Analysis of Structure with Different Infill Material Using ETABS Software

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Abstract— Reinforcement concrete structure frame system widely used around the world. In building structure, structure element is generally taken as Beam, column, foundation. The dead & live load is transferred from beam to column, column to footing then ultimately load distributed into the soil. The wall load is taken by beam. In building design, we mentioned the whole wall on the beam is possible, if it is not possible, we taken concealed beam into the slab below the wall. During the analysis of frame structure, we consider wall as non-structural element. But including walls in the structure analysis is play important role. This study deals with the examination of the impact of infill in structure and their behavior in structure. In present situation high rise building constructed with the various type of infill wall materials. Some of them generally use for example red brick, AAC wall, Hollow concrete block, lightweight Aluminum & Steel panels. So, three types of models are created on ETABS software. In this study 9 storey high rise building is designed in ETABS with taking 3 infill materials like Fly Ash brick, AAC block and Hollow concrete block taken for study which on the most critical earthquake zone IV analysis (Dynamic) is done using ETABS, soil properties assumed medium and importance factor is taken 1.2. The all three infill wall models compare with the basic design parameter like moment, shear force, displacement. The all three models that I passed under seismic loading helped me to reach the conclusion on how all three models perform in the case of seismic loading. And by comparing the percentage growth in the displacement and storey drift we can decide the most efficient building. Because the AAC block has the lowest density hence it should have the least moment generated compared to other bricks almost 20-30 percent difference is expected. And the model with Strut member should have least deflection compared to other models. The difference of 15-20 percent is expected at least.

Keywords: ETABS, Structural Analysis, Masonry Infill, RC Frame, Earthquake, Displacement, Drift, Base Shear, AAC Blocks, Hollow Concrete Block, Bending Moment, Diagonal Strut

I. INTRODUCTION

A. Overview:

A tall structure is a multi-story structure in which most tenants rely upon lifts [lifts] to arrive at their goals. Now a days due to growth of the population Housing has developed into an economy generating industry. Because of these high-rise buildings have become a solution in large cities. The increasing frequency of the earthquakes in the world and building of tall structures, over the last few 10-20 years forces for the development of tremor safe structures. A considerable lot of the tall structures had fell in ongoing tremors and the reasons credited were poor plan and development rehearses. The goal of this work is to talk about the potential outcomes of demonstrating support itemizing of strengthened solid models in common sense use considering different type of infill walls. To carry out the analytical investigations, the structure is modelled and analysis is done in ETABS software.

B. Infill Wall:

The infill wall is the supported wall that works as separator in buildings used to define shape of a room or outer boundary of a building constructed with a three-dimensional framework structure generally made of steel or reinforced concrete. Therefore, the basic edge guarantees the bearing capacity, though the infill divider serves to isolate inward and space, topping off the crates of the external casings. The walls has one of a kind static capacity to shoulder its very own load. Infill walls are outside vertical misty kind of conclusion. As for different types of separators, the infill- walls contrasts from the parcel that divides two inside spaces. The last plays out similar elements of the infill-wall, hydro-thermally and acoustically, however performs static capacities as well.. The use of masonry infill walls, and to some extent veneer walls, especially in reinforced concrete frame structures, is regular in numerous nations. Indeed, the utilization of stone work infill dividers offers a prudent and tough arrangement. They are anything but difficult to fabricate, appealing for engineering and has a productive cost-execution.

Infill walling is the conventional name of a board that is worked in the middle of the floors of the essential auxiliary casing of a working as such Infill board dividers are a type of cladding worked between the basic individuals from a building.

The auxiliary edge offers help for the cladding framework, and the cladding gives division of the inner and outside environments. Infill dividers are viewed as non-load bearing, yet they oppose wind loads. Useful prerequisites for infill board dividers include: They are self-supporting between basic surrounding individuals. They give climate obstruction.

They give warm and sound protection. The give imperviousness to fire. They give adequate openings to common ventilation and coating.

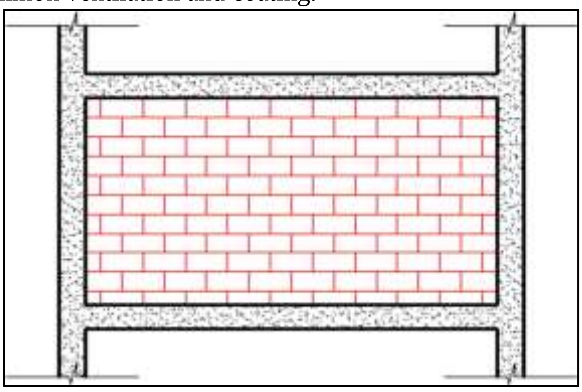


Fig. 1: Infill Wall

C. Design Criteria of High-Rise Building:

In this section, the points of importance to be considered for the design of any high-rise building structure are described. The points which may cause particular consequence in any high rise building and are based on above-mentioned literature are mentioned below.

D. Seismic Analysis:

It has been seen in past seismic tremors that the structures on inclined plane give more overlay. Shivers make substantial damage to structures, for case, loss of people in the building and if the intensity of vibration is high then it can cause collapse of the structure. In past years people has been produced irrefutably and as a result of which cities and towns started expanding out. In light of this reason distinctive structures are being inalienable inclined zones. India sports a wide shoreline forefront which is anchored with mountains and plateau. The structures in these zones are made on inclining grounds. A tremendous piece of the unforgiving ranges in India go under the seismic zone II, III and IV zones in such case working in context of slanting grounds are exceedingly slight against seismic tremor. This is a possible result of the way that the bits in the ground floor differentiate in their statures as showed up by the tendency of the ground. Segments toward one side are short and on flip side are long, by righteousness of which they are exceedingly delicate. Seismic forces acts more separate in inclining zones due to the assistant inconsistency. Moreover it has been examined that the seismic tremor exercises are slanted in inclining ranges. In India, for example, the north-east states. The deficiency of plain ground in inclining ranges powers advancement development on inclining ground realizing diverse imperative structures, for instance, reinforced concrete encompassed specialist's offices, colleges, motels and work environments laying on uneven inclinations. The lead of structures in the midst of tremor depends on the dispersal of mass and immovability in both even and vertical planes of the structures. In slanting district both these properties varies with irregularity and asymmetry. Such improvements in seismically slanted regions make them exhibited to more unmistakable shears and torsion.

