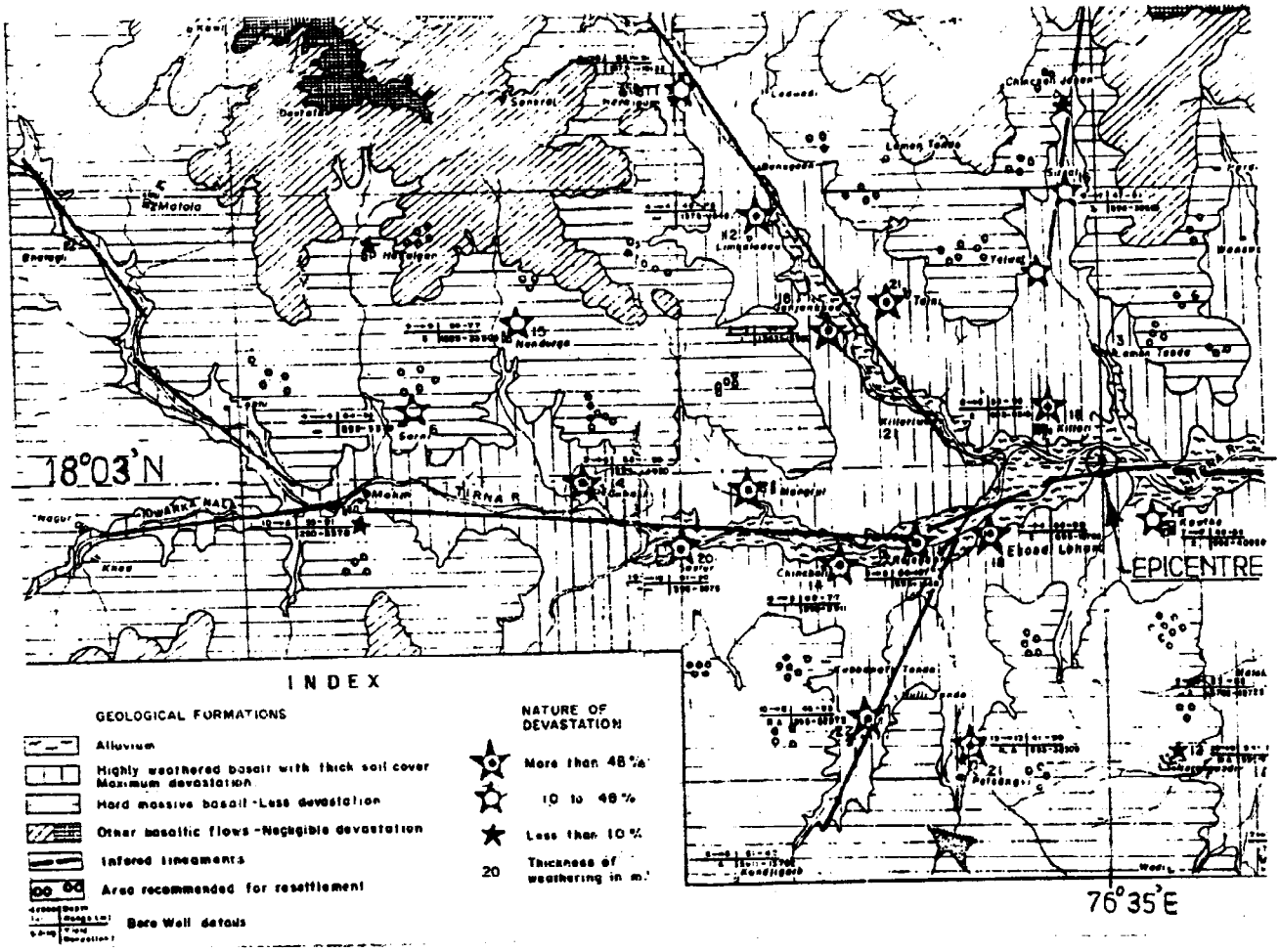


Fig. 1. Epicentre of earthquake
(Source - Central ground water board, central region, Nagpur.)

