Seismic Analysis of Rc Frame Structure (G+15) With, Without Infill Walls and Soft Storey with Different Infill Materials using ETABS

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Abstract- *Masonry infill walls are generally considered as non-structural elements and their stiffness contributions are generally ignored in practice, thus this kind of approach can lead to an unsafe design. The masonry infill walls, though constructed as secondary elements behaves as a component part of the structural system and determine the overall behavior of the structure especially when it is subjected to seismic loads. In this thesis seismic analysis has been performed using Equivalent Static Analysis Method for different reinforced concrete (RC) frame building models that include bare frame, Infilled frame and open first storey frame and modeled with Clay infill and AAC Blocks using ETABS 2013 software. The results of bare frame, infilled frame and open first storey frame are discussed and conclusions are made. In modeling masonry infill panels the Equivalent diagonal Strut method is used and the software ETABS is used for the analysis of all the frame models.*

From the results obtained it was found that masonry infills increase the stiffness and strength of a structure and hence the infills can completely change the dissemination of damage throughout the structure. The different parameters such as storey drift and maximum displacement for column were reduced substantially (i.e. storey drift by about (25-40) % and displacement by about (15-35) % making the structure safer due to increased stiffness, distribution of the storey shear have been compared in various models with, without masonry infills and effect of soft storey i.e. stiffness irregularity was also studied for types of G +15 multi-storied structure.

Keywords:- Compression Strut, Infill Frame, Soft storey frame Storey Drift, Storey Displacement, , Storey Shear.

I. INTRODUCTION

Lots of studies had been conducted both for fully infilled frames and for infills containing openings.

Thomas (1952) and Ockleston (1955) were one of the early major contributors in connection to the interaction between wall and frame. Holmes [1] (1961) studied experimentally on steel frames infilled with brick masonry and reinforced concrete walls and developed semi-empirical design method for laterally loaded infilled frames based on equivalent strut concept. His tests suggested that brick masonry walls increase the strength of frame by around 100%. The infill was considered to fail in compression. The load carried by infill at failure was calculated by multiplying the compressive strength of material by the area of equivalent strut. He states that the width of equivalent strut to be 1/3rd of the diagonal length of infill, which resulted in the infill strength being independent of frame stiffness .

Smith has put up tremendous effort in finding out the interaction between frame and infill. He tested a number of infilled frames subjected to diagonal loading where he used the diagonal strut concept. His design curve gives the effective width of strut, the compressive failure load and the diagonal failure load as related to frame stiffness and infill aspect ratio. Main stone has given equivalent diagonal strut concept by performing tests on model frames with brick infills. His approach estimates the infill contribution both to the stiffness of the frame and to its ultimate strength. The strut width equation according to him is shown in below. Liauw and Kwan studied both experimentally and analytically the behaviour of non-integral infilled frames. Finite Element method was adopted to find the effects of nonlinearities of the material and the structural interface, the initial lack of fit and friction at the interface was considered. Paulay and Preistley [2] gave the width of diagonal strut as 0.25 times the diagonal length of the strut. Hendry has also presented equivalent strut width that would represent the masonry that actually contributes in resisting the lateral force in the composite structure. In addition to these studies, large numbers of researches have been done in the past for fully infilled frames with and without openings.

Prof. P.B Kulkarni [3] discussed about performance of masonry in filled reinforced concrete (RC) frames with open first storey of with and without opening. A symmetrical frame of college building (G+5) located in seismic zone-III is considered by modelling of initial frame. Linear static analysis is carried out on the models such as bare frame, strut frame, strut frame with centre &corner opening, which is performed by STAAD-PRO.

He concluded that According to IS 1893(Part-1) - 2002 Clause No.7.11.1 "Storey Drift Limitation", the storey drift in any storey due to the minimum specified design lateral force with partial load factor of 1 shall not exceed 0.004 times the storey height. But, In bare frame the value of deflection of all Columns is exceeding just by 4-6 mm, which is not satisfying the codal provision given above.

