Analysis and Design of RC Structure with Light Weight Bricks Using Etabs

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Abstract. A Building has to be defined is an enclosed structure intended for human occupancy. Constructions work has been seen in most of the countries developing with the increase of material cost in the construction work, there is a need to find more cost which can be affordable to people. In the manufacturing of brunt clay bricks, smoke evolved at a great extent and also toxic gases which can harm an environment. So, as to overcome with all these problems. From previous research observed that light weight bricks of Recycle paper mill residue (RPMR) and rice husk ash (RHA) which composes of Recycle paper mill residue (RPMR) and rice husk ash (RHA) and cement which are more economical and eco-friendly. The use of recycle factory residue and rice husk ash bricks are reduce load of wall on beams and columns makes it a relatively lighter members and reducing the hundreds (or) moments. This project includes analysis and design of multi-stored RC structure (G+3) with light weight bricks by using ETABS, comparison will be done with conventional bricks.

1 Introduction

Building construction is that the engineering deals with the development of building like residential houses. In a simple building are often define as an enclose space by walls with roof, food, cloth and therefore the basic needs of citizen. In the early past humans lived in caves, over trees or under trees, to guard themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made from timber branches. The shelters of these old are developed nowadays into beautiful houses. Rich people live in sophisticated condition houses.

A homogeneous mixture of RPMR (Recycle paper mill residue) – RHA (rice husk ash) – cement was prepared with varying proportions, each set comprising of varying percentage of RPMR, RHA and cement were prepared. Sample set A has 80% RPMR, 10% RHA and 10% of cement by weight, sample set B has 75% RPMR, 15% RHA and 10% cement by weight whereas sample set C has 70% RPMR, 20% RHA and 10% of cement by weight. Results suggests that the optimum mix, both in terms of the strength parameters and overall physico-chemical characteristics will be 80% RPMR, 10% RHA and 10% cement.

In this project, attempt has to been done to replace the red bricks with light weight blocks. The use of light weight block significantly reduces the cost of construction. Compressive strength of RPMR–RHA–cement brick was increased and found to be more than 11MPa in all the three samples. All brick samples had excellent compressive strength (11–15 MPa) is nearly five times higher than the compressive strength of the conventional burnt clay brick. RHA and RPMR block is a load-bearing construction material that is of lower density(588kg/m3) than other construction materials due to its high porosity. Due to its lower density of these blocks, tall buildings constructed using these blocks have less need for steel and concrete for structural members.

This project mainly deals with the comparative analysis of conventional bricks and light weight bricks, results which are obtained from the analysis of a multi storied building where analyzed by using ETABS software.

2. METHODOLOGY

Steps to Analyse and Design of Building:

Creating of grid points and generation of structure- After getting opened the program, select a new model and a window appears where we had entered the details of grid dimensions and story dimensions of our building. Here the program had generated 2D and 3D structure by specifying the building details in the two windows.

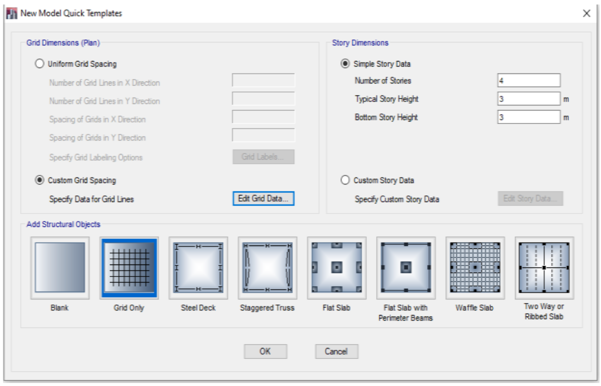

Fig. 1. Creation of grid points & structure generation

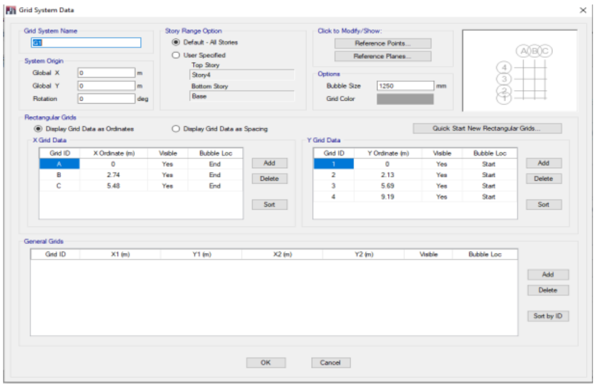

Fig. 2. Grid system data

1. Defining of fabric property and sectional property. After making the grids, begin to outline the fabric property bychoosing outline menu-material properties (define concrete and steel reinforcement). afterward outline section properties (beams, columns, slabs and wall) bygivingthe required details in shaping. Afterward we tend to outline section size bychoosingframe sections as shown below and supplementarythe desired section for beams, column etc.`

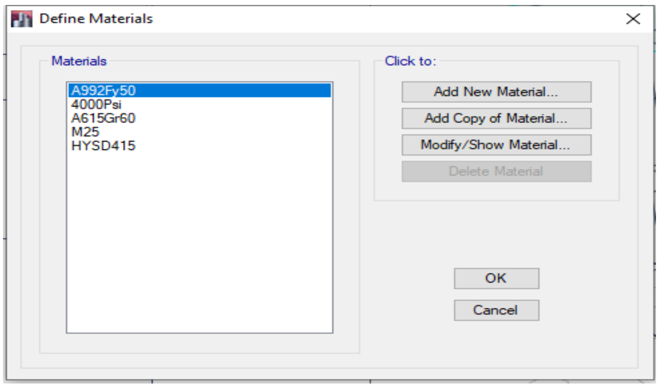

Fig. 3. Defining the material properties

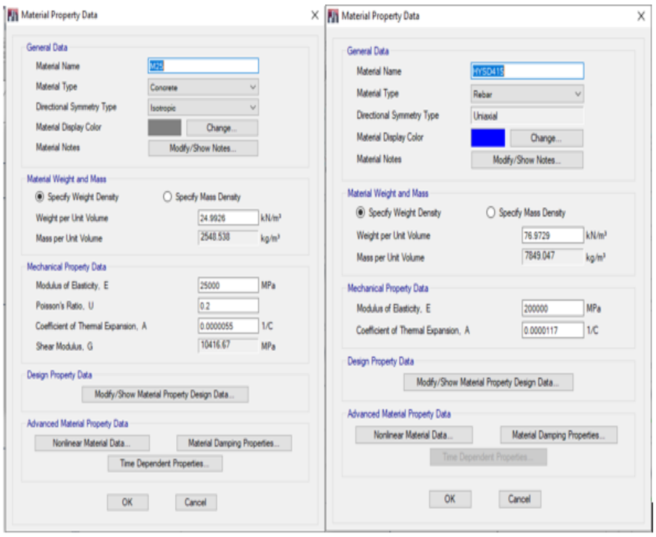

Fig. 4. Assigning of material property data

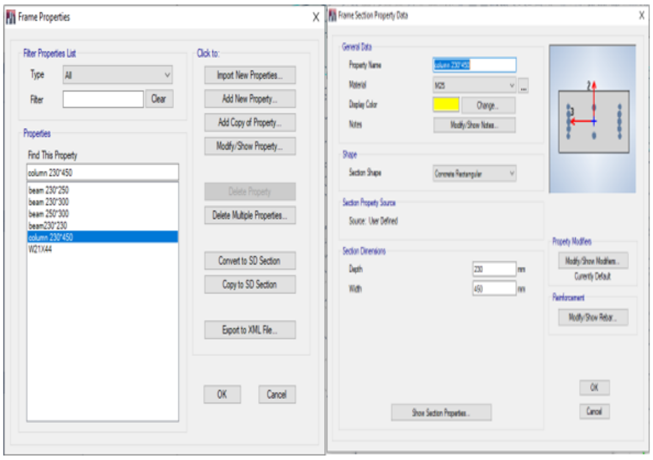

Fig.5. Assigning of sectional property data

2. Assigning of defined properties to the grid points. After defining the property for material and section properties, now draw the structural components using command menu > Draw line for beam and create column in degion for columns by which property assigning is completed for beams and columns sections.

