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Comparative Analysis of Filler Wall Interlock System Using Three Different Wall Material Using ETABS

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ABSTRACT

A reinforced concrete building with masonry infill is most common type of construction in India. Traditionally, conventional clay bricks or concrete blocks which are heavy rigid materials have been used as Infill wall. Though, AAC (aerated light weight concrete) blocks which are lightweight, flexible building materials that provides insulation and fire resistance and have lower impact on environment, can be used as masonry infill (MI) material in buildings. AAC blocks are now also available in India. A number of researchers have studied the behavior of AAC in-filled reinforced concrete (R/C) frames experimentally. Interlocking Bricks are even introduced further which adds an advantage over AAC bricks.

Hence in the report, comparative study of the effect of type of infill wall material on wind response of structure has been presented. AAC blocks, Interlocking Blocks and conventional clay bricks materials are used for the comparison. To check the behavior of RC frames with interlocking blocks, AAC block and conventional clay bricks infill, analysis has been done using ETABS. Three models are considered for comparison. One is infill with conventional bricks, 2nd is infill with AAC blocks and third is infill frame with open ground storey. To model the infill analytically, equivalent diagonal strut method is used. The ends of diagonal strut are pin jointed. Infill behaves like compression strut between column and beam and compression forces are transferred from one node to another. The analysis has been carried out for dead load (DL) live load (LL), and wind load. The results have shown that AAC block infill and interlocking blocks material behaves better under lateral loading than conventional brick. The study of the effect of types of infill materials used on the performance of RC infilled frames is still limited.

Index Terms: Interlocking Blocks, AAC block, Infill frame, Equivalent strut model.

I. INTRODUCTION

Reinforced concrete building with masonry infill is the most common type of construction in India. Masonry walls are provided for functional and architectural point of view and thus they are generally considered as nonstructural elements. Hence interaction of infill with bonding frame is neglected in the design. Though an infill panel interacts with the bonding frame and may induce a load resistance mechanism when subjected to lateral loads. Influence of infill is ignored in modeling of the RC structure which leads to inaccuracy in guessing the actual seismic behavior of framed structures. Infilled frame shows a composite structure which is made by the combination of both RC frame and Infill walls. The Infill walls in infilled frame may be of conventional clay brick, concrete block or AAC block. The study of the influence of types of infill materials on the seismic response of infilled RC frames is still limited.

Thus, in present study focus is given on the effect of type of material on wind performance. AAC blocks, Interlocking Blocks and clay bricks are used as infill in RC frame. AAC blocks are light-weight building materials that provide insulation and fire resistance and have lower impact on environment.

Behaviors of in-filled RC frames have been studied by number of researchers experimentally and analytically. Conclusion is made by them that infill materials influence the lateral response of the in-filled frame significantly. Infill materials improve the performance of RC frame structure. An infill wall decreases lateral deflections, storey drift and bending moments in the frame and increases axial forces in the column thus reduce the probability of collapse. Hence, considering the infill leads to slender frame members in design, reducing the overall cost of the structural system.

1.2 Masonry Infill

The infill wall is the supported wall that closes the perimeter of a building constructed with a three-dimensional framework structure (generally made of steel or reinforced concrete). Therefore, the structural frame ensures the bearing function, whereas the infill wall serves to separate inner and outer space, filling up the boxes of the outer frames. The infill wall has the unique static function to bear its own weight. The infill wall is an external vertical opaque type of closure. With respect to other categories of wall, the infill wall differs from the partition that serves to separate two interior spaces, yet also non-load bearing, and from the load bearing wall. The latter performs the same functions of the infill wall, hygro-thermally and acoustically, but performs static functions too. The use of masonry infill walls, and to some extent veneer walls, especially in reinforced concrete frame structures, is common in many countries. In fact, the use of masonry infill walls offers an economical and durable solution. They are easy to build, attractive for architecture and have a very efficient cost-performance.

Today, masonry enclosures and partition walls are mainly made of clay units, but also aggregate concrete units (dense and lightweight aggregate) and autoclaved aerated concrete units are used. More recently, industry is also trying to introduce wood concrete blocks. Partition walls, made with both vertically and horizontally perforated clay blocks, represent two-thirds of the corresponding market.

Fig 1 Masonry Infill

II. Objectives of the research

Following are the object of this study:

- To study the effects of infill materials on the behavior of RC frame under lateral loading.
- To evaluate the behavior of RC frames infilled with AAC blocks as the lightweight materials and clay brick simulating lateral forces and compare the results in terms of Displacement, Column forces, Beam forces, Storey shear, Base shear and Storey drift.
- To evaluate the behavior of RC frames infilled with interlocking blocks simulating lateral forces and compare the results in terms of Displacement, Column forces, Beam forces, Storey shear, Base shear and Storey drift.
- To find out green and environmentally safe materials such as AAC blocks which can be used in place of conventional bricks and perform better in seismic prone areas.
- To find out effect of infill masonry frame in reinforced concrete buildings compared to bare frame under extreme wind prone area.
- To compare the different parameters such as deflection, storey drift, storey shear, axial forces and base shear in bare frame and infill frame.

III. LITERATURE REVIEW

Ashish Patil and Dr. Ajay G. Dhake (2021) research paper examined the layout notion of the interconnecting structure block and its application as a wall. The walls have their strength characteristics tested using ansys software. Similarly, the use of the particular interconnecting construction block below does not raise electricity more handy, but further minimises the amount of human effort. Such blocks may transfer from one location to another without any problem. The concrete grade M50 has been used for block instruction in the software application.

When comparing the RCC wall with the concrete wall triggered, the strain on the precast wall is significantly less than the RCC wall. The simplified building cycle reduces time, boosts productivity, reliability and efficiency and reduces costs. Precast Construction provides an extended lifetime and reduced maintenance costs. Precast concrete is more densely resistant to chemical attack, erosion, shock, ground suction and is dust-resistant.

Irfan Khan et.al (2021) research paper tested the computational modeling of Dry-Stack Block Masonry (DSM) walls subjected to cyclic monotonic loading. The analytical results were compared with experimental test results of the unreinforced and unconfined DSM cantilever walls subjected to lateral loading along with a constant axial load. ABAQUS has been used for Finite Element Modelling and analysis of the wall. Various material properties are defined for the wall in the software and modelled as a homogeneous material.