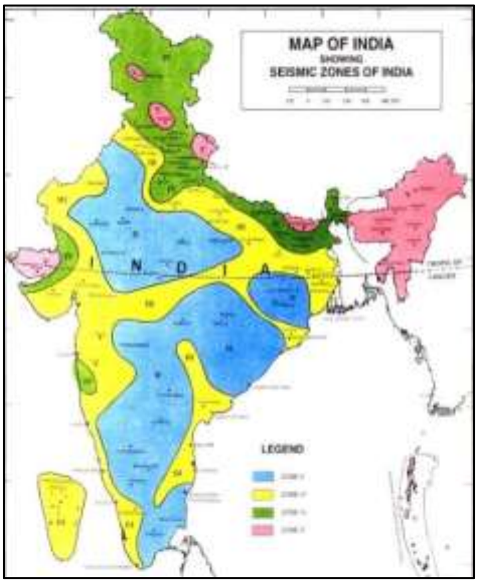


Fig. 2: Seismic Zone Distribution Map

SEISMIC ZONE	II	III	IV	V
INTENSITY	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

Table 1: Seismic Zones and Their Intensity

S. No.	Structure	Importance Factor
1	Important service and community buildings, such as hospitals; schools; monumental structures; telephone exchange, power grid, court, etc.	1.5
2	All other buildings	1

Table 2: Importance Factor for Different Structures

Building Frame System	Response Reduction Factor	Remark
O.M.R.F. (Ordinary moment resisting frame)	3	Ordinary detailing
S.M.R.F. (Special moment resisting frame)	5	Ductile detailing

Table 3: Response Reduction Factor for different R.C.C. building systems

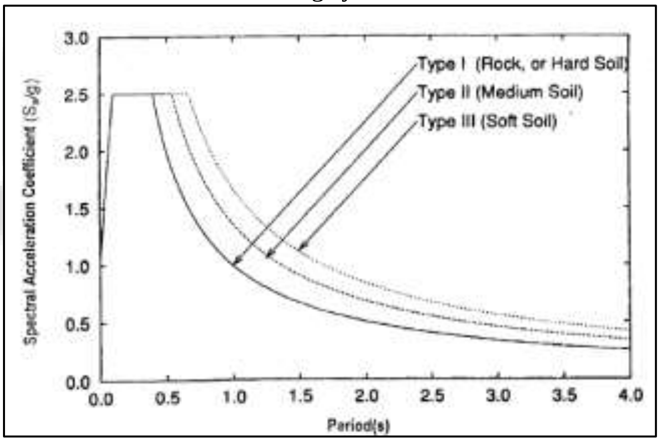


Fig. 3: Response spectra for 5% damping condition

E. Application of Response Spectrum:

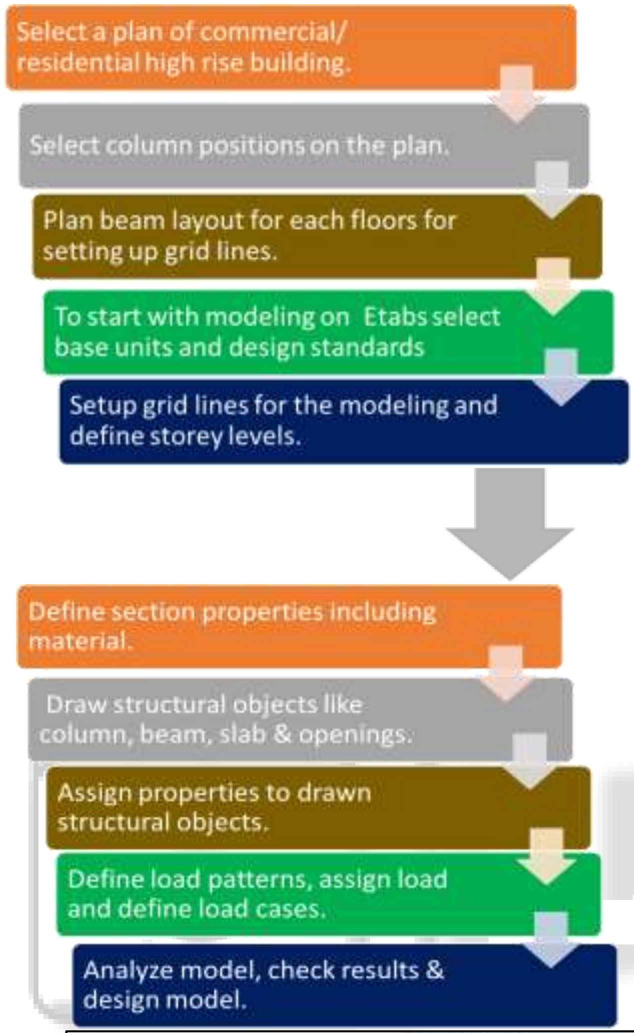
After defining the seismic parameters, dynamic analysis is performed using ETABS'17 software by applying response spectrum method in accordance with IS-1893:2016. It is done by providing acceleration in X-direction using SRSS (Square root sum of the squares) for different types of soil condition.Acceleration in X-direction is calculated using formula = Z/2 x I/R x Sa/g, Where Z = 0.24 (For Zone IV),

The design base shear VB (calculated from the Response Spectrum method) is contrasted and the base shear Vb (determined by observational recipe for the major time period).

On the off chance that VB is not exactly Vb, the majority of the reaction amounts are increased by Vb/VB according to Condition 7.8.2. The ratio Vb / VB is known as multiplication factor (MF) and this process is repeated until MF≤ 1. The same process is applied to other load cases.

II. METHODOLOGY

A. Flow Chart:



B. General Description:

S.NO	Description	Density	Compressive strength
1.	FLY ASH BRICK	Y = 19 KN/m3	10-12 N/mm2
2.	AAC BLOCKS	Y = 8 KN/m3	3-4.5 N/mm2
3.	HOLLOW CONCRETE BLOCK	Y = 14 KN/m3	5.6 N/mm2

Table 4: Material Description

S.NO	PROPERTIES	VALUES
1.	YOUNG'S MODULAS OF ELASTICITY OF STEEL , Es	2.17 × 105 N/mm2
2.	ULTIMATE TENSILE STRENGTH OF STEEL	500N/mm2
3.	GRADE OF CONCRETE	M25
4.	POISION RATIO	0.17

Table 5: Material Properties

S.NO	Description	Value
1	Area	20 X 25 m
2	Number of bays in X direction	4
3	Number of bays in Z direction	5
4	Height of Floors	3.0 m
5	Overall height	27 m

Table 6: Building Geometry

S. No.	Load Type	As per I.S. Code
1	Dead Load	I.S. 875-PART-1
2	Superimposed Load	I.S. 875-PART-2
3	Seismic Load	I.S. 1893-PART-1
4	Load Combinations	I.S. 875-PART-5

