EVALUATION AND RETROFITTING OF BUILDINGS DAMAGED DUE TO JABALPUR (INDIA) EARTHQUAKE OF MAY 22ND 1997

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SUMMARY

Jabalpur area of central India experienced moderate earthquake of magnitude 6.0 on 22nd May1997. As per seismic zoning map of India maximum probable earthquake in this zone is of magnitude 6.7, which is energy wise almost 8 times more than that of magnitude 6.0. There were 40 deaths reported.The loss of life and property was tremendous from such a mild shock. In the event of maximum probable earthquake quite higher than this earthquake, loss of life and property will be beyond imagination. To avoid this, evaluation of all buildings is essential. After critical evaluation, correct retrofitting methods can be suggested and buildings can be made earthquake resistant. In this paper retrofitting methods for four types of buildings are explained.The importance of ductile detailing is emphasized. Special precautions required for a short column, as well as framed structure with flexible first storey, are explained.

INTRODUCTION

Evaluation of existing buildings and Retrofitting of them is the most important issue for saving the loss of life and property of people residing in earthquake prone area. In this paper four types of buildings are considered, these are as follows :-

1) Rural buildings constructed with mud

2) Load bearing buildings in brick masonry

3) Framed structure

4) R.C.C. Framed structure with flexible first storey.

RURAL BUILDINGS CONSTRUCTED WITH MUD

Extensive failure of mud buildings was observed. This was due to long mud walls without buttresses or any

element, which will resist tension, such as collar beam or horizontal band. Photograph no1 shows a collapsed mud house. Collapse of mud houses in general was due to faulty construction practices such as,
1.High gable walls
2.Absence of tieing elements (Beams /Rafters) at lintel level and below roof level.

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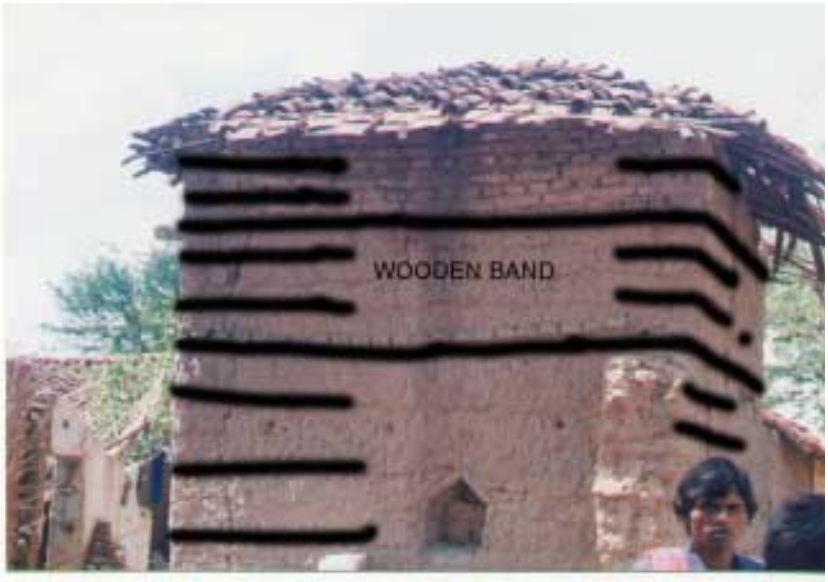
Photograph No.1: -Collapse of gable wall & roof of rural building constructed with mud.



Photograph No.2: -Provision Of Wooden Band For Retrofiting Of Mud House.

There are several mud buildings, which need to be strengthened. Strengthening of corner with the help of wooden member is essential to take tensile forces and for avoiding of separation of joint. This can be done to the existing buildings by providing external wooden band connecting the walls. This will prevent bulging out and collapse. Collar beam at roof level is essential in providing fixity to the rafters, which support the roofing

system. (Photograph no 2 shows provisions of wooden bands.) Similar wooden bands must be provided from inside portion also. Proper preservative treatment must be given to the rafter to prevent its decay. Cracked portion must be filled with properly prepared mud mortar.

LOAD BEARING BUILDINGS IN BRICK MASONRY:

It was observed that the buildings without continuous lintel band suffered badly**.** Separation of walls was observed. Most of the damages are due to the faulty construction practices such as, providing doors and windows near corner without taking proper precaution, providing very large size of opening. Providing foundations to some selected walls only. So, some walls were 100mm thick partition walls, which were unable to provide any resistance during earthquake shaking.

a) ACTUAL CONDITION

b) GREEN COLOUR SHOWS VERTICAL SPLINT AND HORIZONTAL BANDAGE

Photograph No.3: -Retofiting System Sugested For Load Bearing Building.

Cracks at lintel level and sill level

Due to placement of opening near corner and absence of continuous lintel band, several cracks were developed in the building.

Strengthening measures: -

For retrofitting of this types of buildings, provide 6 mm dia vertical bars at the corner. Fix strips of welded wiremesh of size 75x75mm, 2.5mm thick. Provide one layer of chicken mesh. Provide vertical splint and horizontal bandage at lintel level, windowsill level and at top level of parapet. Plaster this surface with rich cement mortar (1:3) or micro concrete. If it is possible, guniting is the best solution.

