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Economic Feasibility Study on Autoclaved Aerated Concrete Blocks over Solid Concrete Blocks in Design of Reinforced Concrete Portal Frames

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***Abstract*— Autoclaved aerated concrete blocks is one of the product of light weight concrete. It is used as an infill for frame elements, the dead load for entire structure gets reduced. In this study an attempt is made to check the feasibility study of autoclaved aerated concrete blocks over solid concrete blocks by comparing the price and quantities of materials required for the framed structure. In this work two models of 4 storey building have been created using an finite element software called staad pro and designed using staad RCDC (Reinforced concrete design compiler). One model is loaded with AAC blocks weight and another with solid concrete block weight and both models beam end forces are compared. From this work it is clear that using AAC blocks as an infill is better choice than solid concrete blocks.**

Keywords*— AAC block, solid concrete block, infill , Staad pro, Staad RCDC.

I. INTRODUCTION

Autoclaved aerated concrete (AAC) is approximately 1/5 the weight of ordinary concrete thus lower densities have very good impact on environments and it is having density ranging from 320 to 1920 kg/m^3 [10] and a compressive strength ranging from 2 to 7 MPa.

AAC is made of either portland cement or lime mortar, sand, water, and an expansive agent such as aluminum powder and is normally produced by a hydrothermal treatment of a mixture of finely ground quartz sand, lime/cement and a small amount of aluminum powder as a pore-forming agent under high pressure steam curing at a temperature typically between 180 C to 200 C. During the slurry phase, the metallic aluminium reacts with calcium hydroxide or alkali to form hydrogen gas bubbles which contribute to the high porosity of the aerated concrete. During autoclaving calcium silicate hydrate along with tobermorite is formed which is responsible for strength parameters.

With the usage of AAC blocks, the total energy consumption of buildings can be declined by 7% and cooling energy by 12% [6]. Autoclaved aerated concrete is an certified green building material being non-toxic, renewable and recyclable. The properties are influenced by their densities and the chemical composition varies with the method of curing [8].

II. OBJECTIVE OF STUDY

The main objective of the paper is to check the feasibility of autoclaved aerated concrete infill over solid concrete infill in design of concrete portal frames.

III. METHODOLOGY OF WORK

A 4 storey reinforced concrete structure is considered and modelled in staad pro and is designed for 1.5(Dead load + live load) using staad RCDC. The building is 23.7m x 33.6m in plan. Two models have been used with different infill loadings, one with solid concrete blocks and another with autoclaved aerated concrete block of densities 2100 kg/m^3 and 710 kg/m^3 respectively. For comparing purpose the concept of equal stress have been incorporated, which gives an clear idea about the same state of stress. Model 2 dimensions have been obtained in comparison to model 1 which is having the same amount of stresses in each of the members. Thus concrete dimensions can be reduced and this leads to savings. Fig 4 and Fig 5 shows that members of both models are stressed to approximately same level of compressive stresses.

Table -1: Member properties of model 1 and model 2

Properties	Model 1	Model 2
Column	0.6 x 0.6 m	0.52 x 0.52 m
Main beams	0.5 x 0.5 m	0.44 x 0.44 m
Secondary beams	0.25 x 0.5 m	0.5 x 0.25 m

Table -2: Building description

Type of frame	ordinary RC moment resisting frame
Number of storey	4
Floor height	4.2 m
Depth of slab	150 mm
Live load	3 kN/m^2
Floor finish	1 kN/m^2
Thickness of wall	200 mm
Density of solid block and AAC block	21 kN/m^3 and 7.1 kN/m^3

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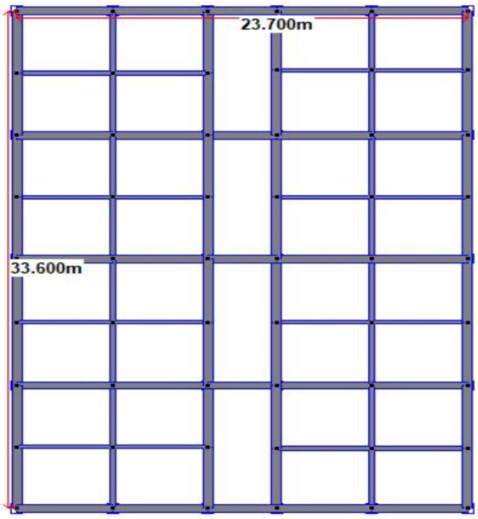