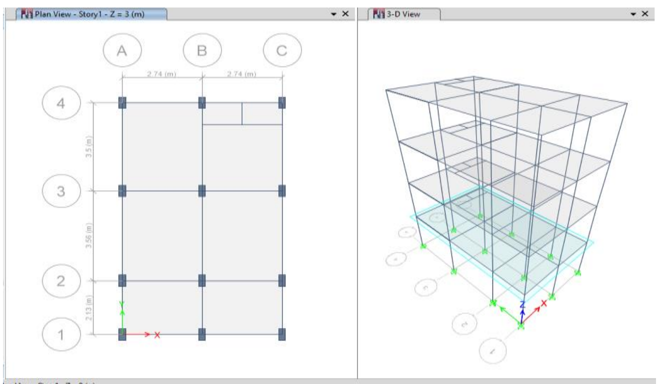

Fig.6. Assigning of different properties to the grid points

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3. Assigning of supports. After drawing the details of building (beams, columns slabs, wall), now assign the supports by going to assign menu > joint menu > restraints > fixed.

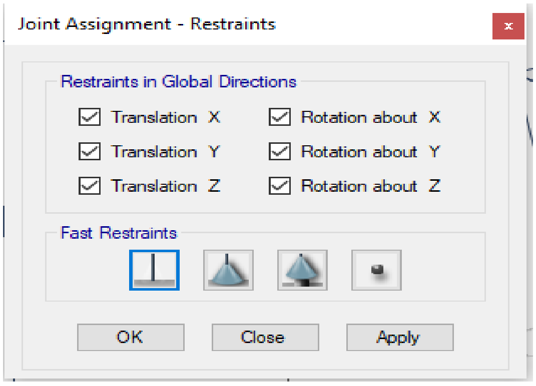

Fig.7. Assigning of supports

4. Defining of loads. The loads in ETABS program are defined as using static load cases command in define menu.

5. Assigning of dead load (IS 875:1987 part 1).After defining all the loads, dead loads are assigned for external walls and internal walls, slabs. As per IS:875(part-1) -1987, Indian Standard code of practice dead load include weight of walls (exterior and interior walls) floor finishes, false ceilings and the permanent constructions within the buildings.

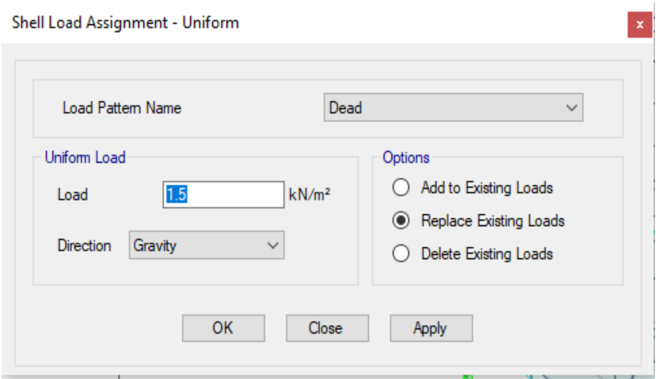

Fig.8. Assigning of dead load

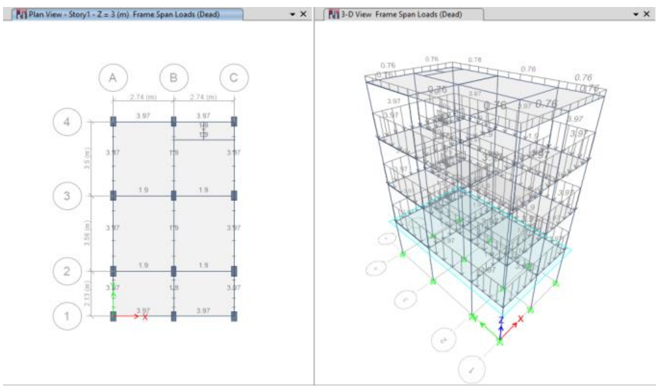

Fig.9. Loading diagram of dead loads

6. Assigning of Live load (IS 875:1987 part 2).Live loads are assigned for the entire structure including floor finishing. This load is created by the moving loads, distributed and targeted masses and also with the supposed use or occupancy of a building.

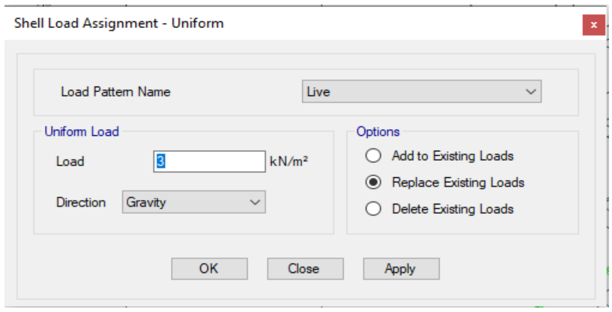

Fig.10. Assigning of live load

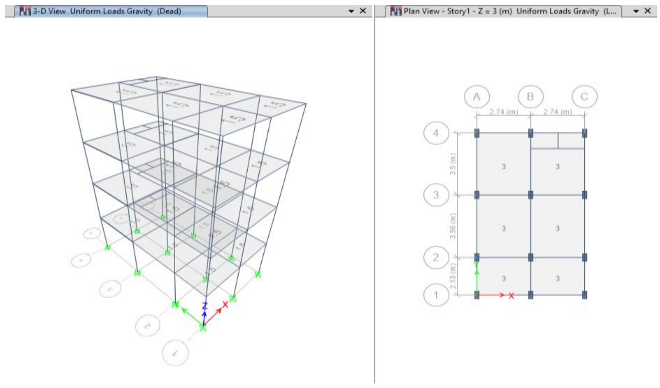

Fig.11. Loading diagram of live load and dead load

7. Assigning of load combinations (IS 875:1987 part 5).Load combinations are given based on IS 875:1987 Part 5 using load combinations command in define menu.

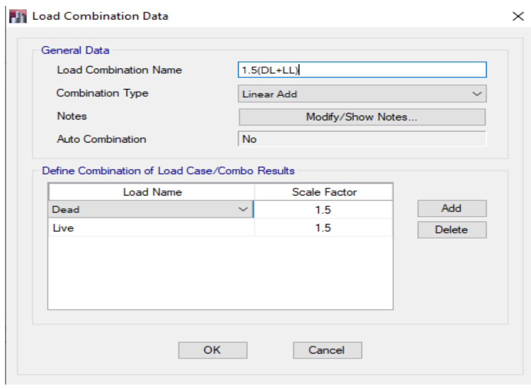

Fig.12. Assigning of load combinations

8. Analysing and checking all the errors. After completion of all steps above, now perform the analysis and check the errors. Errors occurred are resolved at the located frame and section.

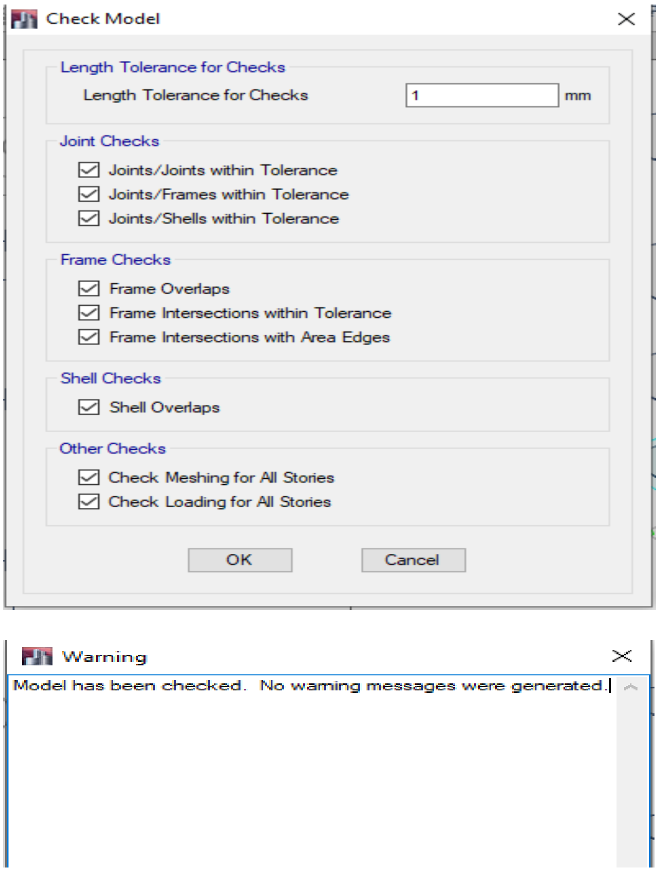

Fig.13. Performing the analysis and checking the errors

9. Performing of concrete design on the structure as per IS 456: 2000 code book.This step considers the last step of procedure. After completing the analysis, now perform concrete design on the structure as per IS code of practice. For this go to Design menu > concrete design > select design combinations. After this again go to design menu> concrete frame design > Start design\ check of structure. Then the ETABS software performs the design for every structural element.