Vikas P. Jadhao, Prakash S. Pajgade [4] The base shear experienced by models with AAC pieces had fundamentally littler than with customary earth blocks which brings about lessening in part drives The execution of AAC square infill was better than that of Conventional block infill in RC outline. In this way, the AAC square material can essentially be utilized to supplant ordinary blocks as infill material for RC outlines worked in the seismic tremor inclined district. Contrasted the execution of edge and full infill as routine dirt blocks and AAC pieces was altogether better than that of exposed edge.

Sattar and Liel discussed [5] on Pre 1975 California construction. RC frame structures of 4 and 8 stories are considered. Each building is evaluated as a base frame and with two different Infill configurations. Push over analysis is done on 4 and 8 stories models in OPENSEES.

He concluded that results of pushover analysis show an increase in initial stiffness, strength, and energy dissipation of the in filled frame, compared to the bare frame, despite the wall's brittle failure modes. Dynamic analysis results indicate that fully-in filled frame has the lowest collapse risk and the bare frames are found to be the most vulnerable to earthquake-induced collapse.

II. MODELLING OF INFILL WALL

Analytical modelling of masonry infill is done by either finite element or strut type modelling. From above two methods strut type model is choose for analysis. This difference in the deformation pattern causes the infill wall to resist the frame deformation through diagonal compression, which in turn results in forces applied along the contact surface between the frame and infill. FEMA 273 suggests method for determining width of strut, which is developed by Mainstone

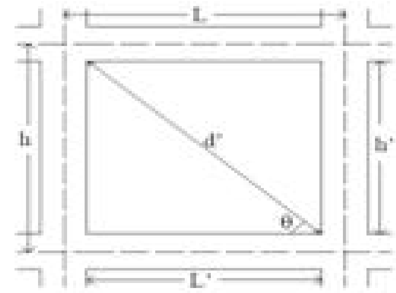


Fig. 1 : Key parameters for modeling infill as an equivalent compression strut

The width of equivalent compression strut is given by:

$$a = 0.175(\lambda_1.h_{col})^{-0.4}.r_{inf}$$

with:

$$\lambda_1 = \left[\frac{E_{me}t_{inf}\sin 2\theta}{4E_{fe}I_{col}h_{inf}}\right]^{\frac{1}{4}}$$

Where,
h_{col}= height of column between center lines of beams = 3m
h_{inf} is the height of infill panel = 2.55m
E_{fe} is the expected modulus of elasticity of frame material = 25000 N/mm^2.
E_{me} is the expected modulus of elasticity of infill material = 3500 N/mm^2.
I_{col} is the moment of inertia of column = 0.003125 m^4
r_{inf} is the diagonal length of infill panel = 5.83m.
t_{inf} is the thickness of infill panel and equivalent strut = 0.23m.
θ is the angle whose tangent is the infill height-to-length aspect ratio = $\tan^{-1}(h_{inf} / Linf)$.
λ_1 is the coefficient used to determine the equivalent width of the infill strut.

From the above 'θ' formula the calculated θ = 36.80^o
Now on putting this θ value in 'λ' formula we get, $\lambda_1 = 0.0169$
By putting all these values in the equation …..1 we get,
$a = 0.175x\ (0.0169x118.1)^{-0.4}\ x\ 167.32$

Therefore,
a = 0.24m (The required value)

III. MATERIALS AND METHODS

A study is undertaken which involves seismic analysis of RC frame buildings with different models that include bare frame, infilled frame and open first storey frame. Different infill material like conventional clay bricks and AAC blocks masonry is taken into considerations. The parameters such as base shear, time period, storey drift are studied. The software ETABS is used for the analysis of the entire frame models.

Following data is used in the analysis of the RC frame building data is used in the analysis of the RC frame building models

- Type of frame: Special RC moment resisting frame fixed at the base
- Seismic zone: III
- Number of storey: G+15
- Floor height: 3. m
- Depth of Slab: 125 mm
- Size of beam: (230 × 450) mm
- Size of column: (400 × 600) mm
- Spacing between frames:
  5 m along X direction
  5 m along Y directions
- Floor finish: 2 KN/m2
- Terrace water proofing: 1.5 KN/m2
- Materials: M 25 concrete, Fe 415 steel ,
- Thickness of infill wall: 230 mm
- Density of concrete: 25 KN/m3
- Density of brick infill: 18 KN/m3
- Density of AAC block infill : 7 KN/m3
- Poison Ratio of concrete : 0.2
- Poison Ratio of brick masonry : 0.16
- Poison Ratio of AAC masonry : 0.25
- Compressive strength of brick masonry : 5 Mpa
- Compressive strength of AAC masonry : 4 Mpa
- Live load on floor: 3 KN/m3
- Type of soil: Medium
- Response spectra: As per IS 1893(Part-1):2002[8]
- Damping of structure: 5 percent