The results obtained from experimental work and numerical analysis using ABAQUS, of DSM walls showed a well-defined similarity in behaviour in the elastic range. The damage patterns of experimental and numerical model for monotonic lateral displacement are closely matching, which shows the authenticity of the Finite Element Package. The monotonic response of multi-story DSM can be predicted accurately based on the results of the ABAQUS software. Though the pattern of Hysteresis loop, obtained from ABAQUS does not accurately match with the experimental plot, yet the cyclic behaviour of DSM can be predicted. The plastic strains match with the corresponding experimental diagonal cracks for cyclic loading.

IV. Steps of Modelling and Analysis

Step 1- the research papers from researchers were summarized at the beginning of the project in order to study the research done till date. Seismic analysis and wind analysis was conducted from different authors considered different types of infill system to understand the behaviour of the structure.

Step 2- ETABS support the option of quick template as per the grip system, here G+14 storey structure is considered with typical storey height is 3m and Bottom storey height us 3m.

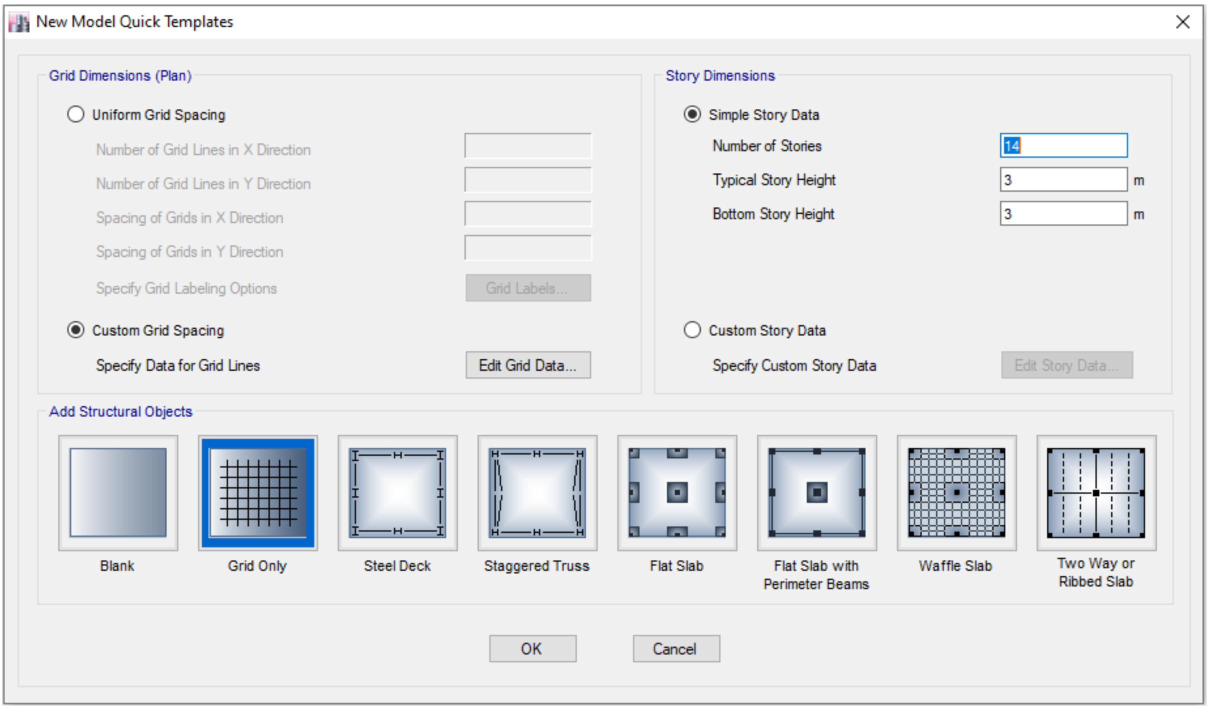

Fig 3.1 New Model Quick Templates

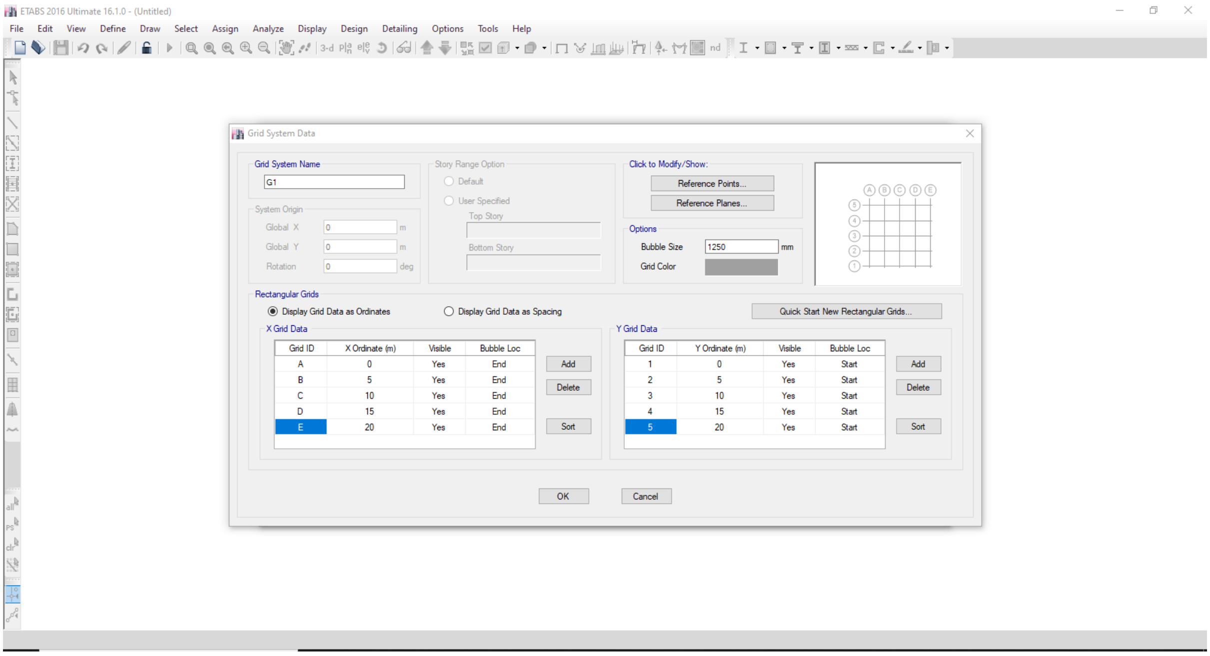

Fig 3.2 Grid System

Step 3- The frame is designed using ETABS in X and Y direction for G+14 storey structure where the height is defined in Z direction. The gap in the grid along the X and Y direction is 5m.