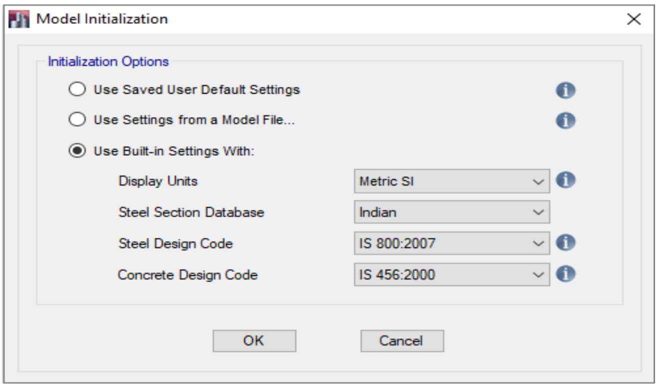

Fig.14. Showing used codes books

3. CALCULATIONS

LOAD CALCULATIONS:

The load calculation of the structure is calculated as follows;

- Live Load :3kN/m2
- Dead Load (floor finishes) :1.5kN/m2
- Wall Loads (light weight bricks)
  - For 9” wall - 0.23 x 3 x 5.76 = 3.973kN/m
  - For 4.5” wall - 0.11 x 3 x 5.76 = 1.903kN/m
  - For parapet wall - 0.11 x 1.2 x 5.76 = 0.760kN/m
- Wall Loads (conventional bricks)
  - For 9” wall - 0.23 x 17.65x 3 = 12.183kN/m
  - For 4.5” wall - 0.11 x 17.65 x 3 = 5.833kN/m
  - For parapet wall - 0.11 x 17.65 x 1.2 = 2.33 kN/m

4. DESIGN AND ANALYSIS

After the detailed analysis of structure, the following results are obtained which shows the area of steel required in respective structural members (beams, columns, shear walls). Along with the steel area, the bending moment details, shear force details and deflections in each beam is also obtained in a systematic manner. All these details are obtained in an auto generated file which is generated automatically by ETABS software while we work on the structure. Necessary snapshots are given in this chapter.

As beams, columns and slabs are designed in detailed manner in ETABS, the design of footing is done in Microsoft Excel Spreadsheets. Also manual calculations have been performed for Beams, slabs and columns and checked with software results.

After obtaining the detailed design reports and necessary AutoCAD plans, the 3D modelling of the structure is carried out in E-TABS for analysis and design. We have also done the Rebar Modelling which shows the reinforcement details structural members as per the design.

STRUCTURE DATA

Story Data

Table 1. Story Data

Name	Height mm	Elevation mm	Master Story	Similar To	Splice Story
Story4	3000	12000	No	None	No
Story3	3000	9000	No	Story4	No
Story2	3000	6000	No	Story4	No
Story1	3000	3000	No	Story4	No
Base	0	0	No	None	No

Grid Data

Table 2. Grid Systems

Name	Type	Story Range	X Origin m	Y Origin m	Rotation deg	Bubble Size mm	Color
G+3	Cartesian	Default	0	0	0	1250	GRAY

Table 3. Grid Lines

Grid System	Grid Direction	Grid ID	Visible	Bubble Location	Ordinate m
G+3	X	A	Yes	End	0
G+3	X	B	Yes	End	2.74
G+3	X	C	Yes	End	5.48
G+3	Y	1	Yes	Start	0
G+3	Y	2	Yes	Start	2.13
G+3	Y	3	Yes	Start	5.69
G+3	Y	4	Yes	Start	9.19

PROPERTIES

Materials

Table 4. Material Properties - Summary

Name	Type	E MPa	ν	Unit Weight kN/m³	Design Strengths
HYSD415	Rebar	200000	0	76.9729	Fy=415 MPa Fu=485 MPa
M25	Concrete	25000	0.2	24.9926	Fc=25 MPa

Frame Sections

The Frame sections that is columns and beams that are used in the structure are given with the material, shape and size used

Table 5. Frame Sections for conventional bricks

Name	Material	Shape	Size
B1 - 230 300	M25	Concrete Rectangular	230mm X 300mm
B2 - 230 250	M25	Concrete Rectangular	230mm X 250mm
B3 - 230 230	M25	Concrete Rectangular	230mm X 230mm
C 230 450	M25	Concrete Rectangular	230mm X 450mm

Shell Sections

Table 6. Shell Sections - Summary

Name	Design Type	Element Type	Material	Total Thickness mm
Slab120	Slab	Shell-Thin	M25	120

Reinforcement Sizes

The following reinforcement sizes are used for the structures.

Table 7. Reinforcing Bar Sizes for conventional building

Name	Diameter mm	Area mm²
12	12	113
16	16	201
25	25	491
26	26	531

Table 8. Reinforcing Bar Sizes for light weight building

Name	Diameter mm	Area mm²
10	10	79
12	12	113
16	16	201
20	20	314

LOADS

The loading information is applied to the models as shown below.

Load Patterns

Table 9. Load Patterns

Name	Type	Self Weight Multiplier
Dead	Dead	1
Live	Live	0

Load Cases

Table 10. Load Cases - Summary

Name	Type
Dead	Linear Static
Live	Linear Static

Load Combinations

Table 11. Load Combinations

Name	Load Case/Combo	Scale Factor	Type	Auto
1.5(DL+LL)	Dead	1.5	Linear Add	No
1.5(DL+LL)	Live	1.5		No

