ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

Green Structural Design of Building using Advance Energy Efficient Material

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***Abstract:*— With advance research in material technology, construction sector is using advance material at different stage of construction. AAC was used as construction material, which reduce the self weight of structure. AAC block are light weight and have less thermal conductivity as compared to traditional bricks. Due to use of advance energy efficient material for walls, energy consumption of building throughout the life span can be reduced. Paper deals with use of alternative material for construction of walls in building. Case study of flat scheme in seismic zone III, was presented to compare the base shear due to earthquake load, RCC estimate and reduction of carbon emission in atmosphere. Comparative was made between building constructed with tradition red brick wall and AAC brick wall. With use of advance building material saving in concrete quantity was observed. Carbon emission in atmosphere is reduced, hence structural designer can use the advance techniques to reduce the consumption of concrete and steel.**

Software are used to calculate base shear of building using different bricks

***Index Terms*— Cellular Light Weight Concrete Blocks, AAC Blocks, Burnt brick walls, Earthquake resistant structure.**

I. INTRODUCTION

With advancing technology, new construction material are available. New construction material is more sustainable as compared to existing material. Traditionally brunt bricks are used for construction of main and partition walls of building. Large amount of carbon is emitted in atmosphere in manufacturing process of burnt brick. Natural fertile soil was used for manufacturing burnt bricks. New wall materials are available which can increase the speed of construction, provide Earthquake resistant design and thermal comfort to occupant. Jointing material available in market is ready to use. With use of factory made precise bricks accuracy of construction can be increased. Total weight of structure comprise of self weight of structure, imposed dead load load like floor finishing and walls, Live load as per purposed of building. Imposed wall load contribute the 30% mass at a floor with use of traditional wall material. With availability of advance material technology wall weight can be reduced. With reduction in wall weight, mass at every floor can be reduced, which reduce the horizontal earthquake forces. With reduction of earthquake forces, self weight of RCC frame can be reduced. Consumption of concrete and steel can be reduced, which ultimately reduce the carbon foot print due to construction. Also due to use of advance material energy consumption of building for cooling can be reduced.

II. AAC BLOCKS

AAC (Autoclaved aerated concrete) is a precast product manufactured by combining silica (in the form of sand / recycled flyash), lime, cement, water, and expansion agent - aluminum powder. Expansion agent aluminum powder reacts with silica and produce millions of very small hydrogen bubbles. Hydrogen bubbles cause mix to expand five times its original volume. Bubbles evaporate, leaving highly closed cell aerated concrete. AAC block contains about 80% of Air. As compared to normal concrete, AAC contains 50% less embodied energy1. When fully immersed, water absorption of AAC block is 15 to 20%. Density of material various from 400 to 800 kg/m3 . Compressive strength was found to be same or above as compared to brunt brick. Thermal conductivity of material various from 0.06 to 0.21 KCal/m/hr/0C for density of material from 300 to 1000 kg/m3 . Blocks are found to be good sound insulation material2. Major three material contributes to energy consumption in building sector are brick, cement and steel. To reduce energy consumption in building , alternative of above three materials are to be found. As per study, energy consumption of building was estimated to 3-5 GJ/m2 of buildup area3. AAC blocks was found to be safe in seismic design of building4.

Embodied Energy5 of Burnt brick Masonry6, AAC Block masonry7, Concrete and Reinforcing steel8 was shown in table

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Table I.

Material	Embodied Energy (MJ)
Burnt Brick Masonry	2235 MJ/m^3
AAC Brick Masonry	818 MJ/m^3
Concrete	1002 MJ/m^3
Reinforcement Steel	28212 MJ/Tonne

III. METHODOLOGY

Case study of flat scheme is presented in paper. On site building is RCC frame structured, in-filled with brick masonry. Building is located at Dist. Yavatmal, Maharashtra which comes under seismic zone III. Frames are considered as non braced and without shear wall. Building is G+3 RCC frame Structure. On every floor live load for residential use i.e. 2 kN/m^2 is considered. Floor finish of 1 kN/m^2 is considered on every floor. Building is resting on medium soil with SBC of 200 kN/m^2. Analysis was done using space frame method.

Four Models are prepared as per following:
Case A - Building using Brunt brick without Earth Quake.
Case B - Building using AAC brick without Earth Quake.
Case C - Building using Brunt brick with Earth Quake.
Case D - Building using AAC brick with Earth Quake.

Space frame Analysis was done. Earthquake loads are calculated using Response spectrum method and as per guidelines in IS:1893(Part 1) -2002 .Design was done using as per IS:456-2000 by limit state method. Results are compared with respect to earthquake loads at every floor, Base shear, quantity of concrete and steel.