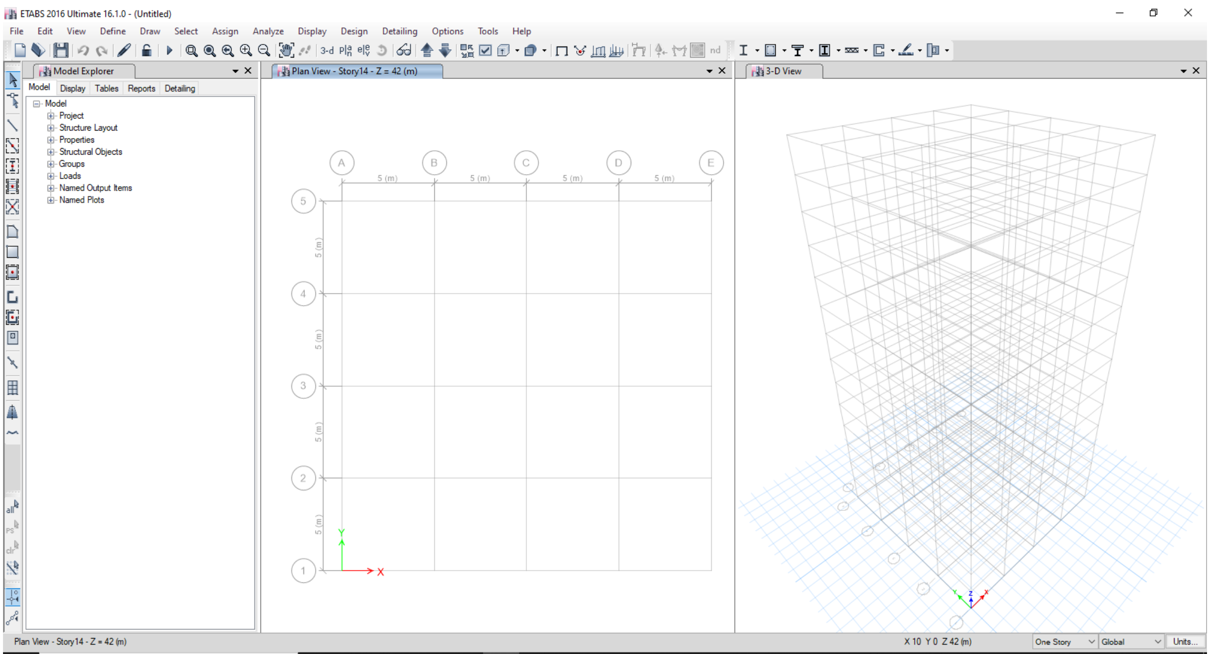

Fig 3.3 Design of the Frame

Step 4- Defining the properties of material for concrete, steel, slab and properties of infill. Here in this research, M30 concrete and HYSD 415 rebar is considered.

