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Seismic Analysis of Lightweight and Conventional Buildings: A Comparative Study

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Abstract: In recent decades, the use of light-weight materials over heavy-weight materials has increased at a faster rate. When it comes to cost and resource savings, lightweight construction is considered to be more essential. AAC block is a lightweight construction material that provides good acoustic and thermal insulation. In seismic zones, the use of lightweight materials in building reduces the percentage of damages. The goal of this research is to conduct a project comparison study of seismic analysis of buildings composed of lightweight and conventional materials. RSM creates a structural model of a multi-story structure (G+3) and analyses it in Etabs (Response Spectrum Method). Buildings constructed using infill AAC (Autoclaved aerated concrete) blocks and traditional clay brick masonry are designed for the same seismic hazard in conformity with Indian norms. The buildings' analytical results will be compared. The project also aims to familiarise students with Etabs2016.

Keywords: Autoclaved Aerated Concrete, Conventional Brick Replacement, Lightweight Construction, Lightweight Material.

I. INTRODUCTION

A structure meant for human occupation and behaviour is referred to as a building. The structure of a building is made up of structural and non-structural elements (e.g. interior, cladding, roofing, ceiling and partition walls). It is sometimes necessary to reduce the weight of a structure rather than increase its strength, especially in heavy structures such as tall buildings and bridges, where the weight of the structure plays a larger role in its design. Designers are now encountering additional issues related to the high weight of the structure as a result of improved and current architectural requirements. Nowadays, light weight structural systems are also used to withstand lateral loads caused by earthquakes, wind, and other natural disasters. In comparison to traditional materials, the light weight material reduced the structure's self-weight. During the 1920s, a Swedish scientist named John Axel Ericson invented autoclaved aerated concrete. However, the idea required a long time to become financially feasible and widely used in a developing economy like INDIA. AAC blocks, on the other hand, are widely utilised in Europe, the Middle East, Southeast Asia, China, and the United States. AAC block is a lightweight construction material that provides good acoustic and thermal insulation. The primary goal of employing autoclaved aerated concrete blocks in construction is to create a light-weight structure by minimising the dead load of infill walls while also improving structure quality and lowering construction and material costs. Buildings made using AAC blocks are more reliable and safer since the impact of an earthquake is directly proportionate to the weight of the building. AAC blocks are a precast, foam concrete, environmentally friendly building material made from quartz sand, calcined gypsum, lime, portland cement, water, and aluminium powder aggregates. The concrete is autoclaved under heat and pressure after mixing and moulding, giving it its particular qualities. Due to their great strength, load-bearing, and thermal insulating capabilities, AAC bricks are in high demand.

II. EFFECT OF INFILL

The stresses in the infill wall, on the other hand, were shown to increase when the Young's Modulus of elasticity increased due to the system's stiffness, attracting more forces to the infill. The lateral stiffness of the framed constructions is improved by the infill wall; nevertheless, the existence of gaps within the infill wall reduces the lateral stiffness. The basic period rises only slightly as the thickness of the infill wall grows, because the thickness increases.

III. ROLE OF INFILL

Infilling has been shown to increase the system's ultimate lateral resistance while resulting in lower ultimate lateral deflection for lower infilling. For increasing percentages of infilling, the effect on both parameters is more pronounced. The response nonlinearity is caused by two occurrences that occur during the loading stage. The first step is to determine how the reinforced concrete stiffness degrades due to load-induced orthotrophy, taking into account both the imposed dynamic load and the frame's inherent deformational characteristics.

The second step is to determine the progressive strength loss of either of the diagonal struts, which should be done in a certain order depending on the level of loading. Almost all of the dynamic properties of reinforced concrete frames are affected by traditional half-brick wall infilling. The effect of infill on the kinetic and kinematic coefficients linked to lateral excitation is found to be dependent on frame characteristics such as the number of stories and bays, as well as the amount and location of infill. The lower the location, the higher the system's strength, stiffness, and frequency. The nonlinearity of the behaviour is mostly caused by stiffness deterioration, which leads to frequency attenuation during the loading regime.

