Comparative Study of High Rise Buildings using Light Weight Infill Blocks and Conventional Bricks

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Abstract— With the developments in the construction industry the requirement of building materials have increased. So we need to use the alternate building materials which consume lesser energy and give more strength. In this study the effect of conventional bricks and light weight blocks is studied on the various structures such as G+10, G+15 and G+20 and are analyzed using STAAD Pro software. Earthquake analysis has been carried out using Equivalent static method and Response spectrum method. The various parameters such as Base shear, BM and SF in a beam, axial forces in a column, Lateral load and Lateral displacements are compared. And the percentage reduction is obtained for each of these parameters. It was found that light weight blocks can basically be used to replace conventional burnt clay brick infill material in RC structure.

Key words: Light Weight Blocks, Conventional Bricks, Equivalent Static Method, Dynamic Method, Base Shear, Lateral Displacement

I. Introduction

Advancement in science and technology has lead to the concept of high rise buildings to accommodate the growing population and compensate the decrease in land. A weight of the structure plays an important role in such construction as it changes directly affects the design of the building. Brick weight is a dead load when decreased can make building more economic, there are many such bricks coming up in market, which are lighter in weight, giving better finishing, few of them are discussed below.

A. Lightweight Blocks

As the name indicates light weight blocks are special type of building blocks whose density is nearly 1/3rd of density of normal clay bricks i.e. if the density of normal clay bricks is around 20KN/m^3 then the density of light weight blocks would be 6-7KN/m^3.

B. Types of Lightweight Blocks

There are mainly two different types of light weight blocks based on their raw materials, manufacturing process and density.

1) Autoclaved Aerated Concrete blocks (AAC Block).
2) Cellular Lightweight Concrete blocks (CLC Block).

The building blocks which are manufactured from this AAC are known as AAC blocks. Lightness is achieved by introducing a large number of closely spaced microscopic pores in the slurry with the help of entraining or foaming Agent .CLC is called as Cellular Lightweight Concrete and it is also called as Foam Concrete.

Cellular Lightweight Concrete (CLC) is a version of lightweight concrete. And are a cement bonded material made by blending slurry of cement. Stable, preformed foam manufactured on site is injected into this slurry to form foam concrete

II. Methodology

In order to carry out the analysis G+10, G+15, G+20 buildings have been chosen. They were analyzed and designed using STAAD-Pro software. Earthquake analysis has been carried out using

- Equivalent Static Method
- Response Spectrum Method

Wind analysis is carried out as per IS 875 Part-3 to check the effects of wind on high rise buildings using STAAD-Pro. But the results showed that lateral displacements obtained in wind analysis were very less as compared to earthquake analysis. So the wind analysis has been neglected and seismic analysis was preferred.

A. Wind Analysis as per IS 875 PART-3

1) Wind load intensities

- $P_z = 0.6V_z^2$ kN/m^2
- V_z= Design wind speed (m/sec^2)
- $V_z = K_1 * K_2 * K_3 * V_b$
- K_1= Risk factor cl 5.3.1 Table 1
- K_2= Height factor cl 5.3.2 Table 2
- K_3= Topography factor cl 5.3.3
- V_b= Basic wind speed (m/sec^2)
- All data is from IS 875 PART – 3

2) Data considered for the wind analysis

- V= 33(m/sec^2)
- K_1= 1.0
- K_3= 1.0 for angle $<3^0$
- K_2= Values are calculated based on height of the building by linear interpolation.

III. Modeling and Analysis

For the analysis of all the three buildings (G+10, G+15, G+20) following four types are considered.