Table 7: Load assignment as per I.S. Code

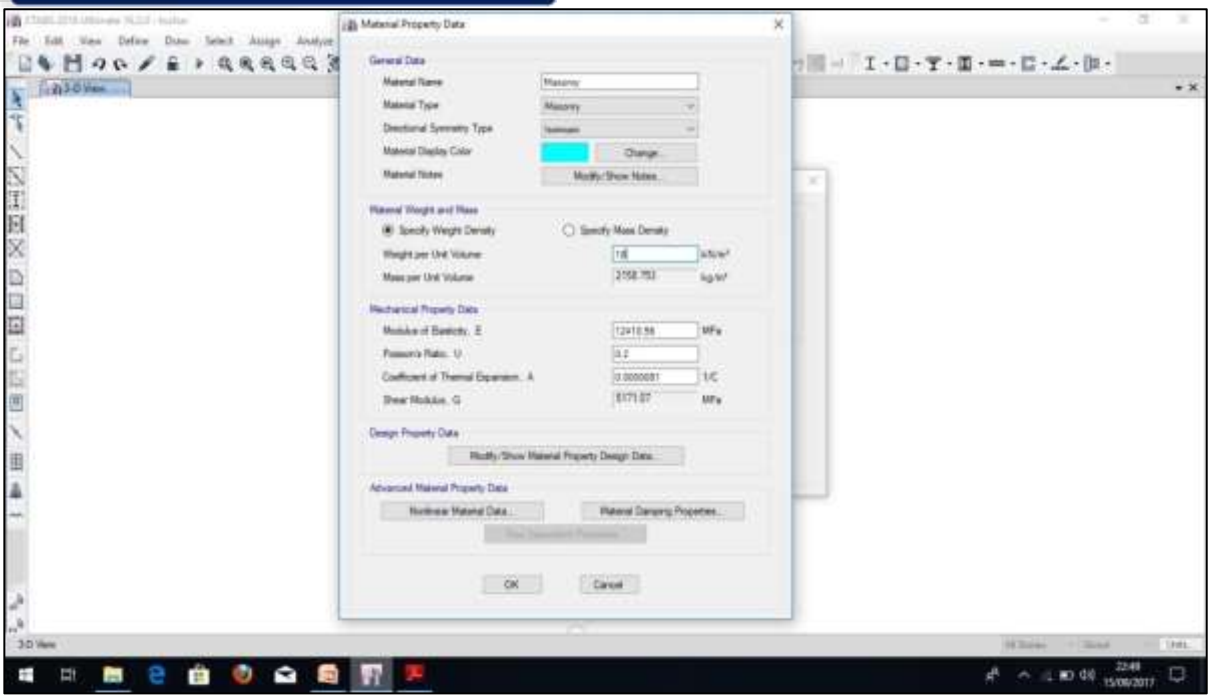


Fig. 4: Material Property Data

S.NO	Types Of Model Formulation In ETABS
1.	RCC Frame Taking with Infill Wall loading. (Calculated Value)
2.	RCC Frame with Assigning Infill-Wall Properties in ETABS
3.	RCC Frame with Diagonal Strut Member Method

Table 8: TYPES OF MODEL FORMATION IN ETABS

S.NO	PARAMETER	VALUE
1.	Zone IV	0.24
2.	Damping Ratio	0.05
3.	Importance Factor	1.2
4.	Response Reduction Factor	5
5	Soil Site Factor	Medium

Table 9: Earthquake Parameters

C. Load Calculation: -

DEAD LOAD –

1) Wall Load

1) FLY ASH BRICK = 0.2X 18X (3-0.5) = 9 KN / m^2
2) AAC BLOCK = 0.2 X 8 X (3-0.5) = 4 KN / m^2
3) HOLLOW CONCRETE = 0.2 X 14 X (3-0.5) = 7 KN / m^2

2) Slab Load

1) 0.125 X 25 X 1 +1 = 4.2 KN / m^2 (Including floor finish)

LIVE LOAD –

Assessable Area – 2 KN / m^2

Live Load (Seismic calculation) 25% of Live load: - 0.5 kN/m^2

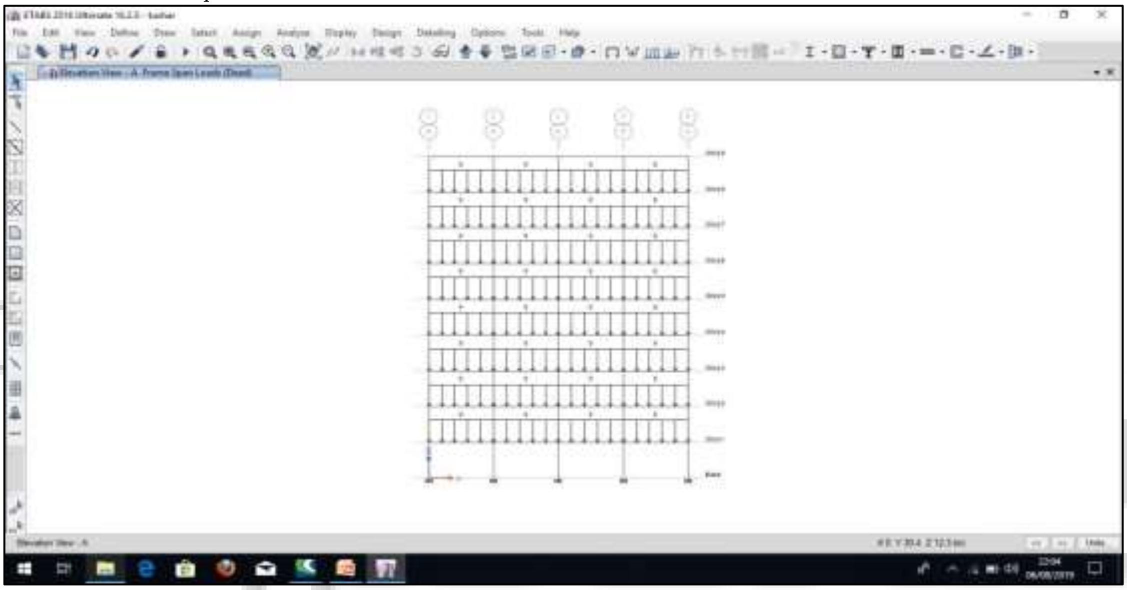


Fig. 5: Wall Loading

D. Sesmic Load –

When a building experiences the ground motion or ground vibration it reacts by shaking. This random shaking of structure occurs in all directions i.e. in (X) and (Y) and also in (Z) direction i.e. horizontal and vertical both way shaking is possible and it causes the building to vibrate in all three directions horizontally, laterally and vertically and this seismic forces can be calculated as per given in IS: 1893:2016.