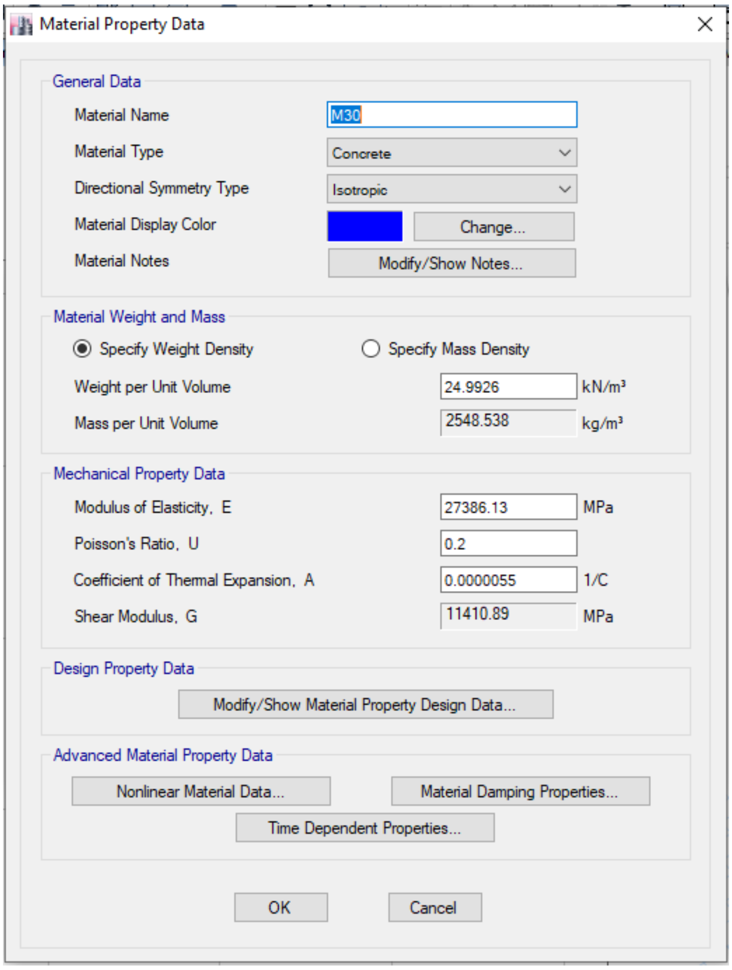

Fig 3.4 Material Property of Concrete

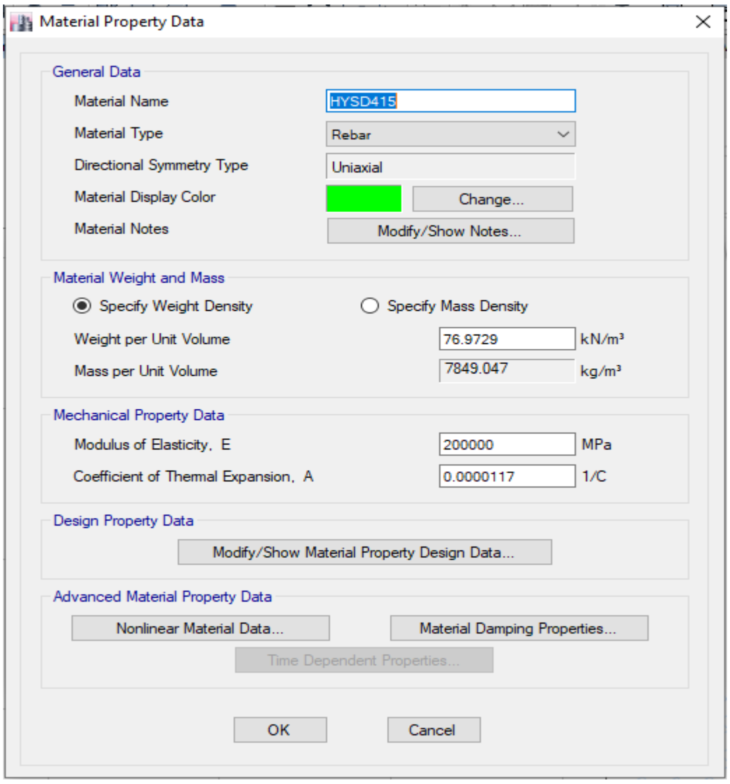

Fig 3.5 Material Property of Rebar

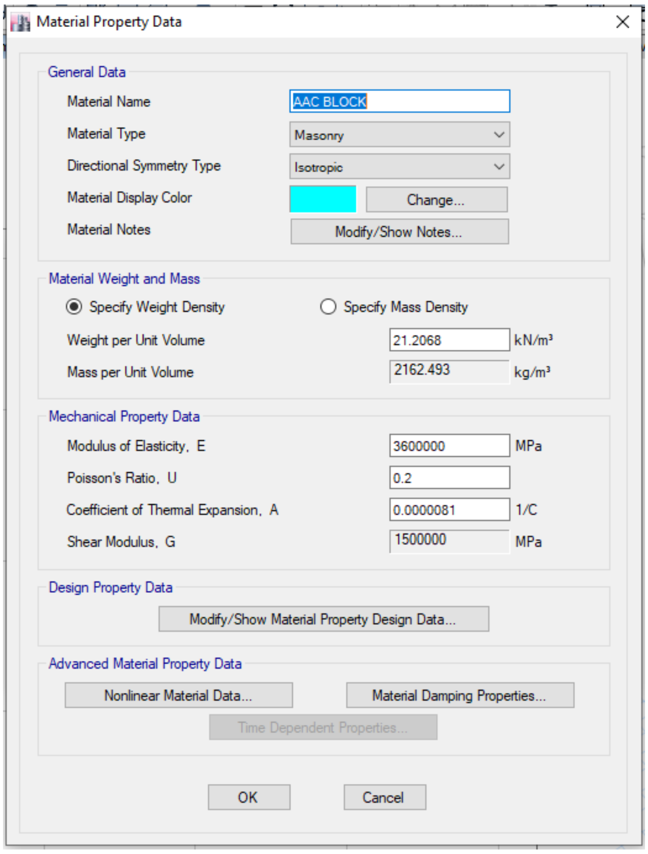

Fig 3.6 Material Property for AAC block

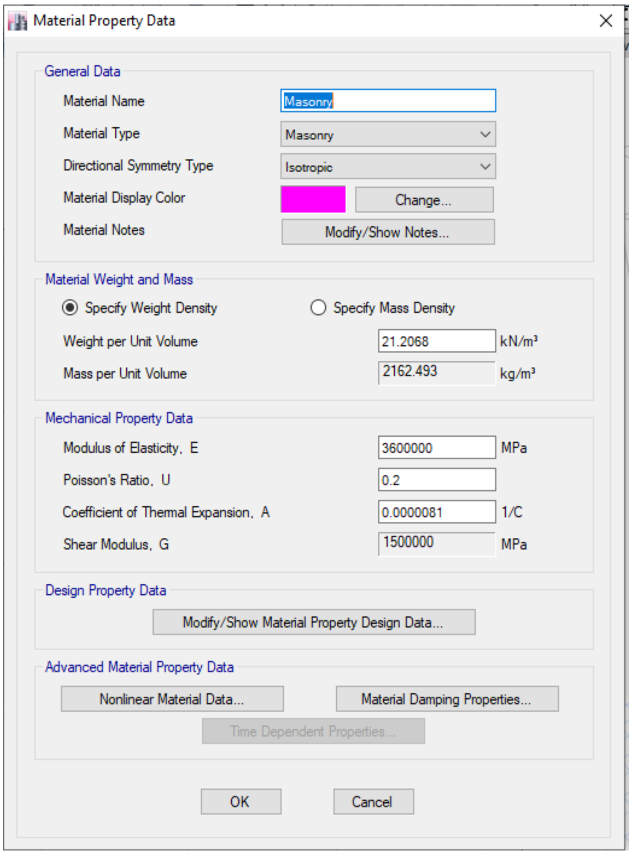

Fig 3.7 Property for Masonry Wall

Step 5- Defining section properties for beam, column, slab and infill wall.