IV. METHOD OF ANALYSIS OF BUILDING AS PER IS 1893 (PART I): 2002

S Seismic codes are specific to a specific area or country. The basic code that offers an overview for determining seismic design force in India is the Indian standard criteria for Earthquake Resistant Design of Structures IS 1893 (Part I): 2002. This force is determined by the structure's mass and seismic coefficient, which are determined by factors such as the seismic zone in which the structure is located, the structure's importance, its stiffness, the soil on which it sits, and its ductility. The following approach of analysis is recommended by the code:

1) Equivalent static analysis
2) Dynamic Analysis

V. MATERIALS

The autoclaved aerated concrete consists of:

1) Sand, or pulverized fuel ash
2) Lime
3) Cement
4) Water
5) Aluminium
6) powder or gas former

A. *Autoclave Aerated Light Weight Concrete blocks*

Very light weight concrete blocks (550 600 kg/m3), 1/4th weight of normal bricks/blocks.

1) Numerous advantages especially for high rise buildings, -Reduction in dead weight.
2) Saving in steel / concrete (>10% Steel and Concrete Combined)
3) Increase in floor area due to reduction in size of columns.
4) Better Thermal /Sound Insulation.
5) Easy to transport on upper floors.
6) Time saving in construction.
7) Technology obtained from M/s HESS of Netherland who are considered to be the best in the field.
8) Works: Hyderabad and Mumbai.

B. *Advantages of AAC Block as Lightweight Material*

1) Easy workable.
2) Resistant to Pest and moisture.
3) It is durable.
4) Being lightweight it reduces the dead load of the structure, resulting in to reduction in reinforcement and concrete on foundation structure work and hence allows construction of taller buildings.
5) AAC’s lightweight saves on labour cost.
6) Lightweight construction is more economical, easier and faster than conventional.
7) Reduction in waste at site.
8) Minimum deterioration over prolong use.
9) It requires minimum repair and retrofitting work due to resistance to weathering.
10) Broken blocks of AAC are also usable

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C. Disadvantages of AAC Block as Lightweight Material

1) The production cost is very high compare to red burnt bricks.
2) Number of manufacturer is limited. So, cost will drastically in places far from the manufacturer and need to travel a long distance.
3) It is not as strong as conventional material

Properties	Normal clay bricks	AAC Blocks
Size	230x115x75 Mm	600x200x100mm
Variation In Dimensions	+/- 5mm	+/- 1mm
Compressive Strength	25-30kg/Cm^2	30-40kg/Cm^2
Dry Density	1950kg/M^3	550-700kg/M^3
Wet Density	2400 Kg/M^3	800-850kg/M^3 (Approx)
Fire Resistance	2 Hour	4-6 Hour Depending On Thickness
Sound Reduction Index(Db)	50 For 230mm Thick Wall	45 For 200mm Thick Wall
Energy Savings	No savings	32% (approx.)
Thermal conductivity	0.18 (approx.)	0.16-0.17 (approx.)
Mortar	0.01/m^3 with 1.35 bag of cement	0.018/m^3 with 0.5 bag of cement

VI. RESULTS

A. Response Spectrum Analysis

The method involves the calculation of only the maximum values of the displacements and member forces in each mode using smooth design spectra that are the average of several earthquake motions. Response spectrum analyses allow the users to analyze the structure for seismic loading.

1) *Storey Displacement:* The storey displacement for (G+3) has been evaluated for conventional and lightweight structure. The storey displacement has been shown in Figure below. The below graph show that displacement are varies with increase in height. The displacement of conventional structure is greater than the lightweight structure.

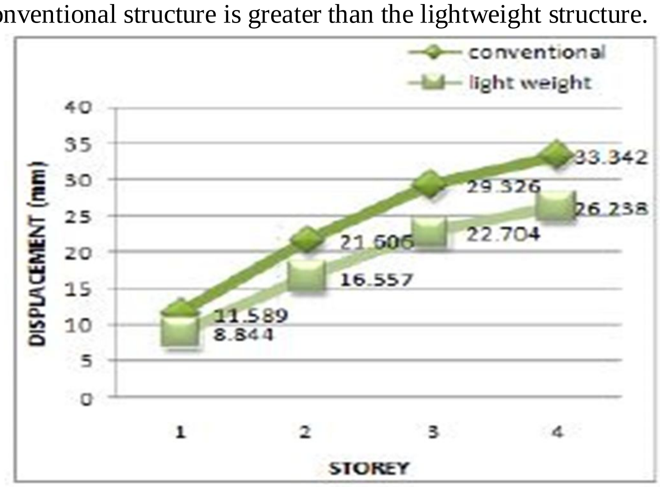

Fig 1.1 story displacement

2) *Comparison of Maximum Axial Force:* The maximum axial force has been evaluated for different numbers of stories of conventional and lightweight building. The below Figure suggest that the maximum axial force in column of conventional structure is more than light weight structure.