- Buildings with clay bricks.
- Buildings with outer main wall made with lightweight blocks.
- Buildings with partition walls made with lightweight blocks.
- Buildings with lightweight blocks

A. Generation of the model

1) Type of structure: Multi-stored rigid jointed plane frame(special RC moment resisting frame)
2) Number of stories: G+10, G+15, G+20
3) Floor height: 3.0 m
4) Infill wall: 230 mm wall thick including plaster
5) Imposed load: 4.0 kN/m^2

6) Materials: Concrete M20, Reinforcement Fe415
7) Column and beam sizes
8) Depth of slab: 130 mm
9) Depth of footing: 2.1 m
10) Specific weight of RCC: 25kN/m^3
11) Specific weight of infill: 20 kN/m^3
12) Specific light weight blocks: 6.5kN/m^3
13) Natural damping of the building: 5%

Normal BBC	G+10	Normal BBC	G+15	Normal BBC	G+20
Below plinth	0.60X0.50	Below plinth	0.80X0.70	Below plinth	0.80X0.70
First five storey	0.70X0.40	First seven storey	0.90X0.55	First ten storey	0.90X0.60
Next six storey	0.50X0.35	Next nine storey	0.60X0.40	Next five storey	0.60X0.40
Beam size	0.45X0.23	Beam size	0.48X0.23	Next six storey	0.5X0.35
				Beam size	0.48X0.23

OUTER LWB	G+10	OUTER LWB	G+15	OUTER LWB	G+20
Below plinth	0.50X0.50	Below plinth	0.60X0.55	Below plinth	0.70X0.70
First five storey	0.70X0.40	First seven storey	0.60X0.50	First ten storey	0.70X0.60
Next five storey	0.35X0.35	Next nine storey	0.60X0.40	Next five storey	0.50X0.40
Beam size	0.40X0.23	Beam size	0.45X0.23	Next six storey	0.45X0.35
				Beam size	0.45X0.23

PARTITION LWB	G+10	PARTITION LWB	G+15	PARTITION LWB	G+20
Below plinth	0.50X0.50	Below plinth	0.70X0.60	Below plinth	0.80X0.70
First five storey	0.50X0.45	First seven storey	0.60X0.60	First ten storey	0.80X0.65
Next five storey	0.40X0.35	Next nine storey	0.60X0.40	Next five storey	0.55X0.40
Beam size	0.40X0.23	Beam size	0.45X0.23	Next six storey	0.45X0.35
				Beam size	0.45X0.23

FULL LWB	G+10	FULL LWB	G+15	FULL LWB	G+20
Below plinth	0.50X0.45	Below plinth	0.60X0.60	Below plinth	0.70X0.70
First five storey	0.50X0.40	First seven storey	0.60X0.50	First ten storey	0.70X0.55
Next five storey	0.35X0.35	Next nine storey	0.50X0.35	Next five storey	0.50X0.40
Beam size	0.36X0.23	Beam size	0.40X0.23	Next six storey	0.40X0.35
				Beam size	0.42X0.23

Table 1: Models

B. Load Calculations

1) Dead load of slab = 0.13X25=3.25kN/m^2
2) Dead load of BBC main wall of 20KN/m^3= 0.23x2.55x20=11.73kN/m
3) Dead load of BBC partition wall of 20KN/m^3= 0.115x2.55x20=5.865kN/m
4) Dead load of BBC parapet wall of 20KN/m^3= 0.115x0.9x20=2.07kN/m
5) Dead load of LWB main wall of 6.5KN/m^3= 0.23x2.55x6.5=3.812kN/m
6) Dead load of LWB partition wall of 6.5KN/m^3= 0.115x2.55x6.5=1.906kN/m
7) Dead load of LWB parapet wall of 6.5KN/m^3= 0.115x0.9x6.5=0.6727kN/m

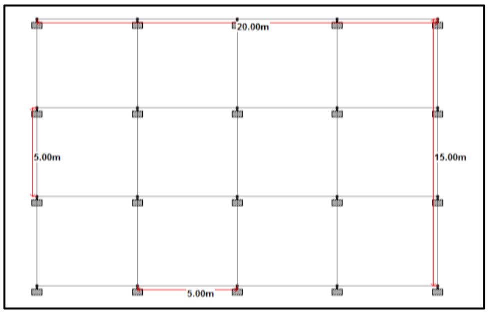

Fig. 1: Top view of the building

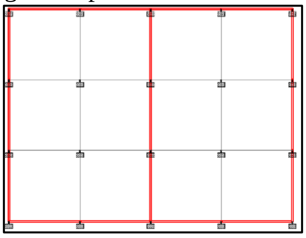
Fig. 2: Plan showing highlighted main walls