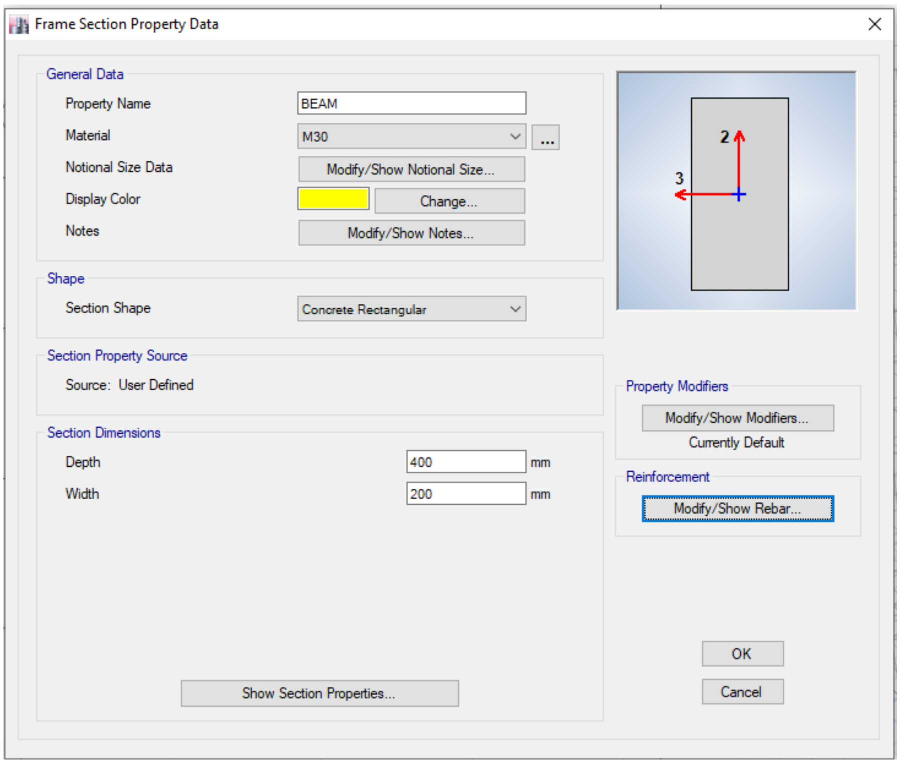

Fig 3.8 Section Property of Beam

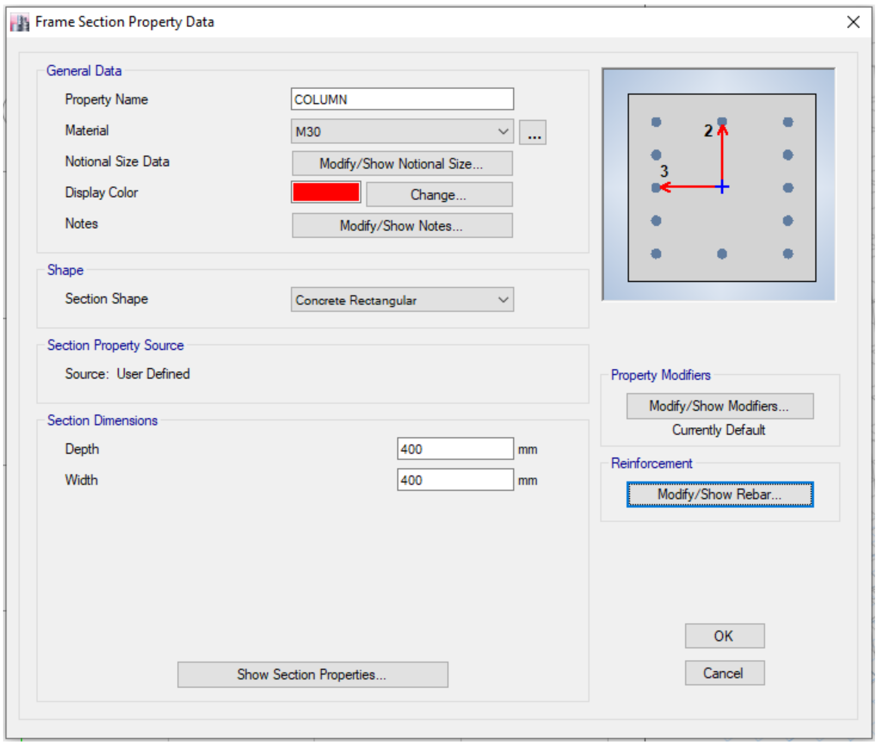

Fig 3.9 Section Property of Column

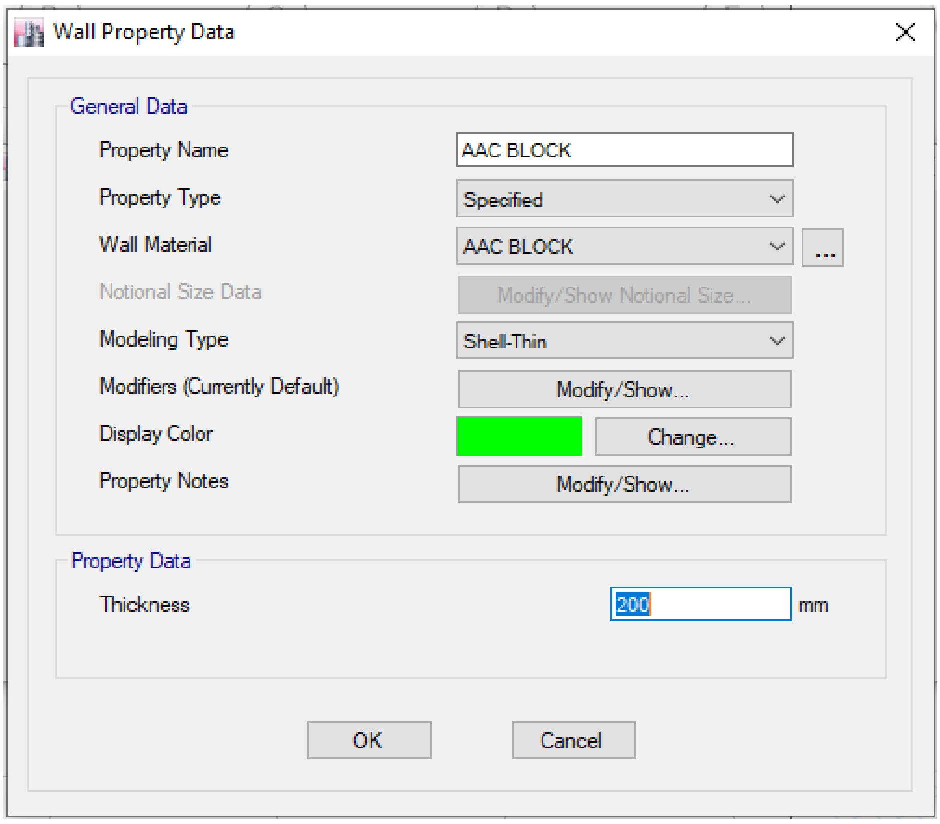

Fig 3.10 Data of Wall Property for AAC block

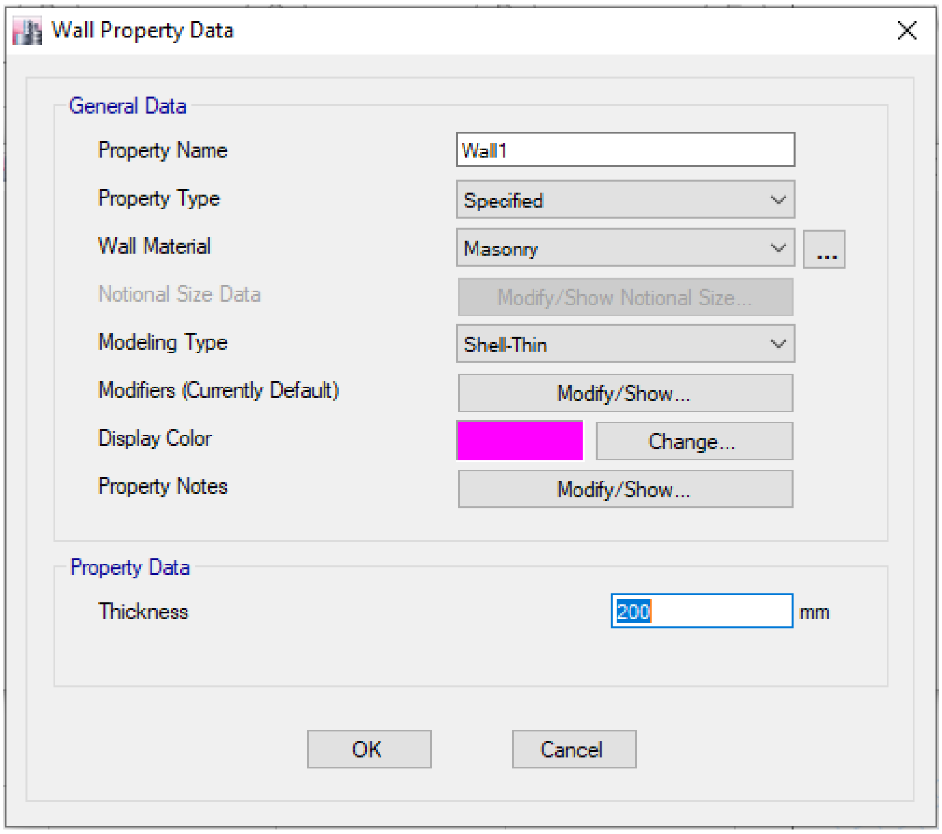

Fig 3.11 Data of Wall Property for Masonry Wall

Step 6- Assigning Fixed Support at bottom of the structure for X, Y and Z direction