E. Different Views of the Structure:

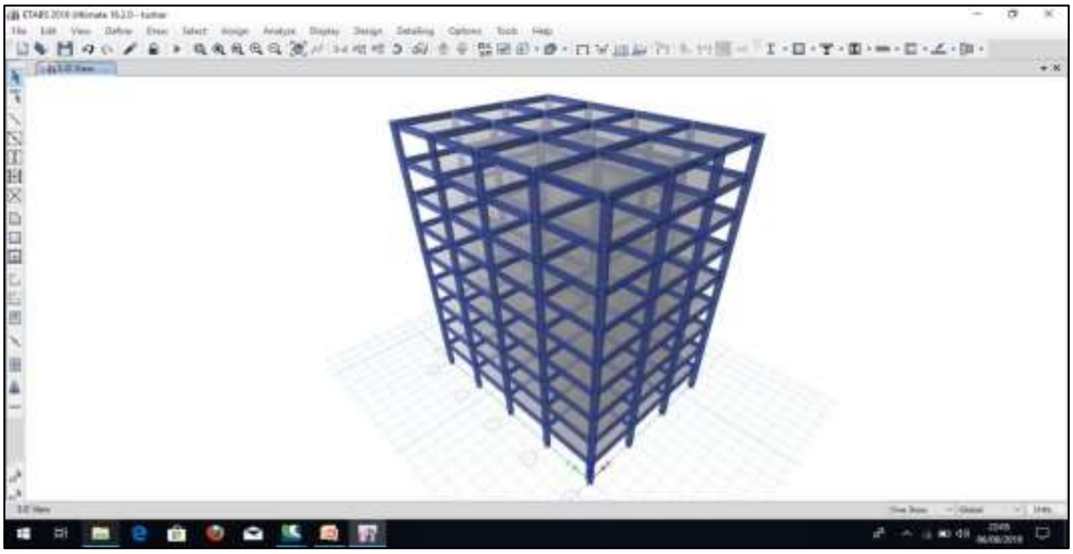


Fig. 6: 3d View of Building

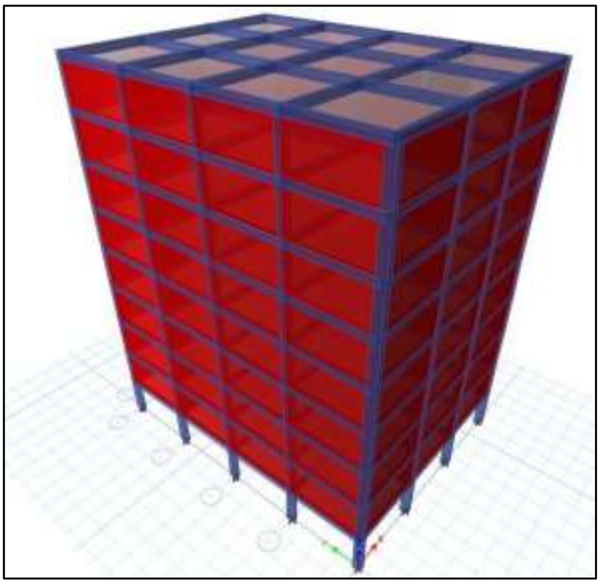


Fig. 7: 3d View of Building with Infill Wall Property

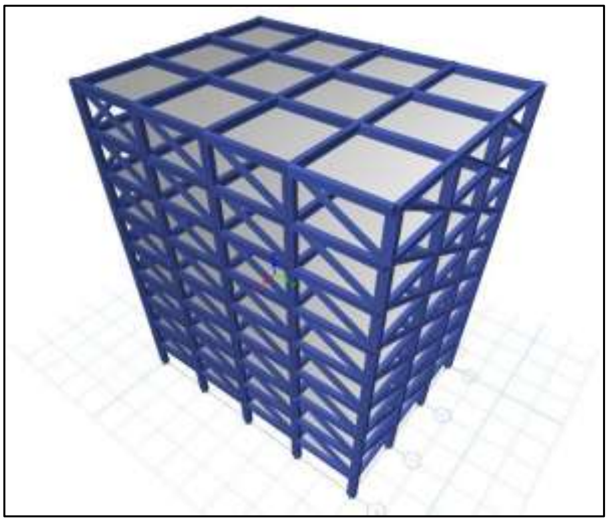


Fig. 8: Etabs Modal with Strut Member

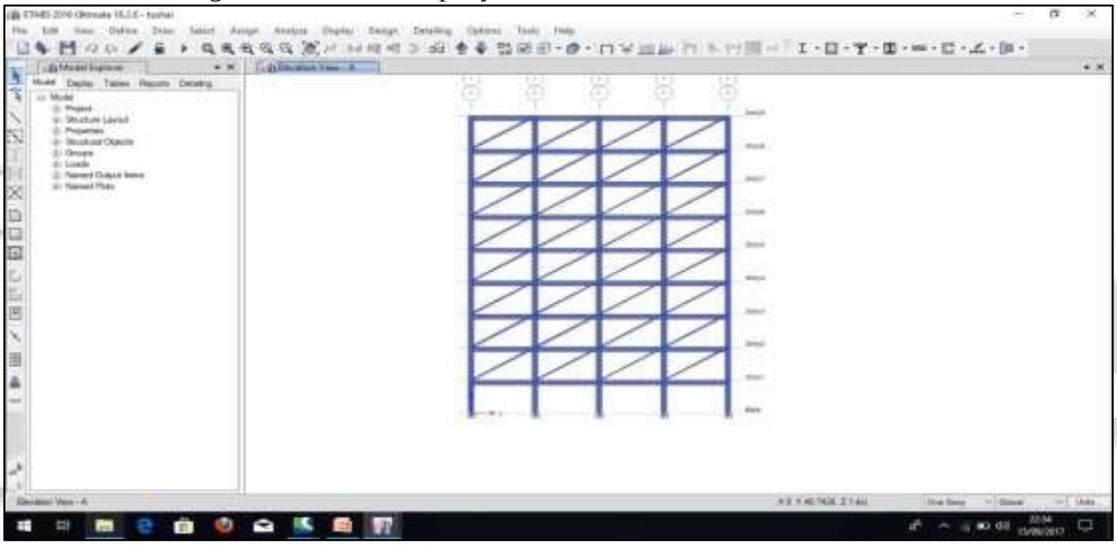


Fig. 9: Side View of Strut Member

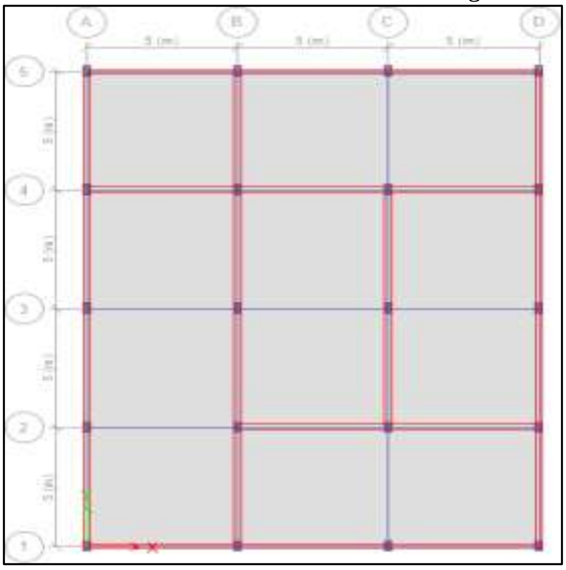


Fig. 10: Plan & Geometry

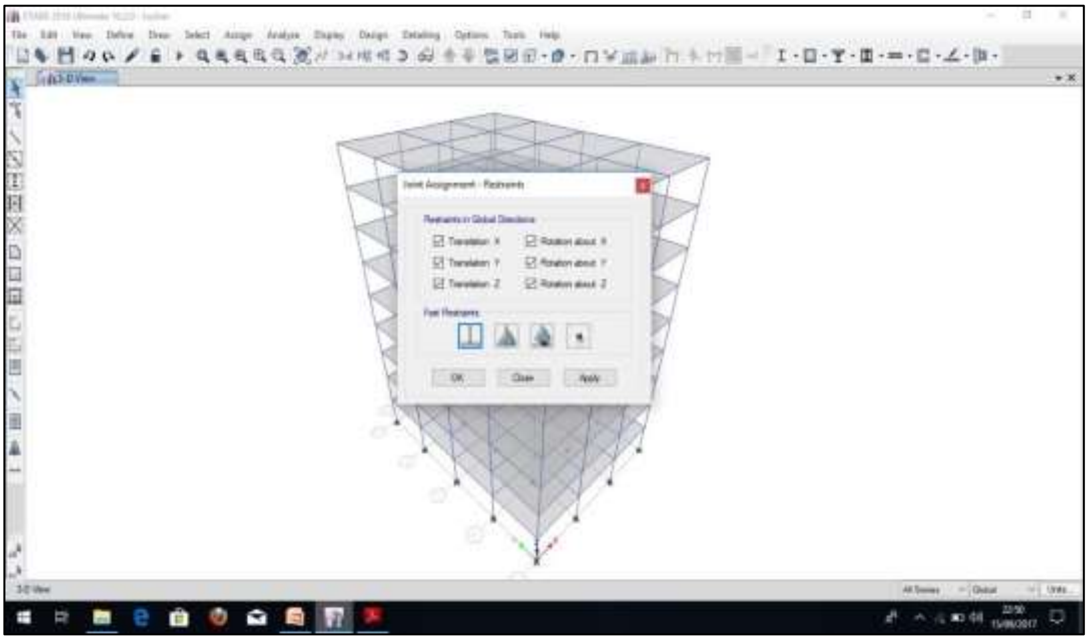


Fig. 11: Support Conditions: Fixed

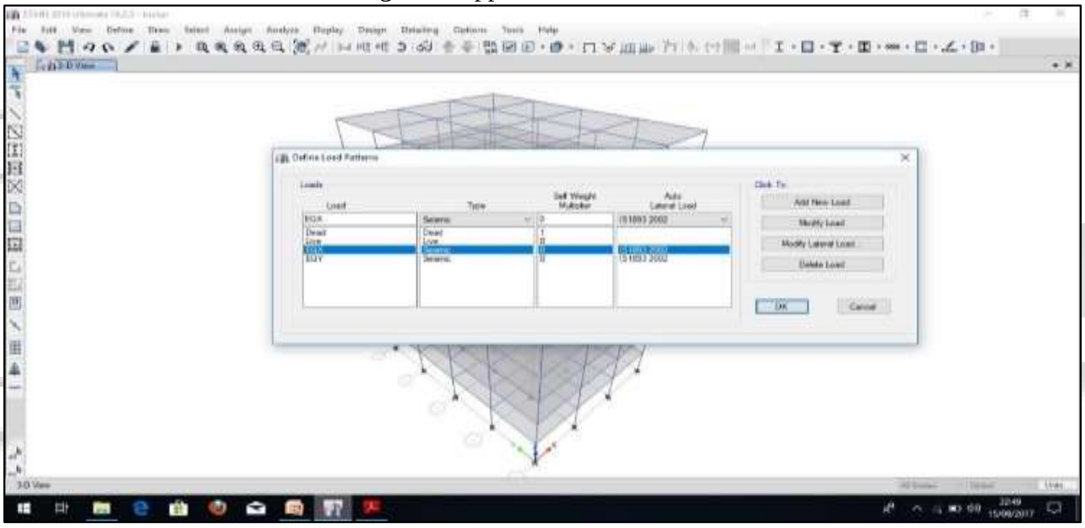


Fig. 12: Defining Load Patterns

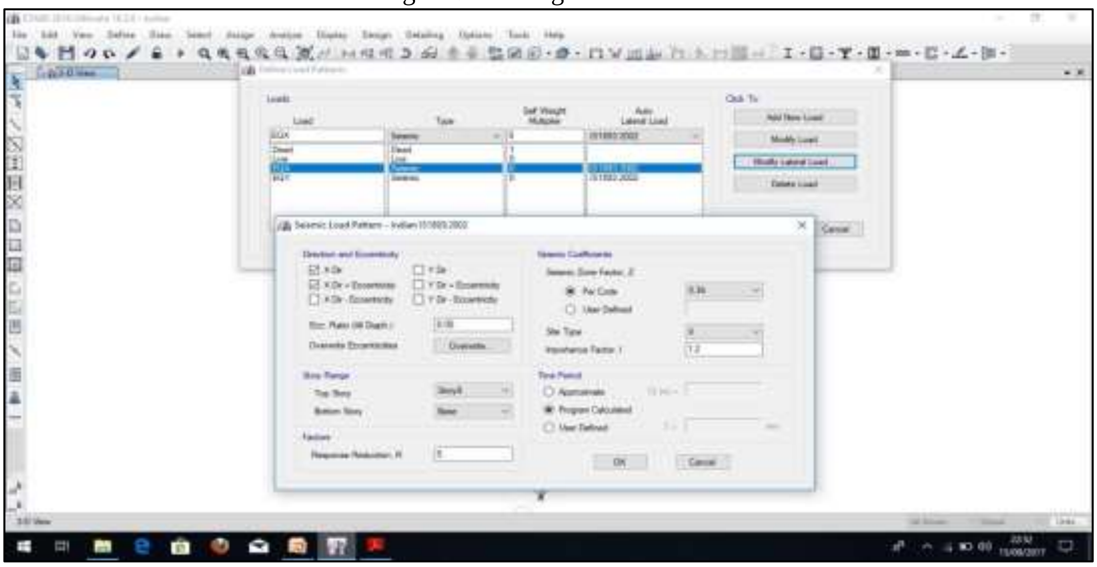


Fig. 13: Defining Seismic Load Patterns

III. ANALYSIS & RESULTS

A. Deflection of All the Models in MM:

S. No.	Model No.1	Model No. 2	Model No. 3
Storey 9	12.646	8.25	5.55
Storey 8	10.55	7.5	4.8
Storey 7	10.22	6.5	3.7
Storey 6	8.23	5.5	2.8
Storey 5	7.52	4.2	1.9
Storey 4	5.2	3.2	1.58
Storey 3	4.8	2.8	1.23
Storey 2	4.5	2.5	1.2
Storey 1	3.2	2.2	1.08

Table 10: Deflection in Fly-Ash Walls Models

S. No.	Model No.1	Model No. 2	Model No. 3
Storey 9	5.44	3.44	2.55
Storey 8	4.44	3.20	2.10
Storey 7	3.25	2.7	2.05
Storey 6	3.10	2.4	1.95