5. ANALYSIS RESULTS

SFD and BMD of Conventional Building

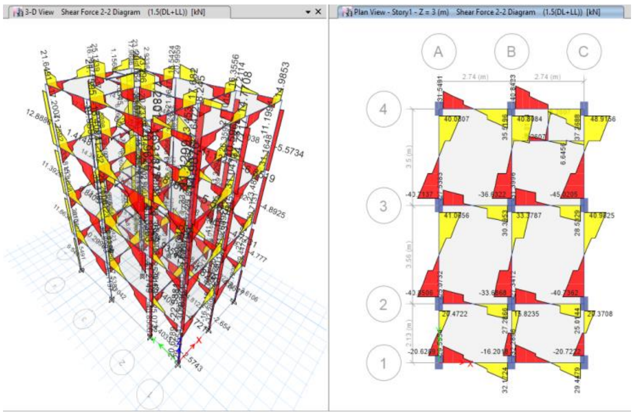

Fig.15. SFD of conventional building

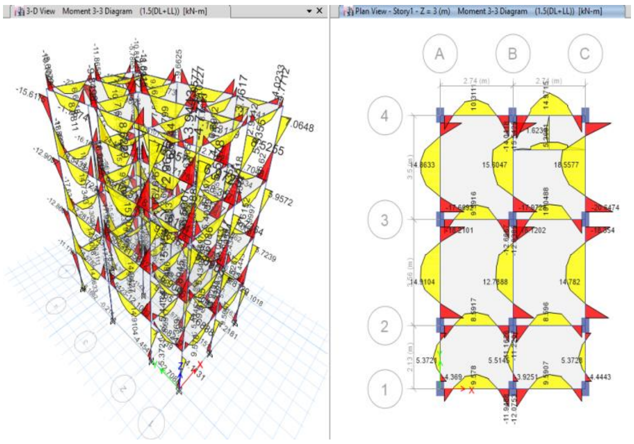

Fig.16. BMD of conventional building

SFD and BMD of Light Weight Building

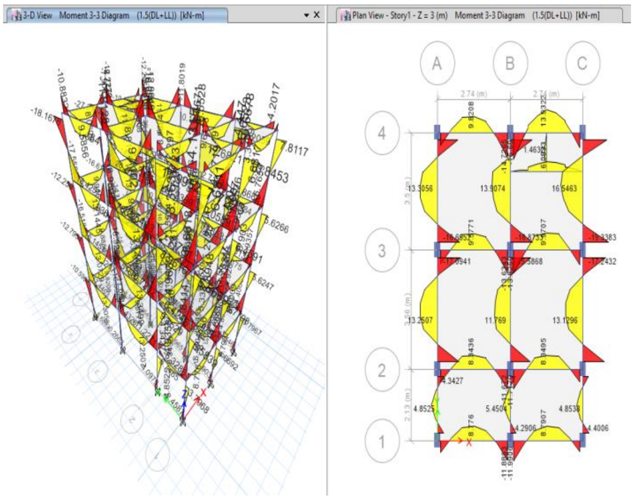

Fig.17. SFD of Light weight building

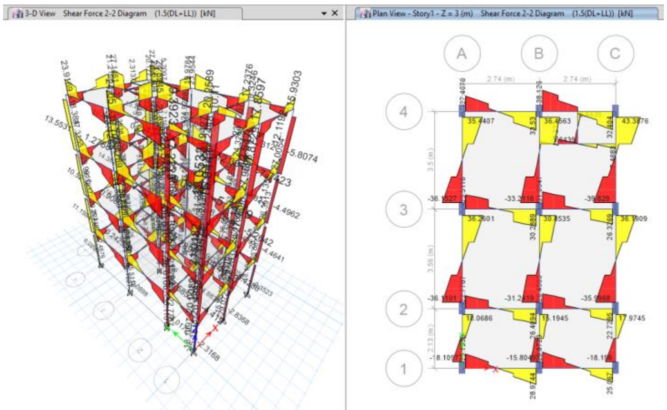

Fig.18. BMD of Light weight building

Deformed Shapes

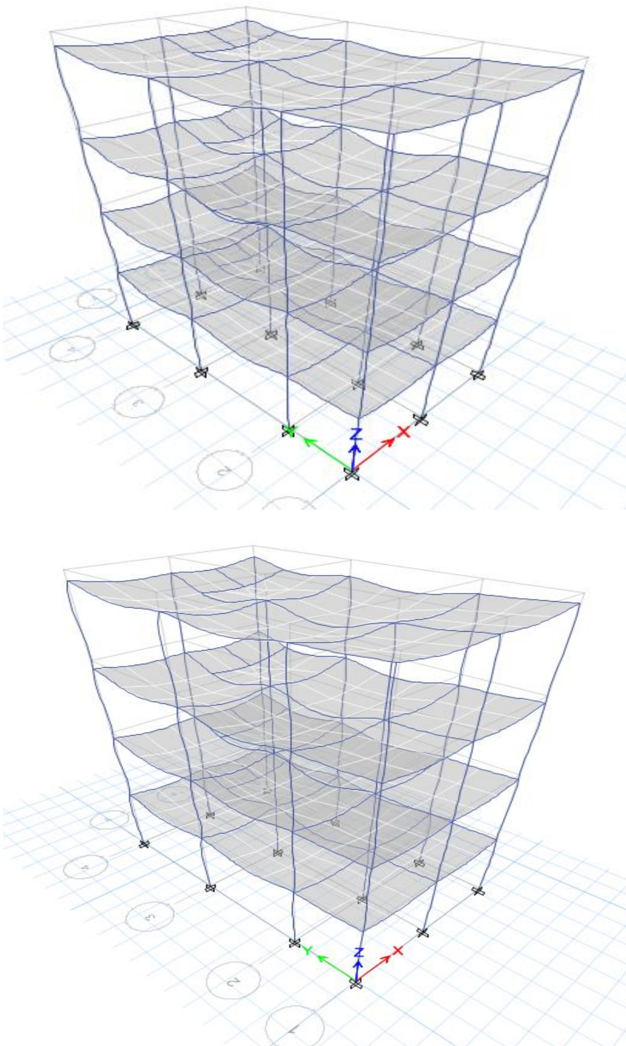

Fig.19. Displacements of Conventional and Light Weight Buildings

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DESIGN RESULTS

Longitudinal reinforcement for different stories of conventional building

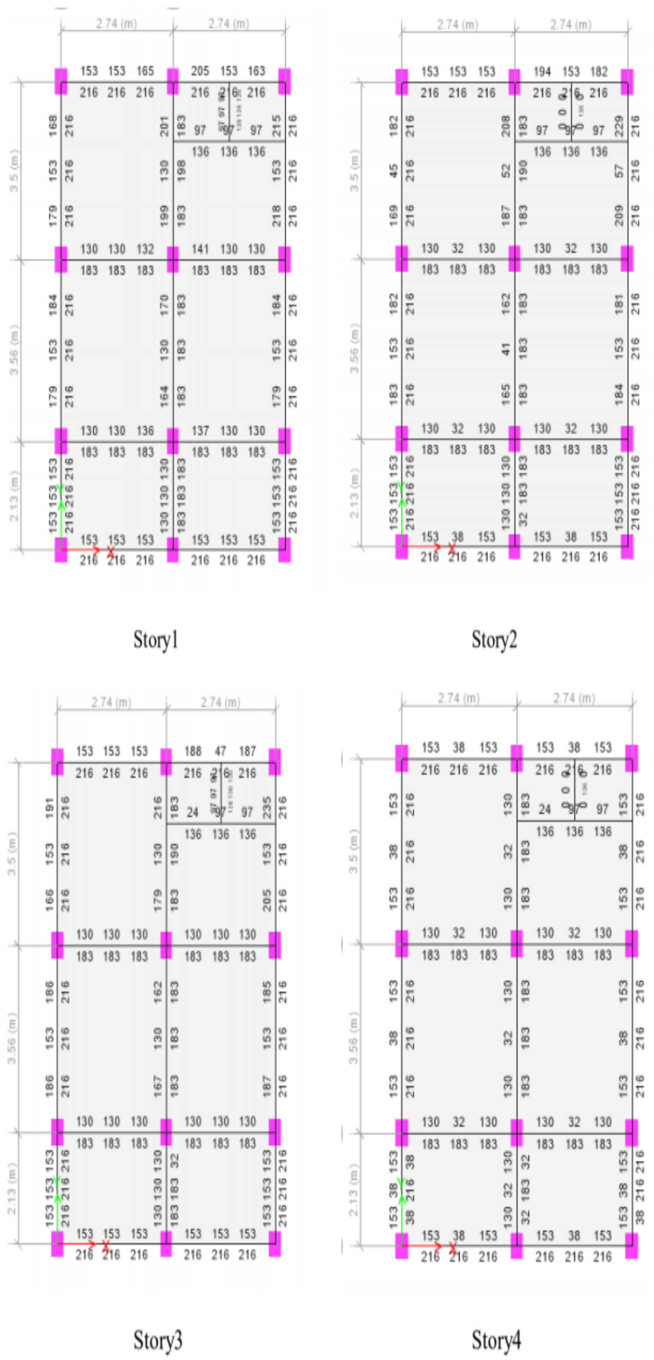