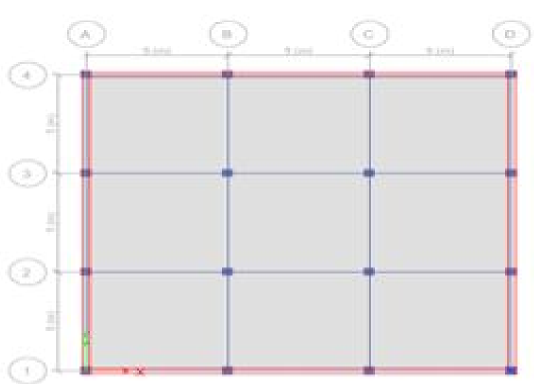


Fig 2: Plan of irregular building

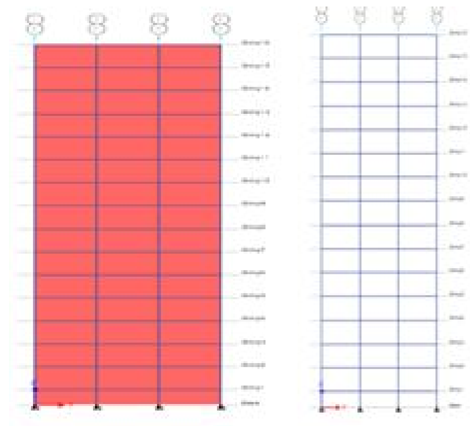


Fig 3: Bare and Complete Fill model

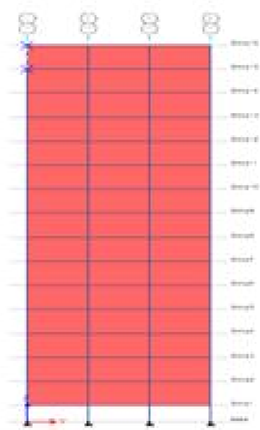


Fig 4 : Soft Storey model

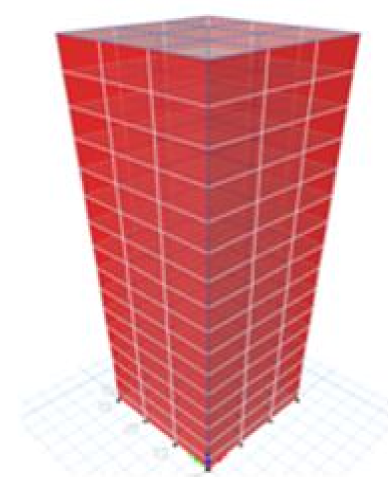


Fig 4: 3D model

IV. RESULT AND DISCUSSION

The seismic analysis of all the frame models that includes bare frame, infilled frame and open first storey frame has been done by using software ETABS and the results are shown below. The parameters which are to be studied are time period, base shear and storey drift.

