Review Paper on seismic study of vernacular structures

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Abstract - *Over the centuries earthquake turns out to be one of the major fatal calamities which has caused economical as well as human loss. Around the total population of the world approximately 70 % of people are living in the vernacular or traditional housing system. Traditional housing or vernacular structures are made from locally available material and they are easy to make. Over the past earthquake it has been seen that there is tremendous destruction in this type of structure. Understanding this as a major concern various research paper was reviewed which shows the various strengthening provision provided in the vernacular structure. Work has been carried in both ways analytically and experimentally. Software like ANSYS was used for modelling and analysis. Researcher had concluded that various strengthening can be provided in these structures to avoid human and economic loss. Geometric shape parameter was also included which shows circular shape behave much better than any other shape. Model was casted and tested in shake table and damage due to shaking was observed. Thus, this research paper shows the various different research paper reviewed and how they give important contribution to this field.*

Keywords: Vernacular structure, earth rammed structure, seismic study, seismic strengthening, Indian vernacular structure, bhunga

1. INTRODUCTION

Numerous study and research work is going on R.C.C and steel structures. In comparison to them very few research works had performed on the vernacular structure or non-engineered structure. These structures are made from mostly locally available materials and they can be venerable during the earthquake. So, there is a need to study the dynamic behaviour of these types of structure to avoid fatal losses of both property and human kind.

Vernacular structure is those structure which is made from local available material which itself depend upon various types of factors such as temperature, topography etc. As per the definition given by Wikipedia, “Vernacular architecture is an architectural style that is designed based on local needs, availability of construction materials and reflecting local traditions. At least originally, vernacular architecture did not use formally-schooled architects, but relied on the design skills and tradition of local builders”.

Adobe blocks are air dried brick made from a puddled earth mix which contains a mixture of clay, sand and silt casted in a mould also known as mud block. Adobe bricks are a fireproof, durable yet biodegradable, non-toxic building material which provides sufficient thermal mass to buildings to ensure excellent thermal performance. Other benefits include low sound transmission levels through walls and a general feeling of solidity and security. The small Adobe units provide great flexibility in the design and construction of earth buildings. Adobe bricks can be easily cut for fitting and can be provided with holes for reinforcing and services.

Rammed earth is simple to manufacture, non-combustible, thermally massive, strong, and durable. However, structures such as walls can be laborious to construct of rammed earth without machinery, e. g., powered tampers, and they are susceptible to water damage if inadequately protected or maintained. One significant benefit of rammed earth is its high thermal mass: like brick or concrete, it can absorb heat during daytime and nocturnally release it. It is formed in minutes by mechanically compacting properly prepared dirt. The compaction may be done manually with a hammer-like device, mechanically with a lever-operated brick-making press, or pneumatically with an air-driven tamping tool. Dynamic compaction using manual or power tampers not only compresses the soil, but it also vibrates the individual dirt particles, shifting them into the most tightly packed arrangement possible. When finished it is as strong as concrete.

2. LITERATURE REVIEWS

Ricardo Barros, Hugo Rodrigues, Humberto Varum, Anibal Costa, Mariana Correia [1] focused on the characterization of the seismic vulnerability of rammed earth construction. In this paper understanding the influence of construction element in a vernacular seismic culture was done. On the basis of simplified case study, derived from a real building a set of numerical analysis was carried out to assess the influence of geometry, layout and different retrofitting solutions typical of vernacular rammed earth construction on behaviour and seismic performance.

A numerical model of the selected building was developed with finite-element software i.e MIDAS FEA was used performed numerical analysis. A simplified model symmetrical in both direction was modelled. Solid tetrahedron elements with four nodes was considered.

For seismic pushover analysis, lateral acceleration varying from 0.2g to 1g was provided and displacement was noted down. Maximum principal strain and damage pattern was observed. It was concluded that out of plane mechanism was mainly responsible for the high seismic vulnerability of the building under horizontal loading.

This fact was also observed in this study: Existing vernacular constructions suffer substantial damage from earthquakes of mid or high magnitudes in Portugal, especially if the traditional seismic reinforcement elements, such as buttresses or tie-rods, are removed from the constructions. For load factors higher than 0.4 g, the level of damage observed is important, and collapse may occur, especially out-of-plane collapses of walls. The geometry-related factors of the construction have influence on the structural behaviour of the construction, especially when eccentricities are induced. The absence or malfunction of structural elements affects the mechanical behaviour of rammed-earth vernacular buildings when subjected to seismic events.

In the present study, it was observed that the buttresses may not significantly reduce the vulnerability of these buildings, and in fact, for buildings with slender and long walls, the collapse mechanism may be controlled best by an out-of-plane collapse.

B. N. Patowary, N. Nath, I. Hussain, H. J. Kakoti [2] represents result of test of soil that has been used in the production of CSEB is shown. Highly compressed un-burnt blocks have been prepared in the laboratory with different composition and varying proportions of sand, clay and stabilizers such as lime, cement etc. Fly ash is also used as stabilizer in replacement of cement. The strength of different blocks is determined and compared to find the composition which gives highest strength and also to compare between different blocks to get the optimized composition and proportion in terms of economy and strength.