Fig.20. Plan views of longitudinal reinforcement details of different stories

Longitudinal Reinforcement for Different Stories of Light Weight Building

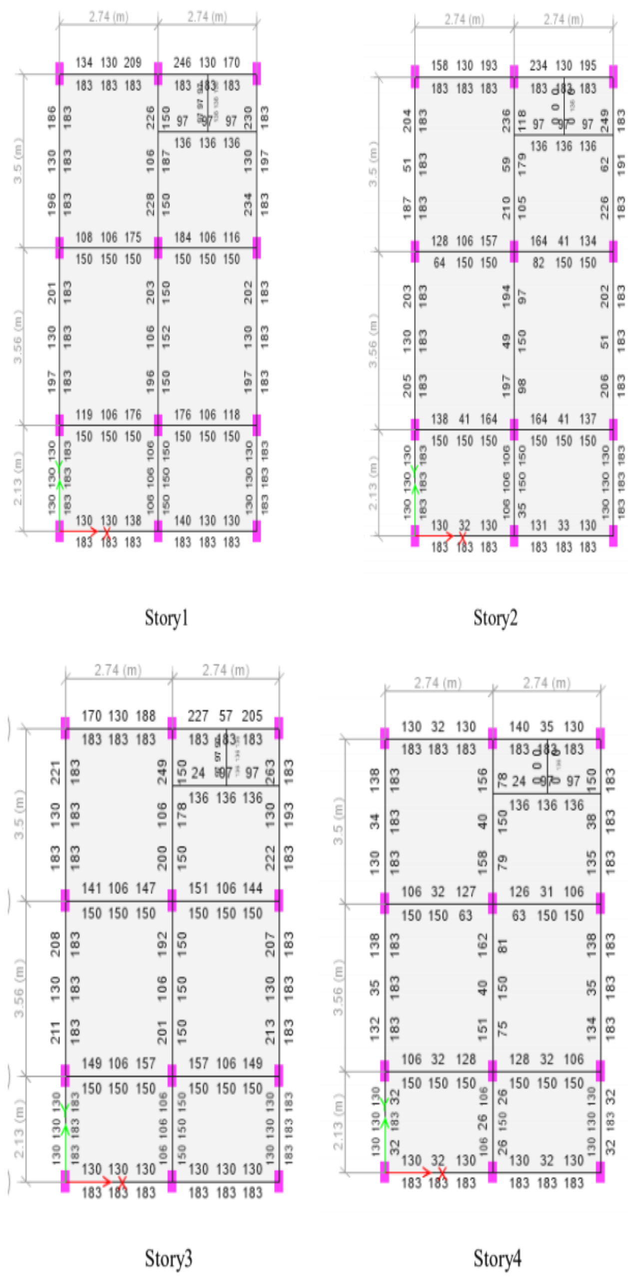

Fig.21. Plan views of longitudinal reinforcement details of different stories

Rebar percentage for Different Stories of Conventional Building

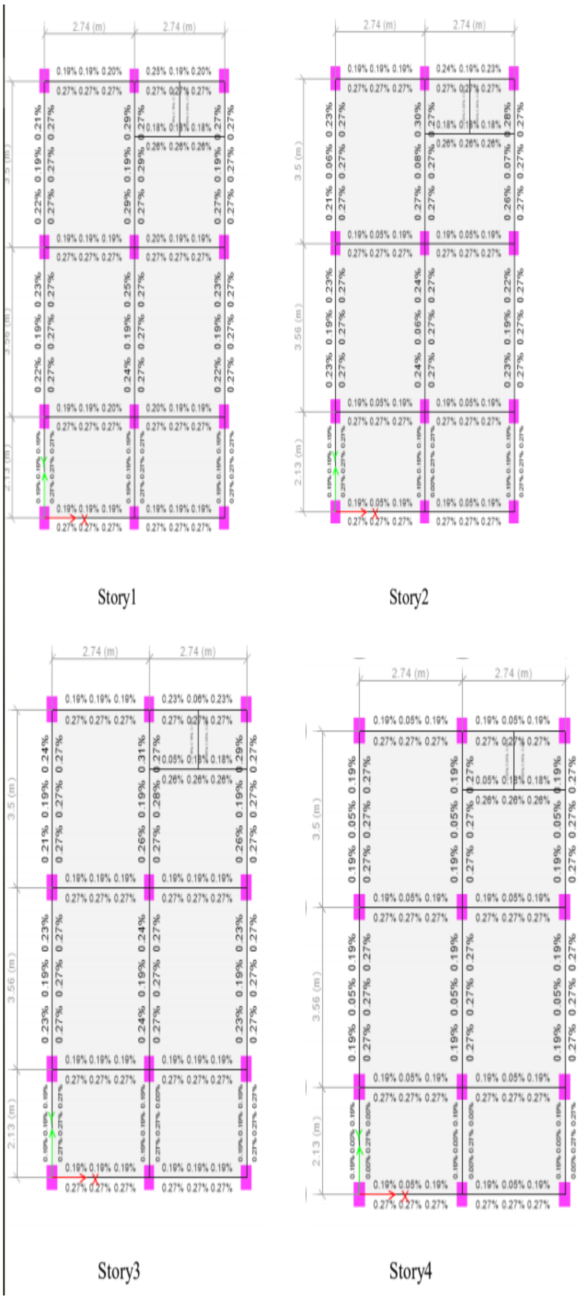

Fig.22. Plan views of Rebar Percentage of different stories

Rebar percentage for Different Stories of Light Weight Building

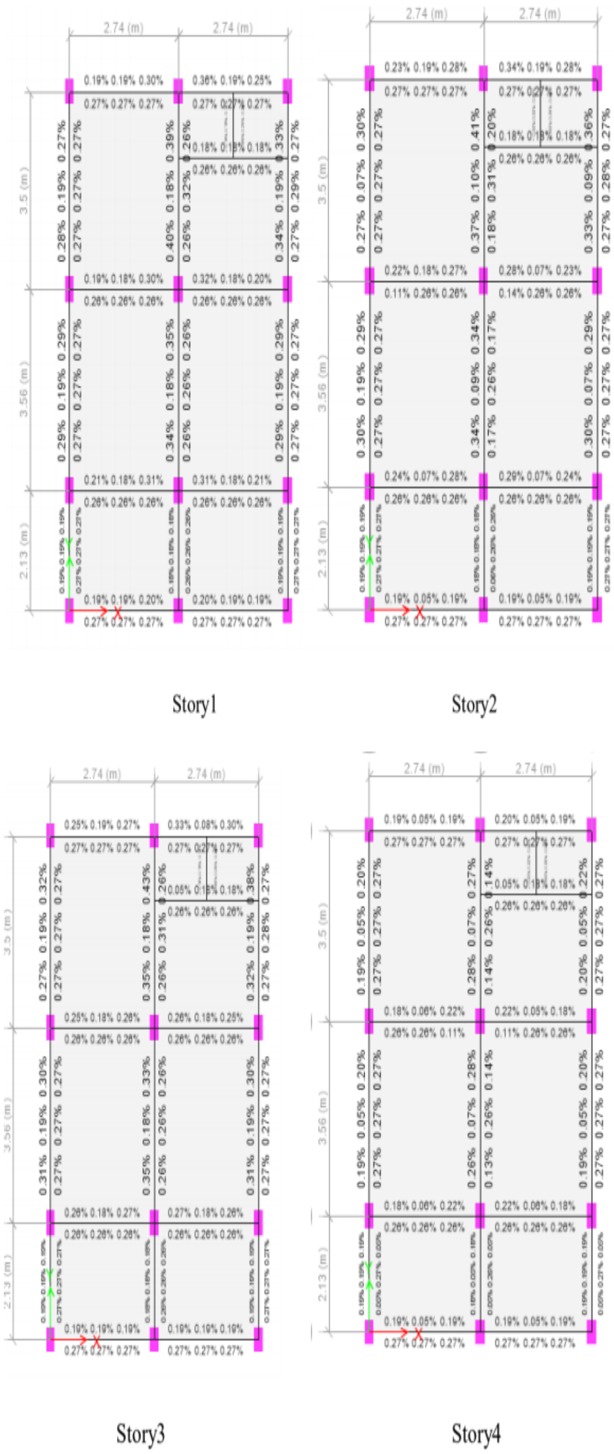

Fig.23. Plan views of Rebar Percentage of different stories

Shear Reinforcement for Different Stories of Conventional Building

https://doi.org/10.1051/e3sconf/202018401120