Time period

For moment resisting frame building without brick infill panel

***Ta** = 0.075 h0.75*

= 0.075 x 450.75

= 1.303 sec

For moment resisting frame building with brick infill panel

***Ta** = 0.09 h /√ d*

= 0.09 x 45 / √15

= 1.04 sec along X direction

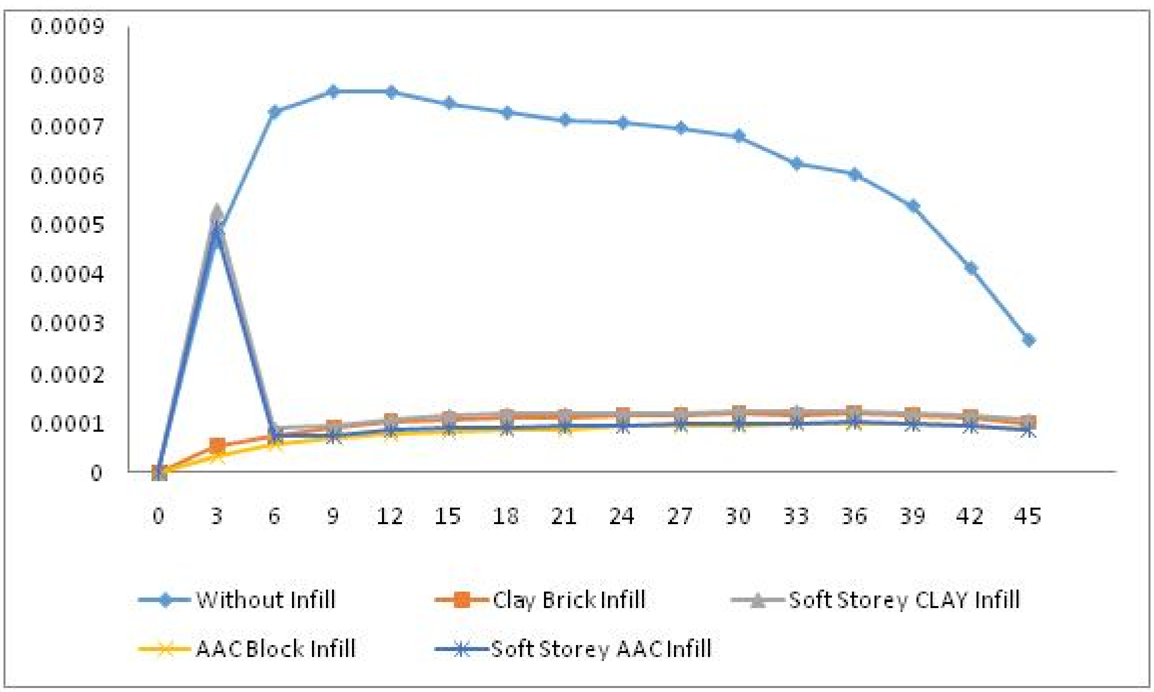
***Ta** = 0.09 h /√ d*

= 0.09 x 45 / √15

= 1.04 sec along Y direction

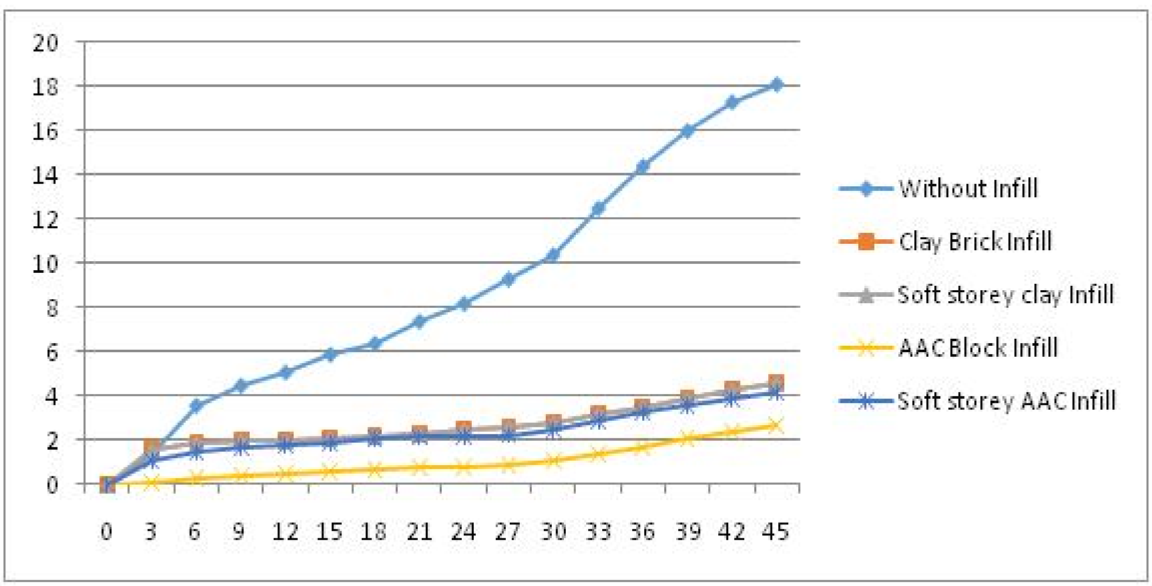
Summary: Storey Drift VS Storey Height

Storey NO	Elevation (m)	Without Infill (m)	Clay Brick Infill (m)	Soft storey clay Infill (m)	AAC Block Infill (m)	Soft storey AAC Infill (m)
Storey 15	45	0.000268	0.000102	0.000106	0.000087	0.000086
Storey 14	42	0.000413	0.000111	0.000115	0.000095	0.000095
Storey 13	39	0.000538	0.000116	0.000121	0.000098	0.000097