Modeling In Software

Typical Building Plan at every floor

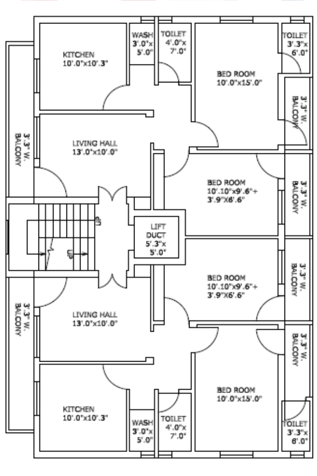

Fig. 1 Typical Floor plan at every floor

Earth quake load parameters

Earth quake loads are generated as per IS:1893(Part 1) -2002. As per Table II. earthquake load parameters are considered. Building is not braced and without shear wall, hence fame is "Ordinary R. C. Moment resisting frame"(OMRF).

Table II.

Parameters	Values
Seismic zone factor, Z	0.160
Importance factor, I	1.000
Response reduction factor, R	3.000
Percentage damping	5 %
No of Modes	5
Soil type	Medium Soil

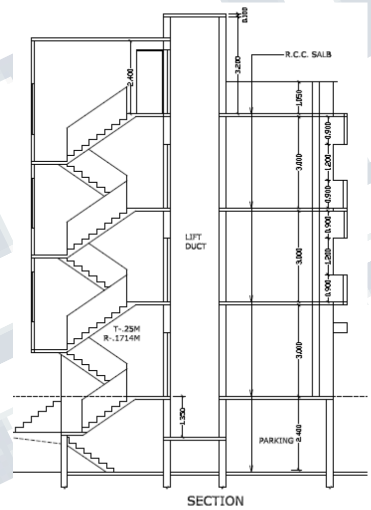

Fig. 2 Section of Building

Static Loading on structure

Live Load of 2 kN/m^2 and floor finish of 1 kN/m^2 are applied on slab at first, second and third floor. Terrace floor is loaded with Live Load of 2 kN/m^2 and floor finish of 2.5 kN/m^2 . Beams are load with wall load as per IS:875 - 1987. At every floor full wall height was considered and at terrace level parapet wall is considered.

Space Frame of model

Space frame was modelled with 560 elements and 384 nodes. M20 grade concrete is attached to all elements. At foundation level for all nodes support are considered as fixed. For analysis and design 16 load combinations are considered. Beam, Column and Footings are designed for envelop forces(Maximum of all load combination).

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Fig. 3 Rendered 3D model of Building

RESULTS AND DISCUSSION

Earthquake Load

Earthquake load are computed using response spectrum method. For modeled building 80% modal mass participation observed at 3rd mode. Fig.4 shows the floor wise distribution of base shear in X direction of Case C (Building using Brunt brick with Earth Quake) and Case D (Building using AAC brick with Earth Quake).

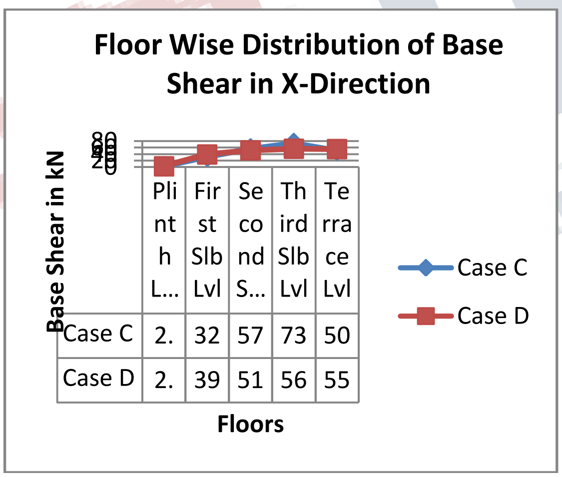

Fig. 4 Distribution of Base shear in X- Direction

Distribution of base shear for 2nd and 3rd floor in model D was less as Compared to Case C in X-Direction Base shear. For other floor it is slightly more.

Fig.5 shows the floor wise distribution of base shear in Y direction of Case C and Case.

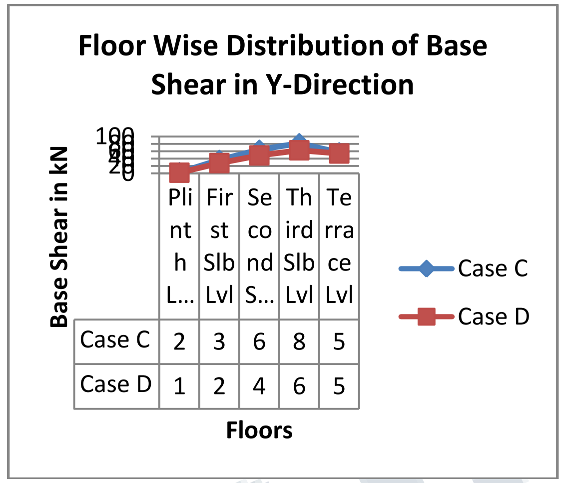

Fig. 5 Distribution of Base shear in Y- Direction

Distribution of base shear in model D was less as Compared to Case C in Y-Direction Base shear. As compared to Base shear in D Case, base shear in model D was reduced by 5 % and 19% respectively in X and Y direction earthquake loading.