Cracking of wall at the location of cupboard

A very large size of cupboard reduced the area of load bearing. This resulted in reduction in strength of load bearing wall, so severe cracks were observed in the wall (Photograph no 4)

Strengthening measures:

A very large size of cupboard reduced the strength of load bearing wall. So, this size of cupboard must be reduced by providing new load bearing brickwork or by providing concrete. Proper bond must be achieved between new and old work. Fix welded wire mesh and chicken mesh on cracked portion of wall. Plastering must be done with rich cement mortar on this surface.

Photograph no. 4:- shows cracking of walls due to very large size of cupboard.

FRAMED STRUCTURE:

Columns supporting midlandings becomes short and stiff columns, which attracts large amount of earthquake forces. If these columns are not designed for the earthquake forces then, brittle failure of column is observed. Photograph no 5 shows such brittle failure of column used for supporting the staircase.

Strengthening measures:

Jacketting of column is required from foundation level so that strength of column is increased to required level. The column under repair must be relieved from the load by providing temporary supports to the superstructure. Crushed concrete must be removed. Size of column required will be evaluated on the basis of forces acting on the column after doing modal analysis. Vertical reinforcement and closely placed stirrups will be provided to have confinement effect.

It was observed that the building resting on soft soil deposit and madeup grounds were badly damaged. This was due to local amplification of ground motion.

Photograph no.5:-brittle failure of short column supporting staircase midlanding.

Photograph no.6:-retrofitting of column with the help of structural angles and concrete jacketting

Separation of walls

In case of frame structures, size of brick panel should be small, if larger panel size is used then brickwork must be connected to the frame by providing concrete bands. These bands must be properly anchored to the columns.

In case of very large and tall brick panel dimension, dummy columns must be provided, connecting upper and lower beams. This way unsupported length of panel can be reduced more effectively. Photograph no 7 shows separation of brick panel from frame.

Strengthening measures

For retrofitting of this brick panel. Remove old plaster. Fix the strip of welded wire mesh and chicken mesh on the frame (i.e. on columns and beam) and on brick panel. These wiremeshes must be properly anchored to the frame and brick panel. This treatment must be done on both sides of wall. Plaster the surface with cement mortar (1:4).

Photograph no.7:- seperation of wall panel from main frame

Ductile detailing:

The primary members of structure such as beams and columns are subjected to stress reversal from earthquake loads. The reinforcement provided shall cater to the needs resisting reversal of moments in beams and columns and at their junctions.

Earthquake motion often induces force large enough to cause inelastic deformation in the structure. If the structure is brittle, sudden failure could occur. But if the structure is ductile, it will be able to sustain the earthquake effects better with some deflections (Delta M) larger than the yield deflection (Delta Y) by absorption of energy. Therefore, besides the design for strength of the frame, the ductility is also required as an essential element for safety from sudden collapse during severe shocks. It has been observed during past earthquakes that structures designed and built for low seismic coefficients survived severe earthquakes with little damage because energy absorption in plastic deformation.

It has been proved that if concrete is confined laterally, then for same grade of concrete higher strength will be available. Effect of lateral confinement can be brought into the structure by providing closely spaced stirrups. So in critical portion closely spaced stirrups must be provided. Appropriate development length must be ensured to all the reinforcement so that brittle failure can be prevented.

Photograph no.8:- brittle failure of column of a building with flexible first storey.

Photograph no.9:- severe cracks in column of a building with flexible first storey.

R.C.C FRAMED STRUCTURE WITH FLEXIBLE FIRST STOREY.

Damages to structures were observed mostly due to negligence on the part of designer and/or contractor. For building with flexible first storey (i.e. building on stilts. This type of arrangement is done for solving parking problem.) modal analysis is required. In frame structure with flexible first storey, first storey columns are subjected to large amounts of moments and shear forces. For retrofitting of these buildings detailed analysis of building is required. After analysis strengthening can be done by adopting following measures.

1) Strengthening of column by jacketting.
2) Providing additional columns.
3) Providing shear walls.

Suitable ductility requirements must be satisfied.

CONCLUSIONS

It was observed that in most of the cases of failures of structure, principles of earthquake resistant planning and designing was not adopted. Retrofitting of structures can be done so as to enable sustainance of maximum probable earthquake without collapse. For deciding retrofitting system for a particular building, seismic evaluation of building is essential. Before going for retrofitting, cost comparision between reconstruction and retrofitting must be done. In most of the cases buildings can be strengthened to the required level with only 2 to 10% cost of reconstruction. So strengthening must be done to avoid future loss of life and property. Ductile structure behaves in better manner, so ductile detailing must be done. Various elements of the structure must be positively connected so that they act as one unit during earthquake.

ACKNOLEDGEMENT:

Authors are thankful to Dr A.S.Arya for his valuable guidance. Authors are also thankful to the owners of the structures for giving the permission for taking the photographs.

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