Storey 12	36	0.000601	0.000119	0.000123	0.000099	0.000104
Storey 11	33	0.000623	0.000118	0.000125	0.000097	0.000101
Storey 10	30	0.000679	0.000121	0.000123	0.000094	0.000099
Storey 9	27	0.000695	0.000117	0.000121	0.000094	0.000097
Storey 8	24	0.000705	0.000115	0.00012	0.000093	0.000094
Storey 7	21	0.000711	0.000112	0.000119	0.000087	0.000093
Storey 6	18	0.000725	0.000111	0.000118	0.000085	0.000091
Storey 5	15	0.000745	0.000108	0.000116	0.000082	0.000089
Storey 4	12	0.000767	0.000104	0.000108	0.000077	0.000085
Storey 3	9	0.000768	0.000091	0.000094	0.000072	0.000075
Storey 2	6	0.000727	0.000075	0.000089	0.000058	0.000074
Storey 1	3	0.000465	0.000053	0.000531	0.000032	0.000495
Base	0	0	0	0	0	0



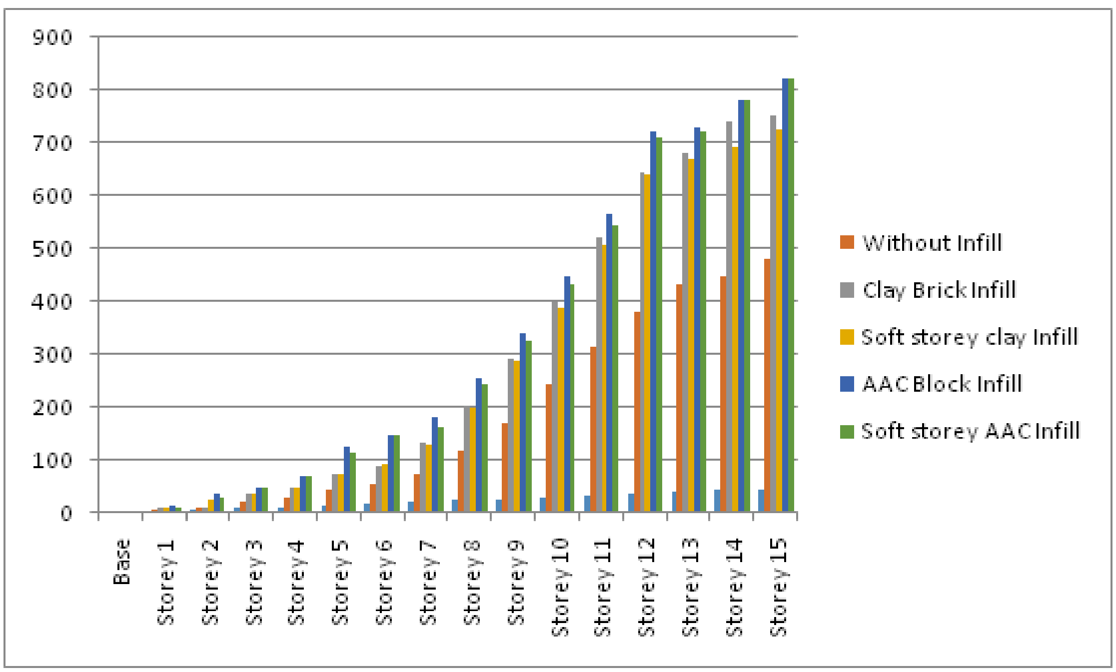
Summary: Storey Displacement VS Storey Height