Besides other additional points, above mentioned points are most important which must be considered while making the structure earthquake resistant. Unfortunately these points were totally neglected in most of the constructions in earthquake affected area. Various types of construction systems are adopted in Killari region. Most common systems are as follows:

1)Timber Flooring System

In this system frame structure of timber is used. It consists of posts and joists of timber. On joists cross beams are laid. On top of this timber planks are provided. For making the structure water proof in the rainy season and cool in summer, thick layer of soil is placed on top of planks. The walls are merely self supporting partitions and load of floor is not transfered to them . These walls were constructed in the mud mortar using all types of randomly placed stones. Generally walls are very thick (Photograph 2). Timber flooring system would have behaved better by addition of bracing members . Even after the disaster, many timber frames were found intact.

Reasons of Failure. Very thick walls generated large inertia forces which led to shattering of walls in most of the cases.(Photograph 1) Thick overburden of soil and impact of heavy walls led to collapse of timber frames at many places.

2 R.C.C.Slab Resting on Thick Masonary Walls

Due to recent increase in cost of timber flooring system people avoided incorporating them and instead used R.C.C. slabs on load bearing masonary walls of same type.(Photograph 2)

Reasons of Failure. Faulty practice of construction of walls led to their shattering, resulting in collapse of slab.

Photograph 1. Timber frame structure.Thick over burden of soil on top. Shattered walls. These were constructed in non-engineered stone masonry with mud mortar.

Photograph 2. Typical cross section of wall. Wall constructed in mud mortar. All sorts of stones,brick bats are used. No through stones.

3 Houses Constructed in Brick Masonsry With Lintel Band.

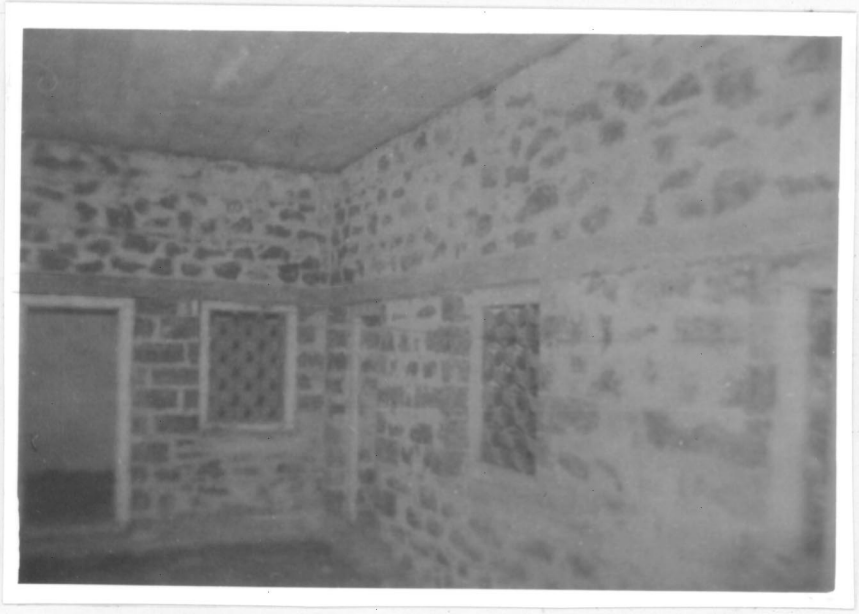
At Killari there was a cluster of 5-6 load bearing brick houses with only R.C.C. lintel bands.These houses suffered no damage,due to tieing effect of lintel band. (Photograph 4)

Photograph 3. Collapse of slab due to failure of walling system.

Photograph 4. Intact house at Killari due to provision of continuous lintel band.

4 Good Quality Stone Masonry

It was observed that good quality stone masonry work such as coursed rubble masonry or uncoursed rubble masonry in cement mortar remained intact.Good quality work means where standard specifications were adopted, regarding size and shape of stone, provision of through stones,method of construction etc. Most of the deaths were reported due to hitting by shattered mud masonry stone walls and burial under them. This led to thinking by pepole that stone masonry is not earthquake resistant and demanding R.C.C. frame structures for their new houses. The various examples from the same area show that stone masonry houses if properly constructed with R.C.C. bands sustain earthquake forces easily. (Photograph 5 & 6)



Photograph 5. Inside view of stone masonry house without any damage due to provision of lintel band. (At Petsangvi 5.5 km from epicentre)