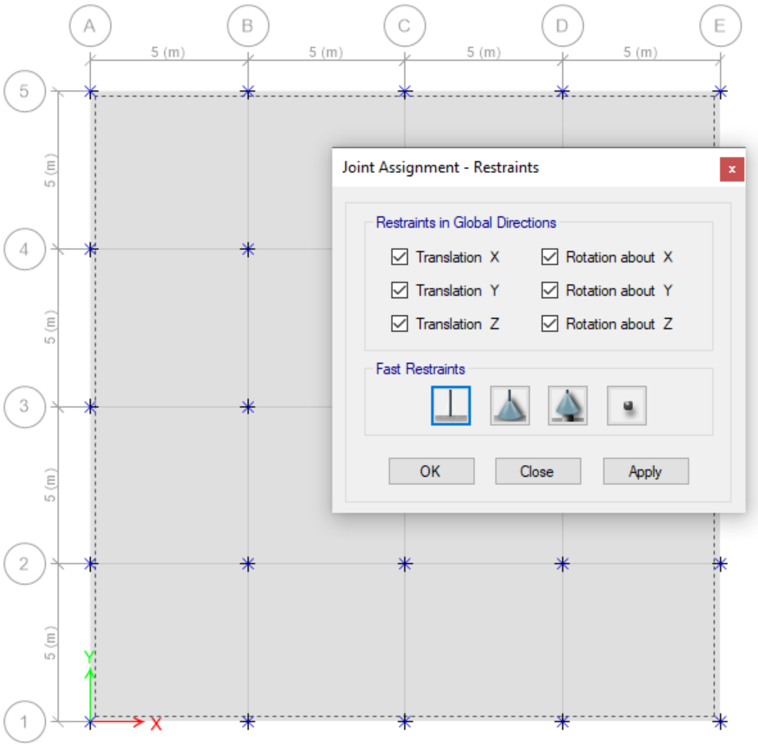

Fig 3.12 Defining Support Condition

Step 7- Defining Load combination, load pattern and and assigning wind load as per IS 875:2015.