After selecting the material, soil samples have been mixed in different proportions and stabilizers are mixed in different proportions with the mixed quantity of soil samples to find strength of compressed stabilized earth blocks with various composition at different proportions.

The maximum strength obtained was 3.11 N/mm^2 for CSEB 1 i.e. Mix of Sand (70%), Clay (20%) &OPC (10%). The minimum strength obtained was0.63 N/mm^2 (CSEB 2) i.e. the block without stabilizer. But if we see the CSEB 7, with stabilizer and mix with Sand (70%), Clay (20%), Fly ash (5%) & OPC (5%), strength obtained was 0.832 N/mm^2. The standard block which was brought from manufactured factory and which was also burnt and used for construction of building, the strength for that block was found to be 3.21 N/mm^2.

The unburnt bricks are more economical than the standard fired blocks for CSEB. Use of OPC as a stabilizer than PPC gives more strength to CSEB blocks. Introduction of Fly ash as a replacement to lime at constant proportion of sand and clay does not contribute to the increase in strength of CSEB, rather it decreases the strength of CSEB.

Maria Idália Gomes, Mário Lopes , Jorge de Brito[3] represents an assessment of the seismic performance of new earth construction in Portugal. Results of a parametric study on a properly designed rammed earth construction, considering several retrofitting solutions, are presented and discussed. It is concluded that single storey houses can have acceptable seismic performance even in high seismicity areas, provided that the structure is adequately strengthened by reinforced concrete columns and beams.

For parametric study a set of five structures with the same geometry and earth properties are analysed. The first one contains no strengthening part while the rest structures have different reinforcing solution. Strengthening material was selected on the basis of their strength which were stone, timber & reinforced concrete. Total five structures were selected. the walls in structure 1 are made of rammed earth only with stone foundations; structure 2 is the same as 1 with stone elements around the openings; structure 3 is the same as 2 with steel cables; structure 4 is the same as 2 with a RC beam at the top; structure 5 is the same as 4 with RC foundations and columns.

All models were analysed for same actions i.e weight of structure and seismic action. Stresses in the structured model was analysed using 3 D finite element model and linear dynamic analysis by response spectra using SAP2000 software. The dynamic result for structure 1 is shown in Table 2.2. On the basis of seismic analysis various modes were analysed and various stress variation in different cases were studied. On the basis of result obtained it was concluded that damage in earth structure can be reduced if earth material is stabilised with cement or other binder. Out of all the cases most effective strengthening strategy is adding RC beams at top of all walls and adding RC column at all wall intersection. From this design rules on new earth construction were suggested without affecting the traditional architecture features, hardly increasing it own weight.

B. Samali, D.M. Dowling & J. Li [4] showed that Traditional, unreinforced adobe-mudbrick houses are highly susceptible to damage and destruction during seismic events. Research at the University of Technology Sydney has included shake table testing of 10 scale model (1:2) u-shaped adobe wall units to assess the performance of different reinforcement systems and evaluate the response to out-of-plane seismic forces. This paper describes the qualitative and quantitative performance of one unreinforced and two reinforced adobe structures. Results confirm the importance of using appropriately time-scaled input spectra to ensure dynamic similitude and induce damaging near-resonance conditions. The testing and analysis revealed both internally and externally reinforced structures to be effective at impeding initial cracking, as well as delaying major structural damage and ultimate collapse. The system incorporating external vertical reinforcement performed significantly better and has the clear advantage of being simpler tconstruct, as well as being a viable option for the retrofit-strengthening of existing dwellings.

E. Leroy Tolles III and Helmut Krawinkler [5] showed that Wall overturning was the most often observed failure mode. Lighter roof delayed initial damaged but had a smaller effect on the model's resistance to collapse. Both Anchored roof beam and bond beams tied the wall together helped prevent overturning and increased the resistance to collapse. It is concluded that life-threatening collapse of adobe buildings can be delayed considerably by adding simple but well-designed details that tie the walls together at the roof level. However, there is no simple means of preventing extensive damage in adobe buildings during severe earthquakes. The design of these details and the extent to which they improve structural performance can only be assessed through analytical or experimental means that are capable predicting dynamic response to the stage of incipient collapse.

3. CONCLUSION

The above papers reviewed and research gap was found accordingly. Our study will be based upon Indian vernacular structures.Earth rammed structure (which is common Indian vernacular structure) will be modelled with geometric scale ratio of 1:6. As circular shape will behave much better during earthquake so the model shape will be adopted as circular. Various seismic strengthening will be provided in the model and it will be checked against the earthquake shaking with the help of earthquake shaking table. The outcome will be compared with different models.

4. ACKNOWLEDGEMENT

I pay extreme gratitude to all the people whose research paper were referred. Those research paper were helpful for the selecting the research gap and concluding to the my research work. I am thankful to my guide Prof C.D. Patel, Applied Mechanics Department, L.D. College of Engineering, Ahmedabad without his constant guidance and support I won't have concluded the research work.

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