Fig.1 Beam column layout

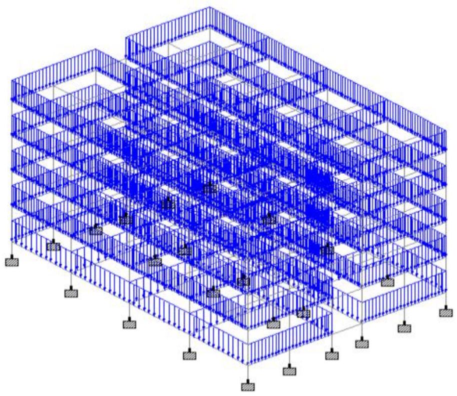

Fig.2 Model 1 with infill as solid concrete block

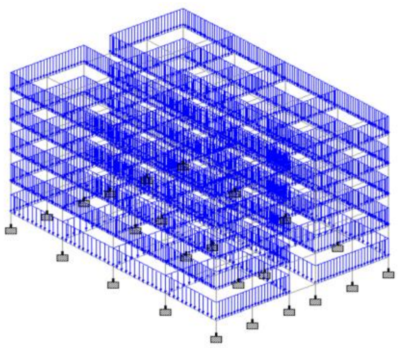

Fig.3 Model 2 with infill as autoclaved aerated concrete

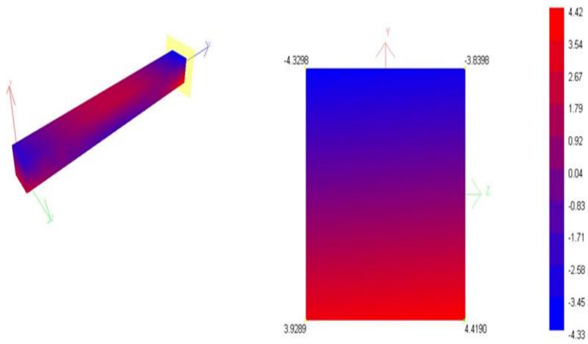

Fig.4 3D beam stress contour for top most left side beam of model 1

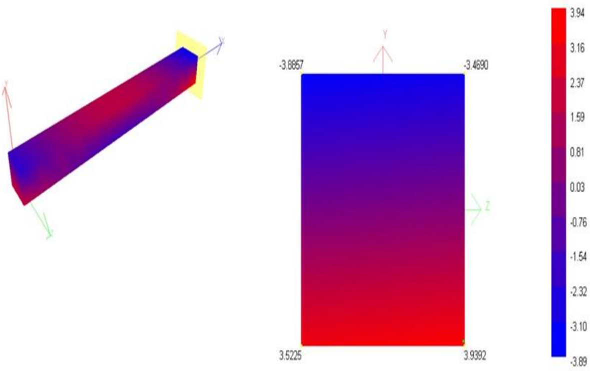

Fig.5 3D beam stress contour for top most left side beam of model 2

IV. RESULTS AND DISCUSSION

4.1 Maximum Displacement

The maximum displacement for the both models was approximately equal and is given in Table 3. This is because of the fact that both models are subjected to same level of stress.

Table -3: Maximum displacement

model 1	model 2
12.69 mm	13.75 mm

4.2 End force of beam

The end forces of beam for model 1 and model 2 are compared with each other and their average percentage difference is tabulated in Table 4.

Table -4: Average percentage difference of beam end forces

ΔFx	ΔFy	ΔMx	ΔMz
38.49%	41.35%	21.19%	38.18%

4.3 End force of columns

The end forces of column for model 1 and model 2 are compared with each other and their average percentage difference is tabulated in Table 5.

Table -5: Average percentage difference of column end forces

ΔFx	ΔFy	ΔFz	ΔMy	ΔMz
37.40%	44.5%	43.28%	45.59%	44.42%

where

Fx represents axial force.