Photograph 6. Two storeyed intact building at Sastur constructed with good quality stone masonry, though no bands were provided.(At 7 km from epicentre)

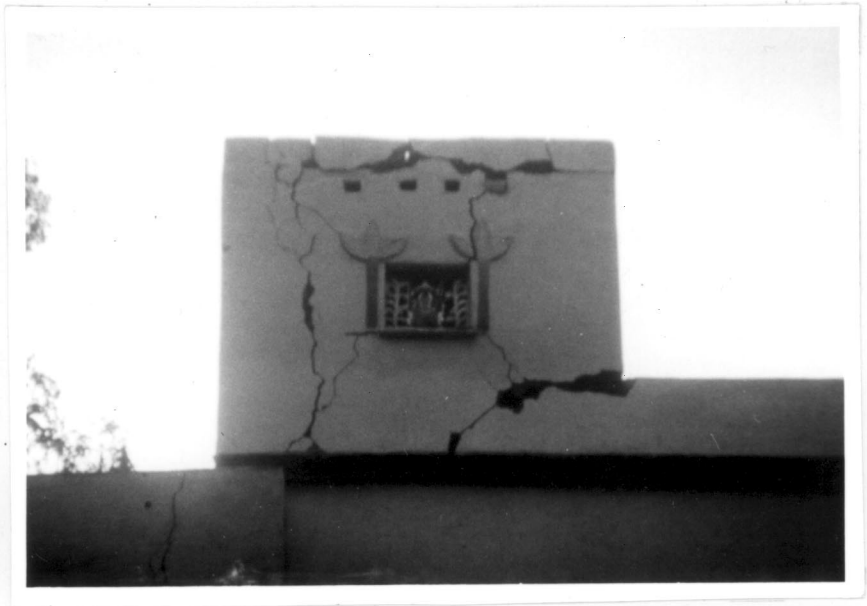
5 Behaviour of Huts

The roofs of these huts and houses were constructed with thatch,G.I. sheets and other light weight materials. The walls were of agrowastes,bamboos and prefabricated cane knitted panels with mud plastering.The maintenance of wall surfaces is done by plastering with cowdung and soil. As the structures were flexible and light weight, negligible damage was observed and nobody was fataly injured.

6 General Damages Observed

Structures having long walls without lintel bands were badly damaged or collapsed. Small structures on top of bigger structures experience more vibrations and hence these must be designed for large forces. It is called as appendage effect.(Photograph 8) Proper detailing is required for such type of structures, otherewise these will be badly damaged.

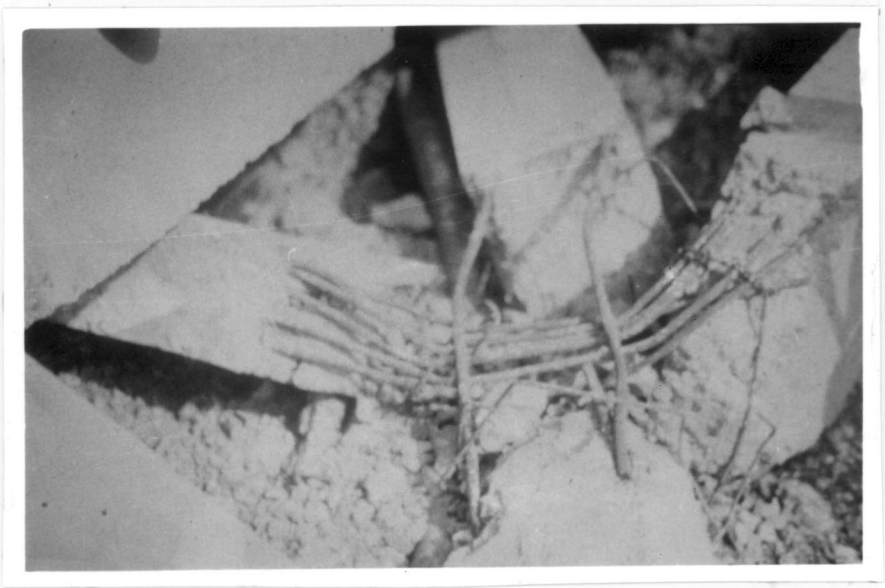
Photograph 7. damage to school building due to long walls without columns & horizontal bands