Storey 5	3.05	1.8	1.85
Storey 4	2.9	1.56	1.58
Storey 3	2.5	1.44	1.23
Storey 2	2.1	1.05	0.8
Storey 1	1.8	0.785	0.65

Table 11: Deflection in AAC Block Walls Models

S. No.	Model No.1	Model No. 2	Model No. 3
Storey 9	8.52	5.25	3.55
Storey 8	7.8	5.02	3.42
Storey 7	6.7	4.8	3.2
Storey 6	6.0	4.3	3.01
Storey 5	3.05	4.0	2.8
Storey 4	2.5	3.8	2.5
Storey 3	2.3	3.5	2.2
Storey 2	1.95	3.15	2

Table 12: Deflection in Hollow Concrete Block Wall Models

B. Shear Force of All the Models in KN:

S. No.	Modal No.1	Modal No. 2	Modal No. 3
Storey 9	131	303	415
Storey 8	334	351	500
Storey 7	489	418	580
Storey 6	604	725	655
Storey 5	683	900	822
Storey 4	734	1120	867
Storey 3	762	200	950
Storey 2	775	1350	1050
Storey 1	778	1400	1250

Table 13: Shear in Fly-Ash Brick Wall Models

S. No.	Modal No.1	Modal No. 2	Modal No. 3
Storey 9	150	425	300
Storey 8	222	500	380
Storey 7	275	570	418
Storey 6	300	548	488
Storey 5	352	592	512
Storey 4	400	618	580
Storey 3	462	700	629
Storey 2	555	822	750
Storey 1	625	1020	892

Table 14: Shear in AAC Brick Wall Models

S. No.	Modal No.1	Modal No .2	Modal No. 3
Storey 9	200	360	250
Storey 8	260	419	288
Storey 7	325	522	322
Storey 6	360	582	342
Storey 5	412	600	380