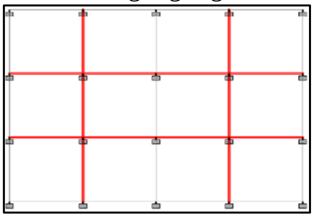
Fig. 3: Plan showing highlighted partition walls

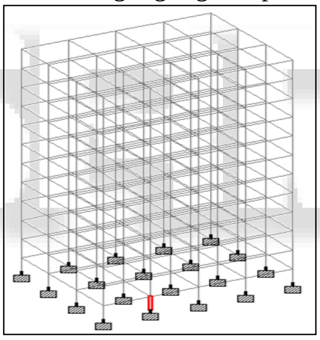
Fig. 4: Column number 48 in G+10 building for comparison

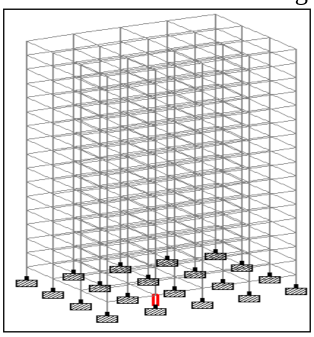
Fig. 5: Column number 48 in G+15 building for comparison

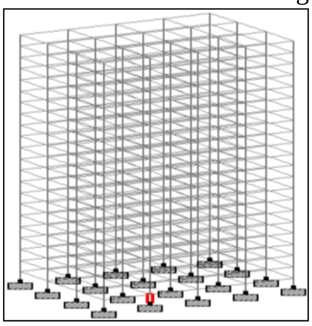
Fig. 6: Column number 48 in G+20 building for comparison

Different cases are considered for the analysis and comparison of the various parameters. Those cases are as follows,

Case 1: Buildings with burnt clay bricks
Case 2: Buildings with outer wall made up of LWB
Case 3: Buildings with partition walls made up of LWB
Case 4: Buildings with full LWB.