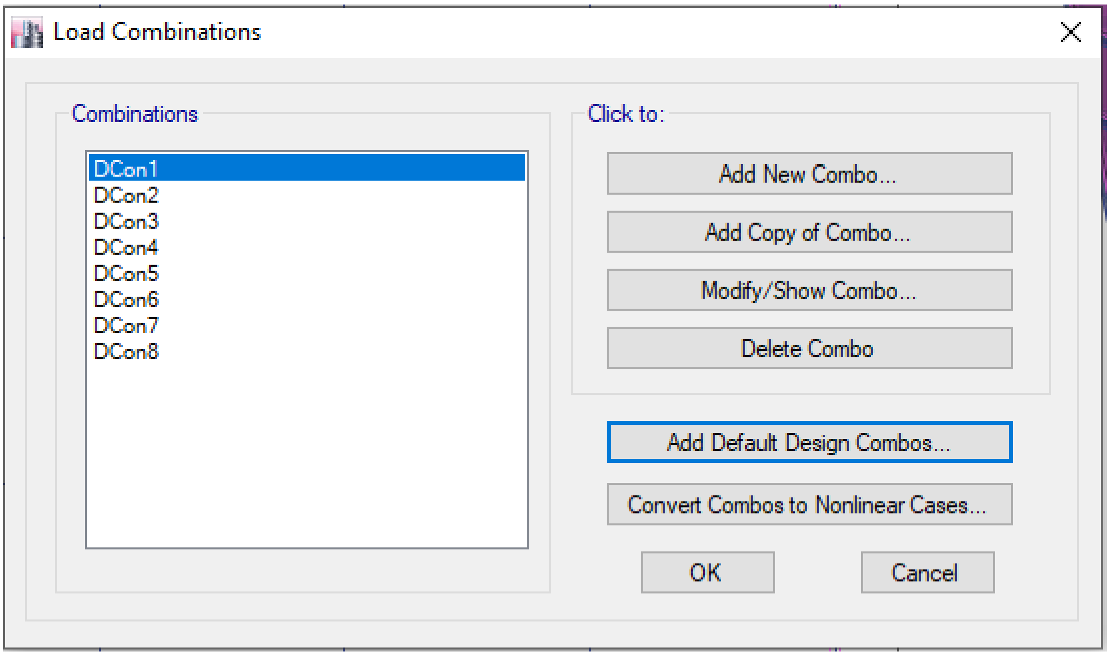

Fig 3.13 Load Combination

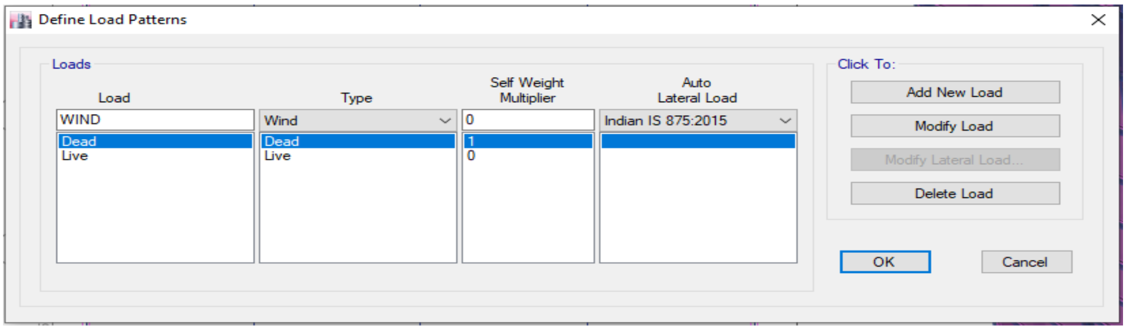

Fig 3.14 Defining Load Pattern

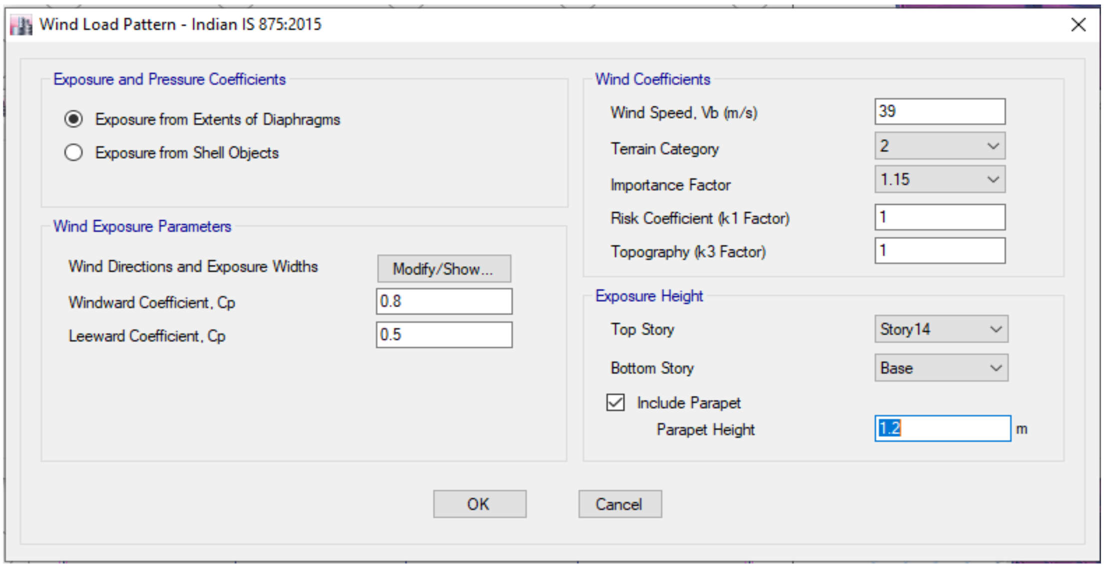

Fig 3.15 Wind Load as per IS 875:2015.

Step 8- Analyzing the structure on parameters of displacement, shear force, bending moment, axial force and base shear.