Storey 4	465	622	416
Storey 3	550	800	522
Storey 2	600	950	625
Storey 1	750	1050	780

Table 15: Shear in Hollow Concrete Block Wall Models

C. Bending Moment of All the Models in KN-M:

S. No.	Model No.1	Model No.2	Model No.3
Storey 9	15305	16607	14808
Storey 8	34585	38801	32681
Storey 7	52761	54223	50555
Storey 6	70367	72945	68428
Storey 5	91348	94567	86302
Storey 4	109800	116247	104175
Storey 3	124987	135795	122049
Storey 2	143673	146834	139923
Storey 1	161856	169260	157796

Table 16: Bending Moment in Fly-Ash Brick Wall Models

S.no.	Model no. 1	Model no. 2	Model no. 3
Storey 9	10945	11106	9854
Storey 8	22557	24511	19793
Storey 7	30274	37916	28542
Storey 6	47348	51321	45699
Storey 5	60371	64726	58411
Storey 4	73455	78131	70432
Storey 3	87326	91537	85360
Storey 2	98732	104942	94765
Storey 1	109432	118347	99723

Table 17: Bending Moment in AAC Block Wall Models

S.No.	Model No. 1	Model No. 2	Model No. 3
Storey 9	13966	17873	11643
Storey 8	30632	32681	28422
Storey 7	45322	50555	40631
Storey 6	62480	68428	59731
Storey 5	82450	86302	79838
Storey 4	99233	107241	95770
Storey 3	119476	125114	107839
Storey 2	130322	142988	124567
Storey 1	156786	160045	134790