Storey No	Elevation (m)	Without Infill (mm)	Clay Brick Infill (mm)	Soft storey clay Infill (mm)	AAC Block Infill (mm)	Soft storey AAC Infill (mm)
Storey 15	45	18.1	3	4.6	2.7	4.2
Storey 14	42	17.3	2.7	4.3	2.4	3.9
Storey 13	39	16	2.4	3.9	2.1	3.6
Storey 12	36	14.4	2	3.5	1.7	3.3
Storey 11	33	12.5	1.7	3.2	1.4	2.9
Storey 10	30	10.4	1.3	2.8	1.1	2.5
Storey 9	27	9.3	1.2	2.6	0.9	2.24
Storey 8	24	8.2	1	2.5	0.8	2.2
Storey 7	21	7.4	0.86	2.3	0.78	2.16
Storey 6	18	6.4	0.8	2.2	0.7	2.1
Storey 5	15	5.9	0.7	2.1	0.6	1.9
Storey 4	12	5.1	0.6	2.02	0.51	1.82
Storey 3	9	4.5	0.5	2	0.4	1.7
Storey 2	6	3.6	0.4	1.9	0.3	1.5
Storey 1	3	1.4	0.2	1.6	0.1	1.1
Base	0	0	0	0	0	0



Summary: Base Shear VS Storey Height

Storey No	Elevation (m)	Without Infill (KN)	Clay Brick Infill (KN)	Soft storey clay Infill (KN)	AAC Block Infill (KN)	Soft storey AAC Infill (KN)
Storey 15	45	480.978	750.477	723.837	820.425	823.546
Storey 14	42	445.797	739.536	690.244	780.263	780.463
Storey 13	39	430.131	680.927	670.186	730.127	720.147
Storey 12	36	381.141	641.715	641.446	721.952	710.545
Storey 11	33	311.672	519.946	506.823	564.468	542.152
Storey 10	30	240.532	398.256	388.035	444.642	433.024
Storey 9	27	167.412	289.657	285.087	339.754	325.279
Storey 8	24	114.665	201.151	197.977	251.611	240.625
Storey 7	21	72.302	128.736	126.705	178.742	160.7832
Storey 6	18	53.321	86.453	89.564	145.567	143.636
Storey 5	15	42.354	72.414	71.2719	122.215	111.252
Storey 4	12	24.435	46.345	45.534	67.435	68.456
Storey 3	9	18.826	32.182	31.6764	45.263	42.875
Storey 2	6	8.345	9.236	23.654	34.342	26.563
Storey 1	3	4.745	8.036	6.6558	11.012	8.364
Base	0	0	0	0	0	0



V. CONCLUSION

The results of the study concluded that masonry infill extremely increases the stiffness and strength of a structure. Simple modeling with equivalent diagonal struts, which carry loads only in compression, was able to simulate the global seismic response of the infilled frames, and was found suitable for practical applications. The study on different parameters indicates that the infills can completely change the distribution of damage throughout the structure.

From the results obtained the following discussions were made

1. Contribution of infill wall resulted in decrease of storey drifts by 70-80 %. It was clear that using frames without infills causes high drifts.
2. Storey drift was observed maximum at Middle storey's for the regular infill model due to the resultant force caused by the overlap of seismic waves. As the drift decreases, the chances of failure will be decreased.
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4. From the results obtained it was observed that different types of infill materials also affect the response of structure to seismic forces.
5. Significant decrease of 35% to 45% was noted for storey displacement when infill walls were provided in the frame.
6. The storey shear was increased in Infill Wall structures by 80 to 100 % when compared with bare frames.
7. Although failure of infills occur in the early stages of an earthquake, their presence is useful in increasing the resistance of the frame.
8. The influence of infills on the seismic response of the investigated structure is beneficial.

Hence, it was concluded that Usage of AAC blocks is recommended over the Conventional Clay Bricks as it reduces the overall weight of the structure and increases stability due to greater modulus of elasticity by which the Storey Displacement, Storey Drift decreases and Storey Shear increases.

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