IV. RESULTS AND DISCUSSIONS

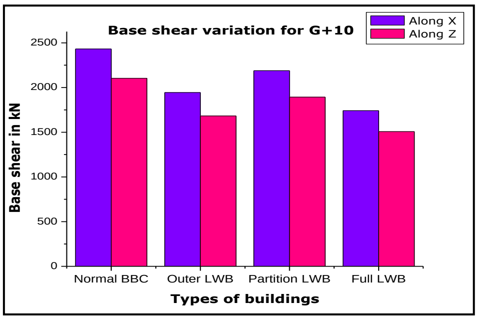

Fig. 7: Graph showing variation of base shear values for G+10 building

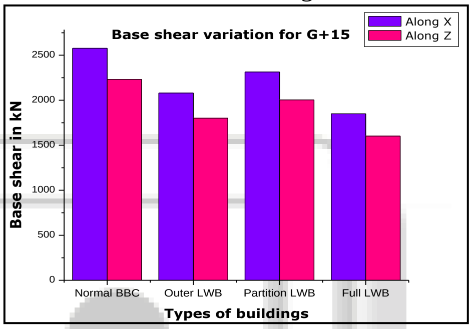

Fig. 8: Graph showing variation of base shear values for G+15 building

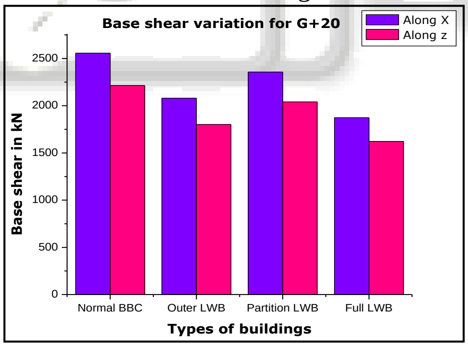

Fig. 9: Graph showing variation of base shear values for G+20 building

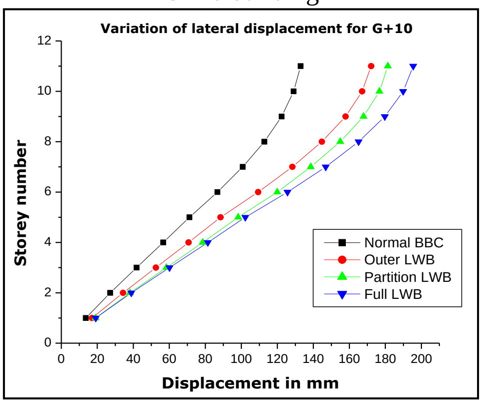

Fig. 10: Graph showing variation of lateral displacement values for G+10 building

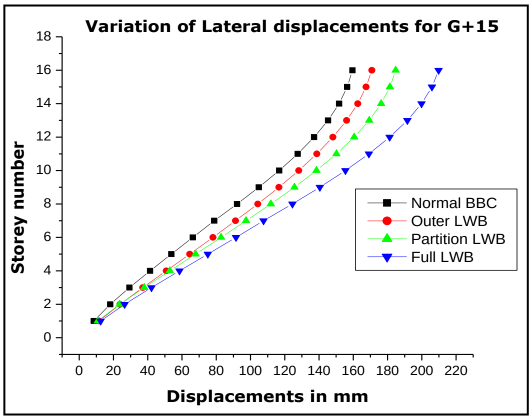

Fig. 11: Graph showing variation of lateral displacement values for G+15 building

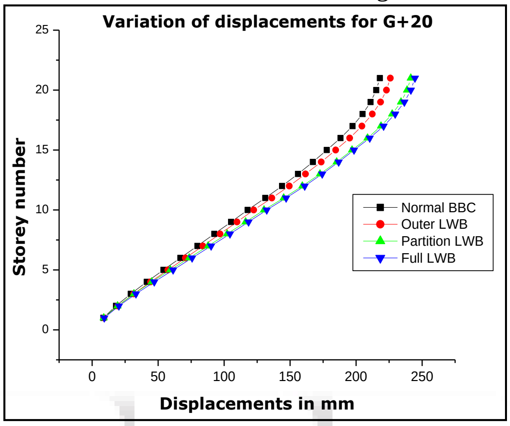

Fig. 12: Graph showing variation of lateral displacement values for G+20 building