Table 18: Bending Moment in Hollow Concrete Block Wall Models

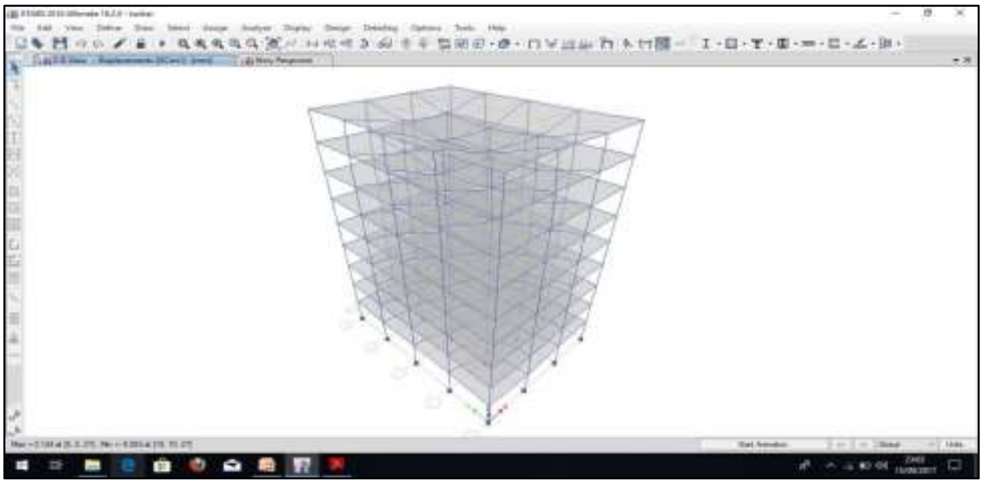


Fig. 14: Response of the Structure

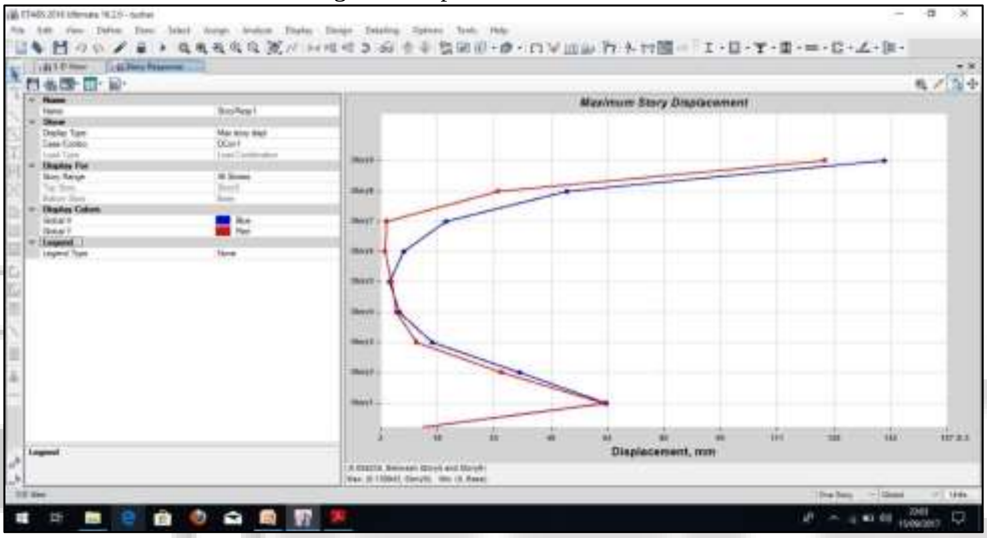


Fig. 15: Displacement Response of the Structure

D. Maximum Story Drifts in Different Stories

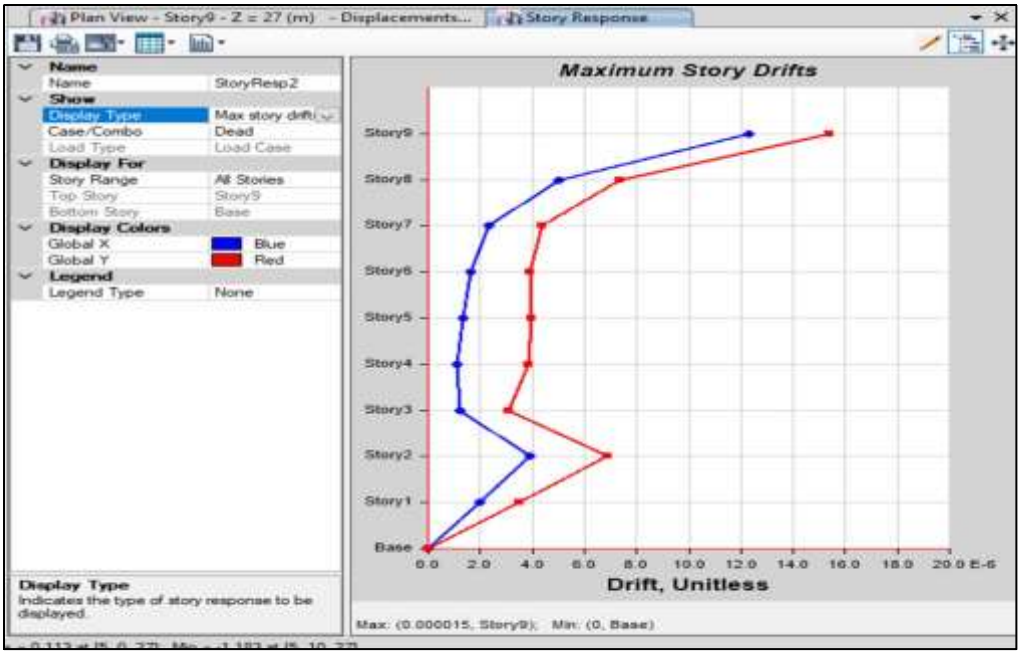


Fig. 16: Storey Drift Data of the Structure

E. Auto Lateral Load in Different Stories

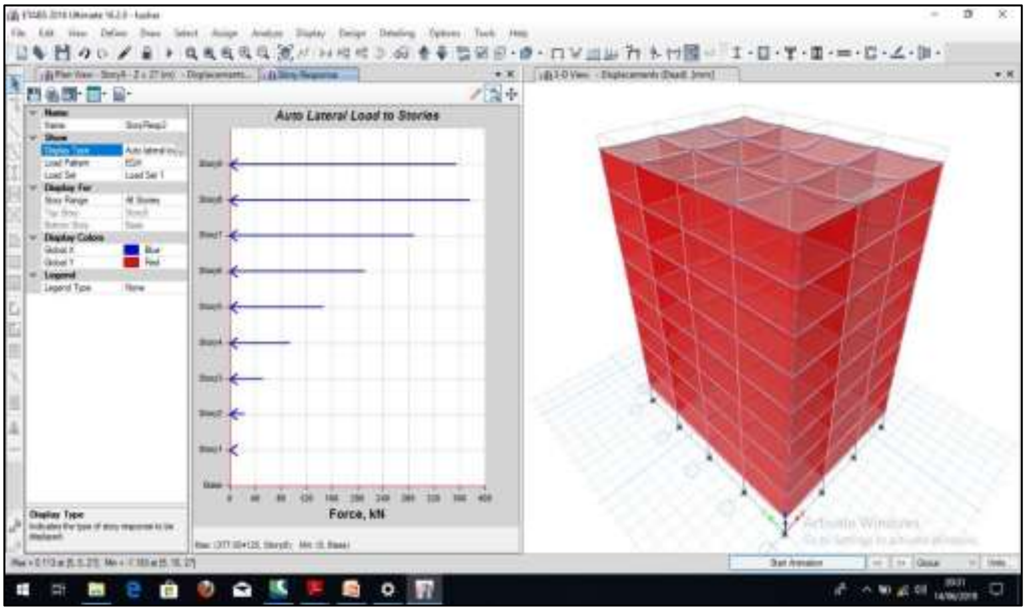


Fig. 17: Auto Lateral Load in the Stories

F. Shear Force in Different Stories:

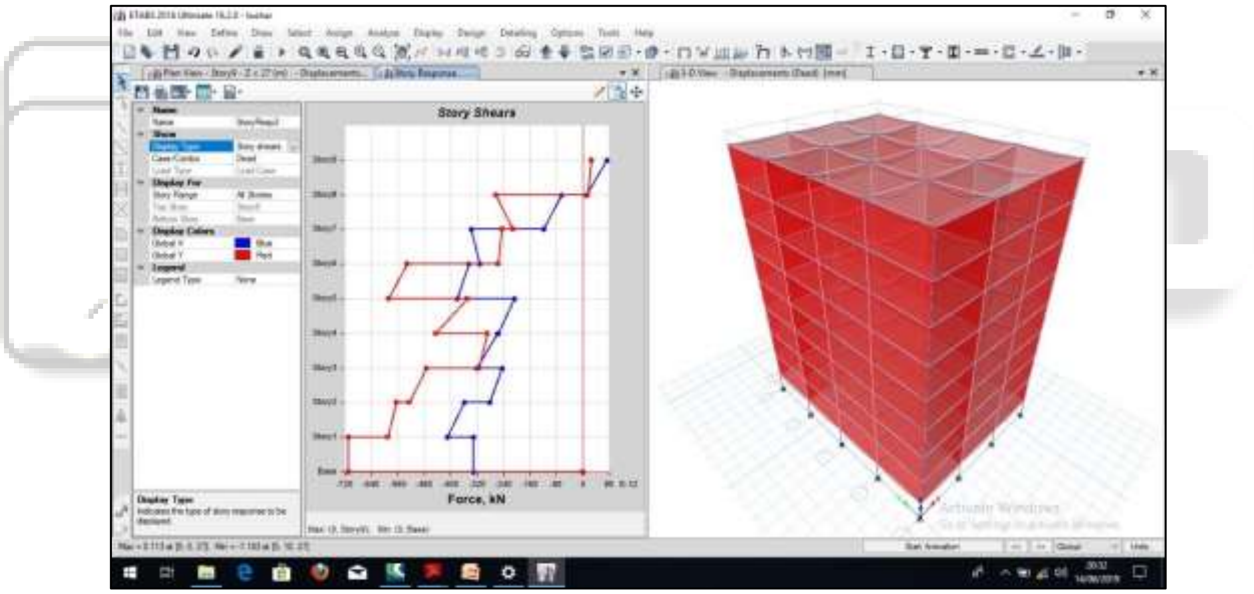


Fig. 18: Storey Shear Data of the Structure

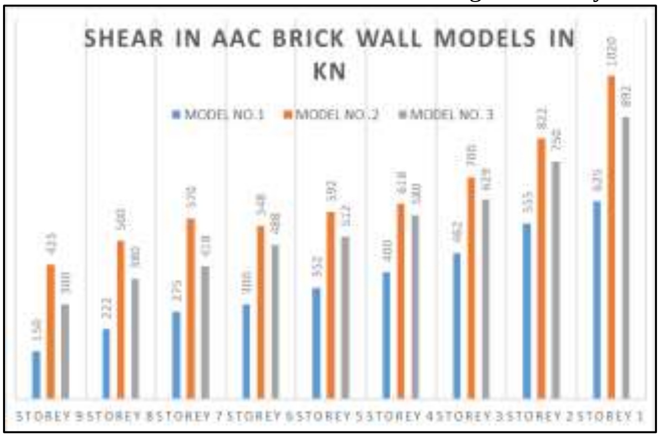


Fig. 19: Shear Force in each Storey of different models in KN

IV. CONCLUSION & FUTURE SCOPE

A. General:

For this research work following outcomes are observed:

1) From the results, it has been found that displacement of structure with AAC block in all three modal cases is found less than conventional brick masonry. While comparing the models 1, 2, 3 for displacements model 3 (infill frame) is having least displacement. In model 3 the strength and stiffness of material is replaced by an equivalent diagonal strut hence it has got least deflections.
2) It is observed from the results that storey shear with AAC and hollow concrete masonry is significantly less when

compared to brick masonry infill panel. It is due to the light weight of AAC blocks and hollow concrete.

3) Model M-2 has more storey shear than M-1, and M-3 because Storey shear depend on stiffness of the frame. The struts in masonry infill resist the lateral seismic forces through axial compression along the strut. The contribution of infill increases the stiffness of the frame this resulting increase in seismic forces. Model M-1 has the least value of storey shear with all three types of infill materials because stiffness has not been considered in case M-1.
4) Following things we can see from the results that the physical properties of the walls has very significant effect in the ability of the structure to handle Lateral loading. The storey displacement was least in AAC block wall in Model 3 with the Diagonal strut in the place of strength and stiffness of the wall material. Storey shear also was seen the lowest in the AAC block walls And the Bending Moment also was seen the lowest in the AAC blocks. Hence we can conclude that the AAC blocks are a better replacement for conventional infill materials in Earthquake prone areas.