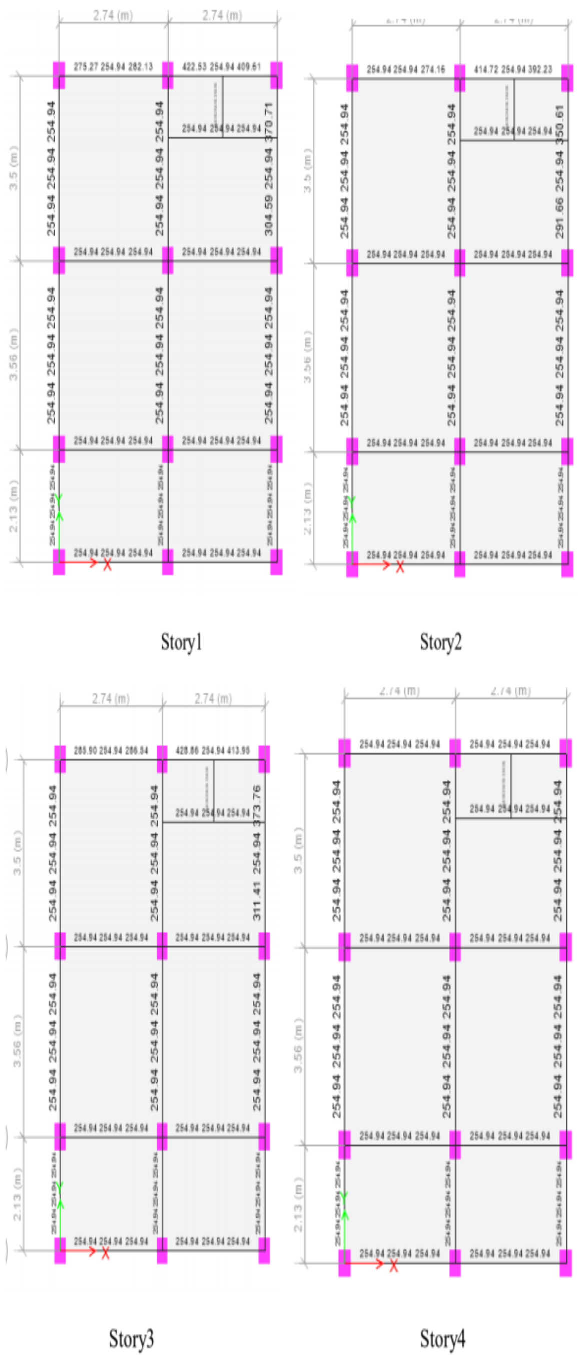

Fig.24. Plan views of Shear Reinforcement details of different stories

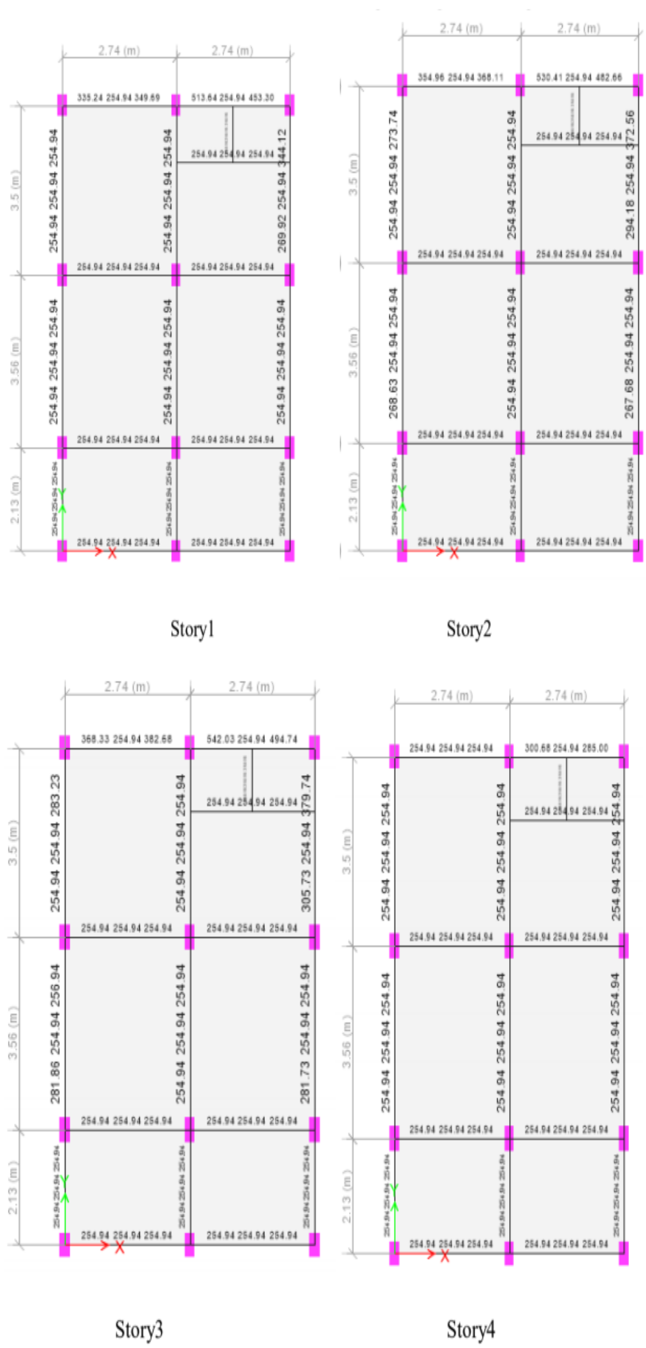

Fig.25. Plan views of Shear Reinforcement details of different stories

Shear Reinforcement for Different Stories of Light Weight Building

6. RESULTS AND DISCUSSIONS

Structural Modelling of Building in E-TABS 2017

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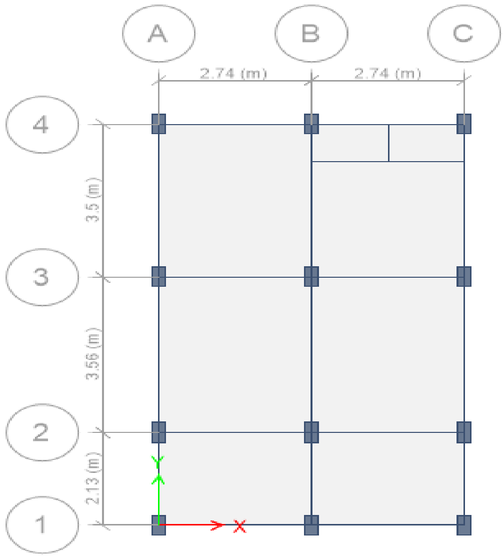

Fig.26. Plan of the model

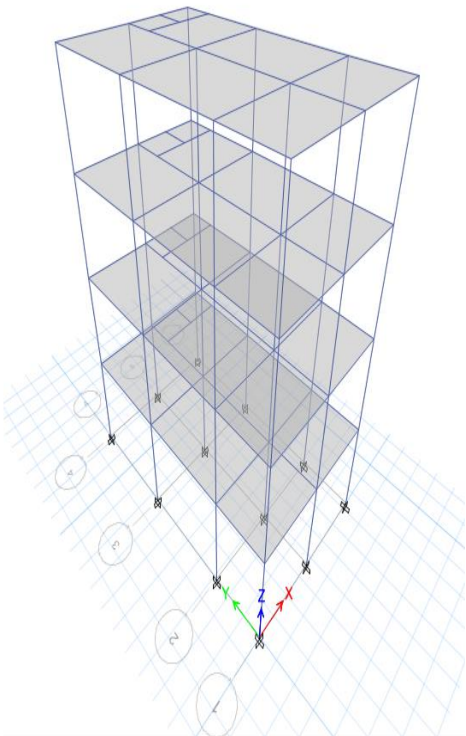

Fig.27. 3D view of the model

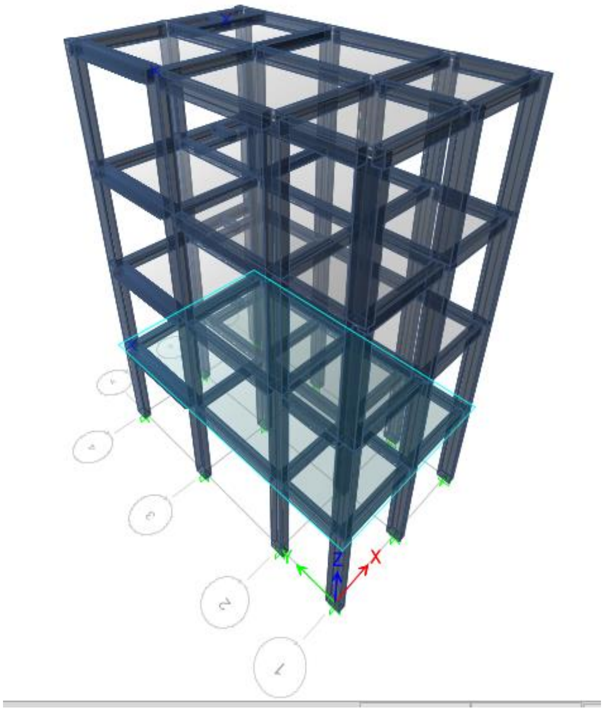

Fig.28. 3D-Render view of the model

Structural Details of a Building with Conventional and Light Weight Bricks at story 1