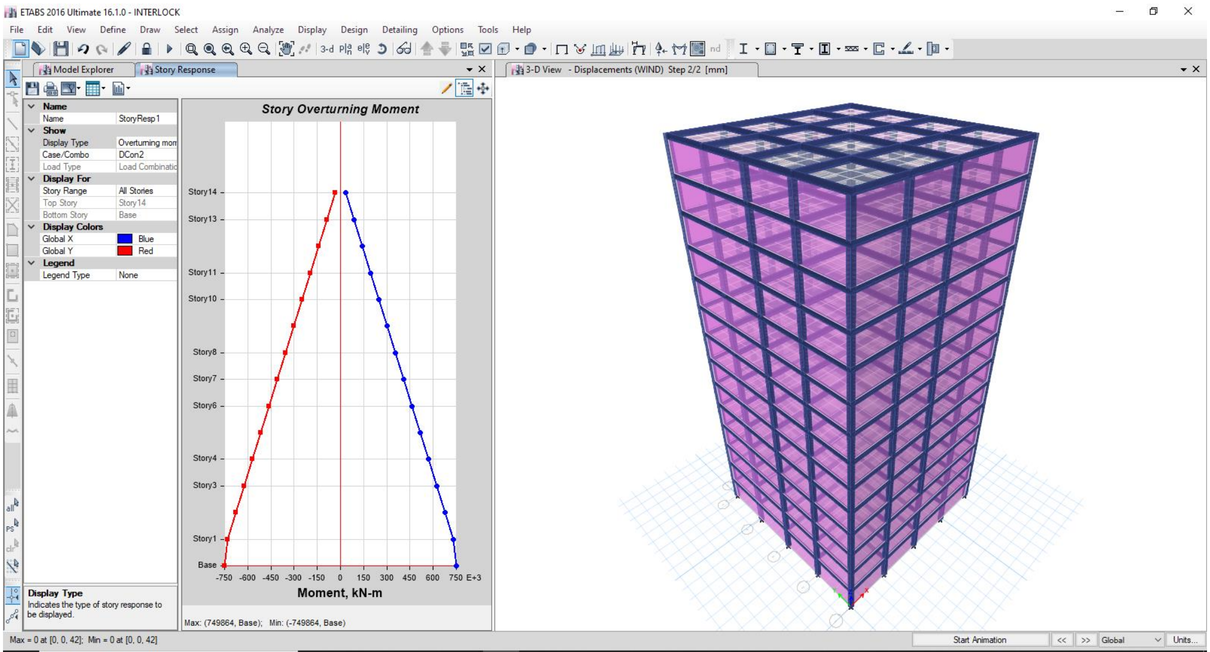

Fig 3.16 Overturning Moment

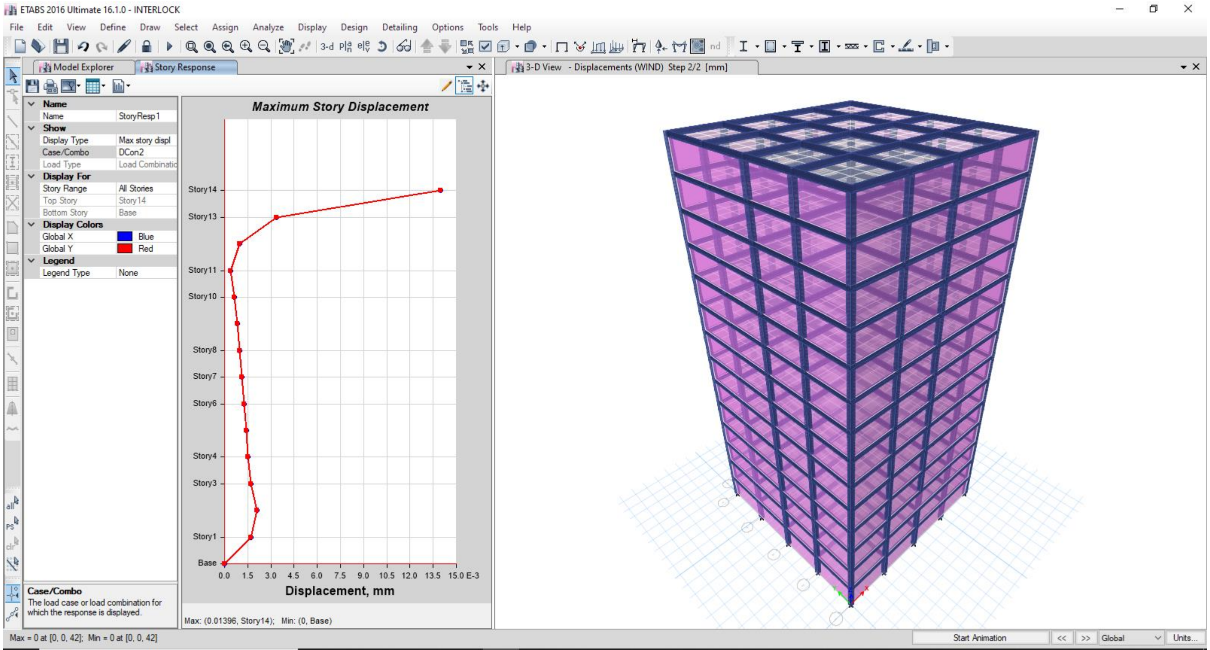

Fig 3.19 Storey Displacement

Step 9- The last step involves tabulation of results obtained from the analysis and presenting a comparative analysis of all the three cases considering the same loading conditions.

Table 1 Geometrical Properties

Type of Structure	G+14
Plan dimensions	13.62 m × 16.30 m
Height of each storey	3 m
Foundation Level to ground	3 m
Size of beams	400x200 mm
Size of Column	400x400 mm
thickness of slab	200 mm
AAC wall Thickness	200 mm
Masonry wall thickness	200 mm
Interlocking Wall Thickness	200 mm

ANALYSIS RESULT:

Table 2 Storey Displacement in mm

Storey displacement in mm			
Floor	Masonry Infill	AAC Block Infill	Interlocking Block Infill
Storey 14	27	25	24
Storey 13	23	22	21

Storey 12	20	18	17
Storey 11	17	16	15
Storey 10	14	13	12
Storey 09	13	12	11
Storey 08	12	11	10
Storey 07	10	9	8
Storey 06	9	8	7
Storey 05	7	7	6
Storey 04	5	5	4
Storey 03	4	3	3
Storey 02	2	2	2
Storey 01	1	1	1
Base	1	1	1

Table 3 Storey Drift in mm

Storey drift in mm			
Floor	Masonry Infill	AAC Block Infill	Interlocking Block Infill
Storey 14	0.000239	0.000222	0.000201
Storey 13	0.000369	0.000336	0.000334
Storey 12	0.00047	0.000425	0.000421
Storey 11	0.000533	0.000483	0.000481
Storey 10	0.000599	0.000514	0.000509
Storey 09	0.000639	0.00061	0.00059
Storey 08	0.000701	0.000689	0.000681
Storey 07	0.000659	0.000623	0.00062
Storey 06	0.00061	0.000583	0.00058
Storey 05	0.000563	0.00052	0.00049
Storey 04	0.000538	0.000505	0.000501
Storey 03	0.000491	0.000474	0.000469
Storey 02	0.000432	0.000433	0.000435
Storey 01	0.0003	0.000308	0.000309
Base	0.0003	0.000308	0.00031

Table 4 Axial Force in kN in column

Axial Force in kN in column			
Floor	Masonry Infill	AAC Block Infill	Interlocking Block Infill
Storey 14	352.23	266.99	164.101
Storey 13	771.56	556.98	454.091
Storey 12	1162.15	825.63	722.741
Storey 11	1529.37	1077.3	974.411
Storey 10	1875.09	1313.05	1210.161
Storey 09	2200.56	1533.74	1430.851
Storey 08	2505.93	1739.45	1636.561
Storey 07	2790.16	1929.53	1826.641
Storey 06	3052	2102.97	2000.081
Storey 05	3280.1	2254.83	2151.941
Storey 04	3327.98	2367.09	2264.201
Storey 03	3579.09	2579.21	2476.321
Storey 02	3896.87	2769.83	2666.941
Storey 01	4079.65	2981.18	2878.291
Base	4178.28	3199.29	3096.401

V. CONCLUSION

Storey Displacement

The lateral displacement of the story in relation to the base is known as story displacement. The building's severe lateral displacement can be limited by the lateral force-resisting system. For a wind load situation, the acceptability lateral displacement limit might be H/500 (others may choose H/400). In comparison to structures with AAC block infill and structures with interlocking Block Infill, the largest Storey Displacement was found at the top storey for structures with masonry infill.

Storey Drift

In general, one would subtract the narrative displacement of level "X" from the story displacement of level "X-1" to determine the story drift of level "X." For example, level 4's storey drift is equal to level 4's total story displacement minus level 3's story displacement. The storey drift in any storey due to the minimum required design lateral force, with a partial load factor of 1.0, shall not exceed 0.004 times the storey height, according to IS 1893 (part 1): 2002 CI. 7.11. 3. In comparison to structures with AAC Block and structures with Interlocking Block, storey drift was greatest at Storey 8 in structures with masonry infill.

Storey Shear

The ratio of the story shear force when story collapse occurs to the story shear force when entire collapse happens is known as the Storey shear factor. Simple formulae are proposed as a result of a series of dynamic analyses to compute the necessary story shear safety factor that may be employed to prevent story collapse. In comparison to other situations, storey shear was 28 percent higher in structures with masonry infill. The results showed that structures made up of interlocking blocks outperformed those made up of AAC blocks.

Axial Force

Axial load is determined by the type of reinforcement utilised in the column as well as the column's size. Axial load is a structural load that acts on the longitudinal axis of a column and is created by a beam slab and a brick wall. Axial loading of a column means that the load is operating on the column's longitudinal axis, which causes no moment. The following is a general formula for axial force: Where E is 7,000 times MPA, KN equals 1,000 times Newton, and d equals 640.3 times mm, Ned equals 270 times KN. Assume that due to centrifugal force, the segments furthest from the door interception are positive and those closest to the door are negative. When compared to the other two cases, the axial load in the structure with masonry infill was 8% higher.

Bending Moment

The coefficients of moments can be calculated by dividing the support moments by the span length. Because the support moment is shared by two spans on the left and right, the coefficient of moment is determined by averaging these spans. Apart from being 6.8% higher in structure with masonry infill when compared to structure with AAC Block infill and 7.1 percent higher when compared to structure with interlocking Bricks infill in all three cases, bending moment was found to be 6.8% higher in structure with masonry infill when compared to structure with AAC Block infill and 7.1 percent higher when compared to structure with interlocking Bricks infill in all three cases.

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