Photograph 8. damage to staircase tower. Appendage effect

BEHAVIOUR OF OTHER STRUCTURES

Most of the engineered structures though not designed for seismic forces survived the earthquake. Two number of R.C.C. overhead water tanks collapsed during earthquake, one of which was at Kawatha village. Improper detailing of column reinforcement was visible at this site. The second collapse of water tank was observed at Chincholi (Rebe) ,which was supported on masonry staging. (Photograph 10) It is suggested that for new constructions in the affected area, Zone IV must be considerd as per IS 1893-1984. Analysis was done for this water tank considering forces for zone IV. Theoritically this tank was safe but it collapsed.Codes indicate that structures will normally experience more ground motion than the one envisagesd in the specified seismic coefficient . It is assumed that the energy absorbing capacity available in inelastic range of ductile structures will be able to resist such shocks without much damage. As there is no reinforcement in vertical direction, masonry stagging of Chincholi (Rebe) water tank became brittle structure and failed. Suitable provision in codes are required for making the structure ductile or higher forces must be recommended for analysis of brittle structure.



Photogaph 9. Collapsed R.C.C. water tank at Kawatha. Junction of column & bracing. Absence of confining steel in the column & beams. Improper placement of steel in bracing.(3 km from epicentre)

Photograph 10. Collapsed water tank at Chincholi (Rebe) 3 km from epicentre

BEHAVIOUR OF NATURAL SYSTEM

Emission of smoke was noticed from the ground opposite the court building in Nilanga, (23 km away from epicentre) which frightened the people. One of the nearby farm of the village Samdurga (26 km away from epicentre) was found to have developed a fissure of 5 cm width and 40 m length. The depth of the fissure was about 1.5 m. Some of the residents of the villages around epicentre found the animals behaving abnormally before the earthquake.Change in water table was also observed in some of the wells.

ROLE OF EXPERTS & NEED OF EDUCATION

In oct 1992 Killari region experienced an earthquake of magnitude 4.5 on Richter scale. That time some Scientists gave an opinion that there is no future possibility of major earthquake in Killari region. But 1993 earthquake shattered this prophecy and people lost their faith in the opinions of scientists and experts. Earthquake can not be controlled but earthquake resistant houses and structurs can be constructed. It is observed

that the extra cost required for making the structure earthquake resistant is less than 5% of the cost of total structure. There are lot of misconceptions, such as only R.C.C.frame structure will be safe during earthquake and brick, stone masonary structures are unsafe.In this earthquake, properly constructed brick and stone masonry houses were found intact(Photographs 4, 5, 6,). Principles of earthquake resistant design are not included even in Syllabi of civil engineering. It is observed that civil engineers incharge of construction and design work are also less informed about the principles of Earthquake resistant design.The portion on earthquake resistant design must be included in Civil Engineering and Architecture courses."A manual of earthquake resistant non-engineered construction" must be published in the regional languages and copies must be easily available to the the people so that they will be able to construct their houses properly. The intact house shown in Photograph 4 was dismantled by owner as he had no confidance about the strength of structure after the earthquake.This type of incidents can be avoided if there is proper dissemination of knowledge.

CONCLUSION

The killari incident shows that eventhough the area may not be designated by scientists as earthquake prone, still earthquake may occur. And if due care has not been taken while constructing the houses and other structures, there will be heavy loss of property and life. There is a need at national level to frame the code of practice for constructions incorporating earthquake resistant design principles. The civil engineers and people at large must be imparted necessary education. The media such as Radio, Television,Newspapers must spread the message of what should one do before, during & after the eathquake. Preventing the earthquake is beyond us,but at least to construct the earthquake resistant houses is in our hand. The voluntary organisations, hand in hand with Government should establish the earthquake (disaster) mitigation cells at urban and village levels. Necessary equipment, food, clothings, medicine etc. must be stored at these cells. For effective implementation of principles of earthquake resistant construction,these must be included in the byelaws, so that it will become mandatory to use these at the time of construction. If this point is stressed by the International Association for earthquake engineering to all the heads of nations, it will help in speedy implementation and threrby reducing the earthquake damages in future.

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