5) One more thing that we see from this study that neglecting the structural properties i.e. not considering walls as a structural element is not beneficial as seen from the Model 1 of every case. Models with structural properties of walls performed well in earthquake conditions.
6) Future Scope of this study is that by proving that the Walls too play an important role in the overall stiffness of the structure in the Earthquake conditions we can design structures with keeping that in mind.
7) In future studies will can analyze the different infill walls effect in the irregular building under the seismic loading dynamic analysis.
8) We can also analyze infill wall effect in large span building (like Flat or PT Slab).
9) Percentage increase and decrease of deflection between models,
   Fly ash bricks, Model 2 has 33% more deflection than Model 3 and Model 1 has 35% more deflection than Model 2.
   AAC bricks, Model 2 has 26% more deflection than Model 3 and Model 1 has 37% more deflection than Model 2.
   Hollow concrete bricks, Model 2 has 33% more deflection than Model 3 and Model 1 has 39% more deflection than Model 2.
10) Percentage increase and decrease of Shear between models,
   Fly ash bricks, Model 2 has 45% more shear than Model 1 and Model 3 has 10% less shear than Model 2.
   AAC bricks, Model 2 has 39% more shear than Model 1 and Model 3 has 12.5% less shear than Model 2.
   Hollow concrete bricks, Model 2 has 28.5% more shear than Model 1 and Model 3 has 25.7% less shear than Model 2.
11) Percentage increase and decrease of bending moment between models,
   Fly ash bricks, Model 2 has 4% more bending moment than Model 1 and Model 3 has 7% less bending moment than Model 2.
   AAC bricks, Model 2 has 7.5% more bending moment than Model 1 and Model 3 has 15.7% less bending moment than Model 2.
   Hollow concrete bricks, Model 2 has 2% more bending moment than Model 1 and Model 3 has 16% less bending moment than Model 2.

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