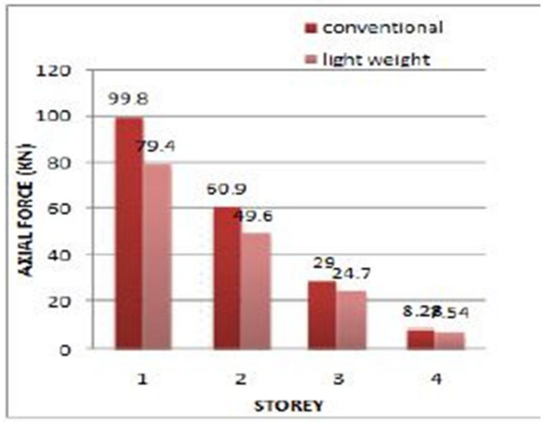

Fig 1.2 Maximum Axial force

3) *Comparison of Maximum Shear Force:* The maximum shear force has been evaluated for different numbers of stories of conventional and lightweight building. The below Figure suggest that the maximum shear force in column of conventional structure is more than light weight structure.

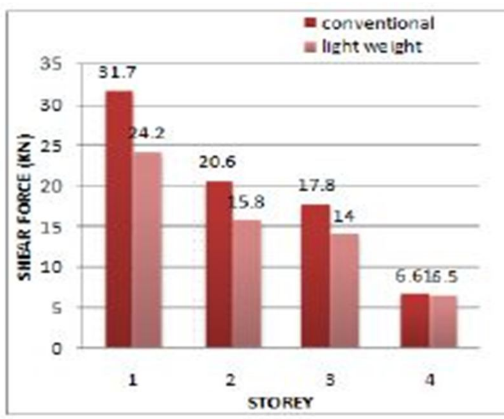

Fig 1.3 Maximum Shear force

4) *Comparison of Maximum Bending Moment:* The maximum bending moment has been evaluated for different numbers of stories of conventional and lightweight building. The below Figure suggest that the maximum bending moment in column of conventional structure is more than light weight structure.

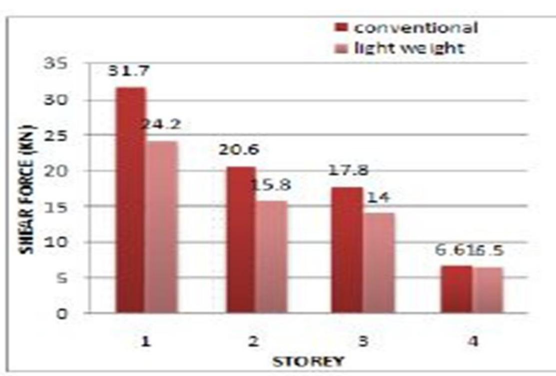

Fig 1.4 Maximum Shear force

5) *Comparison of Total base Shear:* The total base shear has been evaluated for conventional and lightweight building. The below Figure suggest that the total base shear of conventional structure is more than light weight structure by 20% to 25%.

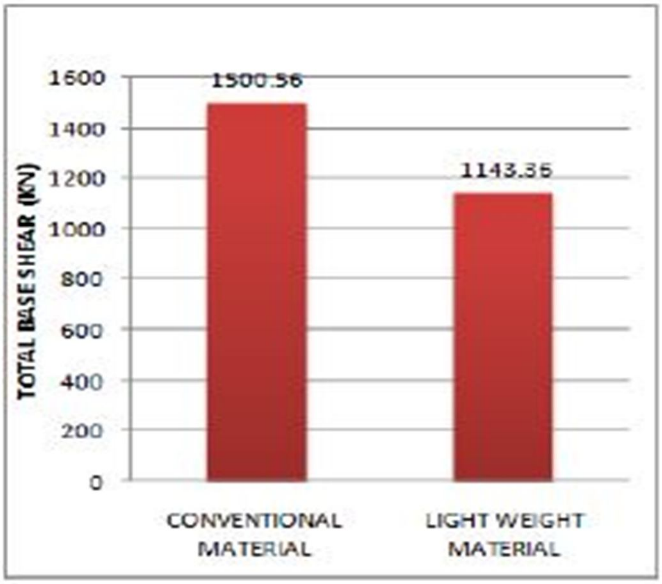

Fig 1.5 Total Base Shear

VII. CONCLUSION

This study compared the effects of seismic loads on multi-story buildings made of traditional bricks versus light-weight infill blocks. By comparing parameters and looking at the overall analysis result, graphs, and bar charts of traditional and light weight building structures, the following conclusion can be drawn:

A. The dead weight of lightweight building structures is found to be 30 to 40% less than that of traditional structures.
B. In response spectrum research, it was discovered that the base shear of lightweight building structures is reduced by 20% to 25% compared to traditional building structures.
C. In a linear dynamic analysis, the axial force of a light weight construction is shown to be 15% to 20% lower than that of a conventional structure.
D. In response spectrum analysis, the shear force in lightweight structures is shown to be 15% to 25% lower than in traditional structures.
E. The maximum negative bending moment in lightweight structures is reduced by 20% to 25% when compared to traditional building structures.
F. According to this initiative, using lightweight materials in seismic zone construction reduces the proportion of damages as well as construction costs.

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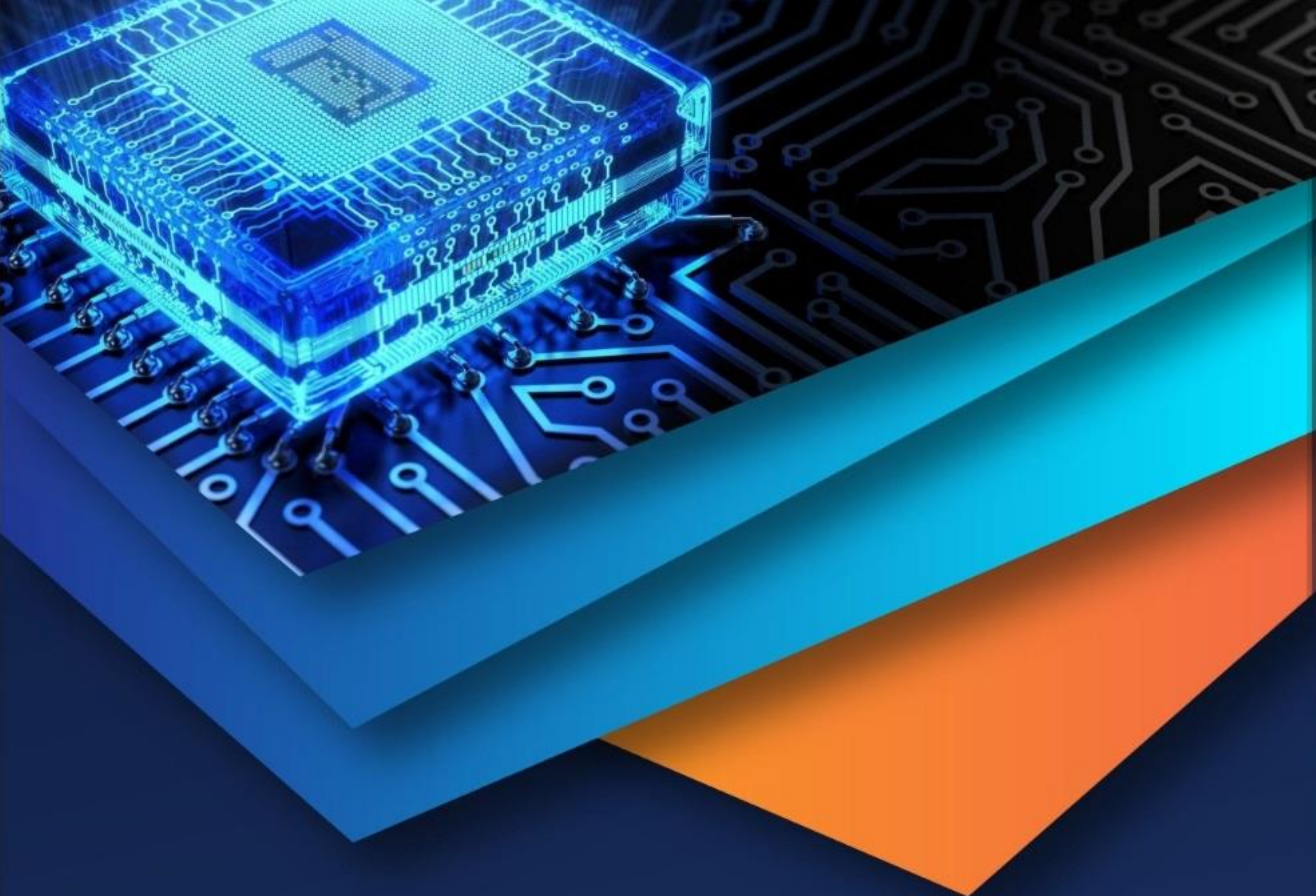

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