Fy and Fz represents shear forces in y and z direction.

Mx represents torsional moment.

My and Mz represents bending moments in y and z direction.

4.4 Reactions

The average percentage difference in reaction for model 1 and model 2 are compared and their average percentage difference is Tabulated in Table 6.

Table -6: Average percentage difference of column end forces

ΔFx	ΔFy	ΔFz	ΔMx	ΔMz
58.02%	36.50%	59.50%	48.53%	52.53%

4.5 Quantities of materials

Design and estimation of quantities of frame elements is carried out using staad RCDC as per IS 456 – 2000. The dimensions of solid concrete blocks are 400mm, 200mm with thickness of 100 or 200mm while the dimensions of aerated concrete blocks are 600mm, 200mm with thickness of 100 or 200 mm. The total number of solid 4-inch blocks required was 98154 while the total number of AAC 4-inch blocks required was 65436. The total number of solid 8-inch blocks required was 49077 while the total number of AAC 8-inch blocks required was 32718 numbers.

Table -7: Quantities of model 1

elements	concrete (cum)	steel (kg)	shuttering (sq.M)
slab	400.16	23,252.76	2,667.72
beam	572.01	99,261.58	3,587.24
column	159.41	21,455.28	974.72
footing	79.86	3,944.62	124.34

Table -8: Quantities of model 2

elements	concrete (cum)	steel (kg)	shuttering (sq.M)
slab	400.16	23,252.76	2,667.72
beam	486.08	83,591.81	3,313.17
column	119.73	18,767.45	852.43
footing	43.75	2,153.61	83.21

Table 9: Percentage savings in quantities

elements	concrete	steel	shuttering
beams	15.02%	15.79%	7.64%
columns	24.89%	12.53%	12.55%
footings	45.22%	45.40%	33.08%

4.6 Estimation

The cost of 4-inch AAC block is 50RS and 8-inch AAC block is 86 RS while the cost of 4-inch concrete block is 29 RS and 8-inch concrete block is 50 RS. This rate data is taken from materials tree construction. The price for concrete is taken as RS 5000/cum and for steel RS 55/kg and for shuttering work is taken as RS 600/sq.M.

Table 10: Total cost of building using 4 inch blocks

elements	total cost of model 1 (RS)	total cost of model 2 (RS)
infill	28,46,466	30,10,056
beams	1,04,71,830	90,16,366
column	25,61,912	21,42,330
footing	9,43,945	5,66,285
slab	48,80,324	48,80,324
sum	2,17,04,477	1,96,15,361
percentage diff	9.62 %	

Table 4.11 Total cost of building using 8 inch block

elements	total cost of model 1 (RS)	total cost of model 2 (RS)
infill	24,53,850	28,13,748
beams	1,04,71,830	90,16,366
column	25,61,912	21,42,330
footing	9,43,945	5,66,285
slab	48,80,324	48,80,324
sum	2,13,11,861	1,94,19,053
percentage diff	8.88%	

V. CONCLUSION

Based on the results of this study with the usage of aerated concrete blocks over solid concrete blocks in design of portal frames, the following conclusions are presented

1. The axial force and shear forces in beams was reduced by 38.49 % and 41.35 % respectively while torsional moments and bending moments in beams was reduced by 21.19 % by 38.18% respectively.
2. The axial force in columns was reduced by 37.4 %, and shear forces in y and z direction was reduced by 44.5 % and 44.42 % respectively and moments in columns in y and z direction was reduced by 45.59 % and 44.42 % respectively.
3. The axial load for design of footing was reduced by 36.50 %, and reaction moments in x and z direction was reduced by 48.53% and 52.53 %.
4. With the usage of 4 inch AAC blocks, 9.62 % of building costs can be saved and with the usage of 8 inch AAC blocks, 8.88 % of building costs can be saved.
5. Overall percentage savings in concrete was 13.34 % and in steel was 13.62 % and in shuttering work was 5.95 %.

Thus it is feasible to use Aerated concrete block than solid concrete block as an infill in portal frame.

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