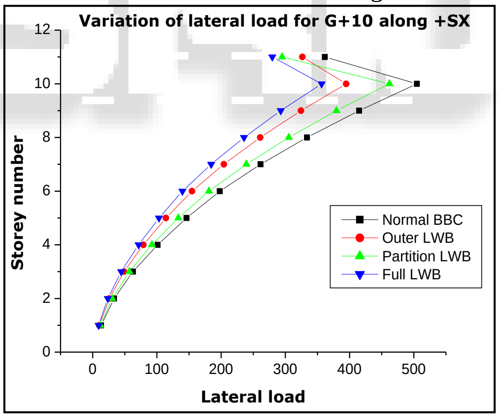

Fig. 13: Graph showing variation of lateral load for G+10 building

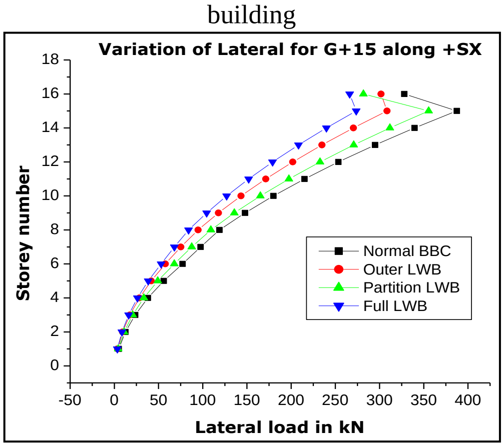

Fig. 14: Graph showing variation of lateral load for G+15 building

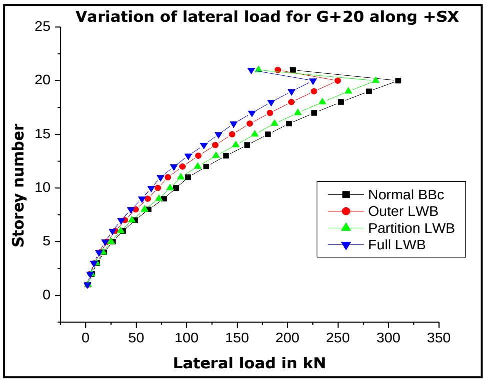

Fig. 15: Graph showing variation of lateral load for G+20 building.

A. *Tabulations of Results*

% Reduction values for G+10						
Type	BM	SF	Base Shear	Axial Force	BM in Column	Building Weight
Normal BBC vs. Outer LWB	20.03	20.23	20.03	31.97	53.80	20.04
Normal BBC vs. Partition LWB	8.03	8.24	9.99	19.85	44.87	10.01
Normal BBC vs. Full LWB	32.06	32.08	28.37	37.98	36.03	28.38

Table 1: Percentage reduction values for various parameters for G+10 building

% Reduction values for G+15						
Type	BM	SF	Base Shear	Axial Force	BM in Column	Building Weight
Normal BBC vs. Outer LWB	-8.38	-7.88	19.30	18.93	72.43	20.48
Normal BBC vs. Partition LWB	8.78	8.91	10.23	8.35	47.09	10.85
Normal BBC vs. Full LWB	18.90	19.05	28.23	27.02	58.90	29.96

Table 2: Percentage reduction values for various parameters for G+15 building

% Reduction values for G+20						
Type	BM	SF	Base Shear	Axial Force	BM in Column	Building Weight
Normal BBC vs. Outer LWB	19.05	19.11	18.66	19.10	40.46	18.66
Normal BBC vs. Partition LWB	20.40	20.35	7.81	6.56	1.67	7.81
Normal BBC vs. Full LWB	34.17	34.17	26.72	25.78	37.49	26.72

Table 3: Percentage reduction values for various parameters for G+20 building

V. CONCLUSIONS

The behaviour of structures such as buildings with conventional burnt clay brick and light weight blocks is studied for different heights, 10, 15, and 20 stories. The buildings are modelled and analyzed using STAAD Pro software by both equivalent static method and response spectrum method. Comparisons have been made among the different cases such as buildings with full conventional burnt clay bricks, buildings with full light weight blocks, buildings with outer main walls with light weight blocks & buildings with partition walls with light weight blocks. All the results of all the cases have been studied and compared. The buildings with light weight blocks have shown better results as compared to one with clay bricks. Based on the analysis data the following conclusions are made as follows.

– The dead weight of the structure is almost 29% reduced in case of LWB blocks as compared to conventional clay bricks. So that economy in the design can be achieved.
– The bending moments, shear forces for LWB have been reduced almost by 35% as that of conventional bricks, so that there is a reduction in the member sizes and ultimately steel quantity can be saved.
– The axial forces and BM in the columns for LWB have been reduced almost by 30% and 44 % respectively as compared to conventional bricks. Thus there is a reduction in the column sizes and also reduction in the reinforcement of the columns.
– There is almost 28% reduction in the base shear for LWB as compared to conventional clay bricks. Lesser base shear will result in lesser lateral forces and storey shear.
– Due to reduction in the building weight there will the reduction in the member sizes, mainly reduction in the column sizes, which increases lateral displacements of the building. These displacements can be reduced by using shear wall or dampers.\
– Overall the performance of the light weight blocks such as AAC blocks is found to be superior to that of conventional bricks in the buildings.
– The better performance of light weight blocks tells that LWB's can be effectively used in high rise buildings in the earthquake prone areas.
– Light weight blocks can basically be used to replace conventional burnt clay bricks as infill material in RC structures.

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