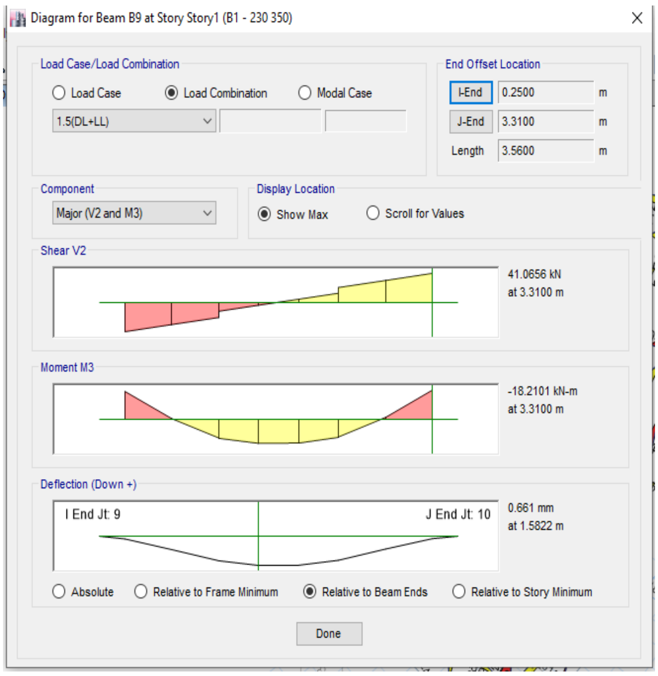

Fig.29. Maximum SF and BM of Beam B9 of conventional building

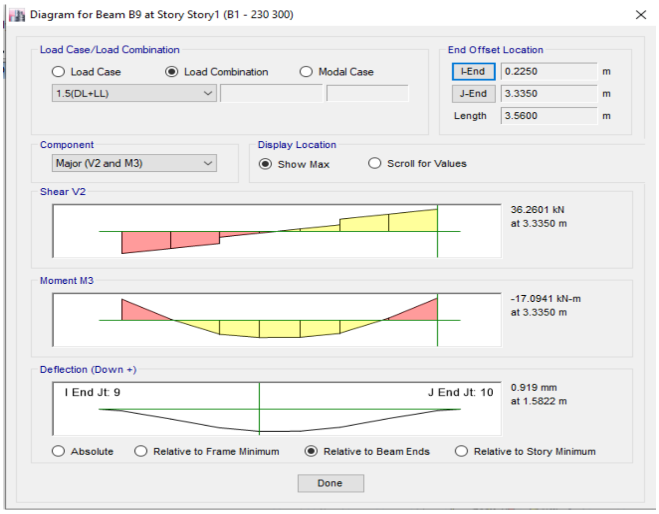

Fig.30. maximum SF and BM of Beam B9 of Light Weight building

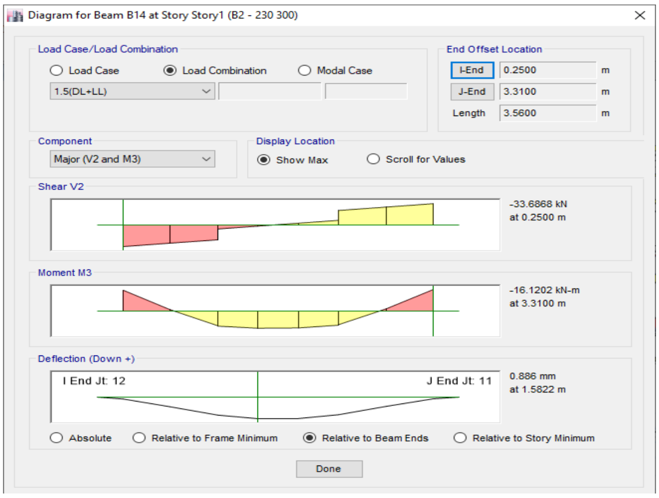

Fig.31. Maximum SF and BM of Beam B14 of conventional building

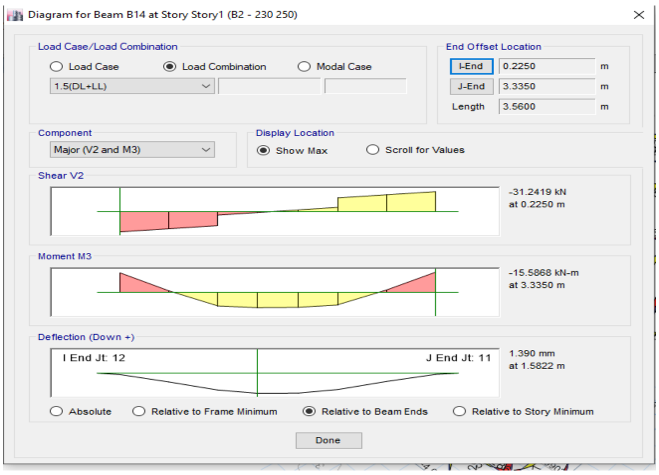

Fig.33. maximum SF and BM of column C1 of conventional building

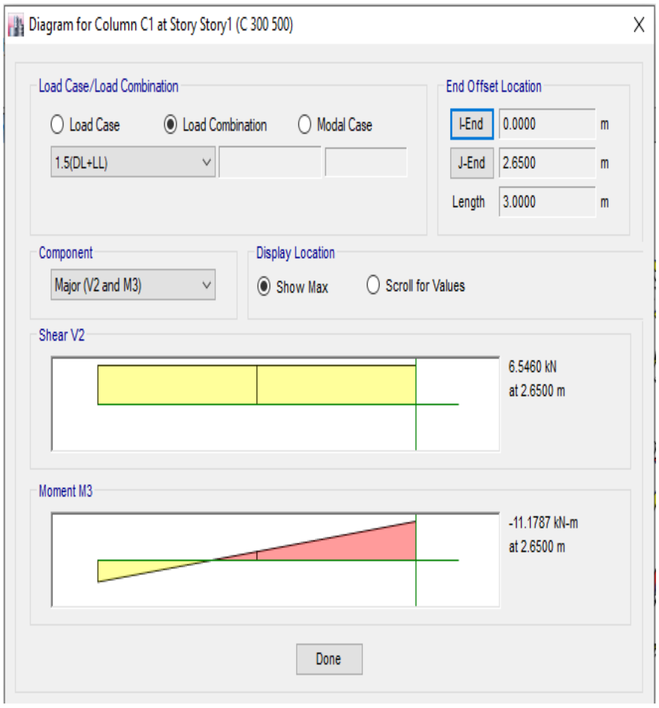

Fig.34. maximum SF and BM of Beam B14 of Light Weight building

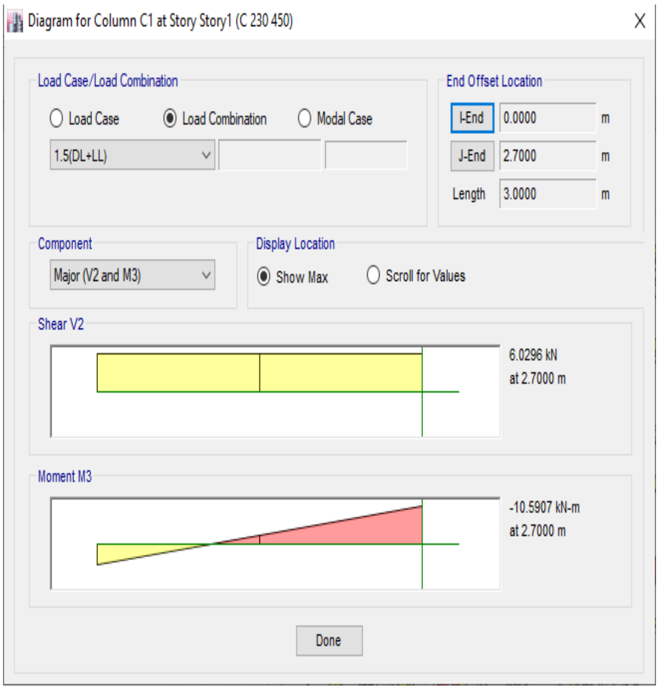

Fig.35. maximum SF and BM of column C1 of Light Weight building

Fig.36. maximum SF and BM of Column C7 of conventional building

Fig.37. maximum SF and BM of Column C7 of Light Weight building

ANALYSIS RESULTS

Percentage of reduction in BM and SF in Corner Beam9 from figures 6.4 & 6.5:

- ➢ From the analysis 6.15% of shear force is reduced in light weight bricks when compared to conventional bricks.
- ➢ Where as 11.690% of bending moment is reduced in beam.