Estimation of Structural Item Quantity

Quantity of Concrete and Steel consumed at every floor was calculated after design of building for cases A,B,C,D. Structure is designed as per IS456:2000 by Limit state method. Maximum Beams are designed as Singly reinforced beam. Some of the beams are designed as doubly reinforced when moments are increasing up to 20 % of beam flexure capacity. Otherwise beam section is revised . Analysis and design was done to consider effect of beam section modification in analysis. Total Concrete and Steel quantity consumed in all cases are shown in Table III.

Table III.

Case	Concrete in m^3	Steel Quantity in kg
Case A	168.187	11266
Case B	157.564	10231
Case C	169.601	12492
Case D	158.382	11051

To study the effect of use of AAC brick as compared to Conventional burnt brick, Case C and Case D was compared with respect to consumption of Concrete and Steel quantity. Fig. 6 shows the concrete consumption variation in every floor for Case C and D.

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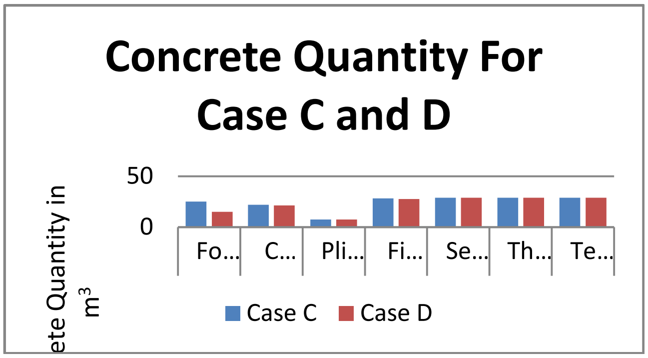

Fig. 6 Concrete quantity for Case C and Case D.

Reinforcement required for Case C and Case D was compared in Fig.7. It is found that Steel Quantity of 12493 kg for Case C was reduced to 11054 kg for Case D.

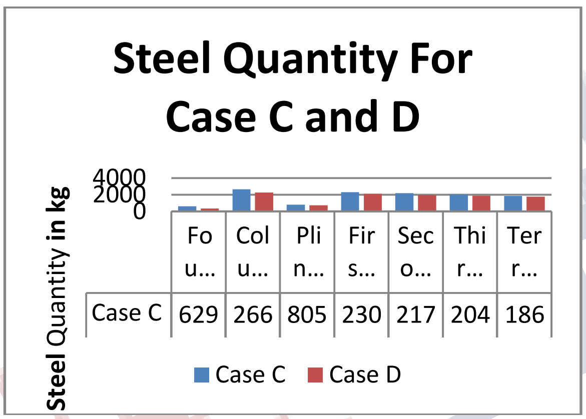

Fig. 7 Reinforcement quantity for Case C and Case D.

Saving in Embodied energy.

As per study saving in concrete and steel quantity was studied. Due to reduction in concrete consumption by 11.22 m3, saving of 11,242 MJ of energy is achieved. Reinforcement steel of 1438 kg (0.1841 m3) was saved. Energy of 40568 MJ was saved. Total energy saved was 51,810 MJ. Embodied energy in steel is 25 to 30 times that of concrete. So it is required to reduce steel consumption in steel.

IV. CONCLUSION

Structural design case study of residential 2BHK flat scheme was presented, with alteration of Wall material. AAC blocks are used as compared to normal burnt brick masonry. Structure is designed for Zone III earthquake forces.

With change in wall material, Base shear in Case D (Building using AAC brick wall), was reduced by 5% and 19% in X and Y direction respectively as compared to Case C building (Building using burnt brick wall). These percentage will change as per building configuration and earthquake zone. Also No of Story will play important role in comparative reduction of base shear.

Due to reduction wall mass at floor level, earthquake forces are reduce and hence the design forces. Quantity of Case D building was found to be less as compared to Case C building. Concrete quantity was reduced by 7 % and reinforcement steel quantity by 12%.

Embodied energy in concrete and steel of 51,810 MJ was saved due to replacement of wall material. Similarly Embodied energy saving can be saved because of wall material.

Use of AAC block as wall material was found to be economical from frame cost of structure and saving in embodied energy. Structural designers can implements the strategy in analysis and design of building to reduce the consumption of concrete and steel. Due to less thermal conductivity of AAC material, energy consumption for maintaining the indoor air environment will be reduced.

Study should be extended for effect of Change in number of floors, safe bearing capacity of soil, Concrete grade, steel grade. With change in building configuration result may vary.

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Authors Biography

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