Percentage of reduction in BM and SF in Corner Column1 from figures 6.8 & 6.9:

- ➢ From the analysis 5.260% 0f shear force is reduced in light weight bricks when compared to conventional bricks.
- ➢ Where as 7.897% of bending moment is reduced in column.

Percentage of reduction in BM and SF in Intermediate Beam14 from figures 6.6 & 6.7:

- ➢ From the analysis 3.312% of shear force is reduced in light weight bricks when compared to conventional bricks
- ➢ Where as 7.244% of bending moment is reduced in beam

Percentage of reduction in BM and SF in Intermediate Column7 from figures 6.10 & 6.11:

- ➢ From the analysis 17.43% 0f shear force is reduced in light weight bricks when compared to conventional bricks.
- ➢ Where as 17.21% of bending moment is reduced in column.

DESIGN DATA

Concrete Frame Design

- **Column details**

Table 12. Conventional Brick Column Summary

Story	Label	Station mm	Load combinations	At v major mm^2/m	At v minor mm^2/m
Story 1	C1	0	1.5(DL+LL)	332.53	554.22
Story 1	C1	1325	1.5(DL+LL)	332.53	554.22
Story 1	C1	2650	1.5(DL+LL)	332.53	554.22
Story 1	C7	0	1.5(DL+LL)	332.53	554.22
Story 1	C7	1350	1.5(DL+LL)	332.53	554.22
Story 1	C7	2700	1.5(DL+LL)	332.53	554.22

Table 13. Light Weight Brick Column Summary

Story	Label	Station mm	Load combinations	At v major mm2/m	At v minor mm2/m
Story 1	C1	0	1.5(DL+LL)	254.94	498.8
Story 1	C1	1350	1.5(DL+LL)	254.94	498.8
Story 1	C1	2700	1.5(DL+LL)	254.94	498.8
Story 1	C7	0	1.5(DL+LL)	254.94	498.8
Story 1	C7	1375	1.5(DL+LL)	254.94	498.8
Story 1	C7	2750	1.5(DL+LL)	254.94	498.8

- **Corner Beam – B9**

Table 14. Conventional Brick Corner Beam Summary

Story	Label	Station mm	Design section	Load combinations	As top mm2	As bottom mm2
Story 1	B9	250	230 x 350	1.5(DL+LL)	179	216
Story 1	B9	718.3	230 x 350	1.5(DL+LL)	153	216
Story 1	B9	1186.7	230 x 350	1.5(DL+LL)	153	216
Story 1	B9	1186.7	230 x 350	1.5(DL+LL)	153	216
Story 1	B9	1582.2	230 x 350	1.5(DL+LL)	153	216
Story 1	B9	1977.8	230 x 350	1.5(DL+LL)	153	216
Story 1	B9	2373.3	230 x 350	1.5(DL+LL)	153	216
Story 1	B9	2373.3	230 x 350	1.5(DL+LL)	153	216
Story 1	B9	2841.7	230 x 350	1.5(DL+LL)	153	216
Story 1	B9	3310.0	230 x 350	1.5(DL+LL)	184	216
					1587	**2160**

Table 15. Light Weight Brick Corner Beam Summary

Story	Label	Station mm	Design section	Load combinations	As top mm2	As bottom mm2
Story 1	B9	225	230 x 300	1.5(DL+LL)	197	183
Story 1	B9	705.8	230 x 300	1.5(DL+LL)	130	183
Story 1	B9	1186.7	230 x 300	1.5(DL+LL)	130	183
Story 1	B9	1186.7	230 x 300	1.5(DL+LL)	130	183
Story 1	B9	1582.2	230 x 300	1.5(DL+LL)	130	183
Story 1	B9	1977.8	230 x 300	1.5(DL+LL)	130	183
Story 1	B9	2373.3	230 x 300	1.5(DL+LL)	130	183
Story 1	B9	2373.3	230 x 300	1.5(DL+LL)	130	183
Story 1	B9	2854.2	230 x 300	1.5(DL+LL)	130	183
Story 1	B9	3335	230 x 300	1.5(DL+LL)	201	183
					1438	**1830**

- **Intermediate Beam – B14**

Table 16. Conventional Brick Intermediate Beam Summary

Story	Label	Station mm	Design section	Load combinations	As top mm2	As bottom mm2
Story 1	B14	250	230 x 300	1.5(DL+LL)	164	183
Story 1	B14	718.3	230 x 300	1.5(DL+LL)	130	183
Story 1	B14	1186.7	230 x 300	1.5(DL+LL)	130	183
Story 1	B14	1186.7	230 x 300	1.5(DL+LL)	130	183
Story 1	B14	1582.2	230 x 300	1.5(DL+LL)	130	183
Story 1	B14	1977.8	230 x 300	1.5(DL+LL)	130	183
Story 1	B14	2373.3	230 x 300	1.5(DL+LL)	130	183
Story 1	B14	2373.3	230 x 300	1.5(DL+LL)	130	183
Story 1	B14	2841.7	230 x 300	1.5(DL+LL)	130	183
Story 1	B14	3310.0	230 x 300	1.5(DL+LL)	170	183
					1374	**1830**

Table 17. Light Weight Brick Intermediate Beam Summary

Story	Label	Station mm	Design section	Load combinations	As top mm2	As bottom mm2
Story 1	B14	225	230 x 250	1.5(DL+LL)	196	150
Story 1	B14	705.8	230 x 250	1.5(DL+LL)	106	150
Story 1	B14	1186.7	230 x 250	1.5(DL+LL)	106	150
Story 1	B14	1186.7	230 x 250	1.5(DL+LL)	106	150
Story 1	B14	1582.2	230 x 250	1.5(DL+LL)	106	152
Story 1	B14	1977.8	230 x 250	1.5(DL+LL)	106	150
Story 1	B14	2373.3	230 x 250	1.5(DL+LL)	106	150
Story 1	B14	2373.3	230 x 250	1.5(DL+LL)	106	150
Story 1	B14	2854.2	230 x 250	1.5(DL+LL)	106	150
Story 1	B14	3335	230 x 250	1.5(DL+LL)	203	150
					1247	**1502**

DATA RESULTS

Corner Beam Details of Conventional Brick and Light Weight Bricks:

➢ From the above tables, we observed that the area of top reinforcement in light weight brick decreases upto 9.4% and also 15.28% area of bottom reinforcement decreased in light weight brick compared to conventional brick.

Intermediate Beam Details of Conventional Brick and Light Weight Bricks:

➢ From the above tables, we observed that the area of top reinforcement in light weight brick decreases upto 9.2% and also 17.92% area of bottom reinforcement decreased in light weight brick compared to conventional brick.

7. CONCLUSIONS

The following conclusions can be enumerated point wise as follows:

1. In Beams, considering light weight bricks effect, the values of bending moment, shear force, area of reinforcement is less compared to conventional bricks.
2. The bending moment in light weight bricks decreased upto 11% and also shear force in light weight bricks decreased upto 8.03%.so there is a reduction in the size of the sections.
3. The area of reinforcement in light weight bricks of columns decreased upto 16.66%
4. The area of reinforcement in light weight bricks of corner beams decreased upto 12.34% and area of reinforcement in light weight bricks of intermediate beams decreased upto 13.56%.

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